Adoption of Pre-Fabricated Building Technology to Address Housing in Kigali City

Patrick Arinawe, Abedenego O. Gwaya, Stephen O. Diang'a

Abstract*: The challenge of housing delivery is of great concern in many countries of the world. This problem is more predominant in developing countries and Rwanda is not an exception. Kigali City like most cities in developing countries is faced with housing shortage mainly caused by the growing urban population, high costs of construction and limited supply of dwelling units to meet the current demand. This study set out to examine if the adoption of prefabricated building technology can improve the delivery of affordable housing in Kigali City. Prefabs have in the past been advocated sustainable approach of reducing construction cost leading to affordable housing. The targeted study population consisted of Registered and practicing professionals(Engineers, Architects and Urban Planners , Manufacturers of prefabricated building materials(Strawtec and Afri-precast), Real estate developers, Staff at Rwanda Housing Authority , Ministry of Infrastructure , City of Kigali involved in housing supply and regulation and Home owners. The study objectives were to: assess the current interventions by government and private sector to increase supply housing in Kigali. Compare the cost effectiveness of using conventional and prefabricated building materials on housing projects in Kigali; Examine the perception of stakeholders towards the use and adoption of prefabricated building materials and finally suggest and recommend a framework for adopting prefabricated building materials on housing projects in Kigali City. The research design was cross - sectional study and it relied on both quantitative and qualitative. Both primary and secondary data were collected from developers, consultants and contractors through checklists, questionnaires, interviews and visual observations. Descriptive statistics was used to analyze the data. They described functional performance, lessons learned, adoption rate, social and economic impacts of prefabs. The study revealed that the costs of the raw materials as high and hence making the adoption rate of the prefabricated building materials in Kigali City low. Additionally, the advantages of prefabs included savings on speed of construction, waste reduction, labor reduction, efficiency and quality production. These impacts are however not aggressively* **propagated or articulated to the general public.** ***This lack of effective dissemination has led to constrained knowledge on the social and economic benefits of prefabs curtailing satisfactory solutions to affordable housing. Thus, the researcher recommends that the Sensitizing the public through open forums, printed pamphlets, show houses, physical demonstrations of construction speeds, active public participation and other promotion methods; of the many advantages of prefabs. These findings of the study should be applied in future projects as a way to promote adoption of the prefabricated building technology.

Index Terms: Adoption, Prefabricated, Affordable housing, alternative building technology.

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I. INTRODUCTION

The Concept of Housing is one of the main three basic needs of mankind and it is the most important for the physical survival of man after the provision of food. Adequate housing contributes to the attainment of physical and moral health of a nation and stimulates the social stability, the work efficiency and the development of the individuals. Housing is also one of the best indicators of a person's standard of living and of his place in the society. Housing, both in units or multiple forms is a significant component of the physical form and structure of a community, while the human and family contents of the house is part of the very spirit of life and prosperity of the society

Rwanda like other developing African countries is saddled with increase in urban population a situation that has led to inadequate housing and overcrowding, recent statistics done in Kigali indicate that the City of currently in a deficit of approximately 10,000 dwelling units per year according to the Kigali housing market study conducted in 2012.

The challenge of adequate and affordable housing provision is a global problem facing developed and developing economies, such as Rwanda, equally conventional construction methods due to their cost implications are a major barrier to addressing this challenge. Prefabrication (prefab) or industrialization of construction is offered as one of the key ways to reduce the cost of delivering housing.

Provision of adequate and affordable housing is a major challenge in both emerging and industrialized countries. With increasing urgency for addressing climate change and other environmental issues these habitats will need to be environmentally sustainable too. Conventional construction, especially in dense urban centers and in rural or remote areas, is putting great pressures on cost and resource efficiency and is compelling the industry and governments globally to question the approach of business-as-usual.)

Nowadays prefabrication technologies play an important role in multiple developing countries and its usage has been increasing every day. Prefabrication process has also been associated with low carbon foot print, green building and eco design in an attempt to reduce greenhouse emissions and reduce energy use in buildings.

This study revealed how alternative building technology like using prefabricated building materials specifically wall panel made out of straw and precast concrete can lead to an increase in housing supply for Kigali.

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II. BACKGROUND LITERATURE REVIEW

A. Definition of prefabricated building materials

Prefabrication is a manufacturing process, generally taking place at a specialized facility, in which various materials are joined to form a component part of the final installation' (Gibb 1999)

According to (construction duniya, 2012) The word "Prefab" is not an industry term like modular home, manufactured home, panelized home, or site-built home. The term is an amalgamation of panelized and modular building systems, and can mean either one. In today's usage the term "Prefab" is more closely related to the style of home, usually modernist, rather than to a particular method of home construction.

Prefabrication is the practice of assembling components of a structure in a factory or other manufacturing site, and transporting complete assemblies or sub-assemblies to the construction site where the structure is to be located. The term is used to distinguish this process from the more conventional construction practice of transporting the basic materials such as bricks, timber, cement, sand, steel and construction aggregate to the construction site for construction

B. History and evolution of prefabricated materials and houses

The first examples of prefabrication dates back to the 1600s ((Haas, 2000)). In Great Britain, a great example of an early-prefabricated structure is the Crystal Palace. In 1851 the Crystal Palace was constructed for Britain's Great Exhibition. The building was designed in less than two weeks, and was made up entirely of prefabricated glass panels, wood, and cast-iron components. Assembly of the prefabricated components lasted just a few months. Once the Great Exhibition was over, the building was then deconstructed and moved (Haas et al. 2000).

Prefabrication owes its birth to the acute housing problems that followed the Second World War. the devastation of the war rendered millions homeless according to construction (Duni, 2012.)

Ågren and Wing (2014) identify moments in the history of industrialized building, describing modular building and prefabrication, but the origin of prefabricated housing in Britain is not discussed. The University of the West of England (UWE) (2014), in a brief and encompassing overview, describes the changes in architecture and building for housing between the Georgian period and the post-war era. However, from this, it might be considered prefabricated housing developed in post industrialized Britain, or more specifically after WW2. British prefabrication is much older than this, and can be traced back to the colonization of North America, and even further to cruck frame construction

Buildings have been built in one place and reassembled in another throughout history. This was especially true for mobile activities, or for new settlements; one of the first buildings at Cape Ann in 1624 was probably partially prefabricated, and was rapidly disassembled and moved at least once. John Rollo described in 1801 earlier use of portable hospital buildings in the West Indies.

Possibly the first advertised prefab house was the "Manning cottage". A London carpenter, Henry Manning, constructed a house that was built in components, then shipped and assembled by British emigrants. This was published at the time (advertisement, South Australian Record, 1837) and a few still stand in Australia. One such is the Friends Meeting House, Adelaide.

The peak year for the importation of portable buildings to Australia was 1853, when several hundred arrived. These have been identified as coming from Liverpool, Boston and Singapore (with Chinese instructions for re-assembly) In Barbados the Chattel house was a form of prefabricated building which was developed by emancipated slaves who had limited rights to build upon land they did not own. As the buildings were moveable they were legally regarded as chattels.

C. Classification of Prefab building materials

According to (Rajjwal Paudel, 2016) The Prefabrication is classified as follows; Large-panel systems, Frame systemsSlab-column systems with walls and Mixed systems

Weidemann, Stefan J., 1990, further asserts that, the way in which prefab construction is carried out varies from place to place. However, there are three major methods of prefab construction. In some cases, these methods may be integrated in a particular construction i.e all methods incorporated in one construction. They include, Panel Method, Frame Method and Modular Method

D. The necessity of adopting Prefabrication Method in housing construction.

According to Rajjwal, (2016) Science and technologies in developed countries are moving very fast. They have no time to look behind. In such time, there are still some countries which follow conventional way of building and waste their crucial time and money. Also, by the strong earthquake in Nepal many buildings and structures were destroyed and the country is pushed many years back. Therefore, to develop the nation in minimum time, minimum cost without disturbing the environment, Prefabrication Methods are very much necessary.

According to (Hong Xue, 2017), Traditional on-site construction, as a common method, has been criticized because of its inherent drawbacks, such as long construction time low productivity external weather constraints, waste of resource, environmental pollution, poor safety, etc. Therefore Prefabrication has been introduced as a major mode for promoting environment and sustainability performance in the construction industry. Prefabrication is called various terms such as industrialized construction, prefabricated construction, assembly, modular construction, mass production, modern method of construction, and off-site construction.

Hayes (1999) and Piroozfar and Farr (2013) suggest that the poor opinion of prefabricated housing in Britain in relation to other cultures can be attributed to a conflict between 'traditional architecture' and prefabricated production, as seen in Scotland.

It is evident that there was a conflict of interest in architects' opinions of prefabrication, partially, due to the fear of it leading to the requirement of fewer architects due to greater standardization and generic design.

E. Advantages of prefabricated building materials

In a report produced by McGraw-Hill (2011) on prefabrication, it was stated that prefabrication in two-thirds of companies that use prefabrication experienced reduced project schedules. Out of those companies 35% reported decreasing schedules by as much as four or more weeks (McGraw-Hill 2011).

This is significant not only because it proves prefabrication reduces project schedules but also because it can yield significant cost savings. Many projects take place on active sites, where business is negatively impacted when construction is occurring. When schedules can be reduced by a month or more, businesses can return to normalcy sooner and help minimize negative impacts to business. A good example of an active site would be a new building being constructed in a hospital complex (McGraw-Hill 2011).

The main advantages of prefabricated structures are assembly of finished elements on site, self-load bearing and quick execution, which have favored their use above all in industry (Rajjwal Paudel, 2016), other advantages include;

- Self-supporting ready-made components are used, so the need for formwork, shuttering and scaffolding is greatly reduced.
- Prefabricated components speed up construction time, resulting in lower labor costs.
- There are less wasted materials than in site built construction.
- Construction time is reduced and buildings are completed sooner, allowing an earlier return of the capital invested.
- The mechanization used in prefabricated construction ensures precise conformity to building code standards and greater quality assurance.
- On-site construction and congestion of site is minimized.
- Better quality control can be achieved in a factory assembly line setting than at the construction site.
- Quality control and factory sealing and design can ensure high energy efficiency.
- Prefabrication site can be located where skilled labor is more readily available and the costs of labor, power, materials, space and overheads are reduced.
- Time spent due to bad weather or hazardous environments at the construction site is minimized.
- Prefabrication allows for year-round construction, work is not affected by weather delays (related to excessive cold, heat, rain, snow, etc.)

Furthermore (Chandra, 2015) highlights more advantages of using prefabricated building materials using BIM

- Faster assembly of units
- Factory fitted units enhances quality of the product
- Less construction time
- It is weather prone as the building units are constructed under controlled conditions
- The construction can be continued in the extreme heat and cold conditions
- The quality can be checked at any time
- Cost effective methods
- Environmental friendly like less noise and pollution at the construction site
- Low energy consumption
- Good designing probabilities
- Increased safety in the construction site
- Reduction of the constructional waste at the construction site
- Cheaper labor costs.

F. Disadvantages of Prefabricated materials

Despite these benefits, node discontinuity is the most critical factor in the event of an earthquake, since the risk of losing the support of the horizontal (Weidemann, Stefan J, 1990)

Other disadvantages highlighted by Weidemann, Stefan J, 1990 include;

- Leaks can form at joints in prefabricated components.
- Transportation costs may be higher for voluminous prefabricated sections.
- The requirement to transport manufactured homes or modules to their intended site can mean that prefabrication potential may be limited for infill projects in inner city areas.
- Increased production volume is required to ensure affordability through prefabrication.
- Higher initial construction cost.
- Lack of background research information.
- Time consuming in the initial design development
- Large prefabricated sections require heavy duty cranes and precision measurement from handling to place in position.
- Larger groups of buildings from the same type of prefabricated elements tend to look drab and monotonous.
- Local jobs may be lost, if the work done to fabricate the components being located in a place far away from the place of construction.
- Prefab structure means that there is less local working on any construction project at any time.
- Design and construction of modular buildings, require high levels of collaboration among project parties, especially architect, structural engineer and manufacturer.
- Prefabricated buildings typically depreciate more quickly than traditional site-built housing because of its shorter economic life..

G. The cost effectiveness of using prefabricated building materials over the conventional building materials

According to Prefab Architecture: A guide to modular design and construction (Ryan E. Smith; 2010), four different principles must be taken into account when considering prefabrication, these include;

Costs

Prefabrication known to be much more cost efficient than other onsite methods of construction. This is because cost consists of three aspects on which prefabrication has an impact: material, labor and time. The first option to reduce cost is to reduce the amount of material implemented in a building project. In an on-site construction, materials are over-ordered to ensure an adequate quantity for the task.

Although prefabrication may save considerably with regard to delivery and staging of material, factory produced components may initially be more expensive. Especially on small projects, due to the short-run amount of components, it is economically unfavorable.

Other costs that may be incurred with prefabrication include transport expenses. Although prefabrication requires larger trucks for transport to site, coordination and transportation for onsite construction does not take into consideration the daily trips to pick up forgotten materials. Placing the cranes at the onsite place is expensive, and cannot be avoided by using prefabrication.

Traditionally, it is not as expensive as with onsite techniques since the construction period is shortened.

Schedule

Again, construction period is shortening is good for another principle. The savings come in the ability to simultaneously construct in the factory while site work is being completed. In traditional onsite construction processes, subcontractors have to wait until the precedent trade has completed its work, in a factory, teams may work together allowing sections to be constructed by more than one trade. Time savings may also come by way of employing lean production techniques. Decisions regarding prefabrication are made early so that schedule savings may be realized from the start of construction.

Labor

Productivity is a measure of efficiency in labor. With offsite fabrication, technical changes including machinery in the factory, evolutions in material science and digital revolutions like BIM have positively impacted the productivity of labor in construction. Some of the means are:

- Amplified human energy to increase output
- Increased levels of control, precision and accuracy
- Added variability to production manipulation
- Improved ergonomics to reduce fatigue

Quality

There are two concepts to evaluate quality; quality of production and quality of design (associated with the work of the architect). As soon as production quality increases, architecture becomes more standardized, while a highly customized design inevitably suggests lack of production efficiency.

According to Ryan E. Smith; 2010 Prefabrication requires the creative abilities of architects, engineers and fabricators to create a method to increase both quality of design and production. Onsite construction is still a handcraft culture in countries like Spain, opposite to other industries, which use automation and precise methods of production. Obviously prefabrication can increase the precision of the products and allow a greater control over each element. Along with increased precision is the ability for manufactured components to have less dimensional tolerance. Prefabrication limits the risk of errors and eliminates the unknowns in a highly multivariable construction.

Fernández, 2014 provides an interesting chart comparing prefabrication and onsite production in many different aspects of the principles seen above:

H. Comparing prefabrication and onsite production quality

As highlighted by Lovell and Smith (2010), although there has been much debate about whether prefabricated housing costs more or less than traditional forms of construction, increasing evidence suggests that prefabrication costs around 10% more than traditional construction initially. Gibb (2001) suggests that, when considering prefabricated components, units are often perceived as more expensive if accounting for factory set-up and overhead costs. However, where the number of units being produced increases, the unit cost decreases significantly (ibid.). Where assessing costs based on a lifecycle assessment of two case study properties,

Monahan and Powell (2011) suggest that, prefabricated properties can deliver a 34% reduction in carbon emissions over traditional construction methods .According to (Shahzad, W.M, Mbachu, J. and Domingo, N. (2014) The use of prefab content has a significant relationship with the cost performance and time performance of the project. The study has quantified the benefits of employing prefab technology in light to medium commercial building projects by concluding that 77% prefab content in light to medium commercial buildings can result in 100% or more cost eperformance and similarly 74% prefab content can result in 100% or more time performance. Findings of this study are likely to encourage the uptake of prefab technology in construction process.

However(Shahzad, W.M, Mbachu, J. and Domingo, N. (2014) further assert that factors other than prefab content might be responsible for the cost and time performance such as quality of project management, site characteristics, procurement strategies etc. are recommended for further investigations

Stefan J. Weidemann, 1990 urges that conventional wisdom would lead one to believe that the production of prefabricated housing under controlled conditions using mass production technology and employing a generally semi-skilled workforce would result in a product less expensive or at least competitively priced to that of conventionally built homes. Indications were appeared to support the contentions made so often by the prefabrication industry that their product is more cost effective than conventional construction (Stefan J. Weidemann, 1990).

Teicholz, 2004 also urges that in the case of conventional construction the quality of the finished product is mainly dependent on the skill of the mason, whereas in the case of prefabrication the components being machine made, the finished product has better consistency in terms of quality.

Construction dunia, 2012 asserts that in the competition between the precast and the cast in situ structures, prefabrication is gaining an ever increasing prominence because it is accompanied by an improvement in quality, whereas the requirement of materials, the working time and the cost show a decrease in tendency.

I. The Case study of housing in Kigali City.

New housing demand in Kigali is primarily driven by population growth. Kigali is expected to double its population until 2022 due in part to "push factors" (migration from the countryside), but also to "pull factors", due to the city's position as the pre-eminent urban centre of Rwanda. Between 2006 and 2011, migrant population in Kigali accounted for almost half the total population in the city and this has been assumed to continue.

With changing national urban policy that emphasizes development of second tier cities and towns, however, this assumption can potentially be revised downward. Population in Kigali in 2011 was 1,059,000. In 2022, if current pace of growth continues and if City policies remain unchanged, it will reach 1,957,312 inhabitants and in 2040 it will reach 5,347,178 inhabitants.

Access to adequate housing is considered a right in Rwanda. This concept emanates from the Rwanda Development Plan (RDP) of 1994, which asserts that minimum housing must be provided to all. Responsibility for housing provision was delegated on the Ministry of Infrastructure (MININFRA), which in 2011 formed the Rwanda Housing Authority (RHA) to implement national housing, urbanization, construction and asset management policies**.**

With the City of Kigali population growing each year, the city needs to build about 31,000 units annually, and 344,068 units will be required by 2020, according to research done by the city in 2012.

According to the (Planet, 2012) Increasing housing supply in Kigali requires simultaneous actions in different sectors to avoid the formation of bottlenecks in infrastructure, long-term funding, residential land and building materials. Increasing supply of housing in Kigali from 2012-2022 requires coordinated multi-sector action to ensure availability of the following inputs:

- 2,562 Ha of residential land as determined by proposed typology in Chapter 3 (not including common uses, such as streets, parks, shopping & service areas and others),
- 2.5 billion USD in long-term funds (net figure, not including only funds from financing entities, to be completed by down-payments from clients),
- Building materials (200,000 tons of cement, 13,000 tons of steel bars, 1.7 million m² of metal roofing),
- Yearly reinforcement of utility infrastructure (increased water supply by 29,598 m³/day; increased power supply by 123 Mwh; treatment of 22,199 m³/day of liquid waste; collection and recycling of 67 tons/day of solid waste; building of 1,480 m²/day of streets;
- Increased transport capacity in 177,588 trips/day)

In addition, capacity of the construction industry must be strengthened to ensure delivery of 17 million m² of residential building annually, which may require up to 50,000 laborers (assuming labor-intensive building technology).

According to the (Consortium, June, 2012), meeting present and future housing needs in Kigali requires coordinated action in several fronts, both in the public and private sectors. This is specially the case for the production of affordable housing, where policies, institutions and plans are required to ensure availability of five key inputs:

- Housing Finance
- Infrastructure
- Land
- Labor
- Building Material

According to construction dunia 2012, Many of the current prefab home designs on the market have jovial, eclectic elements of postmodernism or the clean, simple lines of futurism. Prefab homes have not been particularly marketable in elsewhere ; possible reasons for this include:

- Homes are not currently produced cost effectively enough for current demand.
- Homes are not considered a realistic housing solution by the average consumer
- The consumer is either not familiar with the concept, or does not desire it.
- Social stigma that exists because of low quality mass produced designs used in the past.
- Difficulties obtaining finance due to stricter guidelines being used by lenders to assess prefab home loans.

The assertion by construction dunia does not related to the Kigali scenario since, since the idea of using prefabrication has not yet been adopted, however the article provided some much needed guidance for policy makers to consider while adopting this technology.

J. Current government interventions to address housing supply in Kigali.

The Rwandan Government recognizes that housing is a basic right for its citizens as stated in international declarations such as the (Report of the United Nations Conference on Human Settlements (Habitat II) , June,1996), the Millennium Development Goals (February, 2002), and the World Summit on Sustainable Development (July-August, 2002). In this context, it aims to facilitate access to decent housing and basic infrastructure facilities for its population (National Urban Housing Policy for Rwanda, December,2008)

In July 2004, the Government of Rwanda adopted the National Human Settlement Policy. It is aligned with the national policies led by the Vision 2020 and the national strategic paper for poverty reduction, and takes into consideration the decentralization policy implemented since 2001. Pursued is a model village program for the upgrading of villages with the aim of providing mixed use opportunities for their residents.

The policy resulted in higher emphasis on urban planning and building. Achievements were made in the building of institutions in line with the decentralization policy, and the establishment of tools and plans for improvements to the management of urban and settlement planning.

One significant low cost housing project in Kigali was implemented in Batsinda, Gasabo district in 2008. The neighborhood concept applied a sustainable green building approach using local construction materials (compressed earth blocks), and renewable energies (biogas, rain water, solar for a pilot house)

III. RESEARCH METHODOLOGY

The study was quantitative and qualitative in nature based on the objectives to be achieved; explanatory and descriptive methods of data collection and analysis will be used respectively, furthermore primary and secondary data sources will be deployed for data collection,

Primary data sources included surveys, questionnaires, observations and personal interviews while secondary data sources will include review of publications, books, journal articles and any recent surveys related to prefabrication use and adoption.

This research being largely qualitative used semi-structured methods such as in-depth interviews, focus groups, and participant observation since it seeks to find ways of promoting the use and uptake of prefabricated building materials among home owners, real estate developers and government institutions in Rwanda,

However, in order to get a more in-depth analysis of how prefabricating building materials can be adopted some quantitative tools of data collection like structured questionnaires were adopted

The study used Yamane (1967:886) simplified formula to calculate sample size using a 95% confidence level.

Sample size was estimated based on a proportion where it will be calculated with an approximate 95% confidence level, the following formula was used:

$$n = \frac{N}{1+Ne^2}$$ Where,

n is the sample size,

N is the population size,

e is the level of precision.

By using Yamane's formula, we used a sample size of 67 respondents for study.

The respondents for this study included; Registered and practicing professionals (Engineers, Architects Urban Planners) , Manufacturers of prefabricated building materials (Strawtec and Afri-precast) Real estate developers, Staff at Rwanda Housing Authority , Ministry of Infrastructure , City of Kigali involved in housing supply and regulation and Contractors.

IV. RESEARCH RESULTS AND FINDINGS

In depth analysis was carried out on the data obtained from the survey to enable the researcher make valid conclusions and recommendations, the study revealed the following;

(i) The extent Results showed that 34% of the total respondents were aware of prefabricated building technology while 66% did not know, The study therefore implies that the penetration of information on the existence of prefabs is still low, thus government and the private sector still have work to do in regards to sensitizing the general public on the existence and benefits of alternative building technology.

(ii) The study also revealed the 32% of the respondents would most likely prefer to use traditional construction methods and materials over alternative technology.

(iii) 34%, of the respondents revealed that government had put most of its efforts in largely upgrading existing informal settlements and provided infrastructure subsides to investors who are have shown interest in providing affordable houses on the market, The study also shows that government has given less attention in promoting and investing in the use of prefabs as a solution to the current housing crisis.

(iv) 60% of the study respondents rated the technology used in delivering relatively cheaper and affordable houses as high. 26% rated the technology as average and14 % rated it as low. This would imply that the public is interested in sustainable ACTs but there is a perceived higher initial cost of the construction materials. This is supported by the fact that over 67% of the respondents indicated that the price of the raw materials was high in their project.

(v) The respondents rated the performance of the alternative construction technology that had been used in constructing the buildings being evaluated in the study. This was in terms of structural and physical characteristics, costs and installation process effectiveness. The visual observations noted by the study are also given.

(vi) The study suggest that facilities constructed using alternative technologies had performed well in terms of quality, physical and structural characteristics which included weathering, defects, durability and aesthetics. There were no visible cracks, warping or sagging noticed in the buildings. All the items rated obtained an average mean above 3.2 which suggests good performance and an encouraging user satisfaction level. Good temperature control and sound insulation was an added advantage.

(vii) The results revealed that the technology they had used was high in terms of speed of construction with of mean of 4.4286. Additionally the results showed that the technology used was fair in terms of construction period at a mean of 3.5714.

(viii) These findings show that the technology used improved time scheduling of the work hence high speed of construction, better handling of materials, reduced transport costs and improved productivity. High wastage reduction meant saving on materials costs, and increasing efficiency and better quality control. The reduced time create business-related benefits to the client by early return on capital invested or less down-time' in use of the building. The contractor benefits from less labor costs and overheads.

(ix) The study showed that 58.1% of the respondents indicated that the adoption rate of the technology used in their construction project as low. Respondents (25.7%) also indicated that there was an average rate of adoption of the technology used in their project. A small percentage of 14.2% of the respondents indicated that the rate of adoption of the technology used in their project was high. These results amplify the slow adoption of alternative building technologies. This could be attributed to the strong bias towards traditional materials and techniques, specifically stone and cement. It could also be due to the human nature of not wanting to change, preference of status quo. Lack of awareness of the products and high material costs on small projects could also be a contributing factor.

(x) 69.4% of the respondents rated the technology used in delivering relatively affordable houses as high. 20.3% rated the technology as average and 11.3% rated as low. This would imply that the public is interested in sustainable prefabs but there is a perceived higher initial cost of the construction materials. This is supported by the fact that over 83% of the respondents indicated that the price of the raw materials was high in their projects.

(xi) The study revealed that 63.4% of the respondents acknowledge that the impact of prefabricated technology in delivering relatively affordable houses as very high. 17.6 % rated the impact of prefabs as relatively high and 6.6 % rated the impact as low. This implies that the general public is generally aware of the potential positive impact of using prefabs in delivering large scale affordable housing in Kigali City; this is supported by the fact that over 85 % of the respondents indicated that the use of prefabs would reduce on the time and cost incurred in delivering affordable housing units

V. CONCLUSION

In brief three major observations have been made in this study

1) Firstly, the performances and characteristics data obtained shows very many advantages associated with prefabs, However, these social and economic advantages have not been well explained and articulated to the public

2) Secondly, housing output in Kigali is significantly influenced by the choice building materials and prefabs offer different mode of housing delivery. The cost of raw materials was however found to be high

3) Finally, the rate of adoption and uptake level of the prefabs were found to be low. Public knowledge on the prefabs was also found to be low.

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