ACCEPTANCE CRITERIA OF ALTERNATIVE BUILDING MATERIALS AND TECHNOLOGIES FOR WALLING: A CASE STUDY OF NAIROBI CITY COUNTY

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DECLARATION

This research project is my original work and has not been presented for a degree or any other award in any other University.

Signature……………….………...………. Date……...………………. …..

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B53/7431/2017

This research project has been submitted in partial fulfilment of the examination requirements with my approval as the University of Nairobi supervisor.

Signature……………….………...………. Date……...………………. …..

Professor Robert Rukwaro.

DEDICATION

This research is dedicated to my family for their unrivalled support, encouragement, prayers and believing in me throughout my studies and always urging me on whenever things seemed tough. God bless you.

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ABBREVIATIONS AND ACRONYMS

ABMTs-Alternative Building Materials and Technologies

CSEB- Compressed Stabilized Earth Blocks

DSS-Decision Support System

EPS- Expanded Polystyrene

HABRI- Housing and Appropriate Building Research Institute

ICB-Interlocking Concrete Block

ISSBs-Interlocking Stabilized Soil Blocks

KEBS- Kenya Bureau of Standards

MHUPA- Ministry of Housing and Urban Poverty Alleviation (India)

NCA- National Construction Authority

NCGDP-Nairobi County Government Development Plan

NHC-National Housing Corporation

SPSS- Statistical Package for Social Sciences

SSA-Sub-Saharan Africa

TAM-Technology Acceptance Model

TPB- Theory of Planned Behaviour

UN- United Nations

ABSTRACT

The purpose of the study was to determine the acceptance criteria of Alternative Building Materials and Technologies (ABMTs) for walling. The overall objective was achieved by: (a) investigating the various ABMTs currently in use in Nairobi City County and the rate of adoption; (b) identifying the parameters that need to be considered in acceptance of ABMTs thus developing a conceptual model including the most critical factors that influence the acceptance; (c) investigating end users level of awareness and factors they would consider in acceptance of ABMTs; and (d) identifying various strategies that can be put in place to increase uptake of ABMTs. The study was conducted through a cross section survey method. Primary data was collected from developers, architects, manufacturers, government officials from Department of Housing and Urban Development, Kenya Bureau of Standards and end users using questionnaires and interviews for data collection. Data was analysed using Microsoft excel and Statistical Package for Social Sciences (SPSS).

The study was based on eight dimensions of acceptance criteria of Alternative Building Materials and Technologies for walling, which are economic, social, technical know-how, environmental sustainability, quality, government policies, time and logistics. The study adopted 32 parameters from the literature review out of which respondents identified 18 parameters from the various eight dimensions to be considered in acceptance criteria. A hypothesized mean of 4 and above was set as a critical cut-off point and considered in the final acceptance model for ABMTs. The study therefore recommends that these eighteen parameters that assisted in developing the acceptance model should be considered in future for any study or even by stakeholders in the construction industry who seek to measure or chose the best option from the available ABMTs.

The findings from this research provide useful information on an efficient set of parameters which will also serve as a Decision Support System for various actors in the construction industry. This efficient set of identified parameters will assist various construction industry players to select the most appropriate technologies for construction of buildings from the approach of affordability and sustainability and also strategies that can be put in place to accelerate adoption of ABMTs through well designed marketing strategies for these materials, policy incentives and educational programs.

CHAPTER ONE

INTRODUCTION

1.0: Background and context of study

Construction industry and building materials comprise of one of the most critical sectors in any economy. They form the basic means for the implementation, expansion, improvement and maintenance of all civil engineering and human settlement projects (Omayi, 1993).

Various historical developments have taken place in the construction industry. During the pre-colonial period there was domination of use of locally available materials that were sustainable and skills were passed through apprenticeship from generation to generation (Construction Industry Policy, 2018).

There was use of both local and imported materials during the colonial period, this was due to Europeans presence and influence in Kenya. Majority of the skills were imparted to individuals by means of apprenticeship and formal training. Materials from European and Asian countries also dominated the industry as they were considered to have some level of superiority to the indigenous materials and technologies (Construction industry Policy, 2018).

According to Kagai (2017), property developers are finally inventing a new technique/approach to deal with the increasing costs of building experienced in Kenya. In his opinion, he asserts that this rapid increase in cost is an impediment to owning homes by many Kenyans. To ensue this, technological application in construction is adopted as a remedy to lower costs therefore maximising output, consequently experiencing high standards in terms of quality. In his opinion, if Kenya could borrow the usage of alternative materials emanating from Indian and Chinese developers, then the reduction in period of construction and a cut of cost would be the result.

Roy et al. (2005) alludes existence of an escalating interest for new techniques of building that are considered innovative using a variety of new materials and various building processes. Furthermore, the Government of Kenya has been on the forefront of advocating for low cost housing technologies through the setup of an Expanded Polystyrene (EPS) by the National Housing Corporation (NHC) plant in Mlolongo.

In the Kenyan Industry, countable companies including Prime Ventures International Limited prefer construction termed as “sustainable building design” by Kagai (2017). This is aimed at dealing with the demand for affordable housing which is deemed to be increasing. The company is currently debating on the elimination of stones which are conventional to a modern technology simultaneously proposing a new technology that uses polystyrene panels coated with cement. This new technology utilises the assembled already moulded EPS foam in construction of homes: the EPS is formed in a sandwich manner lying between a concrete seal on both ends (Kagai, 2017).

Other benefits that accrue to this proposed technology according to Kagai (2017) include thermal insulation. This ensures a regulated temperature in the houses. It additionally makes the houses immune to sounds, fire, bullets and resistant to other shocks. He adds that this EPS panel adoption in construction is evident in Rongai and as an Alternative Building Technology it has led to the reduction of cost by a percentage of 25 and concurrently saved time by half. Evidently, this new alternative building method is a remedy to minimising time and labour costs applied in construction. As a result, funds are saved while constructing foundation due to usage of less reinforcement as a result of its light weight (Kagai, 2017).

According to Thiyagarajan et al. (2017), rapid urbanization results into housing demand that is not possible to be fulfilled by using traditional methods of construction. Constructing using conventional or traditional means is a slow process especially when mass housing is involved, there is also the impediment of controlling the quality of outputs for mass housing projects. This therefore calls for a mandatory need of working out a scheme that would lead to the quality of construction and its speed being spontaneously controlled by using a systematic approach.

In every economy, it is pretty clear that housing is one of the major sources of income: economic growth is highly experienced with shelter as one of the key indicators of development in Kenya and elsewhere (Ireri, 2010).

1.1: Problem statement

Over twenty-two percent of the Kenyan population reside in cities and the population in urban areas is gradually increasing at a rate of 4.2 percent annually. As a result of this growth, there is need for new housing; this will require Nairobi in this case to annually construct a minimum of 120,000 new housing units to achieve this present demand. It is regrettable that there are barely 35,000 homes built presently thus a housing deficit growth of 85,000 housing units annually (Okeyo, 2015).

The mismatch in supply and demand has led to prices of houses increasing by 100 percent since 2004.This leads to lower income residents being pushed out from the formal housing sector into the slums. There are various avenues that can be used to address this problem including supply of housing, end user finance or using new technologies available in the market. (Noppen, 2012).

In spite of the various advantages of adopting ABMTs, it is not being adopted by various players in the construction industry especially developers as would have been expected. This accounts for merely three per cent according to a survey conducted by NHC in 2014 in Nairobi as shown in Figure 1.1.

As Okande (2015) put it, a survey was conducted by National Housing Corporation 2012/13 and he highlights that according to the survey, a percentage of 66 of built environment professionals activate for ABMTs use.

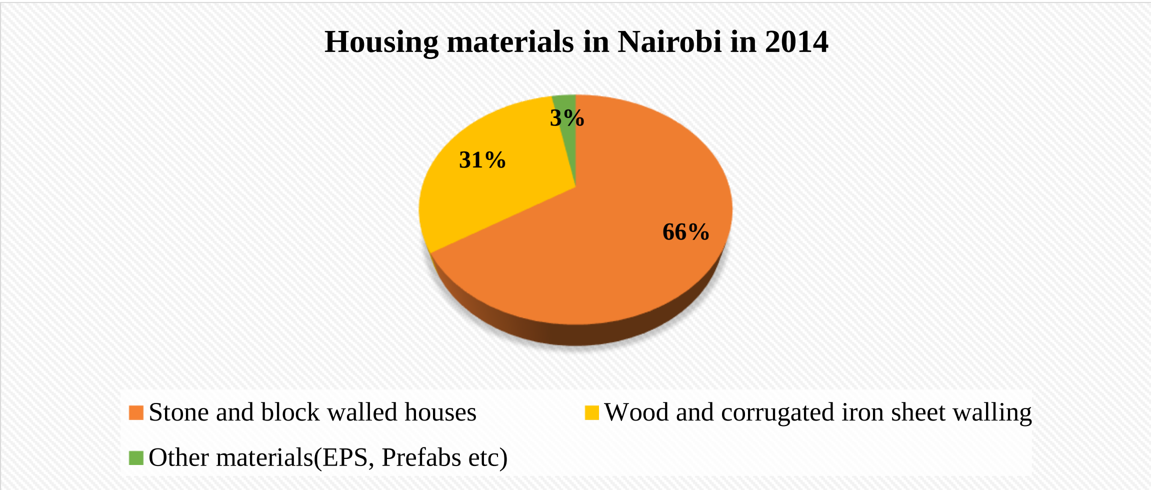

Figure 1.1: Housing materials usage

Source: Nairobi County Government Development Plan (2014)

A slower rate of adoption of new methods of construction is evident in the construction industry despite conventional methods neither being able to meet the demand for housing nor achieve the quality standards required (Pan et al., 2004b). Thus, there is a need for a paradigm shift through advocating for use of invented materials. Builders are seeking for more efficient methods of construction using modern methods as a way of responding to the housing supply shortage. (Mostafa et al., 2014a).

Most ABMTs are manufactured off-site using techniques that are different from the on-site manufactured materials. This off-site production solves a variety of challenges in the Housing

Sector (Blismas and Wakefield, 2009), it is however depicted that the off-site system of construction is slowly accepted than anticipated in the Housing Sector (Pan et. al., 2012a).

According to Buildoffsite (2010), the building industry is under continuous pressure not only for productivity to be raised but also costs to be reduced, health and safety risks to be minimised, quality improved and also sustainability to be enhanced. These conditions cannot be attained without a change on how housing projects are delivered hence there is need for creating better comprehension on the potentials of ABMTs in the construction industry and also determine the selection criteria for their acceptance and strategies that need to be put in place to increase uptake of ABMTs

This study therefore sought to identify and create awareness on the acceptance criteria by looking at parameters that need to be considered when selecting ABMTs for walling as this would help in coming up with key reforms to unlock the potential of housing and provide adequate housing in achieving Kenya’s vision 2030 on housing of providing 200,000 housing units annually, development of Appropriate Building Materials and Technologies and development of quality and affordable houses for low income Kenyans.

1.2: Research questions

The research aims to answer the following questions:

i. Which Alternative Building Materials and Technologies for walling are in use in Nairobi City County?
ii. What is the extent of adoption of Alternative Building Materials and Technologies for walling?
iii. What are the parameters to be considered in acceptance of Alternative Building Materials and Technologies for walling?
iv. What is the end users’ level of awareness, perception and preferences in acceptance of ABMTs for walling?
v. What appropriate strategies can be put in place to increase the uptake of Alternative Building Materials and Technologies for walling in Nairobi City County?

1.3: Research objectives

The main objective of this study was to determine the acceptance criteria of Alternative Building Materials and Technologies for walling. The specific objectives were:

i. To identify the Alternative Building Materials and Technologies for walling that are in use in Nairobi City County.
ii. To determine the extent of adoption of Alternative Building Materials and Technologies for walling.
iii. To identify the parameters that need to be considered in acceptance of Alternative Building Materials and Technologies for walling.
iv. To identify end users' level of awareness, perception and preferences in acceptance of ABMTs for walling.
v. To identify appropriate strategies that can be put in place to increase uptake of Alternative Building Materials and Technologies for walling in Nairobi City County.

1.4: Hypothesis of study

To increase the understanding about the factors that promote acceptance of Alternative Building Materials and Technologies, the following hypotheses are proposed:

Ho_1-Economic issues does not promote acceptance of ABMTs for walling.

Ho_2-Social issues does not promote acceptance of ABMTs for walling.

Ho_3-Technical know how does not promote acceptance of ABMTs for walling.

Ho_4-Environmental sustainability does not promote acceptance of ABMTs for walling.

Ho_5-Quality of structures does not promote acceptance of ABMTs for walling.

Ho_6-Time does not promote acceptance of ABMTs for walling.

Ho_7-Logistics does not promote acceptance of ABMTs for walling.

1.5: Justification of the study

There are various innovative methods and new technologies in the market hence a criterion for their acceptance need to be developed. The lack of an efficient selection criteria of ABMTs for building projects necessitates examination of the various ABMTs currently available critically to identify the criteria used in their selection and the weight of each of the factors so as to enable the optimal performance of building projects, their success and sustainability. This study therefore examines the critical factors considered in acceptance of ABMTs so as to be able to make recommendations to improve the ABMTs selection on projects.

The study is also important in helping to achieve more informed technology decision making criteria in selection for sustainable construction delivery and managing of technological advancements to sustain the deficit for housing.

1.6: Significance of the study

The key outcome of this study is an efficient set of parameters which will act as a decision support system for ABMTs for walling. These parameters will assist various construction industry players to select the most appropriate technologies for construction of buildings from the approach of affordability and sustainability.

It will help highlight key areas where reforms are required by various stakeholders and thus the knowledge can be used by various professional bodies in Kenya to lobby for change and also reform of various policies by the government to enable more venturing into the use of Alternative Building Materials towards achieving affordable housing.

It will also be useful to investors as a beginning of exploring ABMTs for affordable housing and also evaluate the various models in place.

The government of Kenya towards achieving vision 2030 and in their quest of providing adequate and affordable housing, in knowing the parameters than need to be considered when choosing to use ABMTs to increase their acceptance.

The designers of building materials in the building industry who stand a chance of offering more economic and eco-friendly building materials and technologies solutions to their clients as a result of this study findings.

The findings will help to address the knowledge gap by developing ABMTs acceptance model which enable the assessment of ABMTs effectively

1.7: Assumptions

The study assumed that there are various ABMTs for walling being used in Nairobi City County, the extent of adoption by the various organizations is low within Nairobi City County, there are various critical parameters that need to be considered in acceptance of ABMTs and end users within Nairobi City County level of awareness of ABMTs is low and have a negative perception towards use of ABMTs.

1.8: Scope of study

Innovation Diffusion Theory, Technology Acceptance model (TAM), Sustainability and Theory of Planned Behaviour (TPM) was used in the theoretical framework to explain the acceptance criteria of ABMTs.

The data collection was conducted through self-administering of questionnaires by the researcher and interviews to individuals and organizations that have been involved in actual development using ABMTs for walling.

Nairobi City County was chosen because it is the most dynamic and fast-growing County in Kenya. It is also home to Kenya's largest city with a population of 3.36 million as at 2011. In Africa Nairobi City County is one of the rapidly growing cities. The cities rate of growth is four percent annually and this is due to rural to urban migration in search of employment opportunities. This growth in population is expected to increase and reach a figure of 5 million by 2025 (World Urbanization Prospects, 2018)

The estimation of the population of Nairobi as at 2018 was at 4.41 Million. This population has grown by 495,000 yearly since 2015 which is a representation of a four per cent yearly change based on UN World Urbanization Prospects projections. These projection estimates are a representation of Nairobi population and its neighbouring suburban areas. (World Urbanization Prospects, 2018).

1.9: Limitations of study

The use of the ABMTs discussed in this research have been in use in Kenya for a period less than 20years hence lots of literature concerning them is limited as compared to the conventional walling materials. There are few books on the same thus most citations in this research are from journals.

Time required to carry out the study was limited to the academic calendar period and restrictions. This was mitigated by putting in more hours towards the study, proper time management and getting research assistants to collect data questionnaires from the various respondents.

1.10: Definition of terms

The following are key terms used in this study:

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

Hydraform block; is an interlocking compressed earth block made of hydraform press (Hydraform Manual, 2003),

Interlocking stabilised 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 stabiliser after which it is compressed using a manual or hydraulic press machine by forming grooves that interlock either horizontally or vertically (Gbadebo, 2014).

Prefabrication; is off-site production of standardised or adapted components or complete structures

1.11: Organization of the study

Chapter one includes background and context of the study, problem statement, study questions, objectives of the study, hypothesis of study, significance of the study, study justification, scope, limitations of the study and definition of terms.

Chapter two incorporates a review of the relevant literature related to Alternative Building Materials and Technologies, discusses concepts of ABMTs as well as conceptual framework.

Chapter three discusses the methodology used in conducting the study. The research design, sampling, data collection procedures and analysis.

Chapter four comprise of analysis of the data and its discussions.

Chapter five comprises of conclusion, recommendations and areas of further research.

CHAPTER TWO

LITERATURE REVIEW

2.0: Introduction

This section reviews the available literature on ABMTs. The review delves into various theories and models that will guide the research including Innovation Diffusion Theory (IDT), Technology Acceptance model (TAM), Sustainability and Theory of Planned Behaviour (TPB). It further developed a conceptual framework that guided the study. The research relied greatly on written books, journals, brochures, previously related research and various articles on the internet in undertaking the literature review.

2.1: Theoretical foundation

2.1.1: Innovation Diffusion Theory

The applicability of the diffusion and innovation theory which began as an idea to explain human behaviour change have expanded overtime as affirmed by Rodgers (1995). In this theory, he asserts that individuals adopt new products and ideas such as new technologies overtime. These adoption factors cover the socio-economic realms for example in this research, the acceptance of ABMTs relies on various factors.

Rodgers (1995) for instance opines to the understanding of four factors determining the rate and speed of adopting a given technology or idea. The rate or speed with which an idea or practice is diffused is determined by:

i. The character of the innovation
ii. Attributes to the structural characteristics of adopters and non-adopters
iii. Factors having to do with the mechanism whereby diffusion takes place in a particular setting; and
iv. Those originating from firms and industries institutional environment

According to Rodgers (1995), there are five stages involved before adoption:

Awareness stage: during this stage the being of an innovation gets to be known by individuals

Interest stage: the required data concerning the innovation is collected.

Evaluation stage: At this stage, innovation is tried, ascertained or its value fixed depending on individual’s subjective view and decision.

Trial stage: the innovation is experimented on and it is applied to a smaller scale by individuals.

Adoption stage: innovation is used on a larger scale and members of the society give a favourable approval.

The ABMTs are in themselves innovations and the theory of adoption and diffusion innovation can be used to conceptualize their acceptance. Rodgers (1995), defines innovation as newly idealised concept by the mind of a person. Innovation can normally create some level of uncertainty when it is introduced to the adopters. Individuals want certainty of the innovations superiority or more advantages it possesses than the previous practice

According to Rodgers (1995), innovation can be explained using five characteristics:

i. Relative advantage

This is the level of considering (or measuring) an innovation's advantageous properties in comparison to the previous practice. It is generally expressed in terms of "economic profitability, social prestige it conveys or in other ways." An innovations nature will determine the relative advantage dimension (economic, social or others) that the adopters consider to be of importance to them. However, the adopter's characteristics may also determine the sub-dimensions of relative advantage they consider to be very important (Rodgers, 1995).

ii. Compatibility

This is consistency an innovation portrays with respect to the existing values, previous experiences or potential adopters need (Rodgers, 1995).

iii. Complexity

Complexity is defined as the degree of perceiving difficulty in understanding or using a given innovation (Rodgers, 1995).

iv. Trialability

This is the limited basis within which an innovation may be experimented on. Adoption occurs more rapidly if new ideas can be tried on as compared to indivisible innovations (Rodgers, 1995).

v. Observability

This is the extent of visibility of an innovation to others. It includes demonstration results, for example, the ease of telling others an innovations consequence or results (Rodgers, 1995). In discussing the various ABMTs for walling their advantages and challenges have been highlighted since Rodgers (1995) asserts that adopters will want to be certain that an innovation advantages supersede the former practice in our case use of conventional construction methods.

2.1.2: Sustainability theory

Sustainability concept has been utilized in different sectors like environmental analysis, monetary advancement and development, monetary administration, money related administration, education, building industry and medicine. The sustainability concept in this study refers to natural environment protection and enhancing the quality of life without negatively influencing the capacities of who and what is to come (Harrington, 2016). Sustainability theory can be conceptualized in the acceptance of ABMTs for walling since ABMTs are more about sustainability by reducing the rate at which natural resources like stones are depleted from the environment, reduction of pollution through burning of bricks and destruction of trees. Aspects to do with use of recycled materials, reduction of pollution, conservation of water and embodied use of energy also need to be addressed.

2.1.3: Technology Acceptance Model

TAM was advanced initially by Davis (1985). It has two main core variables:

i. Perception in ease of using a given technology- defined as one's degree of belief in using a technology without applying much effort.
ii. Perception in the technologies' usefulness- defined as the degree of belief that the technology used enhances work productivity or output

TAM further development by Venkatesh & Bala (2008); Venkatesh & Davis (2000) lead to suggestion of particular determinants underlying these two key factors. They claim that "perceived usefulness is based on the quality of outputs associated with the new technology, the resulting image of adopters and the impact on process complexity and effectiveness. Perceived ease of use is underpinned by the flexibility of the technology and frustration associated with new processes." These factors align well with the discussion of prefabrication and the potential technical challenges it presents compared to traditional house building practice.

2.1.4: Theory of Planned Behaviour

The Theory of Planned Behaviour is a social brain science hypothesis expressing that planned practices result from expectations which are thus anticipated by individuals' attitudes and frame of mind. Frames of mind in this instance alludes to the good or negative assessment of the components of the conduct, emotional standard to the weight of key persuasive people on the probability of partaking in the conduct and social control to the recognitions an individual hold with respect to their capacity and chance to play out the conduct. TPB conviction elicitation studies don't intend to determine accord, but rather to derive a set of factors that are potential influences on the theoretical beliefs-intention-behaviour pathway (Ajzen, 1991)

2.2: Alternative Building Materials and Technologies for walling (ABMTs)

2.2.1: Interlocking Stabilised Soil Blocks (ISSBs)

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 stabiliser after which it is compressed using a manual or hydraulic press machine (Gbadebo, 2014).

According Gbadebo (2014), individuals construct higher with thinner walls as a result of the input of soil stabilisation. These walls are characterised by improved water resistance and strength. Upon usage of cement as a stabiliser, 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 stabilisers can be applied. These stabilisers 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. Figure 2.1 shows an illustration of wall constructed using interlocking stabilized soil block.

According to United Nations Habitat, the Interlocking Stabilised Soil Blocks (ISSBs) are products of compacted mixture of soil and lime or cement produced in moulds 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).

Figure 2.1: ISSB walling

Source: Author, 2019

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.

In the rural areas the manual or the hand pressed machine shown in figure 2.2 is commonly preferred. This is because this machine is simple to use and that its operation is manual (UN-HABITAT, 2009).

Figure 2.2: ISSB manual machine

Source: Author, 2019

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

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:

i. 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.

ii. Due to the high density and thermal properties of soil, these blocks provide better thermal insulation. Buildings are kept cool on the inside during daytime by being able to absorb heat and warm at night by releasing the heat.

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 (UNHABITAT ,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.

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.

Aesthetics

Aesthetics refers to the advantages ISSBs possess in respect to its appearance. It has the following advantage:

i. 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.

Social

These are various advantages of ISSBs to the society or a given population. They include the following:

i. A small number of individuals can make the ISSB blocks since it requires low man power and are easy to manufacture.
ii. 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;

i. Lack of proper soil for the production of the blocks
ii. The method applied in moulding, the moisture content of the mix and quality of the raw materials used in moulding determines the quality to be produced. (UN-HABITAT, 2009).

2.2.2: Expanded polystyrene (EPS) panels

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 (EPS Specifier Guide, 2019).

It has the following advantages:

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 minimises 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)

Figure 2.3:EPS Panels

Source: Author (2019)

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 (EPS Specifier Guide, 2019).

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 labour and use of material. (EPS Specifier Guide, 2019).

There is also a new EPS panel system in the market in Kenya by Koto Housing shown in Figure 2.4, it is specifically meant for internal partitioning walls, this helps in reduction of cost by 800Kshs per square metre as compared to the normal EPS panels.

Figure 2.4: EPS Partitioning panel

Source: Author (2019)

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 (EPS Specifier Guide, 2019).

Design versatility

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

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 ecocredential nature and its insulation property makes it preferable in construction (EPS Specifier Guide, 2019).

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 (EPS Specifier Guide, 2019).

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 (EPS Specifier Guide, 2019).

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 (EPS Specifier Guide, 2019).

CSIR (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 storeys.
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

2.2.3: Precast concrete hollow wall panels

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 (Shridhar, 2014).

It has the following advantages

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” (Wall Panel Design Manual, 2010).

Green Construction

“Precast concrete does not release toxins when burnt. It provides a medium that delays heat transfer 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).

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 (Wall Panel Design Manual, 2010).

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, cover on the prestressing 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 (Wall Panel Design Manual, 2010).

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 supress 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 (Wall Panel Design Manual, 2010).

2.2.4: 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 infilled 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 and 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).

Advantages

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 and Black, 2011).

Disadvantages

"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 and Black, 2011).

2.2.5: 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).

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

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.

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.

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

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.

2.2.6: 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 (Mahendriyani, 2016).

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).

2.2.7: Aluminium 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);

i. Requires less skills while handling for example lifting. It is therefore free from costly equipment requirements for lifting heavy materials.
ii. The formwork facilitates fast building and construction. This makes it suitable for numerous projects to be undertaken simultaneously on one construction site.
iii. 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.
iv. Durability of the property of the formwork makes it possible to re-use without compromising quality and dimensions accuracy.
v. 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;

i. Initial capital is high.
ii. It has many components.
iii. It is expensive to repair.
iv. It has high chances of theft.
v. It requires more space for stocking.

2.3: Extent of adoption of ABMTs for walling

Nations are seeking the best innovation to embrace. These innovations adoption depend on numerous factors ranging from economical, political and social angles. Evident in the Rodgers (2003) definition, adoption is a decision of applying fully the best identified technology. Nations have firms that have adopted in diverse ways the new materials and technologies in the construction industry.

Referring to Canada, India and United States, the World Economic Forum (2016), emphasises that engineering and construction industries have partially embraced new technologies. These sectors have slowly adopted new technology compared to other sectors. Due to laxity, the World Economic Forum focuses on the means in which these two sectors can maximise adoption of the new technologies and materials (Manseau and Seadon, 2001). To ensure this, there is a suggested measure that the new technologies in these sectors be adopted by individual firms or in collaboration.

Oyedele (2016), in Nigeria indicates in his research that the adoption of new construction methods in Nigeria is still at its rudimentary stage. The large construction companies are showing sign of adoption of the concept. Medium scale and small-scale construction companies are not yet adopting the concept. He further highlights the different rate of adoptions in different countries as shown in table 2.1.

Table 2.1: Countries level of adoption of modern methods of construction

	Countries	**Level of Adoption of MMC**
1	USA	High
2	United Kingdom	High
3	Germany	High
4	South Africa	High
5	Tunisia	Medium
6	Nigeria	Low

Source: Oyedele (2016)

2.4: Parameters to be considered in acceptance of ABMTs for walling

Nanyam et al. (2015) categorizes the parameters to be considered in acceptance of new innovative technologies into “mandatory, preferred and desired attributes” as shown in Table 2.2. These are further broadly classified under six major categories: “Functional requirement, constructability, economic viability, maintenance, sustainability and quality.”

Table 2.2: Attributes for evaluation of new innovative technologies

Attributes for Evaluation of Emerging Housing Technologies								
Primary Attribute	Mandatory Attribute		Preferred & Desired Attributes					
Secondary Attribute	Strength & Stability Requirement	Performance & Statutory Compliance	Functional Requirements	Constructability	Economic Viability	Maintenance	Sustain-ability	Finish Quality
Tertiary Attributes	Stability Against Vertical Loads	Fire Resistance	Design Flexibility	Simplicity in Execution & Versatility	Initial Cost	Maintenance Cost	Eco-friend-liness	Internal Finish Quality
	Stability Against Lateral Forces	Violation of Statutory Provisions	Restriction on Number of Floors	Design Compatibility	Speed of Construction	Frequency of Maintenance	Em-bodied Energy	External Finish Quality
	Performance of Joints		Service Life/ Durability	Foundation Type	Economies of Scale	Type of Maintenance		
			Thermal Comfort	Skilled Labour	Lead Time	Ease of Maintenance		
			Acoustic Performance	Equipment	Efficiency of Design			
			End-user-friendliness	Temporary Service Requirement	Supply Chain Reliability			
			Weather Resistance	Construction Safety	Technology Transfer Possibility			
			Water-Tightness					

Source: Nanyam et al. 2015

Under the functional requirement attribute aspects to do with design flexibility, end user friendliness, durability, sound proofing, acoustic comfort and thermal comfort are considered. According to Nanyam et al. (2015) constructability refers to the ease of construction using a given technology without compromising the overall building requirements. Simplicity in execution, skilled labour availability, design compatibility and construction safety are factors considered under this attribute.

Nanyam et al. (2015) describes economic viability as the “economic competitiveness in the present market conditions and business environment.” Initial investment, construction speed, economies of scale, lead time for procuring the technology which can cause delays in a project if not considered, design efficiency and ease of construction are factors to be considered in economic viability.

Maintenance caters for the separate cost, as well as the expected ease and frequency of maintenance and type of maintenance required over the service life of a particular system

(Nanyam et al. 2015). Sustainability attribute considers material eco-friendliness and embodied use of energy while finish quality of the material considers internal and external finish quality

Economic issues

This aspect pertains to the total cost of construction inclusive of various cost factors like materials, labour, equipment and machinery and profits and overheads. For evaluating various innovative methods of construction, one needs to compare the capital cost to that of conventional method (MHUPA, 2015).

Among the challenges highlighted by Margret (2015) are constructing using ISSB involves purchasing machine used for making the blocks which cost USD 1800 inclusive of the training. It is thus uneconomical to own the machine if one needs to build a single residential unit. However, for commercial business if the benefits of purchasing outweigh the purchasing expenses then it is deemed fit to invest in purchasing one. Thus, initial investment costs and issues to do with economies of scale need to be considered during acceptance of ABMTs.

Three cost factor variables were identified by Magret (2015) that need to be considered: initial cost/ investment cost, cost of training employees and average cost when compared to conventional building methods.

Jailoon and Poon (2008) further supports this by highlighting that the main economic factors that need to be considered are initial costs and transportation costs. For long term development of construction high initial and investment costs are extremely unfavourable.

Hong et al. (2018) shares the same sentiments that the economic performance of prefabricated construction is directly impacted by factors such as initial investment costs, logistic processes and labour costs.

According to MHUPA (2015), maintenance cost refers to “the life cycle value of the system (the recurring cost of maintenance and the replacement cost at the end of the service life of the system) and other costs -cost for periodic maintenance of the system and replacement cost at the completion of the service life of the system- are to be compared with that of conventional system:”

In a questionnaire survey conducted by Mao et al. (2015) in China to determine the constraints to offsite construction from the perspective of developers, the survey findings came up with the following as the most important factors; high investment costs coupled with high cost pressure devoid of the appropriate economies of scale. Theory of adoption diffusion innovation by Rodgers (1995) further asserts the degree of adoption can be measured in economic terms.

According to Rodgers (1995), the rate of adoption of an innovation may be affected by the initial cost e.g. Initial cost of buying ISSBs equipment, initial investment costs on training of workers and others. He further states that a product being introduced for the first time (new) may be based on a technological advancement resulting into production cost reduction, eventually translating into a low-priced product to consumers. Ideally, "an expeditious adoption is achieved when there is a decrease in a new products price during the diffusion." Cost factor should however not be the only criteria considered in taking up or selecting to adopt use of Alternative Building Materials and Technologies.

Quality

Nanyam et al. (2015) indicates that the selection of methods and materials used in construction to a large extent affects the quality of workmanship and ultimately, the quality of output. The desired quality of finishes should therefore be taken into account while analysing the construction technologies.

Logistics

Transportation of large components to restricted sites that may be small in size or difficult to access or requiring hoisting can lead to additional cost and limiting use thus issues to do with logistics have to be considered during acceptance of ABMTs (NHBC Foundation, 2016).

Social issues

Margret (2015) argues that in the urban areas ISSBs housing is affiliated to rural villages building practices using mud and wattle. This perspective is prevalent among the medium and high-income earners who view the technology as of poor quality due to it being branded as low-cost. ISSBs promoters thus find it demanding in re-educating people that "use of cement in soil blocks leads to the desired strength and durability of house."

There are four variables related to the social aspect and opinion of the public:

i. Poor understanding of prefabricated construction
ii. Unavailability of policies, laws, and standards governing prefabricated construction
iii. Lack of acceptance in the market

iv. Lack of governmental subsidies and incentives as a way of promoting their use

Lack of familiarity and knowledge on benefits of ABMTs by beneficiaries has led to the materials not always being accepted. They believe they are receiving a product of less value and also suppliers of the Alternative methods do not sufficiently market their products.

Environmental sustainability

Nanyam et al. (2015) describes sustainability as "the extent to which a particular technology is eco-friendly in terms of use of less virgin material, less energy, cause less pollution and less waste without compromising on the project's economic viability and the comfort, safety and other requirements of its occupants."

An increasing emphasis is not only being placed on the environmental performance of buildings during construction but also sustainability of materials specified (NHBC Foundation, 2006). The level of wasted material is one of the construction processes that is criticised on conventional sites that occurs either through damage or profligacy. They further opined that other environmental factors with respect to impact on local community in terms of noise pollution, air pollution and traffic movements also need to be considered.

According MHUPA (2015), the following criteria should be considered for evaluating how eco-friendly a construction technology is:

i. Local materials usage
ii. Non-renewable resources in manufacturing or production usage
iii. Waste products usage.
iv. Ability of the material to be recycled.
v. Waste generation and utilization of waste generated.
vi. Pollution through emission of hazardous materials.

The non-promoters of ISSBs in a research conducted by Margret for example had concerns with regards to large excavations left in case of mass housing developments. Promoters of ISSBs however plan to use the large open burrows for underground water tanks and soak pits for large developments and compost pits for single residential buildings (Margret, 2015).

Government policies

The economic environment within which the building materials sector operates is set by government policies. If policies and regulations do not support the use of the materials or technologies it will not only hamper their acceptance but also the growth of that building sector. (Gbadebo, 2014).

Technical know-how and lack of information

Nanyam et al. (2015) asserts that the following attributes need to be considered: "construction simplicity and adaptability, equipment requirements and skilled laborers, temporary facilities structures requirement, compatibility with different types of architectural designs, safety and reduction of hazards in the system implementation."

MHUPA (2015) defines skilled labour as "projection and identification of trained work force required for adopting housing technology for construction" and further asserts that the following criteria need to be considered for technical know-how attribute:

i. Labour category required (skilled or unskilled)
ii. Training level required

According to Margret (2015), for a good ISSB to be manufactured and also a straight wall be built training is required. For individuals not having some form of experience and are also not willing to spend time in training for a minimum period of two weeks training ends up being a barrier. The right quality standards are unable to be achieved even if they purchase the press to do it by themselves.

According to Alinatwe (2008), lack of knowledge and skill by workers on how to use these technologies acts as barrier to productivity since these technologies are in a way different from the traditional construction method that uses mortar for bonding. Most technical institutions have not included training on how to use these technologies in their curriculum. Despite being assumed that intensive training is sufficient, some form of certification and testing is however necessary.

Rodgers (1995) in his theory of adoption and diffusion innovation expresses that innovation that is simply understood and used is easily adopted than a complicated innovation requiring additional techniques and understanding. This expresses that a product or an act that is understood, learnt, or used, with difficulty has low probability of adoption.

Lack of technical know-how for production and new technologies also reduces the probability of various professionals in the construction industry using them. This is advanced by lack of information dissemination concerning the use of these materials. Most developers in Sub-Saharan Africa countries are not knowledgeable on the specifications of ABMTs and this leads to poor performance of the final product (UN-HABITAT, 2010, 2011).

Training needs, availability of labour and ease of use are therefore critical parameters to be considered during acceptance of ABMTs since most differ in installation procedures from the conventional methods of construction.

Time

According to MHUPA (2015), construction speed is connected to duration it takes to finalise all construction related tasks using a given technology. Savings in construction time is of significance to various stakeholders in the construction industry thus this criterion is of essence in consideration when assessing the acceptance of ABMTs: evaluating construction speed in comparison with conventional method.

2.5: End users' preferential criteria of acceptance of ABMTs for walling

In a study conducted by Sengupta (2018), he analysed the preferential ranking of different criteria governing the choice of building materials and technologies by end users in different climatic zones. Using a five-point Likert scale in his questionnaires, the following aspects shown in the Table 2.3 were analysed.

The primary three criteria of selection of building material and technology by people belonging to LIG and EWS were found to be safety, cost of construction and maintenance cost. The materials and construction workers should also be available locally as those have also got implication on the cost aspect of construction. People belonging to EWS were found not to have any idea on aesthetics and comfort of the buildings as getting a safe and low-cost permanent shelter is the primary objective for them.

Table 2.3: Preferential ranking for different criteria governing acceptance of materials and technologies

	Preference			
Factors	**HIG/ MIG**	**LIG**	**EWS**	**Combined**
Safety	6	8	7	8
Capital cost	8	7	8	7
Maintenance cost of building	3	6	6	6
Building materials availability	1	4	4	5
Building artisan availability	2	2	5	4
Power consumption during occupancy	4	1	3	3
Aesthetics	5	3	2	2
Comfort	7	5	1	1

Source: Sengupta (2018)

A study conducted by Oppong and Badu (2012) depicts a low acceptance rate of the stabilized earth blocks in Ghana. This is evident especially in the urban centres of the country. Durability and aesthetic factors are alleged as the cause of this unexpected rate of acceptance. Ideas given by urban residents and users of the earth blocks view the material as applicable only to rural construction. Related challenges identified included excessive absorption of water. This led to cracking and deterioration due to “swelling and shrinkage.” Other effects include weakening and disintegration of the walls when it rains and floods. It is viewed that the material is poorly resistant to abrasion and impact. This results into a rapid deterioration through climatic elements and human usage. Rodents and insects equally penetrate the block. Finally, according to the research, another property of the blocks is “low tensile strength making earth constructions susceptible to destruction.”

It was also deduced from the study that majority of the citizens of Ghana and especially the youth were unaware of the stabilized earth blocks. The study also revealed that 31percent of sampled individuals demonstrated complete lack of knowledge of the blocks due to lack of “publicity” of the stabilised blocks. Forty eight percent of the respondents perceived that it was duty of the government to sensitise the public to accept the stabilised soil blocks as a credible alternative material in comparison to sand and cement blocks (Oppong and Badu, 2012).

A study by Brown (2014) in Zambia identified nine factors: "material cost, availability, workability, sustainability, acoustic properties, thermal properties, aesthetics and upmarket potential that influence potential specification of earth construction." He also identified thirteen barriers impeding the use of earth in the construction. Respondents also rated a range of criteria for potential specification alongside identifying earth as building material against a five-point Likert scale. Material cost ranked the highest was had a mean of 4.58 and availability demonstrated a mean of 4.37 and workability showed 4.11 to support the use of earth in construction of houses (Brown, 2014).

Another rating on impediments of earth as a commonly used building material depicted 69% of the respondents agreed with the belief that structural weakness of mean value of 4.50 is the key impediment in specifying earth in their projects. The clients' lack of interest was second depicting a 4.31 mean value. There was a low technological knowledge demonstrating a mean value of 3.50. Other limiting factors included low water resistance and its appearance viewed as unattractive (Brown, 2014).

2.6: Strategies to increase uptake of ABMTs for walling

Gbadebo (2014) highlights that the building codes are standardising the use of local materials thus the need of their adoption while using the Alternative Building Materials and Technologies. He identifies the public sector responsible for establishment of an applicable criterion to use the locally available materials (Gbadebo, 2014).

The institutions of higher learning which also disseminate knowledge to new professionals would contribute effectively in including ABMTs in their curriculum (Mpakati, 2012). According to Gbadebo (2014), there should be a strategic initiative by the government to ensure the spread of new building techniques and innovations. This dissemination should focus on the grass roots areas. According to him, there should be establishment of building centres at state and local Government sectors. There should be ease of access to soft loans by the entrepreneurs with interest of establishing of small-scale production site or sale of alternative building materials. He adds that the Government needs to establish appropriate "economic and monetary policies." This will reduce house inflation negative effects and overcoming other long-term credit and construction finances. There is need for pioneer status to be granted to small scale industries. This is through means of tax holidays. Local builders in a selected locality on the other hand should be entitled to effective protection (Gbadebo, 2014).

Leaders in the government should consequently lead by example. For instance, in a number of countries with governments with commitments to a specific policy, such as the use of ABMT's, the citizens are convinced by executing projects using such materials. Countries in West Africa like Mali, Senegal, Burkina Faso and Algeria, have initiated government projects using stabilized laterite signifying that the ABMTs are used in the government building projects such as official residential housing schemes (Gbadebo, 2014).

2.7: Conceptual framework

From the literature it has been observed that ABMTs for walling have various advantages as highlighted by various authors. They have been used to lower costs in most countries i.e. labour costs resulting into construction time reduction. However, the overall cost of using ABMTs comprises of other costs too e.g. material cost, transportation costs, taxation in case of use of imported material, training costs, initial capital cost of buying equipment and setting up manufacturing factories among others. The economic profitability should therefore not be looked at in terms of one cost factor but the overall cost factors associated with use of ABMTs. Various theories have been used to conceptualize the acceptance of ABMTs and various similarities in certain factors were noted as construed by the different authors. IDT and TAM address the issue of technical know-how in terms of perceived ease of use of the innovation. Innovation diffusion theory also addresses issue of cost, quality of work and social issues.

Parameters to be considered in acceptance of ABMTs for walling were categorised under seven broad themes: Economic issues, social issues, technical know-how, quality, environmental sustainability, time and logistics are the critical independent variables. The acceptance depends on seven factors listed above.

This study attempted to relate how the independent variables have a bearing on the acceptance of ABMTs for walling. Independent and the dependent variables are shown in Figure 2.5. Other variables considered were the moderating variable which included government policies. The research however focused on the independent and dependent variables. The study investigated to what extent each of these independent variables has an effect on the acceptance of ABMTs using questionnaires and interviews.

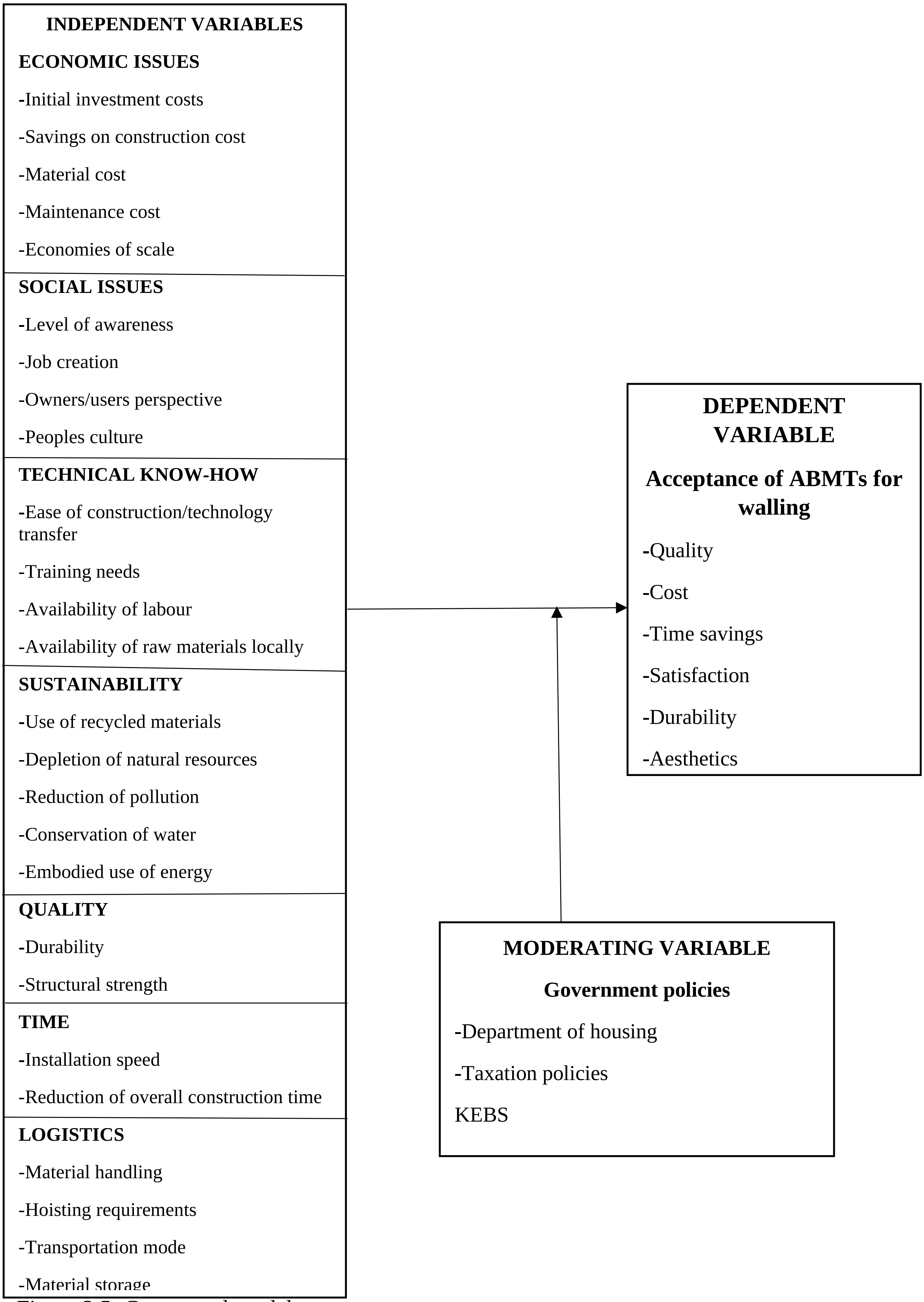

Figure 2.5: Conceptual model

Source: Author, 2019 (Adopted from innovation diffusion theory & TAM)

2.7.1: Conceptual definitions

Table 2.4: Conceptual definitions

1.Economic issues	Value or input incurred in terms of money to produce a commodity
2.Social issues	Aspects that affect the society
3.Technical know-how	The knowledge of undertaking an activity using an instrument or machine
4. Quality	This is related to a product meeting the specifications and customer expectations
5.Environmental sustainability	The maintaining of the aspects and practices that prevent degradation of environment
6.Time	Duration taken for completion of all stages of construction and the various processes involved.
7.Logistics	The coordination and movement of materials from one location, to storage and installation at the desired location.

Source: Business Dictionary (2010)

2.7.2: Operational definitions

This is defining a concept in terms of how one plans to measure the concept. It is also referred to as operationalizing the concept.

Table 2.5: Operational definitions

Concept	What to measure	How to measure
Economic issues	Initial investment/capital costs Savings on construction costs. Material cost Transportation costs Maintenance costs Economies of scale	Ordinal measurement Using 5-point likert scale [5] Very important [4] Important [3] Moderately important [2] Slightly important [1] Not important
Social issues	Level of awareness	Ordinal measurement

	Job creation Owners /users perspective Peoples culture	Using 5-point Likert scale [5] Very important [4] Important [3] Moderately important [2] Slightly important [1] Not important
Technical know-how	Perceived ease of use Training needs Availability of labour Availability of raw materials locally	Ordinal measurement Using 5-point Likert scale [5] Very important [4] Important [3] Moderately important [2] Slightly important [1] Not important
Quality	Durability Structural strength	Ordinal measurement Using 5-point Likert scale [5] Very important [4] Important [3] Moderately important [2] Slightly important [1] Not important
Environmental sustainability	Use of recycled materials Depletion of natural resources Conservation of water Reduction of pollution	Ordinal measurement Using 5-point Likert scale [5] Very important [4] Important [3] Moderately important [2] Slightly important [1] Not important
Time	Installation speed Reduction of overall construction time	Ordinal measurement Using 5-point Likert scale [5] Very important [4] Important [3] Moderately important [2] Slightly important [1] Not important
Logistics	Material handling Transportation mode Hoisting requirements Material storage	Ordinal measurement Using 5-point Likert scale [5] Very important [4] Important [3] Moderately important [2] Slightly important [1] Not important

Source: Author, 2019

CHAPTER THREE

RESEARCH METHODS

In this section the research methodology is presented. It is divided into six main sections that describe the research design, data sources, sampling design, data collection tools and techniques and data analysis and presentation.

3.0: Research design

Kothari (2004) defines research design as “the conceptual structure within which a research is undertaken or the exact nature of research work in a systematic manner. It includes the outline of the study framework, availability of different kinds of data and observations.”

The study adopted a cross sectional survey research design which combined both qualitative study and quantitative strategies, using interviews and questionnaires as the primary research approach.

3.1: Data sources

The study used both primary and secondary data in an attempt to solve the stated problem and address the objectives. The primary data used in this study was sourced from various individuals and organizations that have used these Alternative Building Materials and Technologies for walling. The various developers and organizations listing was sought from the Ministry of Transport, Infrastructure, Housing Urban development and Public works. It involved use of structured and open-ended questionnaires and interviews.

The target population for this research study included architects, developers, manufacturers, end users, KEBS and department of housing and urban development since they are the major stakeholders in the Building industry. In addition to the questionnaires and interviews, data was obtained throughout the study from papers, other material subjects and ongoing and previous literature review Desk research was additionally used for data collection during the study, entailing gathering and analysing information available in print form or published on the internet (Business dictionary, 2010). Information collected using desk research included organizations using ABMTs and various ABMTs.

3.2: Sampling design

3.2.1: Location of study

Nairobi City County was chosen because it is the most dynamic and fast-growing city in Kenya. It is also Kenya’s largest city with a population of 3.36 million as at 2011. In Africa it is also one of the rapidly growing cities. The cities rate of growth is four percent annually and this is due to rural to urban migration in search of employment opportunities. This growth in population is expected to increase and reach a figure of 5 million by 2025 (World Urbanization Prospects, 2018)

The estimation of the population of Nairobi City County as at 2018 was at 4.41 Million. This population has grown by 495,000 since 2015 which is a representation of a four per cent yearly change based on UN World Urbanization Prospects projections. These projection estimates are a representation of Nairobi population and its neighbouring suburban areas. (World Urbanization Prospects, 2018).

3.2.2: Unit of analysis

Analysis unit is defined as "the level of aggregation of the data collected during the subsequent data analysis stage" (Cavana et al., 2001). Unit of analysis in this study were the individuals and organizations.

3.2.3: Population frame

The population frame for this study were architects, developers, manufacturers, end users, Department of Housing & Urban Development and Kenya Bureau of Standards (Institutions mandated with the responsibility of inspection of building projects, setting and managing building and construction standards)

3.2.4: Sampling size

Mugenda and Mugenda (2003) indicate that a representative sampling needs to be a minimum of 30 items. According to Warren (2002) and Bryman (2012), for a qualitative research to be published, it requires a minimum of between twenty and thirty interviews. The study fulfilled this threshold.

According to Ministry of Transport, Infrastructure, Housing Urban development and Public works listing there are 20 organizations (manufacturers and developers and in some cases, they act as both and architectural firms providing professional services on ABMTs) within Nairobi City County that deals with various ABMTs for walling. The researcher managed to reach out to 16 out of the 20 and received positive feedback from 15. Four organizations not reached was due to change of addresses and hence their offices could not be located.

A number of stakeholders were sampled to be able to achieve the study objectives. The developers using the ABMTs gave an insight on the rate of adoption of the ABMT they are using in their projects, parameters to be considered in acceptance and strategies that can be put in place to increase the uptake of ABMTs. Purposive sampling was used to arrive at the participants giving information since there are few developers currently using the ABMTs.

End users were sought from the housing estates that have been developed using ABMTs, this information was sought from the developers. They gave their insights on their level of satisfaction and their preferential criteria in accepting to purchase a house constructed using ABMTs. The end users who haven't used ABMTs were also randomly sampled from all Seventeen sub-counties in Nairobi City County to determine their level of awareness of the existence of the various ABMTs and the factors that would influence their acceptance to use the ABMTs.

Few manufacturers are available in the market therefore purposive sampling was used to get their insights on the rate of adoption of ABMTs based on the demand and purchase of the materials they manufacture and also parameters to be considered in acceptance of the ABMTs.

3.2.5: Sampling technique

The study employed non-probability method of sampling using purposive sampling technique. According to Maina (2012) this technique allows a researcher to use cases that have the required information with respect to the objectives of a study.

3.3: Data collection tools and techniques

Data collection was conducted using questionnaires and interviews. The main tool of data collection were questionnaires. Open ended interviews were preferred to close ended interviews since it allowed participants to discuss their views and opinions (Polit & Beck, 2008).

A face to face interview also allowed for observation of any non-verbal communication but also allowed for seeking any clarification necessary. The interviews were open-ended, and carried out in a conversational style (Appendix B). The questionnaires were divided into two sections; one addressing the general information of the respondents while the second section representing the main issues of the study variables adopted for the study (Appendix A).

For the questionnaires, the questions were close ended multiple-choice questions as well as short answer questions especially on strategies that need to be put in place to increase uptake of ABMTs for ease of analysis and interpretation. The structured questions were rated using a 5-point likert scale assigning [5] Very important [4] Important [3] Moderately important [2] Slightly important [1] Not important. In determining the extent of adoption, the following 5-point Likert scale was used [5] Very high [4] High [3] Moderate [2] Low [1] Very low.

Data collected using the questionnaires and interviews were the various ABMTs for walling that are available for use, the extent of adoption, the parameters that need to be considered in acceptance of ABMTs and the strategies that need to be put in place to increase the uptake of various ABMTs for walling (Appendices).

3.4: Validity and reliability of data collection instruments

3.4.1: Validity

Kimberlin and Winterstein (2008) defines validity as the degree to which a test interpretation is warranted which relies on the use that a test is intended to serve. Li (2016) supports this by defining validity as the degree of accurate measurement of objects by an instrument.

Triangulation was adopted to enhance validity of this study, this involved use of various instruments in data collection. Questionnaires, interviews and observations were the instruments used.

3.4.2: Reliability

This is the extent to which an instrument shows consistent results. It can be measured in terms of internal-consistency, test-retest and inter-rater reliabilities (Li, 2016). In order to test the reliability of the instrument used in this study, piloting method was used. The researcher administered structured and semi-structured questionnaires using pilot study to be able to determine the appropriateness of the questionnaire. This helped refine the questionnaires where necessary. The data collected during pilot study was compared to the data collected during the actual study to check on its consistency.

Cronbach alpha co-efficient test was also used to determine reliability of the questionnaires using the various scores assigned in the Likert scale. A score of 81.5% was achieved and this proof of high internal consistency hence reliability.

3.5: Data analysis and presentation

The primary data collected was systematically organized and analysed using descriptive statistics of weighted averages. This was done by using means, standard deviation and percentages. The final data was then analysed using two computer applications i.e. Microsoft Excel and Statistical Package for Social Sciences. Frequency distribution tables were summarized where percentages and other diagrams such as multiple bar charts and pie charts were used during the analysis to present the data.

TABLES: refer to group of figures systematically arranged in the form of rows and columns. Analytical tables will be used to interpret figures as they are suitable for comparison. The data was analysed and statistical inferences drawn.

CHARTS: bar charts have been used to represent the data and analyse it logically. A bar chart comprises a number of spaced rectangles, which generally has their major axis vertical. They can be used to represent a large number of statistical data. Multiple bar charts have been used, this is more useful when there are more sets of comparable data to be compared and contrasted. Multiple bar charts not only make the actual number of items involved clear but also make it easy for the eyes to gauze the relative position of each group. This therefore makes interpretation easier to understand.

3.6: Ethical considerations

The researcher obtained an introductory letter from the institution to show that there was need to collect data for this study. The researcher also requested for permission to distribute questionnaires to employees and the higher authorities were informed that the study is being carried out. Information collected has been used for only academic purposes with consent of respondents and treated with utmost confidentiality.

CHAPTER FOUR

DATA ANALYSIS AND DISCUSSION OF FINDINGS

4.0: Introduction

This chapter presents the data analysis and discussion of findings obtained from administered questionnaires and conducted interviews with a view to drawing conclusion and recommendations to the study. The specific areas of interest covered in the study included finding out the ABMTs for walling currently being used in Nairobi county, the extent of their adoption, the parameters that need to be considered in their acceptance, end users' level of awareness, factors end users would consider in acceptance to use the ABMTs and the strategies that can be put in place to increase their uptake.

The researcher distributed 140 questionnaires and received 118 back, this represents a response rate of 84%.The response rate of 84% is distributed as follows: 10 Developers, 4 manufacturers who in three cases doubled as developers, 30 architects, 2 government officials from Department of housing, 2 from KEBS and 70 end users from the 17 sub-counties in Nairobi County. A response rate of over 60 % is considered good while 70% and above is considered very good according to Mugenda and Mugenda (2003), thus the response rate in this study was adequate for analysis.

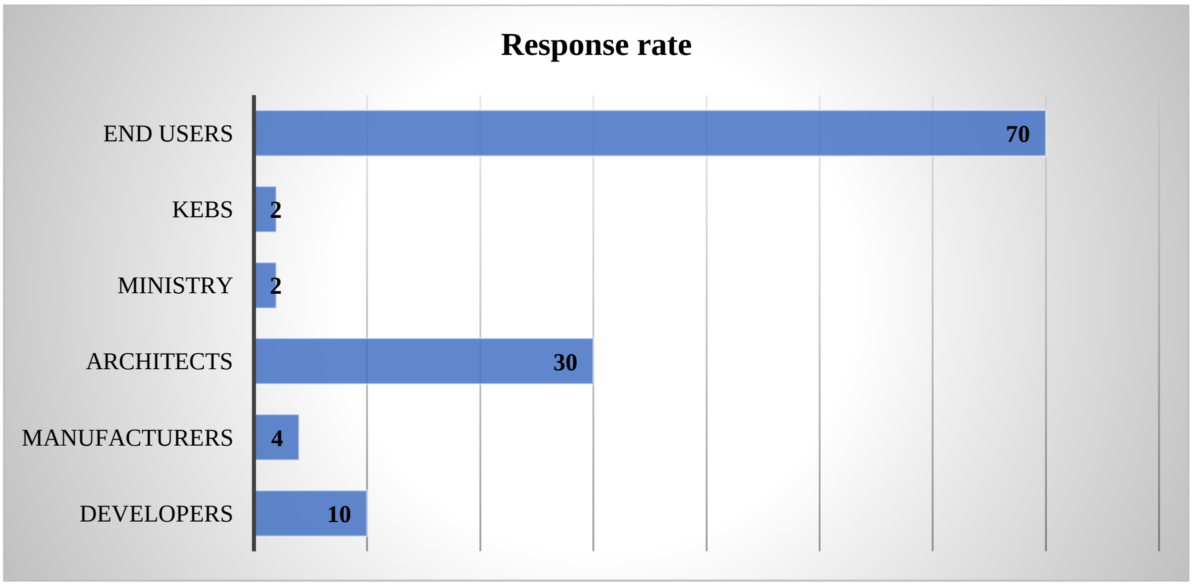

Figure 4.1: Response rate

Source: Field survey, 2019

4.1: Alternative Building Materials and Technologies for walling being used

The first objective of the study was to determine the various ABMTs for walling being used in Nairobi City county. The study revealed that five ABMTs for walling are being used in Nairobi City County by the respondents. These are precast concrete panels, EPS, interlocking concrete blocks, interlocking stabilized soil blocks and aluminium formwork technology.

The findings in Figure 4.2 further revealed that EPS is the most commonly used ABMT for walling by the respondents accounting for 38% and interlocking concrete blocks at 7% was least used. In some cases, respondents were using more than one ABMT or manufacturing more than one. ISSBs and ICB for example was being used hand in in hand also ISSBs manufacturers also produced ICB.

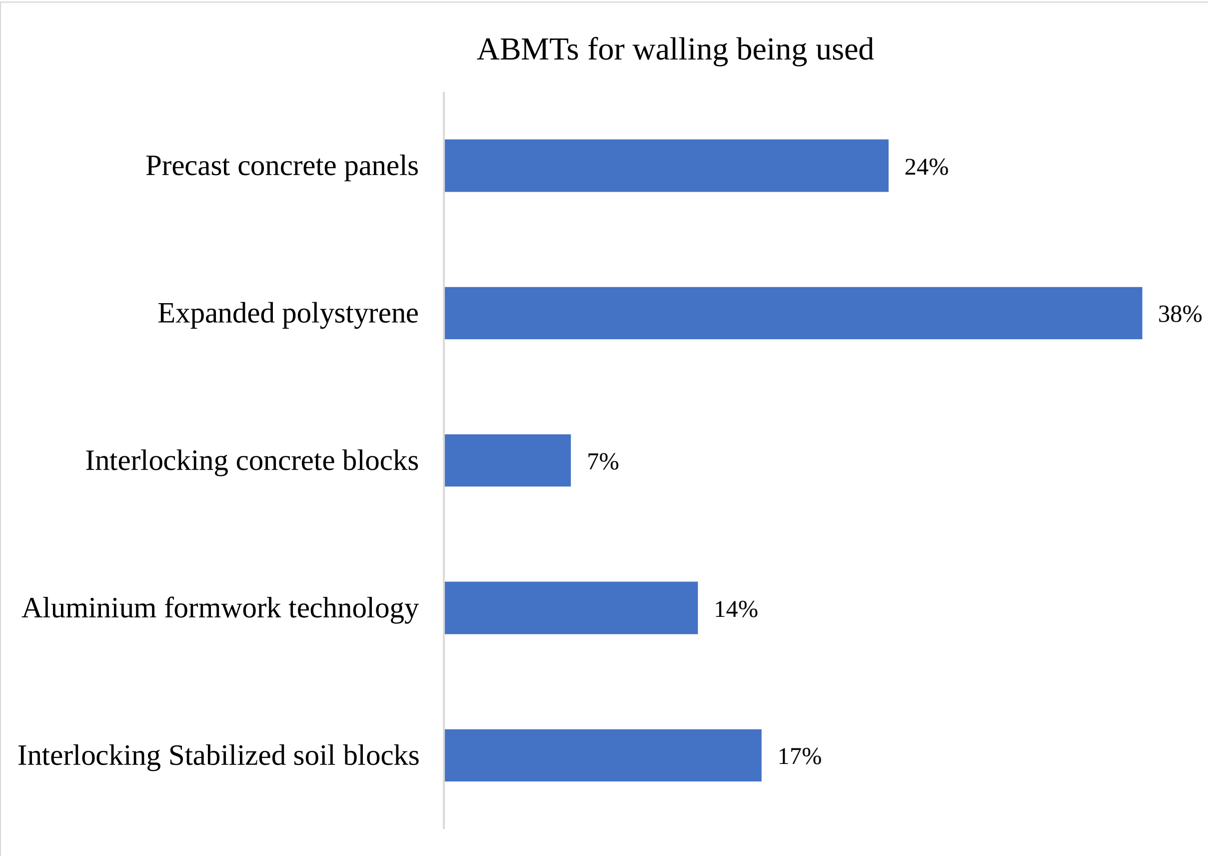

Figure 4.2: ABMTs for walling being used in Nairobi City County

Source: Field survey, 2019

In terms of organizations using the ABMTs, the results in Figure 4.3 suggest that private companies represented a majority at 84% while Government agencies accounted for 16%.

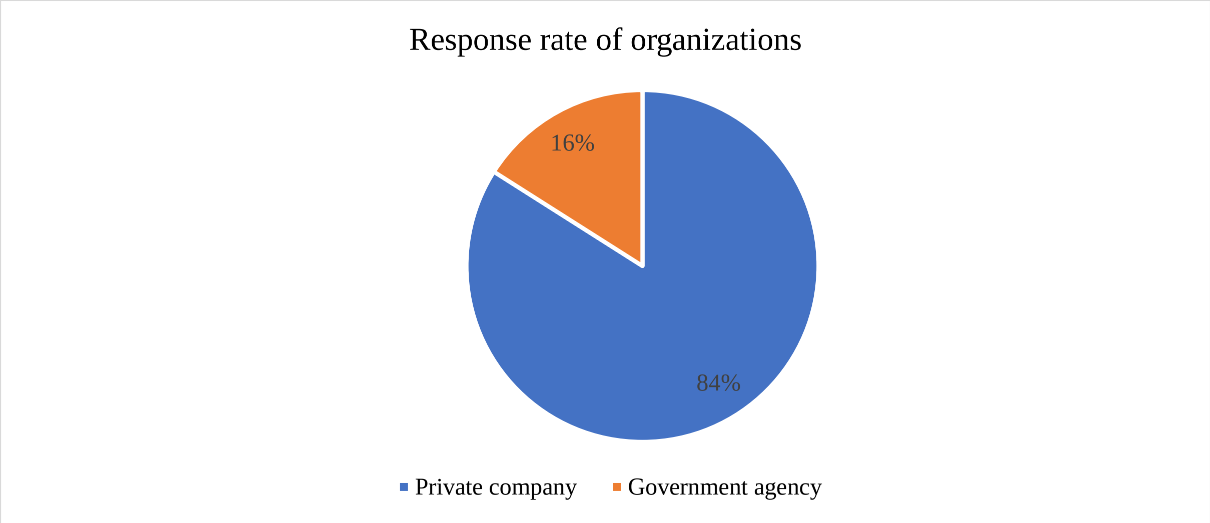

Figure 4.3: Response rate based on organizations

Source: Field survey, 2019

4.2: Adoption rate of ABMTs for walling

The study also sought to determine the level of adoption of the various ABMTs being used by the respondents. In determining the adoption rate a five-point Likert scale was used where 1-Very low, 2-Low, 3-Moderate, 4-High and 5-Very high.

According to findings in Figure 4.4, 52% of the respondents indicated that the adoption rate of the ABMTs they are using is moderate while of 7% indicated very low

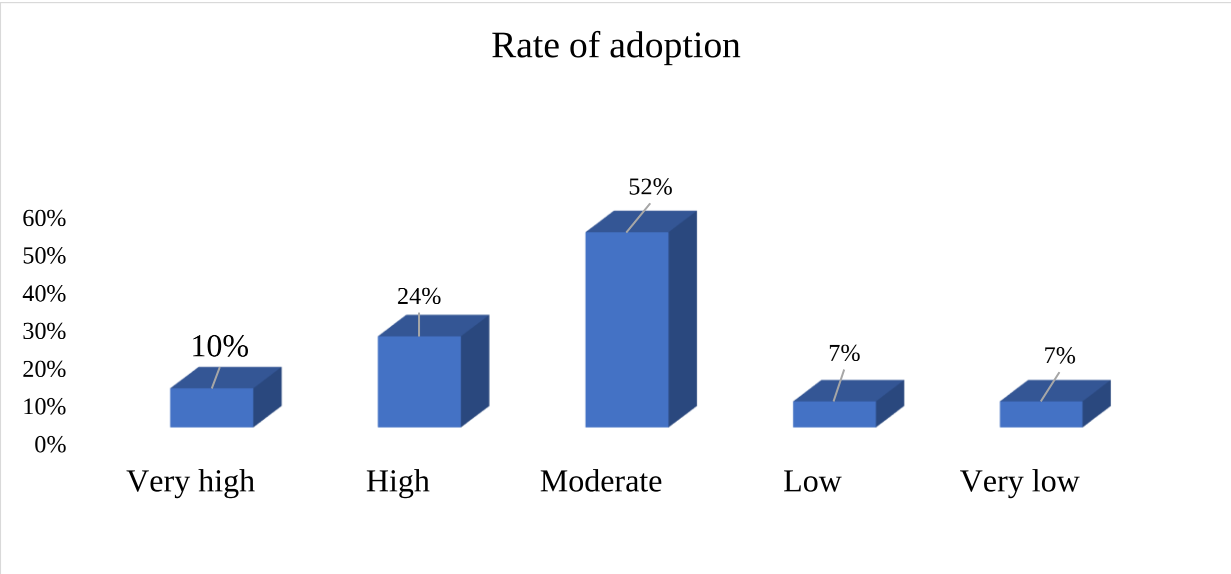

Figure 4.4: Rate of adoption of ABMTs by respondents

Source: Field survey, 2019

4.3: Parameters to be considered in acceptance of ABMTs for walling

The respondents rated the parameters that need to be considered in acceptance of Alternative Building Materials and Technologies. It aimed to validate impact of the seven variables identified: economic issues, social issues, technical know-how, environmental sustainability, quality of structures, government policies, time and logistics.

4.3.1: Economic issues

The respondents rated the economic issues to be considered in acceptance of ABMTs in terms of initial investment/capital cost, savings on construction cost, material cost, maintenance cost, economies of scale and transportation cost. The results are given in terms of mean, standard deviation and percentages as shown in Table 4.1 and Figure 4.5 ranking the degree of importance of various economic issues.

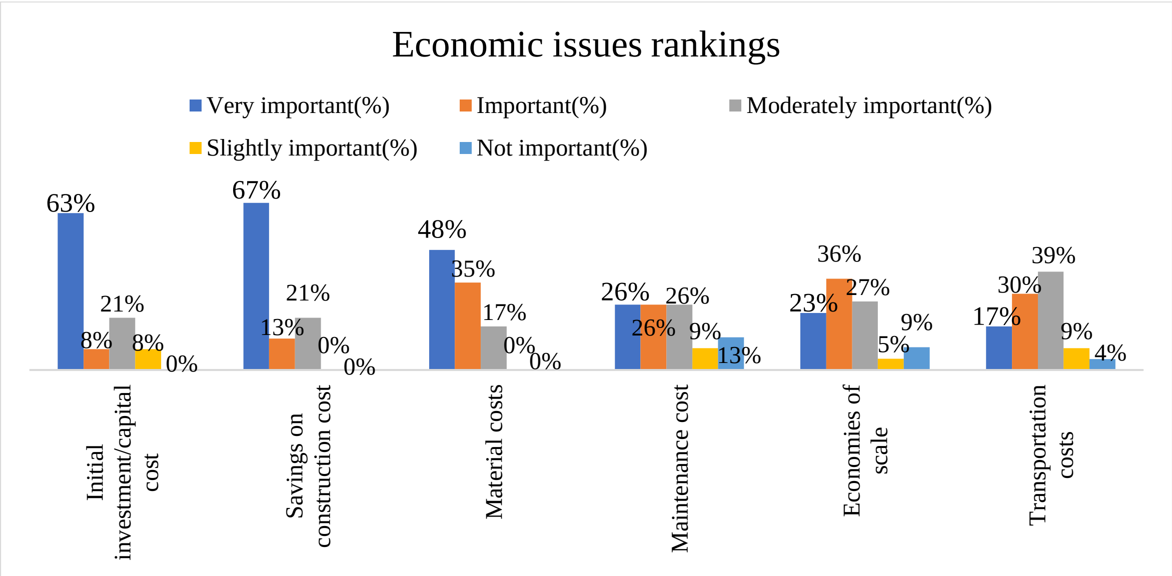

Figure 4.5: Extent of importance rankings of economic issues

Source: Field survey, 2019

Table 4.1: Mean score and standard deviation for economic issues

ECONOMIC ISSUES	N	Mean	Standard dev.
Savings on construction cost	42	4.47	0.819
Initial investment/ capital cost	42	4.20	1.020
Material costs	42	4.13	0.860
Economies of scale	42	3.70	1.089
Maintenance	42	3.50	1.223
Transportation costs	42	3.43	1.135

Source: Field survey, 2019

Under economic issues variable, the results indicate that the most critical aspect is savings on construction cost with a 4.47 mean and 0.819 standard deviation while the least is transportation cost rated at 3.43 mean and 1.135 standard deviation as shown in Table 4.1.

Savings on construction cost is the most critical factor that affects acceptance under the economic issue's variable, this finding is similar to what Rodgers (1995) highlights that relative advantage or superiority of an innovation in terms of profitability will lead to more acceptance. This also can be attributed to developers desire of minimising cost so as to be able to increase profitability.

Material cost mean can also be attributed to the relative advantage the material has with respect to the product it supersedes highlighted by Rodgers (1995).

Initial investment cost was second, this can be attributed to the fact that not all ABMTs for walling require sophisticated equipment's or intense training to be able to use them. Initial investment is a critical factor in acceptance for developers using ISSBs in construction since block making machine require to be purchased by developers involved in mass housing. This was highlighted by Margret (2015) in the literature review. It is also critical for manufacturers setting up factories.

Transportation cost mean can be attributed to the fact that most of the factories for the ABMTs are located within Nairobi City County or its environs therefore it is easier to transport the materials to the various sites but for individuals in other counties this is a critical factor to be considered in acceptance of the materials since it can lead to cost escalations especially if economies of scale aren't considered.

Maintenance cost can be attributed to the fact that most developers are in business but for end users this is a critical factor they consider in acceptance of the ABMTs to avoid escalation of costs in the long run.

4.3.2: Social issues

Social issues variable was further divided into four subthemes and analysed: level of awareness, job creation, owners/end user's perspective and people's culture. Figure 4.6 and Table 4.2 show the extent of importance of the various social issues' variables.

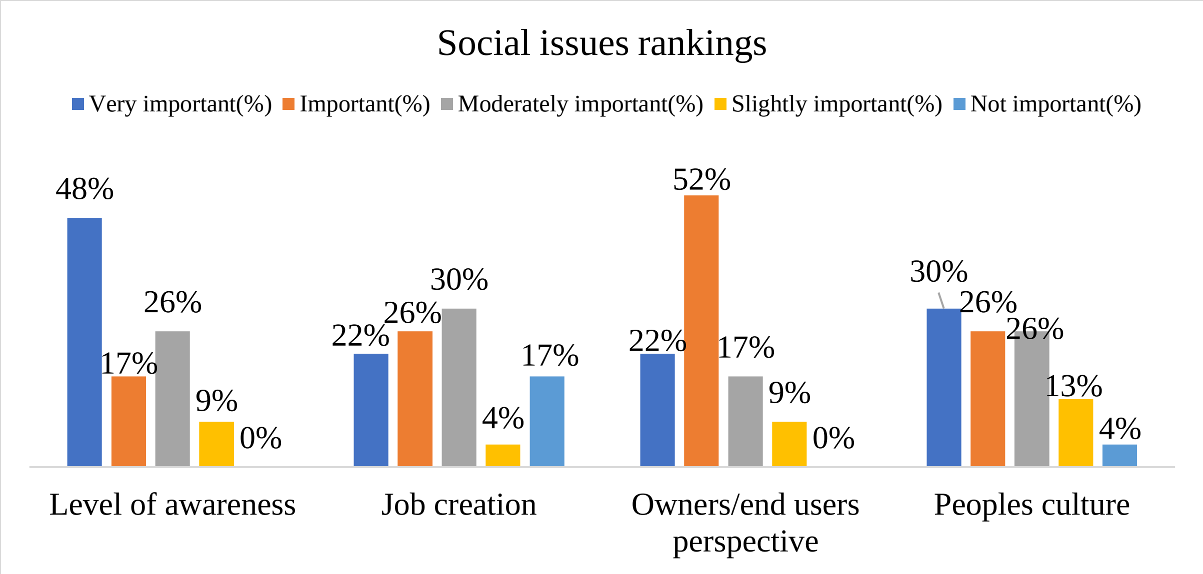

Figure 4.6: Extent of importance ranking of social issues

Source: Field survey, 2019

Table 4.2: Mean scores and standard deviation for social issues

SOCIAL ISSUES	N	Mean	Standard dev.
Level of awareness	42	4.20	1.031
Owners/end user's perspective	42	4.00	0.871
Peoples culture	42	3.63	1.066
Job creation	42	3.37	1.299

Source: Field survey ,2019

The results in Table 4.2 revealed that level of awareness was the most important factor with a mean of 4.20 and standard deviation of 1.031 while job creation was rated the least with a mean of 3.37 and standard deviation of 1.299.

The level of awareness by end users of the ABMTs as a critical factor in acceptance can be attributed to the fact that innovations normally come with some level of uncertainty (Rodgers, 1995).

If end users aren't aware of their existence of ABMTs and the various properties of the materials the acceptance will be very minimal. Their perspectives are also important to be able to educate and disseminate the right information so as to demystify the negative perspectives they might be having about the ABMTs due to misinformation.

4.3.3: Technical know-how

Four subthemes investigated under the technical know variable included: Ease of construction/technology transfer, training needs, availability of labour and availability of raw materials locally. Figure 4.7 and Table 4.3 show the extent of importance of the various technical know-how variables.

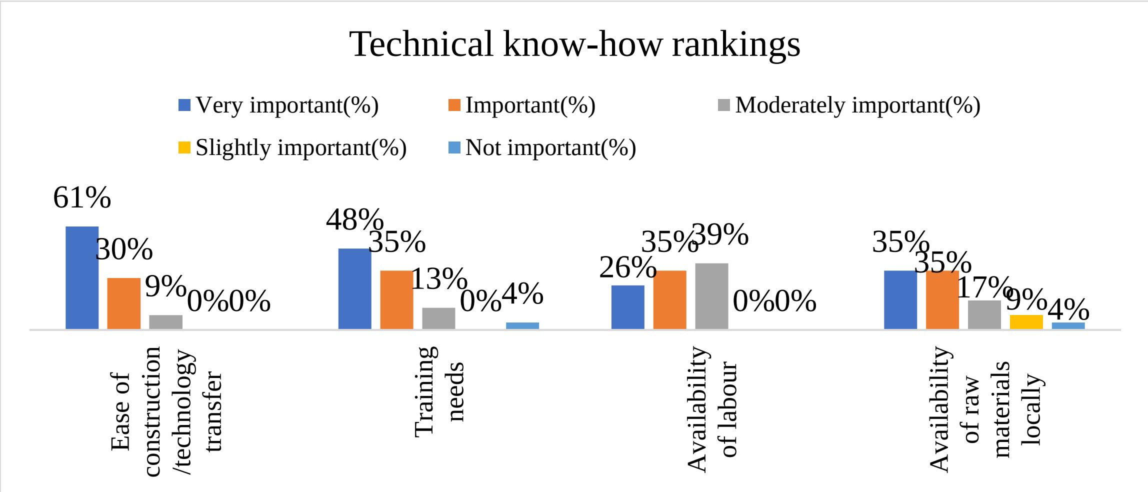

Figure 4.7: Extent of importance ranking of technical know-how

Source: Field survey, 2019

Table 4.3: Mean scores and standard deviation for technical know-how

TECHNICAL KNOW-HOW	N	Mean	Standard dev.
Ease of construction/technology transfer	42	4.57	0.678
Training needs	42	4.23	0.971
Availability of raw materials locally	42	3.87	1.106
Availability of labour	42	3.83	0.747

Source: Field survey, 2019

The findings in Table 4.3 revealed the most critical factor under technical know-how is ease of construction/technology transfer with a mean of 4.57 and standard deviation of 0.678 and availability of labour was rated the least under this category with a mean of 3.83 and standard deviation of 1.106.

Ease of construction/ technology transfer finding being considered as the most critical factor is further supported by Rodgers (1995) on complexity of the innovation. A technology that can be easily used in construction is more acceptable than one that requires complex techniques. This can be further attributed to the fact that developers won't have to invest more on training and also chances of errors are reduced hence acceptability becomes high.

This is also a reflection of developer's reluctance to invest in training. This is also supported by Davis (1985) on "perceived ease of use which is underpinned by the flexibility associated with new technology" whereby a technology that is free from effort of use is more acceptable.

4.3.4: Environmental sustainability

Use of recycled materials, reduction of depletion of natural resources, reduction of pollution, conservation of water and embodied use of energy were the sub-themes investigated under environmental sustainability variable. Figure 4.8 and Table 4.4 show the extent of importance of the various environmental sustainability variables.

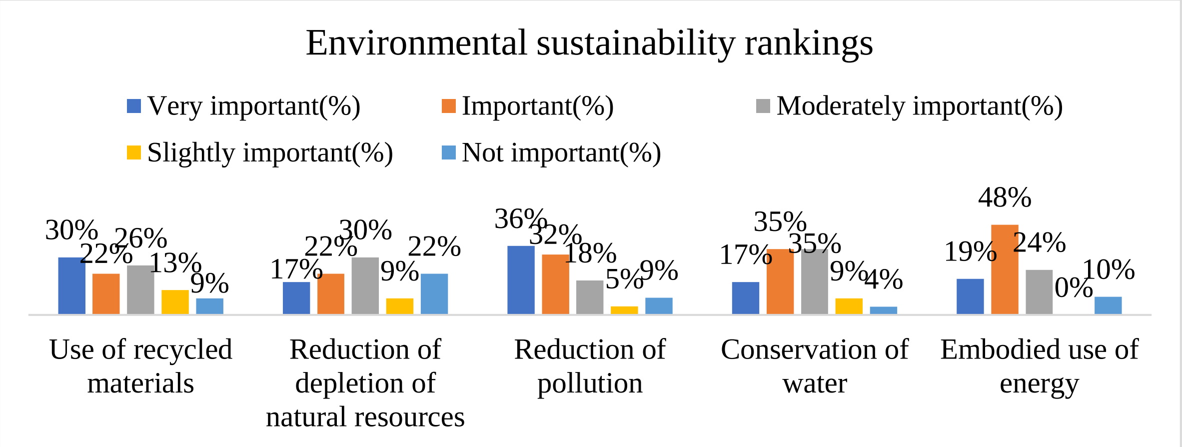

Figure 4.8: Extent of importance ranking of environmental sustainability

Source: Field survey, 2019

Table 4.4: Mean scores and standard deviation for environmental sustainability

ENVIRONMENTAL SUSTAINABILITY	N	Mean	Standard dev.
Use of recycled materials	42	3.30	1.236
Reduction of pollution	42	4.00	1.163
Embodied use of energy	42	3.64	1.026
Conservation of water	42	3.57	1.006
Reduction of depletion of natural resources	42	3.13	1.306

Source: Field survey, 2019

Findings in Table 4.4 revealed that reduction in pollution was the most critical factor under this theme with a mean of 4.0 and standard deviation of 1.236 and reduction of depletion of natural resources was ranked the least with a mean of 3.13 and standard deviation of 1.306.

Findings in Table 4.4 with reduction in pollution with the highest rating are supported by Nanyam et al. (2015) who opines that a material or technology that has less energy usage, reduces pollution and cause less wastage without compromising a projects viability are critical factors to be considered in acceptance. However, on embodied use of energy, use of recycled materials, conservation of water and reduction of pollution the findings are not supported by the literature.

The findings of this study revealed that environmental sustainability was least rated variable that is considered in acceptance of ABMTs. These findings are also proof that most developers aren't concerned much with these issues but despite that it is worth noting that most of the ABMTs being used by the respondents are environmentally friendly in terms of reduction of pollution which was rated the highest. However, most Architects considered this as a critical factor when specifying use of these materials.

4.3.5: Quality of structures

The quality of structures variables was divided into two subthemes: Durability and structural strength of the ABMTs. Figure 4.9 and Table 4.5 show the extent of importance of the various quality of structures variables

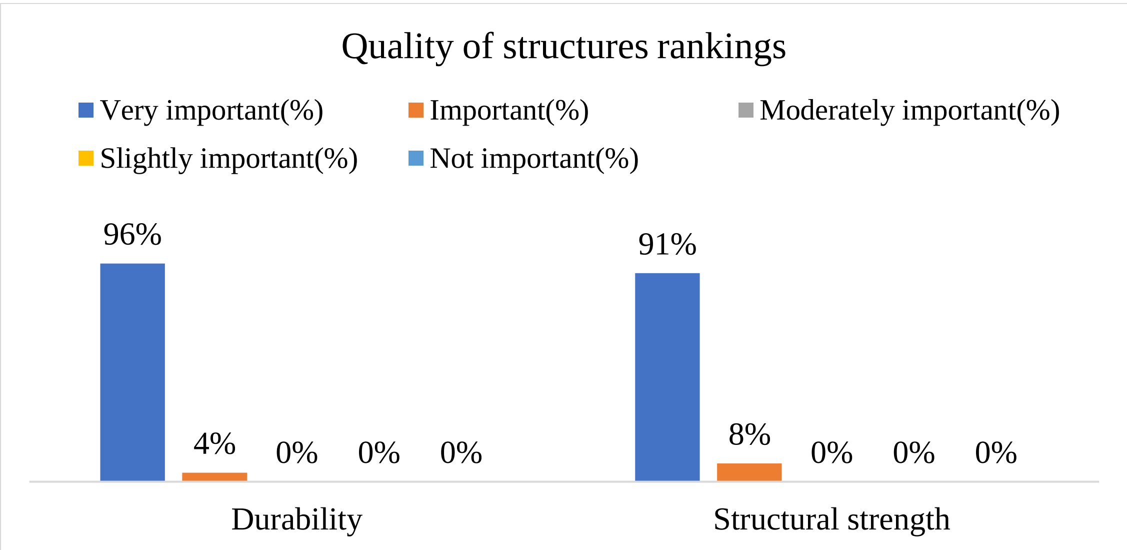

Figure 4.9: Extent of importance ranking of quality of structures

Source: Field Survey, 2019

Table 4.5: Mean scores and standard deviation for quality of structures

QUALITY OF STRUCTURES	N	Mean	Standard dev.
Durability	42	4.90	0.548
Structural strength	42	4.87	0.571

Field survey, 2019

According to findings in Table 4.5 durability and structural strength had the highest rating overall with a mean of 4.9 and 4.87 and standard deviation of 0.548 and 0.571 respectively. Quality of structures is therefore the most critical variable out of the eight variables investigated. If quality of structures isn't achieved it can lead to increased costs leading to loss of profits, reduced health and safety, loss of reputation when buildings collapse and even wastage of time. These can be considered as some of the reasons why all respondents considered quality as the most critical factor among all the variables investigated.

Findings in Table 4.5 are supported by Nanyam et al. (2015) who opines that strength and stability are a mandatory attribute that has to be considered in acceptance of ABMTs. This further concurs with Oppong and Badu (2012) findings on acceptance of ABMTs largely depending on their durability.

4.3.6: Government policies

Taxation policies, environmental regulations (EMCA, OSHA and public health) and building regulations were investigated under government policies variable. Figure 4.10 and Table 4.6 show the extent of importance of various government policies variables.

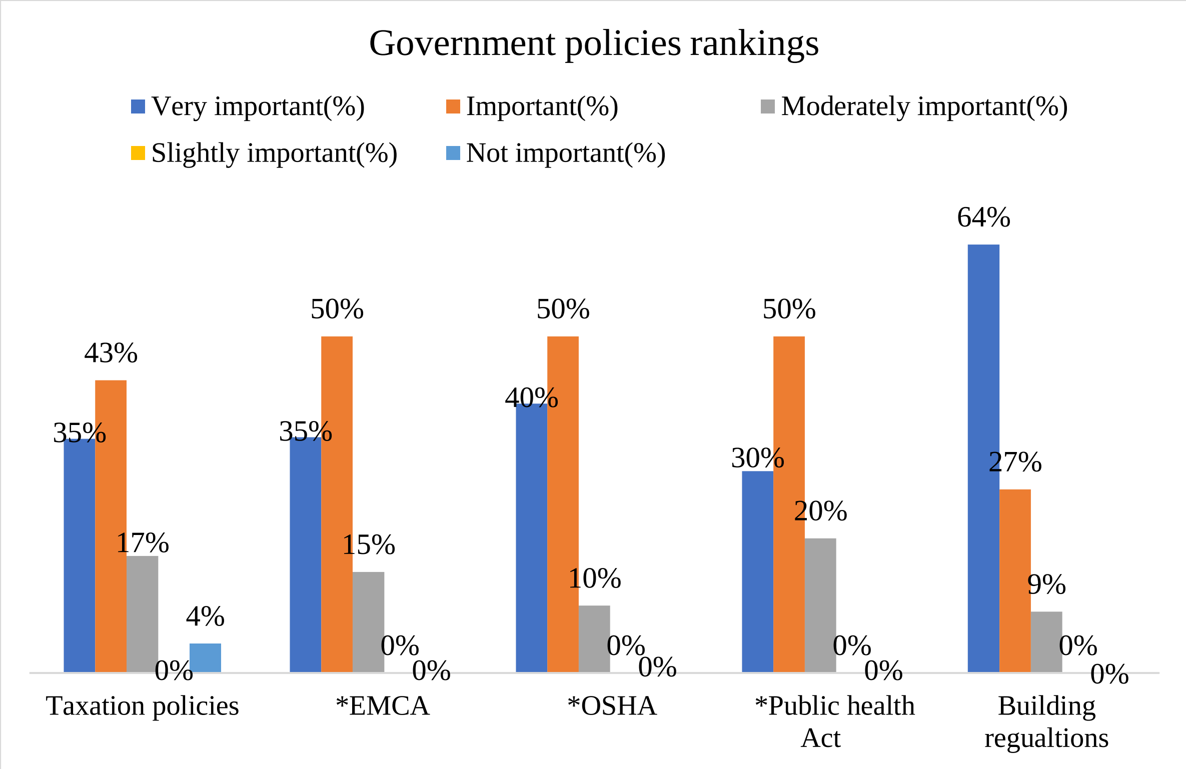

Figure 4.10: Extent of importance ranking of government policies

Source: Field survey, 2019

Table 4.6: Mean scores and standard deviation for government policies

GOVERNMENT POLICIES	N	Mean	Standard dev.
Taxation policies	42	3.9	1.06
Environmental regulations			
*Environmental Management and Coordination Act (EMCA)	42	4.19	0.622
*Occupational Health and Safety Act (OSHA)	42	4.26	0.594
*Public health Act	42	4.11	0.641
Building regulations	42	4.53	0.776

Source: Field survey, 2019

Findings in Table 4.6 revealed that building regulations was the most critical factor with a mean of 4.53 and standard deviation of 0.776 and taxation policies was rated the least with a mean of 3.9 and standard deviation of 1.06. Subsidies on taxes can be used as an incentive to help promote uptake of ABMTs among small scale entrepreneurs.

All the Government policies had a mean rating of 4 and above hence are considered critical factors. This is supported by Gbadebo (2014) who opines that Government policies is a critical factor to be considered in acceptance since if policies and regulations do not support the use of the materials or technologies it will not only hamper their acceptance but also the growth of that building sector.

4.3.7: Time

Installation speed and reduction of overall construction time were investigated under the time variable. Figure 4.11 and Table 4.7 show the extent of importance of the various time variables.

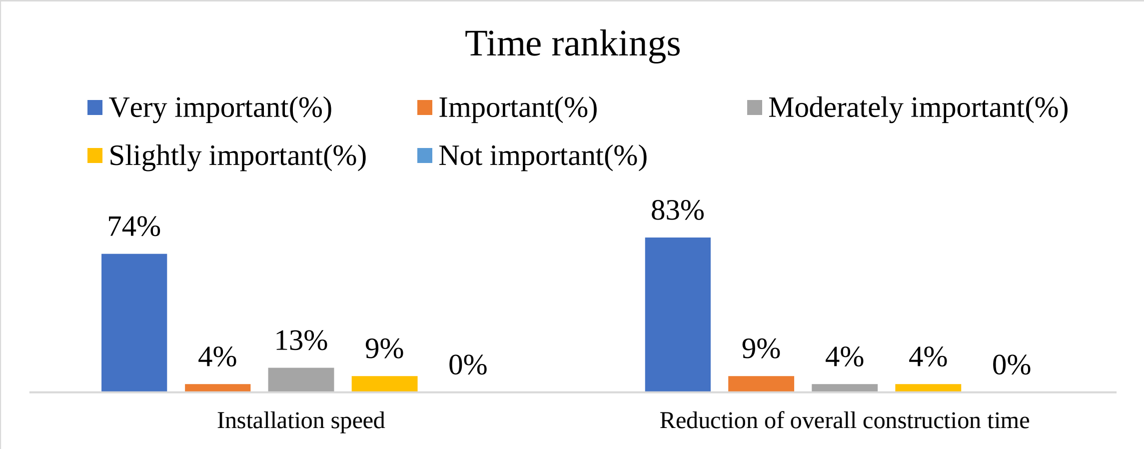

Figure 4.11: Extent of importance ranking of time

Source: Field survey, 2019

Table 4.7: Mean scores and standard deviation for time

TIME	N	Mean	Standard dev.
Reduction of overall construction time	42	4.63	0.718
Reduction of overall construction time	42	4.33	1.028

Source: Field survey, 2019

Findings in Table 4.7 revealed that the highest rated factor was reduction in overall construction time with a mean of 4.63 and standard deviation of 0.718 while installation speed had a mean of 4.33 and standard deviation of 1.028.

Reduction in overall construction time can be attributed to the fact that this helps in reduction of labour costs and also helps to reduce the deficit of housing by being able to produce a number of units within a short period of time .This is further supported by Rodgers (1995) in the literature review where acceptance of an innovation depends on the relative advantage it has to the product it supersedes. For developers an early completion time would also lead to an earlier return on investment thus this would be beneficial to them.

These findings are further supported by MHUPA (2015) who indicates that savings in time of construction is of significance to various stakeholders in the construction industry thus this criterion is of essence in consideration when assessing the acceptance of ABMTs.

4.3.8: Logistics

Material handling, transportation mode, hoisting requirements and material storage were investigated in the logistics variable. Figure 4.12 and Table 4.8 show the extent of importance of the various logistics variables.

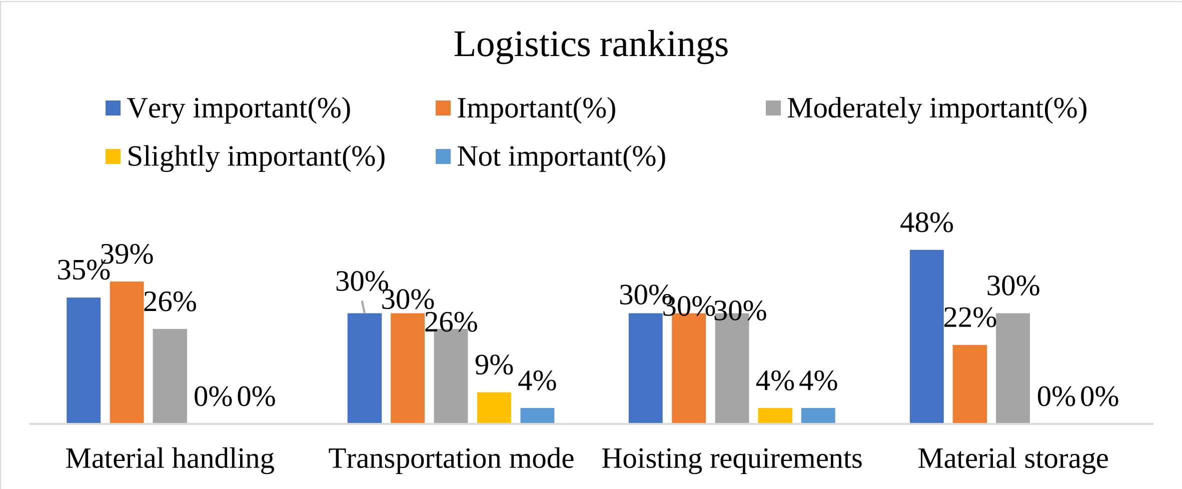

Figure 4.12: Extent of importance ranking of logistics

Source: Field survey,2019

Table 4.8: Mean scores and standard deviation for logistics

LOGISTICS	N	Mean	Standard dev.
Material storage	42	4.13	0.866
Material handling	42	4.00	0.812
Hoisting requirements	42	3.73	1.068
Transportation mode	42	3.63	1.128

Source: Field survey (2019)

The results in Table 4.8 revealed that material storage was the most critical factor with a mean of 4.13 and standard deviation of 0.866 and the least rated aspect was transportation mode with a mean of 3.63 and standard deviation of 1.128.

According to Thirigayajan et al. (2017) on use of aluminium formwork technology the probability of theft of these panels is more hence they need a secured storage area before usage hence the findings of material storage being ranked the highest are supported by this reason.

4.4: End users' level of awareness and factors considered in acceptance of ABMTs

The study revealed that seventy five percent (75%) of end users sampled were aware of the existence of ABMTs while twenty five percent (25%) weren't as shown in Figure 4.13.

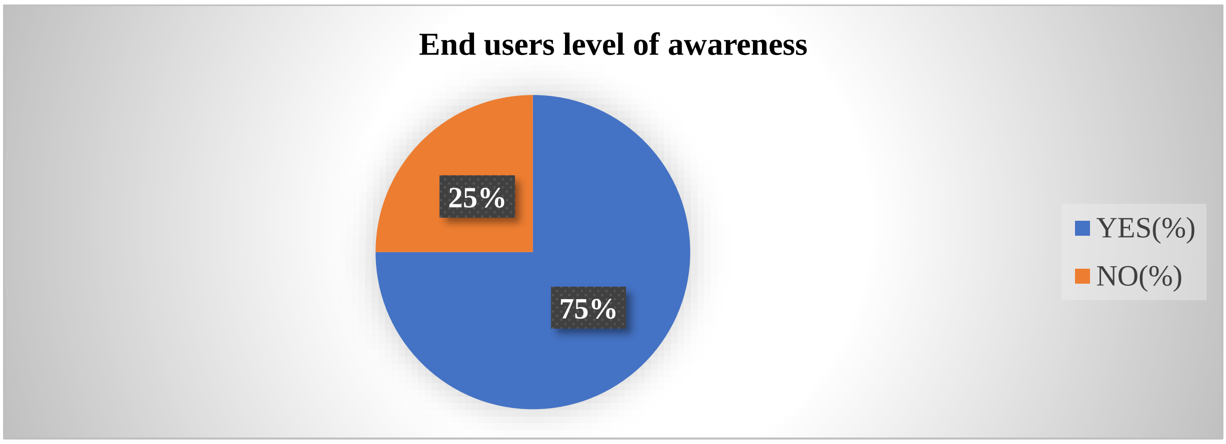

Figure 4.13: End users' level of awareness

Source: Field survey, 2019

ISSBs had the highest level of awareness at 39% whereas awareness on EPS was 24%, Precast Concrete Hollow Panels (PCHP) was 23%, Aluminium Formwork Technology 11% and Others accounted for 3% these included Ferrocement, Containers and Structural Insulated Panels. For the awareness level to increase more public sensitization on all the ABMTs available in the market is required.

Figure 4.14 shows the percentages for the level of awareness of the various ABMTs by the end users who participated in the study. These findings however are supported by Oppong and Badu (2012) whose findings indicated that only 31% of individuals they sampled their views were completely not aware of the existence of ABMTs for a case stabilized earth block in our case only 25% of the sampled individuals aren't aware if the existence of ABMTs.

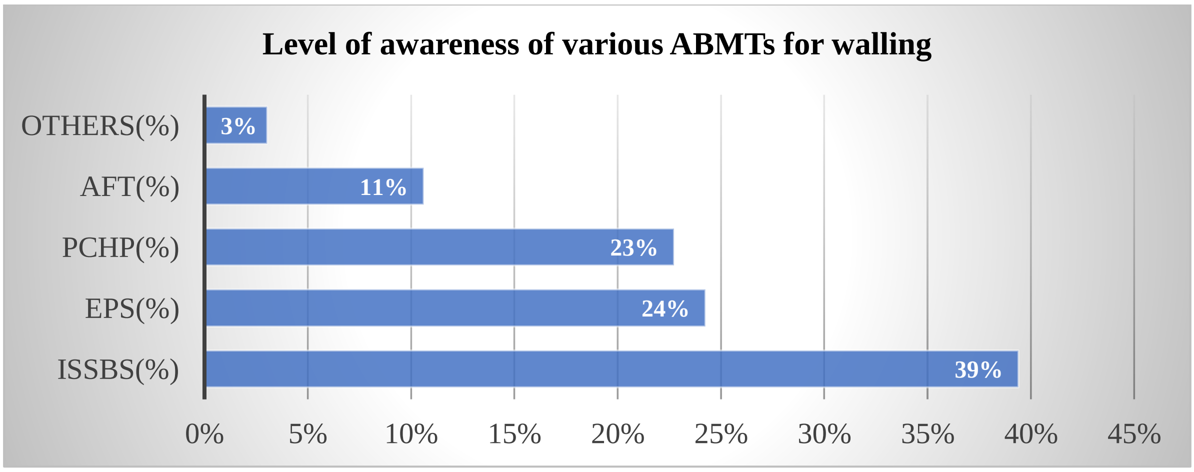

Figure 4.14: End users' level of awareness of various ABMTs

Source: Field survey, 2019

Eight nine percent (89%) of the end users aware of the ABMTs further agreed that they would consider to use ABMTs while eleven percent (11%) wouldn't consider to use ABMTs despite being aware of their existence as shown in Figure 4.15.

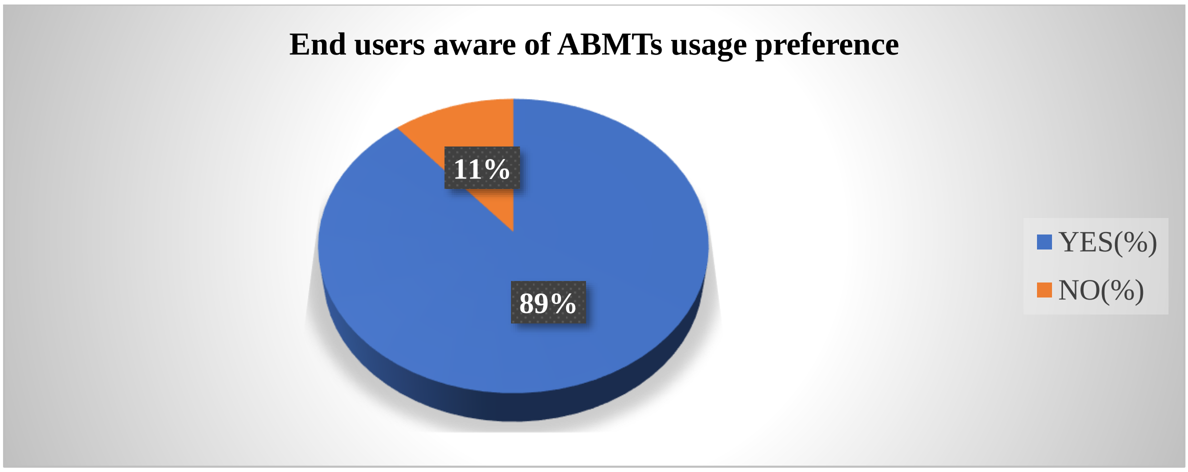

Figure 4.15: End users' preference to use or not use ABMTs

Source: Field survey, 2019

In finding out about some of the factors that end users who agreed they would use ABMTs for walling would consider in acceptance, respondents were given questionnaires listing seven factors. They were asked to indicate the extent to which each of the factors would influence their decision using a five-point Likert scale where 1= Not at all, 2= little extent, 3= Moderate, 4=Great extent and 5= Very great extent. Percentages were thereafter computed and the higher the percentage, the greater the factor would affect end user consideration to use ABMT and vice versa. The results are shown on Figure 4.16.

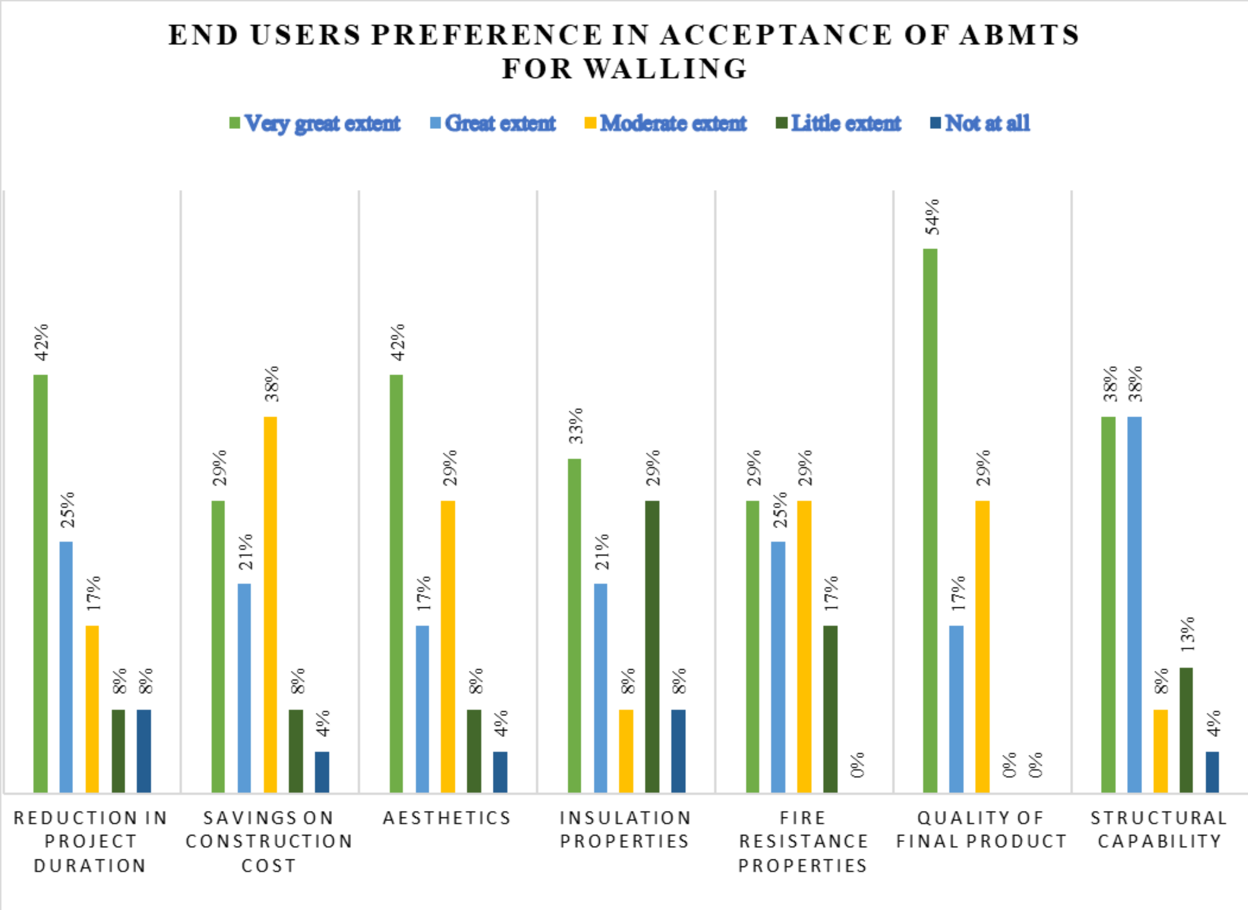

Figure 4.16: End users' preference in acceptance considerations

Source: Field survey, 2019

These findings are supported by Sengupta (2018) and Brown (2014) who indicate that some of the preferential criteria of acceptance for end users' critical factors are material cost, aesthetics, quality of outputs and structural capability.

In finding out about some of the factors that end users who disagreed they would use ABMTs for walling would consider, respondents were given questionnaires listing six factors. They were asked to indicate by ticking the extent to which each of the factors would influence their decision using a five-point Likert scale where 1= Not at all, 2= little extent, 3= Moderate, 4=Great extent and 5= Very great extent. Percentages were thereafter computed and the higher the percentage, the greater the factor would affect end user not consider to use ABMT and vice versa. Unfamiliarity with the product (34%) and uncertainty over structural performance (33%) were ranked the highest factors while low availability of materials and reports on poor prior performance were ranked the lowest at 0%. The results are shown in Figure 4.17.

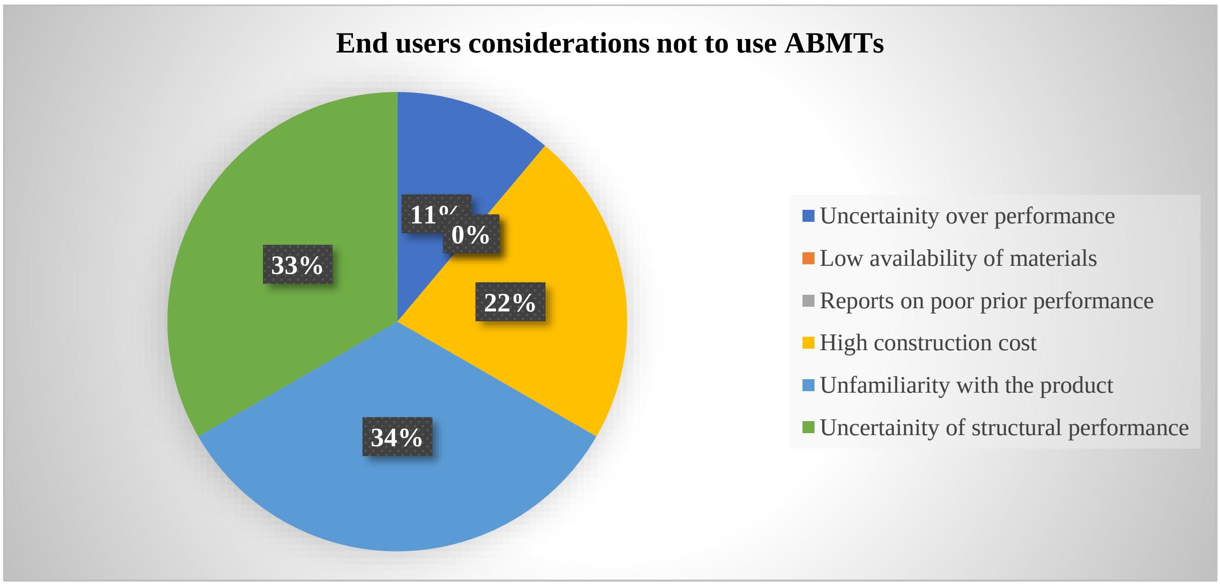

Figure 4.17: End users' considerations in not using ABMTs

Source: Field survey, 2019

These findings are supported by Brown (2014) who indicates that structural weakness is a key impediment to end users specifying ABMTs for use and the findings of this study revealed uncertainty of structural performance is a key limiting factor to accepting these materials and technologies by end users.

4.5: Strategies to increase the uptake of ABMTs

The final objective of the study was to determine the strategies that can be put in place to increase uptake of ABMTs. Using five-point Likert scale respondents were asked to rate the extent to which the enlisted strategies would help to increase uptake of ABMTs. A mean score of the strategies was calculated where a higher mean meant the strategy would greatly promote uptake of ABMTs. Table 4.9 indicates the responses and the mean item score on the factors that are considered to promote uptake of ABMTs.

Table 4.9: Strategies to be put in place to increase uptake of ABMTs

Strategy	N	Mean	Standard deviation
Executing government projects using ABMTs to create confidence to the public	46	4.58	0.584
Taxation subsidies on raw materials imported	46	4.04	1.207
Educating clients /end users using case studies as a way of creating awareness and public sensitization	46	4.64	0.569

Financial incentives to small scale entrepreneurs	46	4.04	1.082
Building centres should be established at county government level as a way of dissemination at grass roots level	46	4	1.291
Curriculum in learning institutions should include ABMTs	46	4.48	0.872
Educating clients/ end users and getting to understand their perception of ABMTs	46	4.44	0.712

Source: Field survey, 2019

The study revealed that educating clients/end users using case studies as a way of creating awareness and public sensitization was one of the key drivers to promote uptake of ABMTs for walling with a mean of 4.64 and a standard deviation of 0.569. This was followed by executing government projects using ABMTs to create confidence to the public with a mean of 4.58 and standard deviation of 0.584, curriculum in learning institution should include ABMTs was third with a mean of 4.48 and standard deviation of 0.872, promoters need to understand the end-user's perception towards the ABMTs and focus on educating clients as a first step had a mean of 4.44 and standard deviation of 0.712, taxation subsidies on raw materials imported and financial incentives with a mean of 4.04 and standard deviation of 1.207 and 1.082 respectively. Building centres should be established at county government level as a way of dissemination at grass roots level had the least mean of 4.0 with a standard deviation of 1.291 (Table 4.9).

These findings are supported by Gbadebo (2014) that leadership by example is key in promoting uptake of ABMTs i.e. executing government projects using the various ABMTs and also building centres being established at both local government levels as a way of dissemination to the grass roots. The findings on including ABMTs in the curriculum as a way of dissemination to new professionals is also supported by Mpakati (2012). These findings are further supported by Oppong and Badu (2012) who indicated that the greatest responsibility for increasing the uptake of ABMTs lies with the government.

Other strategies highlighted by respondents included: need to have a national workshop on ABMTs with a view to exchange ideas, share lessons learnt and disseminate available ABMTs, the forum would bring together the suppliers and users of the ABMTs.

4.6: Inferential statistics

The study sought to establish the extent to which study variables economic issues, social issues, technical know-how, environmental sustainability, quality of structures, government policies, time and logistics affects acceptance of Alternative Building Materials and Technologies in Nairobi County.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.791	.815	32

Figure 4.17: Reliability of data

Source: Field survey (2019)

Reliability test of the various items in the questionnaire was 81.5% and this proof of high internal consistency hence reliability.

4.6.1: Acceptance model development

Table 4.10: Economic issues sample test

One-Sample Test

	Test Value = 4					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference Lower	95% Confidence Interval of the Difference Upper
Initial cost	3.330	41	.002	.633	.24	1.02
Savings on construction cost	6.462	41	.000	.967	.66	1.27
Material cost	4.032	41	.000	.633	.31	.95
Maintenance costs	.000	41	1.000	.000	-.46	.46
Economies of scale	1.099	41	.281	.224	-.19	.64
Transportation costs	-.322	41	.750	-.067	-.49	.36

Source: Field survey, 2019

Results from the t-test for economic issues variables in Table 4.10 indicates that initial cost test {t (41) =3.33, p<0.05} savings in construction cost { t (41) = 6.462, p <0.05 }and material cost { t (41) =4.032, p<0.05 } meet the cut-off point of the hypothesized mean value of 4 used in the test they will therefore be included in the final model as critical factors.

Table 4.11: Social issues sample test

One-Sample Test

	Test Value = 4					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Level of awareness	3.720	41	.001	.700	.32	1.08
Job creation	-.562	41	.578	-.133	-.62	.35
Users perspective	3.144	41	.004	.500	.17	.83
Peoples culture	.685	41	.499	.133	-.26	.53

Source: Field survey, 2019

Results from the t-test for social issues variables in Table 4.11 indicates that level of awareness {t (41) =3.72, p<0.05} and end users perspective { t (41) =3.144, p<0.05 } meet the cut-off point of the hypothesized mean value of 4 used in the test they will therefore be included in the final model as critical factors.

Table 4.12: Technology know-how sample test

One-Sample Test

	Test Value = 4					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Ease of use	8.606	41	.000	1.067	.81	1.32
Training needs	4.135	41	.000	.733	.37	1.10
Availability of labour	2.445	41	.021	.333	.05	.61
Availability of raw materials locally	1.816	41	.080	.367	-.05	.78

Source: Field survey, 2019

Results from the t-test for technical know-how variables in Table 4.12 indicates that ease of use {t (41) =3.72, p<0.05} training needs { t (41) =8.606, p<0.05 } and availability of labour { t (41) =2.445, p<0.05 } meet the cut-off point of the hypothesized mean value of 4 used in the test they will therefore be included in the final model as critical factors.

Table 4.13: Environmental sustainability sample test

One-Sample Test

	Test Value = 4					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference Lower	Upper
Use of Recycled materials	-.886	41	.383	-.200	-.66	.26
Depletion of natural resources	-1.538	41	.135	-.367	-.85	.12
Reduction of pollution	1.996	41	.046	.431	-.01	.87
Conservation of water	.363	41	.719	.047	-.31	.44

Source: Field survey, 2019

Results from the t-test for environmental sustainability variables in Table 4.13 indicates that ease of use {t (41) =1.996, p<0.05} meet the cut-off point of the hypothesized mean value of 4 used in the test it will therefore be included in the final model as critical factor.

Table 4.14: Quality of structures sample test

One-Sample Test

	Test Value = 4					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference Lower	Upper
Durability	9.000	41	.000	.900	.70	1.10
Structural strength	8.308	41	.000	.867	.65	1.08

Source: Field survey, 2019

Results from the t-test for quality of structures variables in Table 4.14 indicates that durability {t (41) =9.0, p<0.05} and structural strength { t (41) =8.308, p<0.05 } meet the cut-off point of the hypothesized mean value of 4 used in the test they will therefore be included in the final model as critical factors.

Table 4.15: Government policies sample test

One-Sample Test

	Test Value = 4					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Taxation policies	2.063	41	.048	.400	.00	.80
EMCA	5.720	41	.002	.685	.44	.93
OSHA	6.638	41	.001	.759	.52	.99
Public Health Act	4.958	41	.000	.611	.36	.86
Building regulations	7.293	41	.000	1.033	.74	1.32

Source: Field survey, 2019

Results from the t-test for government policies variables in Table 4.15 indicates that taxation policies {t (41) =2.063, p<0.05} EMCA { t (41) = 5.72, p <0.05 } OSHA {t (41) =6.638, p,0.05 } public health act {t (41) =4.958, p<0.05 }and building regulations { t (41) =7.293, p<0.05 } meet the cut-off point of the hypothesized mean value of 4 used in the test they will therefore be included in the final model as critical factors.

Table 4.16: Time sample test

One-Sample Test

	Test Value = 4					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Installation speed	4.439	41	.000	.833	.45	1.22
Reduction of overall construction time	8.641	41	.000	1.133	.87	1.40

Source: Field survey, 2019

Results from the t-test for time variables in Table 4.16 indicates that installation speed {t (41) =4.439, p<0.05} and structural strength { t (41) =8.641, p<0.05 } meet the cut-off point of the hypothesized mean value of 4 used in the test they will therefore be included in the final model as critical factors.

Table 4.17: Logistics sample test

One-Sample Test

	Test Value = 4					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference Lower	Upper
Material handling	3.298	41	.003	.500	.19	.81
Transportation mode	.665	41	.511	.133	-.28	.54
Hoisting requirements	1.219	41	.233	.233	-.16	.62
Material storage	4.234	41	.000	.633	.33	.94

Source: Field survey, 2019

Results from the t-test for time variables in Table 4.17 indicates that material handling {t (41) =3.298, p<0.05} and material storage { t (41) =4.234, p<0.05 } meet the cut-off point of the hypothesized mean value of 4 used in the test they will therefore be included in the final model as critical factors.

4.7: Hypothesis testing

T-test was performed at interval confidence level of 95 per cent and α 0.05 with 41 degrees of freedom (df).

Table 4.18: One sample statistic for the variables

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
ECONOMIC ISSUES	42	3.9000	.56494	.10314
SOCIAL ISSUES	42	3.8000	.51445	.09392
TECHNICAL KNOW-HOW	42	4.1085	.60416	.11030
ENVIRONMENTAL SUSTAINABILITY	42	3.5100	.87202	.15921
QUALITY OF STRUCTURES	42	4.8833	.55216	.10081
TIME	42	4.4833	.81456	.14872
LOGISTICS	42	3.8750	.68779	.12557

Source: Field survey, 2019

The study results showed quality of structures had the greatest impact on the acceptance of ABMTs with an average combined mean of 4.88 while environmental sustainability had least impact on the acceptance of ABMTs for walling as depicted in Table 4.18. Its average combined mean had the least rating which was at 3.51. This combined average mean of the various aspects of environmental sustainability was very close to the moderate impact level hence depicting low overall impacts on the acceptance of ABMTs as provided in the Table 4.19

Table 4.19: T-test results for variables

One-Sample Test

	Test Value = 3.5					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference Lower	Upper
ECONOMIC ISSUES	3.878	41	.001	.40000	.1890	.6110
SOCIAL ISSUES	3.194	41	.003	.30000	.1079	.4921
TECHNICAL KNOW-HOW	5.515	41	.000	.60833	.3827	.8339
ENVIRONMENTAL SUSTAINABILITY	.063	41	.950	.01000	-.3156	.3356
QUALITY OF STRUCTURES	13.722	41	.000	1.38333	1.1772	1.5895
TIME	6.612	41	.000	.98333	.6792	1.2875
LOGISTICS	2.986	41	.004	.37500	.1182	.6318

Source: Field survey, 2019

Results presented from the t-test in Table 4.19 this indicates that for economic issues t (41) =3.878, $p<0.05$, since the p-value of $0.01<0.05$ the null hypothesis (Ho_1) is rejected. It is therefore concluded that economic issues promote acceptance of Alternative Building Materials and Technologies (ABMTs) for walling.

Social issues t (41) =3.194, $p<0.05$, since the p-value of $0.000<0.05$ the null hypothesis (Ho_2) is rejected. It is therefore concluded that social issues promote acceptance of ABMTs for walling.

Technical know-how t (41) =5.515, $p<0.05$ since the p-value of $0.03<0.05$ the null hypothesis (Ho_3) is rejected. It is therefore concluded that technical know-how promote acceptance of ABMTs for walling.

Environmental sustainability t (41) =0.063, p>0.05 since the p-value of 0.95>0.05 the null hypothesis (Ho_4) is accepted. It is therefore concluded that environmental sustainability does not promote acceptance of ABMTs for walling.

Quality of structures t (41) =13.722, p<0.05 since the p-value of 0.000<0.05 the null hypothesis (Ho_5) is rejected. It is therefore concluded that quality of structures promote acceptance of ABMTs for walling.

Time t (41) =6.612, p<0.05 since the p-value of 0.000<0.05 the null hypothesis (Ho_6) is rejected. It is therefore concluded that time promote acceptance of ABMTs for walling.

Logistics t (41) =2.986, p<0.05 since the p-value of 0.04<0.05 the null hypothesis (Ho_7) is rejected. It is therefore concluded that logistics promote acceptance of ABMTs for walling.

All the parameters to be considered in acceptance had their t calculated value less than the t critical value (at α 0.05) with degree of freedom (df) 41 except for environmental sustainability which had a t critical value greater than α 0.05.

In brief five major observations have been made in this chapter:

1) Firstly, there are five ABMTs for walling being used in Nairobi county; Expanded polystyrene, precast concrete panels, interlocking stabilized soil blocks, aluminium formwork technology and interlocking concrete blocks

2) Secondly, the adoption rate and uptake of ABMTs being used in Nairobi county is moderate.

3) Thirdly, on acceptance criteria; economic issues, social issues, technical know-how, quality of structures, time and logistics are critical factors to be considered in acceptance of ABMTs.

4) Fourthly, the level of awareness of various ABMTs by end users is high and the major preference in acceptance are quality of final output, structural strength/capability, reduction in project duration, savings in construction costs and aesthetics.

5) Finally, on strategies that can help promote uptake of ABMTs creating awareness and more public sensitization are the main factors that are considered would aid increase the uptake.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.0: Introduction

This chapter presents the conclusion and recommendations with respect to the objectives of the study. The main objective of the study was to evaluate the acceptance criteria for ABMTs. The specific objectives were to: determine the ABMTs for walling that are being used in Nairobi City County, adoption rate by various developers, level of awareness of end users and the factors influencing their acceptance, the parameters to be considered in acceptance of ABMTs and finally strategies that need to be put in place to increase uptake of ABMTs.

5.1: Major findings summary

5.1.1: Alternative building materials for walling being used

The study revealed that five major types of ABMTs for walling are being used in Nairobi City County; EPS, Precast concrete hollow wall panels, interlocking stabilized soil blocks, interlocking concrete blocks and Aluminium formwork technology.

EPS had the highest percentage at 34%, Precast concrete hollow wall panels 24%, Interlocking stabilized soil block 17%, aluminium formwork technology 14% and interlocking concrete blocks 7%.

EPS having the highest rating can be attributed to the government setting up an EPS plant in mlolongo as a way of advocating for the use of the material and various private companies like Koto housing and Boleyn magic wall panels also have manufacturing plants in Mlolongo and Kitengela hence they are readily available on order at any time.

5.1.2: Adoption rate of ABMTs for walling

Findings on adoption rate indicated that 52% of the respondents indicated that the adoption rate of the ABMTs they are using is moderate, 24% indicated its high, 10% very high and an equal of 7% indicated low and very low.

5.1.3: Parameters to be considered in selection of ABMTs for walling

Objective three was to determine the parameters that need to be considered in acceptance of ABMTs for walling. In order to determine this, the study categorized the parameters into eight variables; Economic issues, Social issues, Quality of structures, Environmental sustainability, Technical know-how, Government policies, Time and logistics and they were subjected to a mean item rating scale. A lower mean meant that the theme was least important in consideration while a higher mean meant the theme was very important in consideration during acceptance.

Each variable was further divided into various subthemes. Under economic issues the study revealed that the most critical aspect to be considered in acceptance of ABMTs is savings on construction cost whereas material cost was the second most important aspect. The third most rated critical factor for consideration was initial investment cost and economies of scale. Transportation cost and maintenance cost were the least rated aspects to be considered in acceptance of ABMTs.

Social issues variable, level of awareness was rated as the most critical factor to be considered during acceptance while end user's perspective on the materials was the second most rated important factor.

The findings on technical know-how variable revealed the most critical factor under is ease of construction/technology transfer which had the highest mean rating, followed training needs, availability of labour and availability of raw material locally were rated the least under this category.

Environmental sustainability variable was the least rated out of the eight variables with reduction of pollution rated the highest and reduction of depletion of natural resources ranked the least. However, most of the ABMTs being used in Nairobi City County are eco-friendly especially in terms of pollution reduction which was rated highest.

Durability and structural strength under the quality of structures variable had the highest rating overall. These findings therefore reveal that quality of structures is most critical variable parameter in acceptance from the variables investigated.

Within government policies, the most important sub-factor was the building code, followed by environmental regulations and taxation policies was the least ranked sub-factor.

Findings also revealed that reduction of overall construction period and installation speed were critical aspects considered in time variable.

Finally, on logistics, material storage had the highest, followed by material handling, third was hoisting requirements and the least rated aspect was transportation mode

5.1.4: End users' level of awareness and factors considered in acceptance

In investigating objective three of the study, the findings revealed that a greater percentage of end users sampled were aware of the existence of various ABMTs for walling this accounted for 75% while end users unaware of the existence of the ABMTs accounted for only 25%. Interlocking stabilized soil blocks was the highest ranked ABMT with a greater level of awareness among end users, followed by EPS, precast concrete panels and finally aluminium formwork technology.

89% of the end users who are aware of the existence of the ABMTs further agrees they would consider using ABMTs for walling in constructing their houses while 11% wouldn't consider using ABMTs despite being aware of their existence.

In considering the factors they would consider in accepting to use ABMTs quality of the final output and structural capability were the highest ranked factors. Fire resistance properties was the least factor ranked by end users that they would consider in acceptance.

End users who disagreed that they wouldn't consider using the ABMTs despite being aware of their existence ranked uncertainty over performance as the factor that to a great extent would affect their decision while reports of poor performance was the least ranked factor.

5.1.5: Strategies to increase the uptake of ABMTs

Objective four was to determine the strategies that can be put in place to increase uptake of ABMTs for walling. The study through mean item rating scale revealed that educating clients/ end users as a way of creating awareness and executing government projects using ABMTs to create confidence to the public were the two factors that were considered that would majorly help promote uptake.

However, none of the factors had a rating of a mean of less than 4 and this is proof that in as much as the above stated were the highly ranked strategies, all the seven strategies highlighted would also to a great extent promote uptake of ABMTs.

Other strategies proposed by respondents was the need to have a national workshop on ABMTs with a view to exchange ideas, share lessons learnt and disseminate available ABMTs. The forum would bring together the suppliers and users of the ABMTs. This still sums up to creation of awareness.

5.2: Conclusion

The study was based on eight dimensions of acceptance criteria of Alternative Building Materials and Technologies for walling, which are economic, social, technical know-how, environmental sustainability, quality, government policies, time and logistics. The study adopted 32 parameters from the literature review out of which respondents indicated identified 18 parameters to be considered in acceptance criteria. These include three economic issues, which are initial investment/capital cost, savings on construction costs and the material cost. Level of awareness and end user's perspective of the materials was identified as the key parameters in social issues. Furthermore, ease of construction and training needs were identified as the key parameters in technical know-how and reduction of pollution in environmental sustainability. In addition, durability of the materials and structural strength/capability were the critical factors identified in quality of structures and environmental regulations and building regulations in government policies. Lastly two-time parameters which are installation speed and overall reduction of construction time were identified as key parameters and material handling and storage in logistics dimension. The study therefore suggests that these eighteen parameters that assisted in developing the acceptance model shown in figure 5.1 should be considered in future for any study or even by professionals who seek to measure or choose the best option from the available ABMTs and can help determine the most affordable one.

This research aimed at increasing the understanding about the acceptance criteria for Alternative Building and Technologies factors. Hypotheses of study were evaluated and results led the author to the following conclusions:

Ho_1-Economic issues does not promote acceptance of ABMTs for walling.

Decision-Reject hypothesis

It was found that economic issues promote acceptance of ABMTs and are thus critical factors to be considered in acceptance.

Ho_2-Social issues does not promote acceptance of ABMTs for walling.

Decision-Reject hypothesis

It was found that social issues promote acceptance of ABMTs and are thus critical factors to be considered in acceptance.

Ho_3-Technical know how does not promote acceptance of ABMTs for walling.

Decision-Reject hypothesis

It was found that technical know-how promote acceptance of ABMTs and are thus critical factors to be considered in acceptance.

Ho_4-Environmental sustainability does not promote acceptance of ABMTs for walling.

Decision-Accept hypothesis

It was found that most environmental sustainability aspects do not promote acceptance of ABMTs and are thus not critical factors to be considered in acceptance.

Ho_5-Quality of structures does not promote acceptance of ABMTs for walling.

Decision-Reject hypothesis

It was found that quality of structures promote acceptance of ABMTs and are thus critical factors to be considered in acceptance.

Ho_6-Time does not promote acceptance of ABMTs for walling.

Decision-Reject hypothesis

It was found that time promote acceptance of ABMTs and are thus critical factors to be considered in acceptance.

Ho_7-Logistics does not promote acceptance of ABMTs for walling.

Decision-Reject hypothesis

It was found that logistics promote acceptance of ABMTs and are thus critical factors to be considered in acceptance.

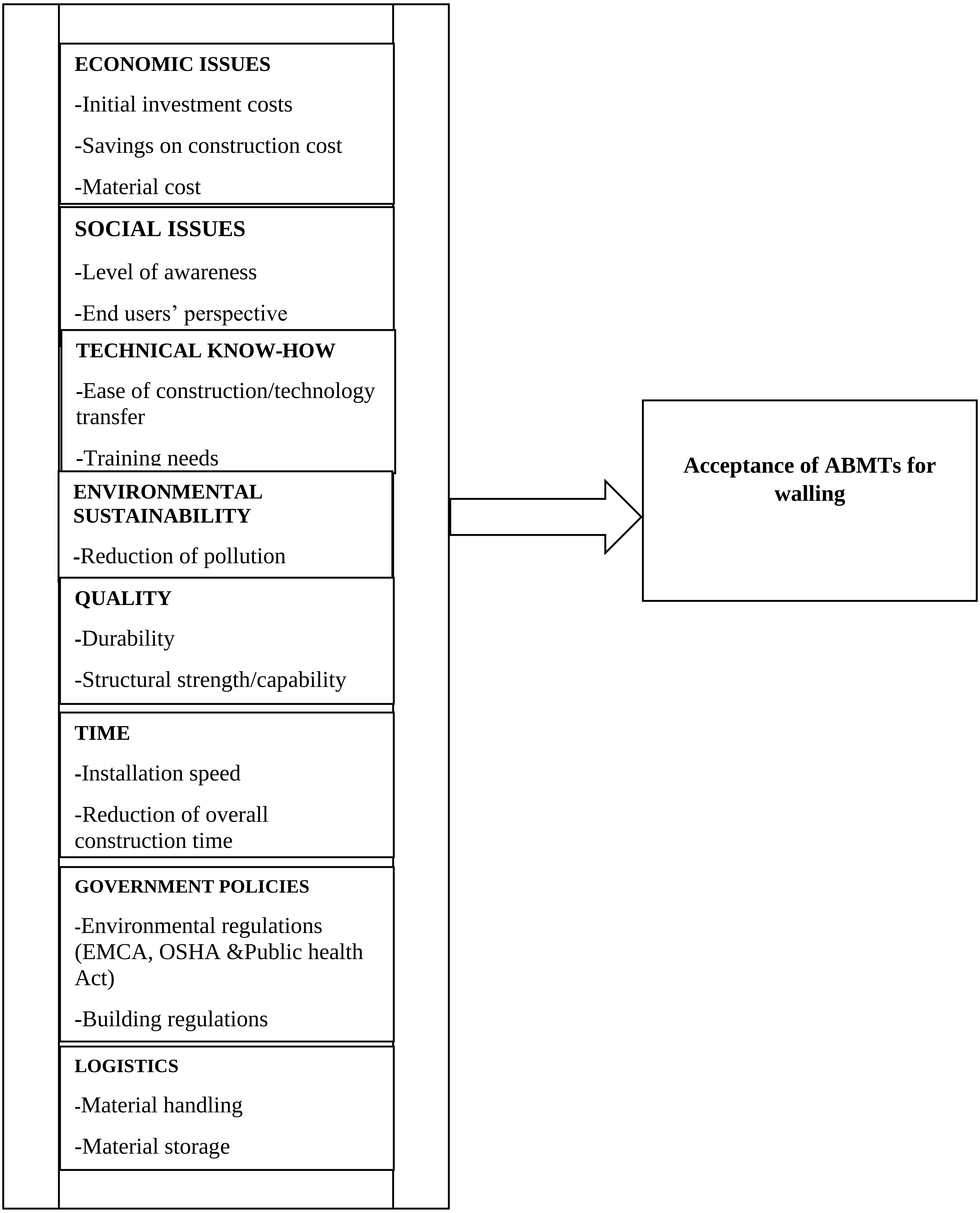

Figure 5.1: Acceptance model for ABMTs

Source: Field survey, 2019

5.3: Limitation of findings

The research undertaken is significant and the findings are important to various stakeholders in the construction industry helping them to select the best Alternative Building Materials and Technologies (ABMTs) for walling. However, there are various limitations associated with the study. The research was principally concerned with identifying acceptance criteria for ABMTs for walling. Therefore, the research might only be confined to walling element and not other building elements even though the methodology may remain appropriate for any building element.

In addition, the criteria of acceptance that has been identified in this research might be limited to this point in time of research since individuals' level of awareness of various aspects change with time. Thus, the model will require regular updates.

In identifying the critical factors in acceptance criteria, the study was confined to construction professionals within Nairobi City County. Therefore, this research might only be valid to the characteristics of this region and other advantages this county might have in comparison to other counties.

5.4: Contribution to knowledge

The results from this study provides information about the most critical factors to be considered in acceptance hence serving as a decision support system. This will help various construction industry stakeholders and investors who would be interested in venturing into construction using ABMTs select the most appropriate technologies or materials from the perspective of affordability and sustainability. These critical factors are economic issues (Initial investment costs, savings on construction costs and material cost), social issues (level of awareness of end users about the material or technology and end users perspective), technical know-how (ease of use of the technology and training needs required), environmental sustainability)reduction of pollution by the ABMTs), quality of structures (durability and structural strength/capability of the materials), time (installation speed and the reduction in overall construction time), government policies (environmental regulations and building regulations) and logistics (ease of material handling and storage requirements)

It also provides relevant information to stakeholders who have adopted use of ABMTs or are into manufacturing on the preferential acceptance criteria for end users and also understanding the perceptions of end users who aren't willing to use the materials. Thus, designers of ABMTs and material specifiers in the industry stand a chance of offering more cost-effective and environment friendly and sustainable alternative building materials and technologies solutions to their clients as a result of the findings of this study. End users consider quality of final output, structural capability of the materials, reduction in project duration, savings in construction cost and aesthetics as critical factors they consider in acceptance of ABMTs.

5.5: Recommendations

The following recommendations are hereby made with a view of increasing the uptake and acceptance of Alternative Building Materials and Technologies for walling:

The study established that the extent of adoption of ABMTs is moderate. In light to these findings, the study recommends that more efforts should be directed towards educating various professionals in the construction industry especially in learning institutions by coming up with an education programme or units on the same. Other professionals in the construction industry also need to be made aware of the criteria for acceptance of these materials so that they are able to select the best option based on the various weighting factors and project requirements.

The study established 18 key parameters: Initial investment costs, savings on construction costs, material cost, level of awareness of end users about the material or technology, end user's perspective, ease of use of the technology, training needs required, reduction of pollution by the ABMTs, durability, structural strength/capability of the materials, installation speed, reduction in overall construction time, environmental regulations(EMCA,OSHA and public health act), building regulations, ease of material handling and storage requirements that are considered critical in acceptance of ABMTs for walling. Thus, the study recommends these key parameters should be considered by stakeholders in the construction industry who seek to choose the best option from the available ABMTs.

End users not willing to use the materials major area of concern is the uncertainty over performance. Success stories based on successful projects executed by the government in different counties would not only create awareness but also boost confidence of end users and make them more receptive to the various ABMTs.

In order to increase uptake of ABMTs, more awareness and public sensitization is required. More demonstration projects by Government is a key element that would help enhance ABMTs acceptance. End users not willing to use the materials major area of concern is the uncertainty over performance. Success stories based on successful projects executed by the government in different counties would not only create awareness but also boost confidence of end users and make them more receptive to the various ABMTs.

5.6: Areas of further research

Successful completion of this research lead to suggestions on future focus on: Investigating other building elements besides walling with the opportunity to draw comparisons between different elements of a building as this may provide new insights and structural strengths of Alternative Building Materials and Technologies for Walling,

Construction stakeholder's perception in relation to the importance of environmentally sustainable ABMTs is an area of concern. Further research can be developed to explore the changes on the 8 themes considered in the context of their impact in different counties to draw some interesting inter-county comparisons.

REFERENCES

Ajzen, I. (1991). *Theory of planned behaviour: theories of Cognitive Self-Regulation,* 50(2), 179-211.

Alinaitwe, H. M. (2008). *Improvement of Labour Performance and Productivity in Uganda's Building Industry.* University of Lund, Division of Construction Management.

Brown, M. (2014). *Compressed earth block (CEB): A viable building alternative for Olancho, Honduras (Master of Science).* Colorado state university. Colorado.

Bryman, A. (2012). *Social Research Methods*. New York: Oxford University Press.

BuildoffSite (2010). *Buildoffsite Review 2010*. Buildoffsite, London.

Centre of Building Research institute (2017). *Manual for EPS core panel system and its field application*. Government of India.

Construction Industry Policy (2018). Nairobi, Kenya.

Davis, F. D. (1985). *A technology acceptance model for empirically testing new end-user information systems: Theory and results. (PhD*). Massachusetts Institute of Technology, Cambridge.

Dow chemical company (2014*). Invention of Styrofoam: Building solutions*. Retrieved January 07, 2019 from http://building.dow.com/about/invention.htm.

EPS Specifier guide. Retrieved January 08, 2019 from www.epsconstructiongroup.com.

Gbadebo, M.A. (2014). *Promoting use of alternative technologies in Nigeria: The problems and recommendations.* International Journal of Advancements in Research & Technology, Volume 3, Issue 11, November -2014.

HABRI. (2003). *Manual for selection, testing and production of ISSB*. University of Nairobi, Nairobi.

Hong, J., Shen, G.Q., Li, Z., Zhang, B.; Zhang, W. (2018). *Barriers to promoting prefabricated construction in China: A cost benefit analysis. China.*

Ireri, F. (2010, July 19). Monday View, Daily Nation, p.27.

Jaillon, L., Poon, C.S. (2008). *Sustainable construction aspects of using prefabrication in dense urban environment: A Hong Kong case study*. Construction Management Economics.

Kagai, D. (2017). *Why builders are rushing to adopt new technology*. Retrieved December 28,2018 from: https://www.constructionkenya.com/3479/kenya-builders-prefab-technology/

Kalpesh , J (2013). Importance of data analysis in research. Retrieved January 09,2019 from http://www.dissertationindia.com/blog/importance-of-data-analysis-in-research

Kimberlin, C. L& Winterstein, A. G (2008). *Validity and reliability of measurement instruments used in research.*

Kothari, C. R (2004). *Research methodology methods and techniques: Quantitative techniques 2nd edition*. New Delhi: Vikas publishing house print ltd.

Li, Y. (2016). *How to determine the validity and reliability of instruments*. Retrieved January 7, 2019 from https://blogs.miamioh.edu/discovery-center/2016/11/how-to-determine-the-validity-and-reliability-of-an-instrument/

Mahendriyani, D. (2016). *Alternative building materials for green construction.* Asia green buildings. Retrieved 03/02/2019 from AsiaGreenBuildings.com

Maina, J. (2012). *Qualitative & Quantitative Research Methods simplified*. Nairobi: Frajoba Printers Mall.

Mao, C., Xie, F., Hou, L., Wu, P., Wang, J., Wang, X. (2016). *Cost analysis for sustainable off-site construction based on a multiple-case study in China.* Habitat international.

Mao, C., Shen, Q., Pan, W. (2015). *Major Barriers to Off-Site Construction: The Developer's Perspective in China.* China.

Margret M. N. (2015). *Investigating the rationale for material selection in tropical housing projects in Uganda – A Case for Interlocking Stabilised Soil Blocks (ISSBs) Technology (Master of Philosophy).* University of Cambridge, United Kingdom.

Mbaire, J. (2017). *Low cost housing-is it possible*? Retrieved December 28, 2019 from http://house.jumia.co.ke/journal/low-cost-housing-possible/.

Ministry of Housing and Urban Poverty Alleviation (2015). *Multi-attribute evaluation methodology for selection of emerging housing technologies*. India.

Mohamad & Angela L. (2009). *Use of stabilized earth in the construction of low-cost sustainable housing in Africa-An energy solution in the era of climate change*.

Mostafa, S., Chileshe, N. and Zue, J. (2014a) *A Synergistic Supply Chain Enhancing Off-Site Manufacturing Uptake in Australian Housing Projects*. In: Raiden, A.B. and Aboagye-Nimo (Ed), Procs 30th Annual ARCOM Conference, 1-3 September 2014, Portsmouth, UK, pp: 1143-1152.

Mpakati, E. C., Wamuziri, S. C., and Sloan, B. (2012). *The use of alternative building material in developing countries: Addressing challenges faced by stakeholders.* World Construction Conference 2012 – Global Challenges in Construction Industry 28 – 30 June 2012, Colombo, Sri Lanka

Mugenda O.M. & Mugenda A.G (2003). *Research Methods: Quantitative and Qualitative approaches.* Nairobi: Acts Press.

Nairobi County Government (2014). *Nairobi County Government Development Plan*. Nairobi.

Nanyam, N. V., Basu, R., Sawhney, A., and Prasad, G. K. (2015). *Selection framework for evaluating housing technologies.* Creative Construction Conference 2015 (CCC2015).

Ngugi, H. N., Kaluli, J.W., Abiero, Z. (2017). *Use of Expanded Polystyrene Technology and Materials Recycling for Building Construction in Kenya*. American Journal of Engineering and Technology Management. Vol. 2, No. 5, 2017, pp. 64-71.

NHBC Foundation (2016). A guide to modern methods of construction. NF 1. Milton Keynes.

Njuguna S.G. (2014). *An investigation on the extent of use of expanded polystyrene panels for building construction in Kenya (BSc Thesis)*. University of Nairobi, Nairobi.

Noppen A.V. (2012). *The ABC's of Affordable Housing in Kenya*. The Acumen Fund report. Nairobi

Okande, A. (2015). *Why professionals could be the weak link in use of appropriate building technologies*. Standard digital, 03 Dec.2015. Retrieved 05/01/2018 from https://www.standardmedia.co.ke/article/2000184179/why-professionals-could-be-the-weak-link-in-use-of-appropriate-building-technologies-abts.

Okeyo, V. (2015). *Low-cost housing seen as answer to urban housing problems*. rozenbergquarterly.com. Daily Nation, 29 Apr. 2015. Retrieved 06/01/2019 from http://rozenbergquarterly.com/verah-okeyo-low-cost-housing-seen-as-answer-to-urban-housing-problems/.

Omayi, M.M. (1993). *Constraints to the Dissemination and Utilization of Fibre Concrete Roofing Tile and Stabilized Soil Block Technologies in Kenya (Masters of Arts Thesis)*. University of Nairobi, Nairobi.

Oppong, R.A and Badu, E. (2012). Evaluation of stabilised earth block (TEK) for housing provision in Ghana. Journal of Science and Technology, Vol. 32, No. 2 (2012), pp 104-118.

Oyedele, O.A. (2016*). Assessment of Adoption of Modern Methods of Construction (MMC) in Nigeria.* Conference paper: FIG Working week 2016.

Ngigi, P.N. (2016). *Evaluation of alternative construction technologies in the delivery of affordable housing-A case study of Nairobi county (MSc Thesis)*. Jomo Kenyatta University of Agriculture & Technology, Juja.

Pan, W. and Goodier, C. (2012) House-Building Business Models and Off-Site Construction Take-Up, Journal of Architectural Engineering, 18(2), 84-93

Polit D.F. & Beck C.T. (2008). *Nursing research*. 8th edition. Lippincott, Williams & Wilkins: Great Britain.

Sangori, R.O. (2012). *Adoption of hydraform ISSBs and its impacts on the environment in Nakuru County (M.A Thesis)*. University of Nairobi, Nairobi.

Sengupta N., “Use of Cost-Effective Construction Technologies in India to Mitigate Climate Change.” Current Science, vol. 94, no.1, January 10, 2008, pp 38-43.

Rogers, E. M. (1995). *Diffusion of innovations*. Third edition. New York: Free Press.

Roy, R., Low, M. and Waller, J. (2005). *Documentation, Standardisation and Improvement of the Construction Process in House Building*. Journal of Construction Management and Economic, (23), 57-67.

Shridhar Rao (2014). *Precast: A competitive advantage (Bronchure)*. India: Elematic pvt.

Sutton, A. and Black, D. (2011). *Straw bale: An introduction to low impact building materials. BRE information paper 15/11*. United Kingdom.

Syagga P. M. (1993). *Promoting the Use of Appropriate Building Materials in Shelter Provision in Kenya*. Habitat Intl. 17(3), 125-136.

Thiyagarajan, R., Panneerselvam, V., and Nagamani, K. (2017). *Aluminium formwork system using in high-rise building construction.* International Journal of Advanced Research in Engineering and Technology (IJARET) Volume 8, Issue 6, Nov - Dec 2017, pp. 29–41.

UN-HABITAT (2009). *ISSBs: The eco-friendly building material*. Nairobi, Kenya.

Venkatesh, V., & Bala, H. (2008). *Technology Acceptance Model 3 and a Research Agenda on Interventions*. Decision Sciences, 39(2), 273-315.

Venkatesh, V., & Davis, F. D. (2000). *A theoretical extension of the technology acceptance model: Four longitudinal field studies*. Management Science, 46, 186-204.

Warren C. (2002). Qualitative Interviewing. In Gubrium, J., and Holstein, J., (2002) Handbook of Interview Research: Context and Method. New York: Sage Publications Limited.

Wall Panel Design Manual (2010). *Providing engineered concrete solutions*. EnCon design, LLC.

World Urbanization Prospects (2018). *Population Division-United Nations*. Nairobi, Kenya.

APPENDICES

Appendix A: Questionnaire

INTRODUCTION

Dear respondent,

This questionnaire aims to collect information related to extent of adoption of Alternative Building Materials and Technologies (ABMTs) for walling, the parameters to be considered in acceptance of ABMTs, perception of end users and factors they would consider in acceptance and the strategies that can be put in place to increase uptake of ABMTs in Nairobi County. The information given is for academic purpose only and will be treated with utmost confidentiality. Kindly tick (√) the box that matches your answer to the questions and give the answers in the spaces provided as appropriate.

UNIVERSITY OF NAIROBI
DEPARTMENT OF REAL ESTATE AND CONSTRUCTION MANAGEMENT
P.O. Box 30197, 00100 Nairobi, KENYA, ***Tel: No. +254-020-491 3531***
E-mail: *dept-recm@uonbi.ac.ke*

Ref: B53/7431/2017 **Date:** 18th March, 2019

To Whom it May Concern

Dear Sir/Madam,

RE: EDNA WAYODI ODONGO

This is to confirm that the above named is a second year student in the Department of Real Estate & Construction Management pursuing a course leading to the degree of M.A. Construction Management.

She is carrying out a research entitled "***Constraints to Uptake of Alternative Building Materials and Technologies***" in partial fulfillment of the requirements for the degree programme.

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

CHAIRMAN
DEPARTMENT OF REAL ESTATE
AND CONSTRUCTION MANAGEMENT
UNIVERSITY OF NAIROBI

Isabella N. Wachira -Towey (PhD),
Chair & Senior Lecturer
Department of Real Estate & Construction Management

Section A: Respondent information

1. **Category**

Architect [ ]

Developer [ ]

Manufacturer [ ]

End User [ ]

KEBS [ ]

Department of Housing [ ]

2. **Professional experience (If applicable)**

Below 5years	6-10years	11-15years	16-20 years	Above 20 years
[ ]	[ ]	[ ]	[ ]	[ ]

3. **Company categorization (If applicable)**

In which category does your company fall in?

i. Private company [ ]
ii. Non-governmental [ ]
iii. Government agency [ ]

4. **Number of housing units (If applicable)**

What was the number of housing units put up by your company in the last three years?

i. 1-100 [ ]
ii. 100-500 [ ]
iii. 500-1000 [ ]
iv. More than 1000 [ ]

Section B: Questionnaire to Developers, Architects and Manufacturers

Kindly tick (√) the box that matches your answer

5. **What Alternative Building Materials and Technologies for walling are you using in your projects/ have you specified for use/manufactured?**

ABMTs for walling used/specified/manufactured		Tick appropriately (√)
i.	Interlocking Stabilized Soil Blocks (ISSBs)	
ii.	EPS	
iii.	Interlocking Concrete Blocks	
iv.	Precast concrete panels	
v.	Aluminium formwork technology	
vi.	Others (Please specify) ……………………….	

6. **What is the extent of adoption of the ABMTs of the material you use/specified material or specified by your company/manufactured?**

Using a 5-point Likert scale, where: 1=Very low, 2=Low, 3=Moderate, 4=High, 5=Very high. Tick accordingly.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

7. **What parameters need to be considered in acceptance of Alternative Building Materials and Technologies (ABMTs)?**

From your experience what are the key parameters that need to be considered in acceptance of ABMTs for walling, using a 5-point Likert scale score their importance level, where: 1=Not important, 2=Slightly important, 3=Moderately important, 4=Important, 5=Very important. **Tick accordingly √**

	ECONOMIC ISSUES					
		1	2	3	4	5
	Initial investment/capital cost					
	Savings on construction cost					
	Material cost					
	Maintenance costs					
	Economies of scale					
	Transportation costs					

	SOCIAL ISSUES					
		1	2	3	4	5
	Level of awareness					
	Job creation					
	Owners/users perspective					
	Peoples culture					

	TECHNICAL KNOW-HOW					
		1	2	3	4	5
	Ease of construction/technology transfer/ ease of production					
	Training needs					
	Availability of labour					
	Availability of raw materials					

	ENVIRONMENTAL SUSTAINABILITY					
		1	2	3	4	5
	Use of recycled materials					
	Reduction of depletion of natural resources					
	Reduction of pollution					
	Conservation of water					
	Embodied use of energy					

	QUALITY OF STRUCTURES					
		1	2	3	4	5
	Durability					
	Structural strength					

	GOVERNMENT POLICIES					
		1	2	3	4	5
	Taxation policies					
	Environmental legislations					
	• EMCA					
	• OSHA					
	• Public Health Act					
	Building regulations					

	TIME					
		1	2	3	4	5
	Installation speed					
	Reduction of overall construction time					

	LOGISTICS					
		1	2	3	4	5
	Material handling					
	Transportation mode					
	Hoisting requirements					
	Material storage					

8. How would you rate the performance of the ABMT for walling you use/ has specified/manufacture, using a 5-point Likert scale where: 1-Very poor, 2-Poor, 3-Average, 4-Good, 5-Very good.

	Statement					
		1	2	3	4	5
	Savings on construction time					
	Final quality of output					
	Overall cost reduction					
	Aesthetics					

	Structural capability					
	Availability of the material					
	Ease of construction					
	Reduction of pollution					
	Sustainability					

9. **What strategies can be put in place to increase uptake of ABMTs for walling**?

Which of the following strategies do you think would promote uptake of ABMTs for walling in Kenya using a 5-point Likert scale score their importance level, where: 1=Not at all, 2=Little extent, 3=Moderate extent, 4=Great extent, 5=Very great extent. Tick accordingly (√)

	STRATEGIES	**1**	**2**	**3**	**4**	**5**
1.	Executing government projects using ABMTs to create confidence to the public					
2.	Taxation subsidies on raw materials imported					
3.	Educating clients /end users using case studies as a way of creating awareness and public sensitization					
4.	Financial incentives to small scale entrepreneurs					
5.	Building centres should be established at county government level as a way of dissemination at grass roots level					
6.	Curriculum in learning institutions should include ABMTs					
7.	Educating clients/end users and getting to understand their perception of ABMTs					

OTHERS (SPECIFY)

Section C: Questionnaire to end users

Tick accordingly (√) the box that matches your answer

1. **Are you aware of any Alternative Building Materials and Technologies (ABMTs) for Walling in Kenya?**

   YES ☐ NO ☐

2. **If Yes kindly specify which one.**

ABMTs for walling	Tick appropriately (√)
Interlocking Stabilized Soil Blocks	
EPS	
Precast concrete hollow panels	
Aluminium formwork technology	
Others (Please specify) ………………………………………………..	

3. **Would you consider in constructing a house using ABMTs or purchasing a house constructed using ABMTs?**

YES ☐ NO ☐

4. **If YES what are some of the preferential acceptance criteria you would consider in using ABMTs?** Using a 5-point Likert scale score their level of importance, where: 1=Not at all, 2=Little extent, 3=Moderate extent, 4=Great extent, 5=Very great extent. Tick accordingly (√)

	Reasons	**1**	**2**	**3**	**4**	**5**
1.	Reduction in project duration					
2.	Saving on construction costs					
3.	Aesthetics					
4.	Insulation properties					
5.	Fire resistance properties					
6.	Quality of final product					
7.	Structural capability					

OTHERS (SPECIFY)

5. **If NO what are some of the reasons that would make you not consider using ABMTs?** Using a 5-point Likert scale score their level of importance, where: 1=Not at all, 2=Little extent, 3=Moderate extent, 4=Great extent, 5=Very great extent. Tick accordingly (√)

	Reasons	**1**	**2**	**3**	**4**	**5**
1.	Uncertainty over performance					
2.	Low availability of materials					
3.	Reports on poor prior performance					
4.	High construction cost					
5.	Unfamiliarity with the ABMTs					
6.	Uncertainty over Structural capability					

OTHERS (SPECIFY)

7. **Which ABMT for walling has your house been constructed with. Tick appropriately.**

ABMTs for walling	Tick appropriately (√)
Interlocking Stabilized Soil Blocks	
EPS	
Precast concrete hollow panels	
Aluminium formwork technology	
Others (Please specify) ……………………………………………..	

8. What is your level of satisfaction with the final product? Using a 5-point Likert scale where 1- Very satisfied, 2-Satisfied, 3-Neutral, 4-Dissatisfied, 5-Very dissatisfied

   1 { } 2 { } 3 { } 4 { } 5 { }

9. How would you rate the performance of the ABMT for walling your house has been constructed with, using a 5-point Likert scale where: 1-Very poor, 2-Poor, 3-Average, 4-Good, 5-Very good

	Statement					
		1	2	3	4	5
	Savings on construction time					
	Final quality of output					
	Overall cost reduction					
	Aesthetics properties					
	Structural capability					
	Insulation properties					
	Ease of maintenance					

Section D: Questionnaire to Department of Housing and Urban Development

1. **Were there any challenges faced during roll out of Alternative Building Materials and Technologies (ABMTs) for walling?**

YES ☐ NO ☐

2. **If YES what are some of the challenges you faced during roll out of Alternative Building Materials and Technologies?**

----

3. **Have these challenges been addressed?**

YES ☐ NO ☐

4. **If YES how were these challenges addressed?**

----

5. **What parameters need to be considered in acceptance of Alternative Building Materials and Technologies (ABMTs)?**

From your experience what are the key parameters that need to be considered in acceptance of ABMTs for walling, using a 5-point Likert scale score their importance level, where: 1=Not important, 2=Slightly important, 3=Moderately important, 4=Important, 5=Very important. Tick accordingly.

	ECONOMIC ISSUES					
		1	2	3	4	5
	Initial investment/capital cost					
	Savings on construction cost					
	Material cost					
	Maintenance costs					
	Economies of scale					
	Transportation costs					

	SOCIAL ISSUES					
		1	2	3	4	5
	Level of awareness					
	Job creation					
	Owners/users perspective					
	Peoples culture					

	TECHNICAL KNOW-HOW					
		1	2	3	4	5
	Ease of construction/technology transfer					
	Training needs					
	Availability of labour					
	Availability of raw materials locally					

	ENVIRONMENTAL SUSTAINABILITY					
		1	2	3	4	5
	Use of recycled materials					
	Reduction of depletion of natural resources					
	Reduction of pollution					
	Conservation of water					
	Embodied use of energy					

	QUALITY OF STRUCTURES					
		1	2	3	4	5
	Durability					
	Structural strength					

	GOVERNMENT POLICIES					
		1	2	3	4	5
	Taxation policies					
	Environmental legislations					
	• EMCA					
	• OSHA					
	• Public Health Act					
	Building regulations					

	TIME					
		1	2	3	4	5
	Installation speed					
	Reduction of overall construction time					

	LOGISTICS					
		1	2	3	4	5
	Material handling					
	Transportation mode					
	Hoisting requirements					
	Material storage					

6. **What strategies can be put in place to increase uptake of ABMTs for walling**?

Which of the following strategies do you think would promote uptake of ABMTs for walling in Kenya using a 5-point Likert scale score their importance level, where: 1=Not at all, 2=Little extent, 3=Moderate extent, 4=Great extent, 5=Very great extent. Tick accordingly (√)

	STRATEGIES	**1**	**2**	**3**	**4**	**5**
1.	Executing government projects using ABMTs to create confidence to the public					
2.	Taxation subsidies on raw materials imported					
3.	Educating clients /end users using case studies as a way of creating awareness and public sensitization					
4.	Financial incentives to small scale entrepreneurs					
5.	Building centres should be established at county government level as a way of dissemination at grass roots level					
6.	Curriculum in learning institutions should include ABMTs					
7.	Educating clients/end users and getting to understand their perception of ABMTs					

OTHERS (SPECIFY)

Section E: Questionnaire to KEBS

1. **Which Alternative Building Materials and Technologies (ABMTs) have you tested and certified for usage in Nairobi county?**

ABMTs for walling Tested & certified	Tick appropriately (√)
ISSBs	
EPS	
Precast concrete hollow panels	
Aluminium formwork technology	
Others (Please specify) --- --- --- ---	

2. **Is there any ABMT for walling which has been declined approval by KEBS?**

   YES ☐ NO ☐

3. **If Yes which one and what were the reasons?**

   ----

4. **What strategies can be put in place to increase uptake of ABMTs?**

Which of the following strategies do you think would promote uptake of ABMTs for walling in Kenya using a five-point Likert scale score their importance level, where: 1=Not at all, 2=Little extent, 3=Moderate extent, 4=Great extent, 5=Very great extent. Tick accordingly (√)

	STRATEGIES	**1**	**2**	**3**	**4**	**5**
1.	Executing government projects using ABMTs to create confidence to the public					
2.	Taxation subsidies on raw materials imported					
3.	Educating clients /end users using case studies as a way of creating awareness and public sensitization					
4.	Financial incentives to small scale entrepreneurs					
5.	Building centres should be established at county government level as a way of dissemination at grass roots level					
6.	Curriculum in learning institutions should include ABMTs					
7.	Educating clients/end users and getting to understand their perception of ABMTs					

THANK YOU

Appendix B: Interview schedule and guide questions

Item	Designation of interviewee	Interview focus	Date	Duration
1.	Architects	Parameters for acceptance of ABMTs Strategies to adopt to increase uptake of ABMTs	March 2019	40minutes
2.	Developers	Parameters for acceptance of ABMTs Strategies to adopt to increase uptake of ABMTs	March 2019	40 minutes
3.	Department of Housing	Parameters for acceptance of ABMTs Strategies to adopt to increase uptake of ABMTs	March 2019	40 minutes
4.	End user	Factors they would consider in selecting to use or not use ABMTs	March 2019	40 minutes

1. What are the parameters that need to be considered in acceptance of ABMTs?
2. What are the challenges encountered during roll out?
3. What strategies can be put in place to increase uptake of ABMTs?

4. What are some of the factors you would consider in accepting to use or not use ABMTs?

Appendix C: Observation checklist

Description	Remarks
1. External appearance	
2. Pollution of the environment	
3. Ease of construction with the technology	
4. Quality of workmanship	
5. Use of locally available materials	
6. Use of locally available labour	