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PUBLIC PERCEPTION AND TECHNICAL KNOWHOW AS DETERMINANTS OF THE ADOPTION OF PREFABRICATED BUILDING TECHNOLOGY: A CASE OF NATIONAL HOUSING CORPORATION, NAIROBI COUNTY

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ABSTRACT
The current practice of adopting prefabrication methods improves building durability while reducing costs, which defeats the concept of on-site construction, due to heightened understanding and perception of the various cost constraints in the innovative approach in the prefab-construction model. A rise in the prefab-technology adoption benefits the construction industry, hence the need to gauge the determinants of the level of adoption of this innovative construction technology in the housing sector is needed. This survey sought to find out how public perception and technical know-how affects the adoption of prefabricated building technology in the case of the National Housing Corporation in Kenya. The study adopted a descriptive research design on a sample of 71 users of prefabricated construction technology and 12 prefab experts registered at the NHC. Structured questionnaires were used for data collection and the qualitative and quantitative data was analyzed through SPSS, while OLS regression was done to ascertain the relationships among the variables under study. The study found that technical know-how and public perception showed a positive statistically significant relationship with the level of adoption of prefabricated building technology. The study therefore confirmed that improvement in technical know-how and public perception would result in an improvement in the level of adoption to prefabricated building technology. The study suggests that this topic should be further researched in a bid to widen its generalizability and allow further research on the topic to unearth even more determinant factors, hence this study suggests further study of this topic in different and wider geographical zones.

Keywords: *Innovative Construction Technology; Prefabricated Building Technology; Public Perception; Technical Knowhow*

INTRODUCTION
The past few decades have seen the construction sector experience high levels of technological proliferation with organizations chasing performance improvement and growth in an environment of intensive competition due to globalization. Technological proliferation, industry labor-intensive nature, dwindling skill levels, and poor craftsmanship are some of the highlighted hindrances (Sharifah, et al., 2018). Solutions to these constraints caused departure from on-site construction methods leading to the invention of various off-site construction methods like prefabrication and modularisation to increase efficiency and quality, (Barnes, 2020). Contemporary construction challenges, such as scarcity in housing project funding, increasingly complex planning, stringent

environmental requirements, manual laborers' shortage, future increases in building materials cost, and an ever-widening gap between supply and demand for housing; are some of the key reasons behind the broad endorsement of off-site construction methods due to the perception among stakeholders that it tends improving productivity (Jiang et al., 2020). Indeed, Li, Shen & Xue (2014), show off-site production involving fabrication of the sub-element components results in more than 40% per employee efficiency gains.

The prefabrication technology is not a fully new concept in the building industry as it has been extensively and widely used at a global scale for many years. Terms frequently used to describe the manufacture of building components, either constructed on or off-site, includes prefabrication, pre-assembly, system building, modularisation, and industrialized buildings, and cover the manufactured, modular, pre-cut, and pre-engineered construction systems (Barnes, 2020). Despite these terms being used interchangeably, their accurate descriptions heavily rely on the experience and understanding of users that vary in different countries. This study prefers the term 'prefabrication' due to its special emphasis on building of components off-site in a factory and its wide usage within the Kenyan construction industry. Prefabrication is an interesting topic internationally providing an effective construction technique in quality, cost, function, time, safety, and productivity management.

The pursuit to highlight all the benefits of alternative building technologies may boost the performance of numerous and diverse building systems. Through use of a prioritization scheme, a person can initiate this sizeable effort by focusing on building components with the optimal impact on cost and time consumed. According to Nahmens & Reichel (2013), such an approach entails concentration on the large elements of construction that a building is constituted of, for example the walling system. Additionally, the risks posed by use of innovative technologies are greater and potentially harbour negative impacts to the contractors due to construction costs overruns, technological uncertainties, and delays in the construction schedule. Consequently, a significant need to nurture "early adopter" and "innovator" homebuilders emerges to kick-start the development of the learning curves and guide the future adopters in the construction decision-making process within the adoption process' trial stages. This process leads to the improvement, stimulation, and shortening of the adoption curve in the future by contractors and building owners.

Many prefabrication technologies can deliver a better product since the construction process is undertaken within a quality-controlled and sheltered environment. Studies have shown that it can be considered as a key tenet in refining 21st-century construction (Li, et al., 2018; Shri and Shri, 2013). This was echoed by Sepasgozar & Bernold when they observed that the emphasis of off-site assembly lies on key market need of changing construction culture towards talent recruitment and retention, and simultaneously offer improved performance desired by clients. Whether the systems are based on concrete, steel, or timber materials, they have shown clear advantages of prefabricated building systems.

According to Bernstein, et al., (2017), the inherent advantages of prefabrication as an industrialized way of construction include high capacity permitting achievement of construction project objectives; factory made products that hasten the construction process; shorter construction time estimated as less than half the conventional cast in-situ construction; freedom from effects of adverse weather conditions during construction; and easy to implement quality surveillance

system. They observed that prefabrication offers clients better performance to realize all requirements, such as good architecture; fire resistant materials; healthy buildings; lower energy consumption attained from the concrete mass ability to store heat; environment-friendly constructions with optimal materials use, waste products recycling, reduced noise and dust level, and, cost-effective construction solutions.

The use of prefabricated and pre-cast structural elements have been commonly used in developed countries but has had a slow uptake in developing countries, with the first African country, South Africa, being in global position 36 in prefabrication trade value, while Kenya holds the second position in Africa at global position 53 (World Bank, 2018). The term prefabricated is mainly applied in instances where the main material used is steel, wood, glass, or high-grade plastics, while pre-cast mainly applies to the use of concrete as the main material. Both terms can be used in relation to construction systems where the elements are prepared within a factory setting and is later transported to the construction site for installation in the final assembly (Li, et al., 2014). The processed construction materials include the pre-cut structural and cladding materials that are custom fabricated. The components of prefabricated construction includes simple building blocks, usually involving a single building trade, with vast majority of modern buildings using some form of prefabrication, including precast panels, steel frame panels, building envelope/façade systems, structurally insulated panels (SIP's), precast cladding, timber frame panels, insulating concrete formwork (ICF), composite panels, Light Steel Frame (LSF), pre-cast structural elements, and tunnel form construction (Khudzari, et al., 2021).

Due to the growing concerns of environmental impact of construction, there is rising need for alternative housing forms to be less energy and resource-intensive than what is being currently offered, (Kaicheng, et al., 2019). Prefabrication is widely considered a key strategy in the promotion of construction waste minimization, being shown to effectively reduce waste and is therefore considered able to help achieve sustainable development and conserve landfill capacity (Zhang et al., 2011; Aye et al., 2012; Lu and Yuan, 2013). This contemplation is largely hinged on the minimal dependence on conventional construction technologies for prefabrication technologies such as bamboo scaffolding, cast-in-place concrete, and timber formwork in the reinforcement, tiling, and plastering works (Otieno, 2020). Prefabrication is known to diminish the complexity of wet-trade work, and thereby contributes to waste minimization in constructions (Li et al., 2014). However, Li et al., (2014) observed that the practical experience in the construction industry indicates that tools for effective forecast of the possible impact of prefabrication in waste generation and subsequent waste disposal activities are lacking.

Adoption of Prefabricated Building Technology

The technology deployment decision is a function of a variety of causes, though little is known of the process contractors apply in making the adopt decision and the factors influencing this decision. Developing a clear benefit is a critical objective within construction projects; but cost is every so often not among the key factors influencing the decision to uptake construction technology. A survey by TriComB2B (2011) discovered that the total ownership cost is only deliberated 56% of the time the purchasing decision in the construction industry are made, while it is considered 71% of the time in the purchasing decisions for the energy related industries. Exhibitors of technology products divulged that in trade shows, item prices are enquired far later in the purchase process as cost isn't the main question asked by exhibition visitors. Conversely,

car exhibitors indicated that price is one of the first information pieces sought by buyers.

Thus, there are other factors critical to the adoption decision making in the construction industries besides cost which ought to be explored. Sepasgozar and Bernold (2011) endorse future research focusing on factors affecting decision making at the pre-adoption stages, rather than studying the adoption decision itself. They propose studying the elements behind innovations adoption prior to the development of the technology. O'Brien (2017) established a need for theory building on the implementation decisions, especially on technology purchase decisions. Moreover, the process of technology adoption in the construction industry and the factors influencing adoption are poorly understood and studies on this area are very few. The role of a client in innovation adoption was studied by Baldwin et al., (2012) where he proved that existence of a strong client focus is detrimental to innovating companies as client demands limit their innovative edge. This study concentrated on alternative technology and not specifically the prefabricated technology. This study identified the factors that attract potential adopters of prefabricated building technology, to illuminate the technology adoption process in the construction sector and address the prefabrication technology vendor business behaviour and the customers' needs.

Public Perception and the Adoption of Prefabricated Building Technology

Public perception is a concept sitting somewhere between the truth and opinion, given that a person's reality is shaped by facts they know that are blended with popular opinion, media coverage, and reputation. It is not based on something other than facts and can at times be inaccurate, as people do have access to a wide range of information on a host of subjects and at times tend to rely upon hearsay, rumours, or other opinions (Easen, 2018). However, at times cultural biases, upbringing, or prejudice creeps in and introduce a bearing to that opinion.

Few studies assessed the public perception of prefabricated housing, with many people failing to recognize the value of many modern construction methods. According to MacFarlane, (2018), nearly half the people surveyed believed that modular homes have less durability as compared to those using traditional construction methods. However, Booth (2017) differed with the argument that "when people question the quality of a prefabricated house, an argument can be raised that those 100 workers on an indoor production line will bring more quality than the same amount on a muddy building site out in the elements". Past researcher such as Nanyam et al (2017), Steinhardt and Manley (2016), Švajlenka and Kozlovská (2018), backs up above statement.

Technical knowhow and the Adoption of Prefabricated Building Technology

Among factors affecting the adoption of modular construction, 'people' is the core component of construction quality assurance. The technical level of construction workers is directly reflected in the quality level of prefabricated buildings, and the uncontrollable risk of 'people' is the biggest factors affecting prefabricated buildings (Hong *et al*., 2017). Therefore, construction companies must strengthen the management of technical personnel, strengthen the ideological and moral education of relevant technical personnel through various activities such as safety education at all levels, improve the personnel's sense of responsibility, attach importance to quality, attach importance to safety, and increase technology (Ayalp & Ay, 2019).

In a highly competitive market, experienced suppliers provide high-quality components at reasonable prices, designers deliver diverse designs, and contractors are more familiar with prefab construction methods. According to Lei et al., (2018), there is a lack of experienced contractors, suppliers, and designers in the market specializing in prefabricated construction. This lack of technical personnel leads to a series of problems such as poor structural performance and inferior site management due to a lack of global uniform standards, leading to the inefficient production of prefabricated components. Additionally, prefabricated construction lacks the production specifications and quality testing standards, thus serving inability to guarantee mechanical properties such as strength and stability of components.

Prefabrication in the Kenyan Real Estate Sector

The Kenyan development agenda relies a lot on the construction industry as envisaged in the country's vision 2030 development plan. The industry is very vital for national development efforts and is central to the realization of economic growth. Macharia (2015) posited that the construction industry grew by 13.1 % in 2014 mainly due to a steady expansion in real estate sector and the commissioning of massive infrastructural projects. The contribution of the construction industry to the Kenyan GDP in 2014 was 4.8%, which when translated to monetary value is Kshs. 5.36 trillion. This growth was reflected in cement consumption trends which increased to 5,197 thousand tonnes in 2014 from 1,726 thousand tonnes in 2006 (Kenya National Bureau of Statistics, 2015). Credit advances by commercial banks to this sector was observed to increase in 2013 to 2014 from Kshs. 70.8 billion to Kshs. 80.4 billion. The report indicated that the value of private building plans in Nairobi alone was estimated to be Kshs. 205.4 billion whereas completed buildings' value was estimated as Kshs. 59.1 billion. The Kenya Economic Report (2017) indicated that the construction industry grew by 9.2% with a real estate sector growth of 8.8% between 2015 and 2016 financial years, also driven mainly by increased private sector credit and loans. The sector has been in a very great growth trajectory with greater future improvement.

Builders in Kenya are betting big on prefabricated technology as their innovative way of addressing the acute housing shortage in the country in a cost-effective way (Otuki, 2013). Prefabricated technology involves manufacturing modular houses (prefabs) within a factory, mostly in small standard sections for easier transportation, which are then assembled on-site. The overall construction cost decreases by at least 30% through prefab technology usage combined with reduced construction timelines, thus allowing supply of more affordable homes (Otieno 2020). Property analysts argue that the counties could potentially adopt prefabricated homes on a large scale, particularly when homeowners are persuaded that prefabricated buildings are more secure and affordable alternatives to conventional housing, (Makena, 2014).

Several companies have shown interest in prefabrication construction technology by engaging in the supply of prefab houses to the low and middle income segments. One such company, ardent to revolutionize the housing market in Kenya, is Elsek Construction. The Elsek & Elsek (K) LTD., the local subsidiary for Elsek Construction – Turkey; has introduced fiber cement and galvanized steel for construction in the Kenyan construction market. The technology which applies fiber cement boards in walling ensure the walls are bullet proof up to 9 mm bullets and fire proof for up to 800° Celsius. The walling process use cement, stone and a glue chemical that offer extra strength to the walls while windows are constructed with double glass or glazing for high insulation. The latest entrant in the local housing sector, Koto Housing Ltd, recently announced its ability to build

a three-bedroom house in a span of 14 days at a reduced cost of Kshs. 1.8 million, nearly half the usual cost, using 'Koto Building System' (Makena, 2014).

Some of the prefabricated building systems use modified pre-cast sandwich concrete panels along with steel fibre reinforcement. This method has resulted in a greater ease in construction and reduced costs in rural areas where it has been adopted. Additionally, Styrofoam or inexpensive, locally available, and environmentally friendly sugar factory wastes are being incorporated with cement construction to drive costs down even further, and to make the concrete panels lighter and easier to move without using costly additional labour or cranes, which aren't available in rural areas (Kagai, 2014). The prefabricated construction industry has received wider financing interests in Kenya. One example is that of Equity Bank, who in 2012 ventured into prefabricated technology financing by launching micro mortgage products in partnership with Mabati Rolling Mills (MRM).

The cost of purchase of these pre-fabricated structures from MRM is financed by the bank (Mariera, 2016). Also keen on tapping the benefits accrued from the new building technology is the Kenya Commercial Bank (KCB) which has entered a partnership with a construction consortium - Zen House - to fund their provision of prefab houses to Kenyans (Sagini, et al., 2016). The embrace of new building technology observed among financial institutions such as banks and mortgage providers clearly indicates that prefab technology is set that revolutionizes the housing market in Kenya. These are positive news to the country, though the adoption levels among Kenyans is still at low levels.

LITERATURE REVIEW

Theoretical Literature Review

There is an extensive range of literature reflecting a strong diversity of theoretical views. These theories endeavour to expound on the interactions between the concepts of technology adoption. There are several theories which sought to explain the behavioural underpinnings of adoption decisions that the study was hinged upon, which include: theory of reasoned action; systems dynamics theory, and triple constraints theory. This study was anchored upon the theory of reasoned action to highlight the aspects behind prefab adoption.

Reasoned Action Theory

The reasoned action theory was postulated by Ajzen and Fishbein (1975) highlighting the linkages of the elements of conscious intentions and attitudes leading to a certain behaviour. It was hailed as 'prominent beliefs of the consequences of performing a certain behaviour multiplied through evaluation of those consequences,' (Li et al., 2014). Barnes (2020) observed that the path to a purchase decision involves a series of mental or behavioural steps made by prospective adopters. The description of this adoption exposes the crucial steps to present a product in the organization's daily operations (Damanpour & Schneider, 2016). Like any other decision-making process, information collection and processing are a vital stage in the technology adoption process as envisioned in the theory of reasoned action. Practically, there seems not to exist an applicable uniform adoption process for different domains, particularly within the construction industry. This study proposed a technology adoption model for construction sector validated by collected data.

Systems Dynamics Theory

Systems dynamics theory is one of the most complex theories conceptualized over time since its development in 1975 as a mathematical modelling system for framing, understanding, and discussing complex issues and problems by Prof. Jay Forrester. The theory's contemporary design directly arises from the developments in appreciating complex and non-linear systems in mathematics and physics, while following a lengthy and deep confidence in systems thinking within biology and psychology (Thelen & Smith, 2005). System dynamics can match the key characteristics in the flow of materials and may help seal the knowledge gap within the existing research. Therefore, this approach is applied in this paper to guide the identification of the determinants of prefabrication technology adoption in the construction sector.

Triple Constraint - (The Iron Triangle) Theory

The triple constraints theory proposed by Burke (1974) highlights the core factors for project success. A project's success is measured by various parameters as highlighted in Figure 2.1. Project success is dominated by the conservative methods of time, cost and quality (Toor & Ogunlana, 2010). In project management, time, cost and quality are the predominant parameters in assessing project realisation. Participants in the construction industry (clients, contractors, consultants and project managers) accept the convention that there are many additional parameters as stated in the new iron triangle such as; scope, risk, resources, and customer satisfaction. All these measure project success and remain the basic parameters of project success (Lombard, 2011). Ebbesen & Hope (2013) demonstrated the dependency between the iron triangle parameters. They considered the parameters in relation to each other, and how they indirectly impact one another, coming up with a diagrammatic representation of this relationship. But with regards to their studies, only cost, time and quality would be considered since it became a more common method for measuring project success. Therefore, stakeholders should endeavour to deliver the 'ideal project', not compromising on high-quality project to be delivered on time, quality and within budget.

Empirical Literature Review

Public Perception and the Adoption of Prefabricated Technology

Many studies dwell upon the technological benefits of a building system, as well as its sustainability and lifespan aspects, hence dwell more on the beneficial traits of the industry. McGrath and Horton (2011) observed that users' biggest worries lay in the noise levels, though only fifteen percent of those who commented linked this view to the building itself. However, the outcomes cannot be considered to embody other prefabricated buildings with minimal worries on noise as the target group was relatively small and many participants exuded limited knowledge of building typologies and required some explaining to grasp most of the concepts, added to the view that most complaints from student halls are linked to noise, making it hard to fully contextualize.

A survey commissioned by the HOME group through YouGov to explore the public perception of modular homes succeeded to collect the opinions of more than 2000 people within the UK. The main observation made about modular homes was the lack of recognition of many modern types by a majority of the studied public, with nearly half of the surveyed people believing that modular homes are less durable than the traditional construction systems (HOME group, 2018). However, Booth (2017) refuted this perception when he found that when individuals question the quality of a prefabricated house, an argument is advanced that a hundred workers in an indoor production line offers higher quality than the same quantity of workers in a muddy building site out in the

elements; an explanation that is self-defeatist since perception is from users' point of view, rather than at the production line of view. Past researchers, such as Steinhardt and Manley (2016), Nanyam et al., (2017), and, Švajlenka and Kozlovská (2018), confirm Booth's viewpoint into modular building systems.

According to Hartley and Blagden (2017), stakeholders favour off-site construction due to its inherent characteristic of solving skills shortages in the construction industry. This form of off-site construction permits 'outsourcing' of the construction process to other contractors, leading to less labour investment in traditional on-site processes, and addressing the labour deficiency. Indeed, Li et al., (2014) highlighted labour deficiency as the most important motivation for the adoption of off-site construction among British construction companies. They indicated that 61% of the construction industries cited skills deficiency as the driving force in this respect. Though this is trivial for the case of building companies, skill shortage compensation for craft workers remains among the top six motives behind general contractors applying off-site construction methods.

A study conducted by Mustafa & Ghazali (2018) developed a conceptual framework for the house buyers' satisfaction with housing projects. Within their study, the authors indicated that the house buyers' satisfaction in construction projects arises from the consideration of the price, delivery system, project location, service quality, product quality, and house buyers' characteristics. They found that the most important customer demands concerning the design of multi-storey timber frame houses are: good economy (investment, operation and maintenance), attractive layout of flats (inner and exterior design), low environmental impact (indoor environment and resources), high quality (product quality), and flexible design (movable and variable).

A study by Shah et al., (2020) looked at the public perception regarding prefabricated construction in the UK using mixed methods research, where it was found that the UK public are struggling to accept prefabricated houses due to a lack of information regarding prefabricated housing. They highlighted a common belief that the UK government ought to back this innovative housing design through financing packages to encourage the purchase of prefabricated houses and inspire builders to inject more prefabricated buildings into the market.

Technical Know-how and the Adoption of Prefabricated Technology

In a conference paper on construction innovation that dwelt on key factors driving and hindering innovation in the construction industry, Park, et al., (2012), recognized the key role played by the clients in promoting innovation as the most prominent theme in innovation within the construction industry. Incompetence in innovation among clients, especially those clients who are risk averse, is a key constraint in innovation activity. They further argued that the clients' innovation competence is a major element of supplier-led innovation, such as the prefabrication process innovation that was demonstrated by Lombard (2011). This therefore recognizes the challenges created by clients' beliefs, precognition, and prevailing cognitive rule-of-thumb, thus, providing opportunities to identify barriers to overcoming inertia in decision making among the construction industry clientele.

A further look at the adoption of prefabricated construction from a developed European standpoint was undertaken by Barnes (2020) who found that skills accessibility is a minor reason among

construction customers: with very few people (6%) mentioning 'people' allied reasons, including lack of skilled workforce and given that off-site construction is intended to have fewer people working on the site. He explained this discrepancy with the observation that clients have lower levels of awareness of the dynamics of the construction industry and they aren't able to understand the skills shortage problems within it as compared to building companies and contractors. Indeed, he observed that construction clients are unlikely to appreciate the benefits and shortcomings of off-site construction methods compared to other stakeholders. As such, Khudzari et al., (2021) observed that the construction industry customers are likelier to support off-site construction systems from 'visible' motives such as higher quality and shorter construction time frames than any other reason obscured from them such as skills availability.

A study done by Ngigi (2016) looked at the rate of adoption and public knowledge of alternative building technology used in the construction projects, where he observed that 85.7% of the public has very little knowledge of the technology used in construction projects. This implies that a huge portion of the Kenyan public lacks sufficient knowledge on the use and access information about alternative building technologies, an outcome which explicates the low rate of adoption of alternative building technologies in Kenya.

CONCEPTUAL FRAMEWORK

The conceptual framework provides a look at various factors affecting the adoption of prefabricated building technology which includes public perception and technical knowhow. The diagram hypothesizes the presence of a direct relationship between the level of adoption of prefabricated building technology, the public perception, and technical knowhow.

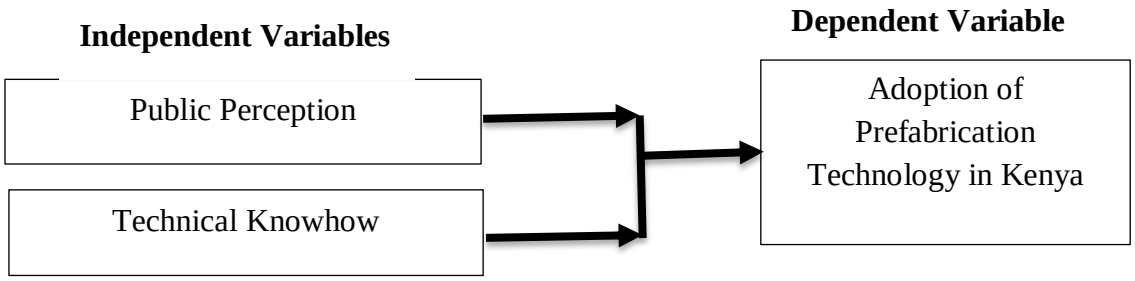

Figure 1: Conceptual Framework

HYPOTHESIS TESTING

In view of these considerations, the study proposes that the level of public perception, and technical knowhow affects the level of adoption of prefabrication technology in Kenya, which was tested by empirical analysis of specific aspects of that general relationship. This discourse leads to the statement of the study hypotheses:

H_{o1}: Public perception affects the adoption of prefabricated building technology in the Nairobi Real Estate Sector.

H_{o2}: Technical knowhow affects the adoption of prefabricated building technology in the Nairobi Real Estate Sector.

RESEARCH METHODOLOGY

This study adopted an exploratory research design. This design allowed the study to describe the existing conditions and attitudes toward the adoption of prefabrication technology through observation and interpretation practices. It allowed for access to comprehensive information that was vital in enabling the establishment of the factors affecting the adoption of prefabricated construction technology in the Kenyan construction industry, and specifically through the National Housing Corporation. The study target population comprised of the customers and employees of National Housing Corporation within Nairobi County. Going by the records sought from NHC, there are 38 prefabrication technical experts of NHC, comprising managers, engineers, builders, and contractors of the prefabrication section involved in development, manufacture, and installation of prefabricated building technology within Nairobi County. These were targeted to inform the study, together with select customers who the institution estimated as 3,258 annually (2014 - 2020 average number of customers of prefabrication materials), (NHC).

From this population, the study realized a sample of 71 prefabrication technology customers of NHC within Nairobi County. Additionally, out of the 38 prefabrication technology experts at NHC, the study sampled 12 experts to inform the study from the expert's point of view. The study applied a stratified random sampling technique in the selection of sample elements from the population. The sample was stratified along the NHC categorization of their customers as 18 large contractors, 22 small contractors, and 31 individual contractors who were NHC customers of prefabricated building technology and 12 NHC technical experts involved in prefabrication technology, making up a total of 83 respondents.

The study relied on both primary and secondary data which was in qualitative and quantitative format. Primary data was collected using a semi-structured questionnaire which was then supplemented by the usage of secondary data. The questionnaires were administered by the researcher assisted by a research assistant to the select study respondents to determine the factors influencing prefabricated construction technology adoption from customers and experts, and a few interviews aimed at enhancing the data collected from the firms. Upon collection of data, it was coded and entered into the statistical packages for social sciences (SPSS version 22) computer package for analysis. The quantitative data was analysed using descriptive statistics such as frequencies, mean, and standard deviation, and inferential statistics such as ANOVA and regression model which allowed assessment of the relationships. Inferential statistics were utilized to test the formulated hypotheses and to assess the relationship among the study variables which mainly involved the use of Pearson correlation and regression analysis, and goodness of fit tests.

RESEARCH FINDINGS

Demographic Characteristics of Respondents

The study demographics highlighted the respondents' gender, position held in the organization, education, and experience level. The study confirmed from the demographics that the respondents fit the needs of the study sample, with all the demographic characteristics indicating that the respondents had the ability to meet the study needs. The study found that the majority of the respondents rated highly the level of adoption of building technology in Kenya where the average rating (out of a 5-point Likert scale) was 4.069, indicating that the respondents perceive prefabricated building technology as well adopted in the Kenyan housing sector. This high

adoption level was linked to the high rating realized for the technology adoption constructs which were measured informing the variable. The respondents highlighted twenty (20) prefabricated technologies that are widely used in the housing sector in Kenya.

A look at the regional spread of the construction projects in Kenya that the experts have undertaken using prefab building technology as presented in Table 4. The study found that most of the prefab construction projects have been done in Nairobi (36.6%); with Central (12.0%), Coast (25.1%), and Nyanza (11.4%) being regions the respondents have implemented construction projects using prefab technology. Only a small proportion of the respondents have implemented projects using prefabricated building technology in Rift Valley (7.6%), Eastern (7.9%), Western (6.9%), and North-Eastern (2.5%) regions. This shows that the regional spread of prefabricated building technology is nationwide in Kenya.

Table 1: Notable prefab building technology used by respondents

Prefab technologies used among respondents	**Frequency**	**Proportion**
Precast panels	19	25.7%
Timber frame panels	8	10.8%
Steel frame panels	3	4.1%
Building envelope/façade systems	36	48.6%
Insulating Concrete Formwork (ICF)	3	4.1%
Composite panels	5	6.8%
Walling and roofing materials	4	5.4%
Precast concrete wall panels	7	9.5%
Concrete roofing tiles	3	4.1%
Precast cladding	11	14.9%
Light Steel Frame Building Systems (LSF)	5	6.8%
Pumping Ready Mix Concrete (PRMC)	8	10.8%
Pre-cast structural elements	2	2.7%
Tunnel form construction	13	17.6%
Steel prefabricated in flooring	7	9.5%
Structurally Insulated Panels (SIP's)	3	4.1%
Waffle slabs	6	8.1%
Expanded Polystyrene panels (EPS)	18	24.3%
Pre-stressed floor slabs	3	4.1%
n	**74**	**100%**
Others: Interlocking blocks; Polystyrene materials; Pre-cast plastic for plumbing		

Descriptive Statistics

The study collected data that would inform the study on the state of adoption of prefabricated building technology and the factors affecting this adoption in Kenya, while highlighting the state of technical knowhow and public perception. The factors were measured using a five point Likert scale (1 the lowest score and 5 the highest score) and analyzed descriptively using percentages and mean as presented in tables within this section. The adoption of prefabricated building technology was rated highly with each of the indicators revealing high ratings for the various benefits of using prefab technology (mean 4.270), followed by prefab technology performance (mean 4.242), demand drivers for prefab technology (mean 4.106), and the least rated was access to prefab

technology (mean 3.659). The overall adoption level of prefabricated building technology is rated at a mean of 4.069 in a 5-point Likert scale rating which shows that adoption of prefabricated building technology has been able to gain momentum in the Kenyan construction sector and is highly rated by respondents who are users and experts of this construction technology.

Table 2: Adoption level of prefabrication building technology.

Adoption level of prefabricated technology	N	1	2	3	4	5	Mean	S.D
Access to Prefab Technology	74	3.4%	8.1%	24.3%	51.0%	13.9%	**3.659**	**1.056**
Prefab Technology Performance	74	.5%	4.4%	14.2%	44.7%	36.0%	**4.106**	**1.199**
Benefits of using prefab technology	74	.0%	3.4%	12.2%	38.5%	45.9%	**4.270**	**1.217**
Demand drivers for prefab technology	74	0.8%	4.3%	12.5%	35.0%	47.4%	**4.242**	**1.201**
Overall Average	**74**	**1.2%**	**5.1%**	**15.8%**	**42.3%**	**35.8%**	**4.069**	**1.210**

The study sought to understand technical knowhow in the adoption of prefabrication building technology in Kenya. It was found that technical knowhow in prefabricated construction among the study respondents was rated relatively moderate with an average rating of 3.676. This reveals that users and experts of prefabricated technology have average level of technical knowhow in prefabricated technology. The study looked at public perception regarding prefabricated building technology in Kenya, where an overall rating of 3.682 from a 5-point Likert scale was realized as the rating for public perception on prefabricated building technology.

Table 3: Indicators of the adoption of prefabricated building technology

Indicators of prefabrication building technology	N	1	2	3	4	5	Avg.	S.D
Adoption level	74	1.2%	5.1%	15.8%	42.3%	35.8%	4.069	1.210
Public perception	74	3.2%	10.5%	24.3%	39.1%	23.0%	3.682	1.047
Technical knowhow	74	2.1%	9.3%	27.8%	40.5%	20.3%	3.676	1.035

Inferential Statistics

The main objective in the study was to assess the factors affecting the adoption of prefabricated building technology in Kenya. To realize this objective, the study undertook a quantitative analysis that involved a correlation and a regression analysis that provided a view of the relationship between the study variables. The inferential analysis was undertaken through computations of correlation and regression analysis using the SPSS tool. The Pearson correlation in Table 4 revealed the link between the study variables showing how the factors relate to each other. The study found that adoption of prefabricated building technology has a statistically significant positive correlation with the technical knowhow ($r=0.559$; $p<0.05$). This implies that technical knowhow and the adoption of prefabricated building technology in Kenya are correlated 55.9% of the time when other factors are held constant. Similarly, the other factor of public perception ($r=0.477$; $p<0.01$) was found to have statistically significant positive correlation coefficients. The significant positive correlations have the implication that the higher the level of technical

knowhow and public perception, the higher the level of adoption of prefabricated building technology in Kenya.

Table 4: Correlation between study variables

		Adoption of Prefab Technology	Technical Knowhow	Public Perception
Adoption of Prefab Building Technology	Pearson Corr.	1		
	Sig. (2-tailed)			
	N	74		
Technical Knowhow	Pearson Corr.	.559**	1	
	Sig. (2-tailed)	.001		
	N	74	74	
Public Perception	Pearson Corr.	.477**	.386**	1
	Sig. (2-tailed)	.000	.001	
	N	74	74	74

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

To highlight the factors affecting adoption of prefabricated building technology, the study undertook a regression analysis assessing the relationship between adoption of prefabricated building technology against factors such as technical knowhow and public perception. Table 5 gives a regression analysis summary which consisted of the regression model's coefficient (R), the coefficient of determination (R^2), and the model error estimates.

Table 5: Regression Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Est.
1	.698[a]	.487	.425	.1884

a. Predictors: (Constant), Technical Knowhow, Public Perception

It was observed that the study model showed a high correlation coefficient of 0.723, an indication that there is a much-defined relationship between the adoption of prefabricated building technology and various factors suspected to affect this adoption such as technical knowhow and public perception. This view was further enhanced when a high coefficient of determination (R^2) of 0.487 was realized which indicates that the study independent variables (technical knowhow and public perception) can be able to explain 48.7% of the variability in the dependent variable (adoption of prefabricated building technology), which indicates that there exists a relationship between adoption of prefabricated building technology and technical knowhow and public perception.

Table 6: Regression ANOVA

Model[a]		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	14.388	4	3.597	15.846	.000[b]
	Residual	21.381	82	.261		
	Total	35.769	86			

a. Dependent Variable: Level of adoption of prefabricated building technology

b. Predictors: (Constant), Technical Knowhow, Public Perception

According to the ANOVA outcomes in Table 6, the p-value (sig.) was 0.000 (P<0.05) indicating that technical knowhow and public perception, have statistically significant influence on level of adoption of prefabricated building technology in Kenya. This confirms that the ability of technical knowhow and public perception to influence the adoption of prefabricated building technology is statistically significant as earlier observed in the goodness of fit model (model summary).

Table 7: Regression Coefficients

Model[a]		**Unstandardized Coefficients**		**Standardized Coefficients**	**t.**	**Sig.**
		B	**Std. Error**	**Beta**		
1	(Constant)	.102	.638		3.227	.000
	Technical Knowhow	.216	.155	.148	2.990	.011
	Public Perception	.444	.223	.311	4.838	.000

a. Dependent Variable: Level of adoption of prefabricated building technology

According to the findings of the regression model coefficients presented in Table 7, technical knowhow (0.216, p=0.011) and public perception (0.444, p=0.000) influence the adoption of prefabricated technology in Kenya since this relationship was observed to be positive and statistically significant. The regression model indicates that the relationship between the prefabricated technology independent variables (technical knowhow and public perception) and dependent variable (Level of adoption of prefabricated building technology) have positive regression coefficients and a statistically significant (p<0.05) constant of 0.102 (p=0.000).

The regression model of this relationship is presented as:

$$Y = 0.102 + 0.216\,X_1 + 0.444\,X_2 + \varepsilon$$

Where:

β_0 = constant coefficient of intercept;
Y = Level of adoption of prefabricated building technology;
X_1 = Public Perception (independent variable);
X_2 = Technical knowhow (independent variable);
ε = Error term.

Therefore, we can confirm that technical knowhow and public perception are the two factors that were confirmed to affect the level of adoption of prefabricated building technology in Kenya. The study observed that positive changes in technical knowhow and public perception would cause a subsequent change in the level of adoption of prefabricated building technology in Kenya. Therefore, these factors, technical knowhow and public perception, ought to be integrated into prefabricated building technology adoption programs in Kenya to ensure enhancement in the level of adoption for this technology in the Kenyan market.

CONCLUSION

The study set out to identify the factors affecting adoption of prefabricated building technology among experts and customers using this technology in Kenya. The study identified four key factors that stood out in literature including technical knowhow and public perception and set out to determine the effect these factors have on the level of adoption of prefabricated construction

technology. The study found that experts and customers of prefab technology exhibited high rating of adoption of prefab technology, which means adoption of prefabricated building technology in Kenya is improving.

Technical Know-how and the Adoption of Prefabricated Building Technology

Technical know-how refers to the ability to innovate prefabricated building technology. It looks at the level of skills presence to identify, apply and develop new building technology within the construction sector, a role that was highlighted by Park, et al., (2012), who recognized the key role played by clients with technical know-how in promoting innovation as the most prominent theme in innovation within the construction industry. The study found that technical know-how in the prefabricated construction sphere is at average level with a relatively moderate rating of 3.676 being realized, though most of the respondents (60.8%) rated strongly their technical know-how in prefabricated technology.

The study further found that technical know-how has a positive correlation coefficient (0.559) with the level of adoption of prefabricated technology, insinuating of a positive relationship with the adoption of prefabricated building technology, which was confirmed by a positive regression coefficient (0.477) in this relationship which was statistically significant. This confirms that improvement in technical know-how would lead to a positive improvement in the level of adoption of prefabricated building technology. This relationship confirms the observations made by Lombard (2011) who found that clients' beliefs, precognition, and the prevailing cognitive rule-of-thumb provides an opportunity to identify barriers of overcoming inertia in decision making among the construction industry clientele. When technical knowhow is paired with public perception, it was observed to have the ability to explain 48.7% of the variability in the adoption of prefabricated building technology, a significantly high predictive power. However, these views are against observations made by Barnes (2020) who found that skills accessibility is a minor reason among construction customers; and Ngigi (2016) who found public has little knowledge of alternative building technology in construction projects. This study confirmed that technical know-how in prefabricated building technology is at an average level, and that technical know-how positively affects the level of adoption of prefabricated building technology.

Public Perception and the Adoption of Prefabricated Building Technology

Public perception which relates to the understanding of and opinion about a prefabricated building technology was also considered a key factor in determining the adoption of prefabricated building technology. Public perception is informed by person’s reality realized from a blend of facts they discern and popular opinions, reputation, and media coverage. The study found that public perception in prefabricated building technology was rated at an average rating of 3.682 out of a 5-point Likert scale, though majority of the respondents (62.1%) rated strongly the public perception in prefabricated technology. This observation was also observed by Nurul *et al.,* (2013) who found that stakeholders perceive prefabricated toilet unit (PTU) as a worthy solution to the leaking problem within the toilet area, notwithstanding the inadequate supply of PTU in the local market.

A look at the relationship between public perception and the adoption of prefabricated building technology revealed a statistically significant positive correlation with a correlation coefficient of 0.477 to reveal existence of a direct relationship between public perception and the adoption of prefabricated building technology. Further regression analysis revealed the outcomes that a

positive and statistically significant relationship exists between prefabricated building technology and public perception with a regression coefficient of 0.444. This was against HOME group, (2018) findings that the lack of recognition of many modular building causes lower uptake with surveyed people believing that modular homes are less durable than the traditional construction systems, a view that was supported by Shah *et al.,* (2020) who linked the low public perception on prefabricated construction in the UK to the lack of information regarding prefabricated housing. However, contrary findings were reported by Booth (2017), Steinhardt and Manley (2016), Nanyam et al., (2017), Mustafa & Ghazali (2018), and Svajlenka and Kozlovska (2018), who confirmed this relationship, indicating that public perception does affect the level of adoption of prefabricated technology. The study therefore confirmed a positive relationship between prefabricated building technology and public perception, with improvement in public perception expected to cause a positive improvement in adoption of prefabricated building technology.

RECOMMENDATIONS

The study found that unlike in public opinion, there is high levels of adoption of prefabricated building technology in the Kenyan housing sector. However, the study observed low levels of input from the NHC and the whole housing sector to improve access and adoption of modular construction. This is linked to the policy environment under which the housing sector operates. This study found that with the proper policy inputs which affect, for the better, the technical knowhow and public perception, a greater level of adoption of prefabricated building technology in the Kenyan housing sector. The study recommends institutions such as NHC, Financial Institutions, and relevant government bodies should guide their policy development towards improving access and adoption, thus are well suited to generating competitive policies that would guide future growth in this technology. The study therefore recommends that policy makers in this field should be mobilized towards generating improve technology adoption policies, which would lead to the improvement of the level of adoption of prefabricated building technology.

The study found that the factors affecting the adoption of prefabricated building technology in the housing sector of Kenya are technical knowhow and public perception. The study therefore recommends the enhancement of the level of adoption of prefabricated building technology within the housing sector in Kenya by improving on technical knowhow and public perception within the sector. This can be achieved by all the stakeholders in the housing sector initiating concerted efforts aimed at improving usage of this technology. Institutions such as ministry of Housing and Urban Development, National Construction Authority, TVETs involved in skills generation, private businesses involved in the supply of prefabricated materials or services, should come together, and develop mechanisms that these four factors can be leveraged upon. The study suggests that prefabricated technology experts, workers and users should observe these factors to optimize access and adoption of this technology, thus benefiting more people in the Kenyan Housing sector.

The study was also limited in geographical scope to the Kenyan region and can be generalized to the other countries in the region where nearly similar characteristics face the adoption of prefabricated building technologies. However, the findings of this study may not apply at the international level as the conditions of adoption and access in Kenya are unique to that of other countries and the sectors are governed from a unique set of laws and regulations as well as operational atmosphere. This makes it hard to generalize the study findings into other countries, hence the study suggests similar research study to assess this phenomenon within the country's

unique construction management environment to confirm or dispute the study outcomes and enhance clarity of the issues at hand.

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