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MAKING A CASE FOR MODULAR INTEGRATED CONSTRUCTION IN WEST AFRICA: RETHINKING OF HOUSING SUPPLY IN GHANA

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Concomitant with the rapid population growth in West Africa is the increasing difficulty in providing adequate housing for the masses. As housing constitutes the most expensive individualized basic human need, the gap between incomes and rents for homeless households have created housing hardship of epic proportions. Meanwhile, there is housing glut in Ghana amid the deficit. These indicate that a practical solution must offer a quadruplet benefit of speed, quality, affordability and economy in the housing production. This research examined the failures of previous industrialized housing initiatives in Ghana and highlighted the prevailing opportunities and potential barriers to the delivery of industrialized housing systems (IHS) in Ghana. Methodologically, the paper draws on a review of policy and academic literature to establish strong support for the adoption of modular integrated construction (MiC) to deliver affordable IHS in Ghana. Despite the failures of industrialized housing production initiatives in the 50s and 70s, the research found that opportunities such as improved infrastructure and manufacturing power, existence of prefabricated construction market, government recognition of innovative housing projects in Ghana and the availability of wealth of experiences, lessons and MiC best practices are favorable conditions which render MiC and industrialized housing construction (IHC) feasible in Ghana. The research used two case studies to justify the feasibility of MiC and IHC in Ghana. However, the lack of substantial experience with MiC, failure of previous IHS initiatives, absence of MiC implementation framework, lack of MiC technical guidance, design codes and standards, higher initial capital cost, and the incomplete MiC supply chain are potential barriers to the adoption of MiC in Ghana. A multi-stakeholder framework is proposed to guide the implementation of MiC in Ghana. Thus, this research contributes to the praxis and practice of the affordable housing discourse in Ghana and West Africa.

Keywords: Ghana, housing deficit, modular integrated construction

INTRODUCTION

Though it is estimated that 90% of the global population increase between 2018 and 2050 will occur in Asia and Africa (United Nations Department of Economic

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and Social Affairs, 2015, 2018), such aggregate statistics have a tendency of masking significant regional and national variations in the spate of population growth. Particularly, Sub-Saharan Africa (SSA) recorded unprecedented population growth, following a hitherto population stagnation under the shackles of the slave trade and colonization for several centuries. From the 20th century onwards, SSA witnessed a phenomenal population growth from 100million in 1900 to 229million in 1960 and 1.1billion in 2017 (United Nations Department of Economic and Social Affairs, 2018; World Bank, 2019). This profound population surge provokes increased demand for housing, infrastructure, services, food, energy, and water (UN-HABITAT, 2004). One critical challenge associated with the rapid population growth and urbanization is the provision of adequate, decent and affordable housing for the masses, especially for the lower- and middle-income households (UN-HABITAT, 2016; United Nations, 2017).

Housing accounts for over 70% of the spatial uses in cities and constitutes a critical determinant of urban forms and densities (UN-HABITAT, 2016). The housing and infrastructure deficits in SSA are worsening because the urban transformation in the region is largely chaotic and unplanned (UN-HABITAT, 2004; United Nations, 2017) and in which the spate of urbanization is not accompanied by commensurate industrial and economic growth (UN-HABITAT, 2004). As a result, housing and infrastructure deficit continue to soar up without a sustained supply. Notably, SSA alone accounted for over 56% of the total increase in slum population in developing countries between 1990 and 2014 (UN-HABITAT, 2016). Again, however, these aggregate trends of the SSA region have a tendency of masking the significant national variations in the magnitude of the housing shortfalls. Although the SSA countries share similar trends in developmental challenges, the similarities are more overt among the West African nations.

Ghana whose population is currently estimated at 29 million people (World Bank, 2019) is the focus of the current research. Although the slum population of Ghana declined from 65.5% in 1960 to 37.9% in 2015 (United Nations, 2017), the housing backlog remains higher than 2 million units, of which over 55% of the deficit thrives in the urban areas (Bah et al., 2018). With an estimated shortfall of 2million units in 2010, the UN-HABITAT (2011) estimated that Ghana's housing need will hit 5.7million rooms in 2020. This meant that 3.8 new rooms must be completed in every minute of the working days for ten years, starting from 2011 to successfully meet the shortfall. This rapid and continuous housing production requirement is overwhelming for the traditional cast-in-situ construction approach which is inelastic to supply in the short-run. Additionally, there is a paradox in the Ghanaian housing market as glut exists amid the deficit. According to Smith-Asante (2018), there are over 40% vacancy rates in the national housing estates operated by the State Housing Corporation. Besides, the Ghana Real Estate Developers Association (GREDA) continue to advertise houses for sale amid the exclaimed deficit. This suggests a clear mismatch between the prices (or rents) of homes and wages of preponderances of the masses. Certainly, the gap between wages and rents for homeless households have created housing hardship of epic proportions.

Housing is one of the most expensive individualized basic human need. Yet, over 65% of Ghanaians are situated within the lower and middle-income bracket (Bank of Ghana, 2007), the majority of whom survive under US$2.5 daily (UN-HABITAT, 2016). These pathetic income levels of the masses cannot support their housing and other basic needs. Although the Ghanaian Government "is still committed to improving housing delivery stock, but in line with a current global paradigm shift, it has largely withdrawn from directly providing housing to playing the role of a facilitator" (Ahadzie et al., 2004, pp.620). Essentially, the Ghanaian housing market is dominated by private and individual developers who meet their housing needs through self-help, self-build and incremental building (Amoako and Frimpong Boamah, 2017; Tipple et al., 1998). However, complete house construction under the self-help and incremental building models often span between 5 and 15 years (Bank of Ghana, 2007; Tipple et al., 1998). This longer housing production cycle is not capable of matching the rapid spate of the increasing housing shortfall. The nature of housing supply, income levels of the masses and the increasing rate of the shortfall in Ghana demand a construction business model which can deliver a quadruplet benefit of affordability, quality, economy, and speedy housing delivery. While existing housing studies have suggested policy-related remedies to the deficit, this study argues that technological intervention is required to generate quality mass affordable housing for the masses. This is because as the global housing shortfall persists, most countries have struggled to meet their own housing needs using industrialized housing systems through modular integrated construction (Terner and Turner, 1972). Countries such as China (Zhai et al., 2014), Malaysia (Kamar et al., 2014), the United Kingdom (Gibb and Isack, 2003), and Singapore (Wuni et al., 2019) have established clear roadmaps in using offsite production techniques to meet their rapidly increasing housing shortfalls.

Although Ghana's two attempts at mass housing production using prefabricated construction in 1952 and 1978 failed and were abandoned (Essienyi, 2011; Ofori, 1989; United Nations Technical Assistance Programme, 1957), this research seeks to establish a strong support for the adoption of modular integrated construction (MiC) to deliver industrialized housing systems (IHS) in Ghana based on some prevailing favourable conditions. The paper presents findings of an ongoing Ph.D. research project which seeks to develop a best practice framework for the implementation of MiC in Ghana. Concomitant objectives of the paper include (i) to review and highlight the factors which accounted for the failures of previous IHS in Ghana (ii) to expound on the existing favourable opportunities in Ghana which supports the adoption of MiC, (iii) to highlight the potential barriers to the adoption and implementation of MiC in Ghana, and (iv) to propose a multi-stakeholder framework to guide the implementation of MiC in Ghana. As such, the paper contributes to the policy discourse in seeking a lasting solution to the housing deficit in Ghana and opens a new research gate which will trigger academic debates in helping to rescue the housing conundrum.

RESEARCH BACKGROUND AND CONCEPTUAL BASIS

Industrialized Housing Systems and Prefabricated Construction in Ghana

Mass industrialized housing production and prefabricated housing business models are not entirely new in the Ghanaian construction industry and housing market (Ahadzie et al., 2008). Mass housing production involves "the design and construction of at least 10 speculative standardized house-units, usually in the same location and executed within the same project scheme" (Ahadzie et al., 2008, pp.676). Although there are several mass housing building projects in Ghana, there have been only two unique attempts at deploying prefabricated construction technique to deliver mass IHS in Ghana (Essienyi, 2011; Ofori, 1989).

In 1952, the Gold Coast (now Ghana) Government attempted to implement IHS through parodying the post-war prefabricated housing model of Britain (United Nations Technical Assistance Programme, 1957). The Gold Coast Government (GCG) commissioned Messrs. N. V. Schokbeton; a Hollander Consultant to ascertain the economic and technical feasibility of producing prefabricated housing in the country. The Schokbeton prefabricated building method was intended to generate mass affordable housing from local precast members (Essienyi, 2011; Ofori, 1989). Amid the feasibility study, the GCG signed two agreements with Schokbeton in 1952 and 1953 to construct 168 prototype houses in Accra, Kumasi, and Takoradi at a lump sum of £336K, of which 64 units alone were constructed at a sum over £160K (Essienyi, 2011). This rendered the costs of construction far expensive compared to those of the cast-in-situ construction approach. As a result, the GCG invited the United Nations Technical Assistance Housing Mission to Ghana in 1954 to assess the practicality and reasonableness of the Schokbeton survey report (United Nations Technical Assistance Programme, 1957). Following a comprehensive review, the Mission advised the GCG to abandon the Schokbeton Housing Scheme because: (i) the project costed 80% higher than the budget and the houses were far expensive than the traditional units, (ii) the project demanded full government intervention and purchase of all produced units, and (iii) there were other affordable IHS options such as partial prefabrication which could meet the housing demand (Ofori, 1989; United Nations Technical Assistance Programme, 1957).

The second attempt at mass production of industrialized housing in Ghana occurred between 1962 and 1978. The Government of Ghana (GoG) signed an official agreement with the Soviet Union or Union of Soviet Socialist Republics (USSR) in 1962 to set up prefabrication plants in Accra to fabricate precast components for mass housing production in the country (Ofori, 1989). The IHS were to be designed and engineered in the Soviet Union and modified in Ghana. The prefabricated concrete panel factory (PCPF) was built in 1996 but owing to political unrest in the country at the time, the first standard structural components were produced in 1972 following substantial rehabilitation of the PCPF (Ofori, 1989). In 1978, the first factory-built house was accomplished in Ghana. The Scheme aimed to construct 2-story houses and 4-story blocks of flats using the slogan 'own your house in 30-days' (Ofori, 1989). The Scheme could not meet demands for its units and was eventually abandoned due to (i) non-availability of sufficient supply of cement and mild steel reinforcement to feed the plants, (ii) low production efficiency of the plants following excessive wear and tear, (iii) unfamiliarity of the technology to local contractors, and (iv) lack of cranes and lifting equipment in the country (Ofori, 1989).

However, Essienyi (2011) noted that the significant failures of the 20th Century's prefabricated construction in most developing countries were due to poor functioning market economies, minimal industrialization, less infrastructure, and poorly structured housing markets. Similarly, this research argues that the post-war prefabricated housing failures were a global syndrome, of which the stigma was even severer in Europe following the collapse of the 22-story prefabricated

Ronan Point Apartment Tower in East London in 1968. However, lessons were learned, and as a result, prefabricated construction has become popular in many countries in the last couple of decades as a construction business model for addressing the rapidly growing housing shortfall. As such, Ghana also has enough reasons to make a third attempt at using MiC to deliver IHS.

Overview of Modular Integrated Construction (MiC)

Modular construction, industrialized building systems, prefabricated construction, and prefabricated prefinished volumetric construction are similar offsite construction techniques and denotes modular integrated construction (MiC) in this study where "free-standing integrated modules (completed with finishes, fixtures, and fittings) are manufactured in a prefabrication factory and then transported to site for installation in a building" (Hong Kong Buildings Department, 2018). Consistent with the concept of modularity in computer engineering and the business model of the automobile industries, MiC constitutes the highest order of prefabricated construction whereby 90-95% of a house can be completed in a manufacturing plant (Jaillon et al., 2009; Smith, 2016). MiC operates in four levels: component manufacture and subassembly, non-volumetric preassembly, volumetric preassembly and complete modular building (Gibb, 1999). The supply chain of MiC can be reified as modular design, manufacturing, engineering, transportation, buffer, storage and onsite assembly (Li et al., 2016). MiC delivers industrialized building systems where the same design details and specifications generate diversified and highly individualized houses (Richard, 2006b). The three major forms of MiC include reinforced concrete modules, steel frame modules, and hybrid modules (Wuni et al., 2019; Wuni and Shen, 2019a). MiC may take the form of post & beam, slab & column, panels & frames, integrated joint, factory-made section module, monolithic systems or boxes, mobile homes, container houses, load-bearing service core, mega-structure, and site mechanization (Richard, 2005). The operation of MiC demands the total integration of all subsystems and components into an overall building system utilizing industrialized production, transportation, and assembly techniques.

For the housing industry, MiC is a revolutionary technology with manifold benefits. Richard (2006a) demonstrates how MiC generates industrialized (ability to amortize a process capable of simplifying the production and reaching a high level of quality); flexible (ability to accommodate functional changes over time and in the space without destroying partitions and/or external walls); and demountable (capability of meeting the needs for reconfiguration or even relocation without demolition) housing systems. The primary benefits and advantages of MiC include speedy construction, improved certainty of cost (Blismas et al., 2006), attractive design, improved and controlled quality, flexibility of use, lower impact on continuity of business (Modular Building Institute, 2017), reduced community disturbance, reduced construction waste (Jaillon et al., 2009) and lower carbon emissions (Mao et al., 2013). Based on the opinions of MiC clients in the UK (Gibb and Isack, 2003), Table 1 shows the benefits of the technology.

There are several ways in which MiC could offer a lasting solution to the quality mass affordable housing needs of Ghana. Firstly, the manufactured modular components are not merely construction products but systems and processes where the modular buildings are houses in boxes (Alderton, 2019). The modular building components are prefabricated volumetric boxes on an assembly line in a factory which are then transported to a job site for final assembly and installation. The speedy construction associated with MiC has positive implications on the cost and affordability of the housing systems.

Table 1. Benefits of MiC based on the opinions of clients in the UK

Benefit	Descriptions
Time	Less time on construction site – speedy construction *
	Speed of delivery of product
	Less time spent on commissioning
	Guaranteed delivery, more certainty over the programme, reduced management time
Quality	Higher quality – on the construction site and from factory
	Products tried and tested in factory
	Greater consistency – more reproducible
	More control of quality and consistent standards
Cost	Lower cost *
	Lower preliminary costs
	Increased certainty and less risk
	Increased added value
	Lower overheads, less on-site damage and less wastage
Productivity	Includes less snagging
	More success at interfaces
	Fewer site disruptions
	Reducing the use of wet trades
	Removing difficult operations
	Products work the first time
	Work continues on-site independent of the off-site production
People	Fewer people on-site
	People know how to use products
	Lack of skilled construction workforce and labour
	Production off-site is independent of local labour issues
Environment	Less construction waste*, lower resources consumption
	Lower water footprint
	Less greenhouse gas emissions, lower embodied carbon*
	Lower energy footprint

Note: * *indicates a high incidence (Gibb and Isack, 2003)*

The 30-70% reduced construction time translates into faster solvency for developers and cost-effectiveness for housing authorities. Accepting time as a driver of costs, the speedy construction results in quality affordable housing owing to the controlled factory condition (Alderton, 2019). Secondly, MiC supports mass customization and housing production. Coupled with the speedy construction, MiC is highly elastic to the mass housing demand because supply could be increased within a shorter period. This attribute of MiC has a moderating effect on rent and a ripple effect on the wider housing market. Alderton (2019) noted that rents plateaued at the upper end of San Francisco's housing market owing to the elasticity of supply using MiC. On the ripple effect, Alderton (2019) reported that increased housing supply deflated luxury housing rental bubbles which resulted in increased affordability, lower competition, and cost for middle-income housing and reduced pressure on the residential market. Finally, increased efficiencies due to the repetitive and quicker learning curve associated with MiC facilitates the mass production of affordable housing by housing authorities. Although more does not necessarily mean better as quality may be compromised in mass affordable housing, MiC can generate quality mass affordable housing. Despite benefits and promises of MiC in meeting the housing needs of Ghana, there are some barriers which may hinder the strategic application of the technology in the country (e.g. insufficient expertise, higher capital costs, absence of design codes and standards, and diseconomies of scale). Some potential barriers are explained in later sections.

RESEARCH DESIGN AND APPROACH

The paper adopted a qualitative research design where the authors have established strong support for the adoption of MiC to deliver IHS in Ghana. The research deployed a comprehensive methodological framework comprising the definition of the research problem, literature retrieval and analysis, qualitative data synthesis, case study analyses, and discussion of findings (Figure 1).

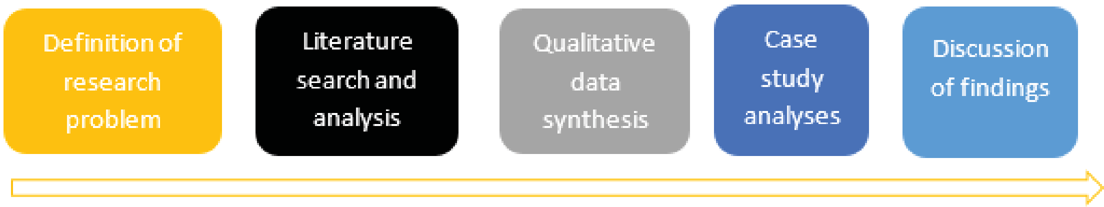

Figure 1. Methodological framework of the research

In making the compelling case, the paper relied heavily on literature review as a methodology and case studies to demonstrate the feasibility of using MiC to quickly generate mass affordable housing. Based on journal articles, conference paper, technical reports, and authoritative policy documents, the paper highlighted the housing needs of Ghana, drew lessons from previous industrialized housing systems and prefabricated construction, provided an overview of MiC, and identified the prevailing favorable opportunities in Ghana which support the adoption of MiC. The paper further described two case studies which deployed MiC to meet the need for quality, affordable and timely housing. The case studies served as demonstration projects to highlight the feasibility of using MiC to deliver IHS in Ghana. The two case studies were purposively sampled because they constitute some of the most successful MiC initiatives in Ghana. Drawing on empirical industry surveys in other developing countries such as China and Malaysia, the paper further documented the potential barriers to the adoption of MiC in Ghana and proposed a multi-stakeholder framework for MiC implementation in Ghana.

FINDINGS AND DISCUSSIONS

Opportunities for MiC and Industrialized Housing Systems in Ghana

Although industrialized housing initiatives failed in Ghana and many other countries in the past, the last few decades witnessed a renaissance and reinvigorated promotion of MiC as a practical and feasible technology for meeting the rapidly growing housing shortfall (Arif and Egbu, 2010; Gibb and Isack, 2003). Like the favorable conditions in other developing countries such as China and Malaysia, there are some opportunities which are congenial for the implementation of MiC and IHS in Ghana, viz-a-viz the lessons from the previous prefabricated construction failures.

Improved infrastructure and manufacturing power in Ghana

The success of the 20th century's prefabricated housing in some developed countries was fuelled by the existence of social infrastructure, substantial industrialization and structured housing industries (Essienyi, 2011). The absence of these factors which hindered the success of the 1952 and 1978 industrialized housing initiatives Ghana have been improved. There is reliable supply cement to feed modular production industry, improved transport systems in the major cities, the improved housing sector, availability of cranes and lifting equipment, and substantial manufacturing power to support the MiC technology in Ghana (Mulgrew, 2017). For instance, of four international branches, Ghana has the biggest housing manufacturing plant located in the Tema free zone operated by the Red Sea Housing Services Department (Red Sea International Company, 2018). Following its establishment in 2004, the Tema manufacturing facility has an annual production capacity of 285, 600 km2. The housing manufacturing plant produces Composite PVC panels, Sandwich panels, Steel containers and Roughneck in larger quantities (Red Sea International Company, 2018). The Housing Services Department of Red Sea International Company delivers innovative housing solutions to African and South American countries using its fast and effective logistics (ibid). These and many other manufacturing plants are critical success factors which could support the effective deployment of MiC in Ghana.

Existence of prefabricated construction market in Ghana

According to Essienyi (2011), mass production of modular components together with a developed market for the produced modules over the number of amortized years of the colossal capital investment are required for the profitability and success of MiC.

Table 2. List of some Prefabricated Building Construction Companies in Ghana

Name of company	Location	Name of company	Location
Red Sea International Company	Tema	Mammut Building Systems	Accra
Karmod Prefabricated Technologies	Accra	Mabani Steel	Tema
Asanduff Group of Companies	Accra	Atlantis Structures Ltd.	Tema
Hilton Inc.	Accra	Mcfar Structures Gh. Ltd.	Accra
Trasacco Estates Development Company Ltd.	Accra	WAC Properties Ltd.	Airport City
Independence Properties Ltd.	Accra	Eureka Engineering Structures	Accra
Isopanel	Tema	Brand Source Group	Accra
Inhabitat	Accra	Red Sea Housing Services	Tema
ITALCONSTRUCT International Ltd.	Tema	Cemboard Modular Housing Ltd.	Accra
Penta Build Ltd.	Accra	CLOTAN STEEL (PTY) LTD	Accra
Dala Steel Industries Ltd.	Tema	IGNIS CONSTRUCTION	Accra
Run On Time Engineering	Takoradi	FALCON Group (Ghana) Ltd	Accra
ABM Structures Ltd.	Accra	Zamil Steel	Accra
Takoradi Steel Co. Ltd.	Takoradi	Ebaco International Ltd.	Accra
Metalin Engineering Ltd.	Accra	Forever Construction and Consultancy Limited (FCCL)	Accra

Though there is no available official account of the prefabricated construction market in Ghana, anecdotal evidence suggests that there are increasing numbers of prefabricated building construction companies (PBCCs) in the country. Table 2 shows some PBCCs in Ghana. Of 223 prefab homes Ghana products offered by Jack Ma's Alibaba, 56% of them are prefabricated houses. Mainland China together with

142 prefab homes Ghana suppliers located in Asia currently supplies 100% of prefabricated homes to Ghana. Although the list (Table 2) is not exhaustive, the existence of at least 30 PBCCs in Ghana suggests that MiC is gaining increasing attention in the country. It is also an indication that MiC recognized as a modern construction technique and a potential technological solution to housing delivery in Ghana.

Given that these companies exist even though MiC is not explicitly recognized in the national housing policy suggest that there is a growing MiC supply market in Ghana which can be improved.

Government recognition of innovative housing projects and financing schemes
The use of MiC to deliver industrialized housing systems is an innovative technology which engenders significant changes to entrenched construction practices and conventions (Smith, 2016). Owing to the long-standing conservative mindset of the construction industry towards innovation and the higher initial capital requirements of MiC (Blismas et al., 2006), governments have been at the forefront of the industrialized construction paradigm. Typically, government recognition and financing are critical success factors (CSFs) for early stages of MiC (Jaillon et al., 2009). Consistent with these CSFs, the Ministry of Works and Housing (Ghana) recently extolled Forever Construction and Consultancy Limited (FCCL) for its affordable housing scheme involving two semidetached housing projects at Tsopoli-Agotor within the new proposed Airport site (Sam, 2019). The scheme deployed IHS to construct houses within a shorter time span and was recognized as a useful technology for meeting housing needs. Additionally, the United Nations Office for Project Services (UNOPS) under the Social Impact Investment Initiative (S3i) signed a deal with the government of Ghana in 2019 to deliver at least 100,000 affordable houses nationwide to be constructed using innovative technologies and local materials (United Nations Office for Project Services (UNOPS), 2019). This project is expected to last for 6 to 10years at a gross development cost of $5.3 billion. Given that this project will deploy innovative housing systems, it offers a useful basis for making strong support for the adoption of MiC in Ghana.

Availability of wealth of experiences, lessons and MiC best practices
Although the post-war prefabricated housing projects failed in many countries, especially in the third world economies (Essienyi, 2011), countries such as Sweden, the Netherlands, Singapore, Canada, UK, USA, Australia, and Germany have sought to overcome the post-war prefabricated housing stigma and reinvigorated the IHS. They have succeeded in achieving substantial progress in MiC implementation within the 20th and 21st centuries. Noteworthy developing countries making similar efforts include China and Malaysia (Jiang et al., 2017; Kamar et al., 2014). Notably, the Construction Industry Development Board (CIDB) of Malaysia implemented the 2003 – 2010 and 2011 – 2015 Industrialized Building Systems Roadmaps with concomitant revisions to the building codes, regulation, and permits to support and promote the uptake of the MiC technology in the country (Kamar et al., 2014). Similarly, the Chinese government under the National New Urbanization Plan 2014-2020 developed roadmaps and strategies to promote the uptake of MiC in the country (Jiang et al., 2017). With the increasing availability of exemplary projects, MiC is resisting all barriers and gaining increasing application in these countries. Thus, Ghana may learn from the existing wealth of experiences,

lessons and MiC best practices to guide and improve the success of MiC implementation in the country. This paper draws on a full-time Ph.D. research project which seeks to develop a best practice framework for implementation of MiC in Ghana.

High-profile MiC Cases in Ghana

Case 1: Limavady Firm's Modular Housing in Ghana

In 2017, the Government of Ghana sought international delivery and financing initiatives to tackle the growing housing shortage. Mass affordable housing was recognized as a potential panacea to the crisis. As such, a Northern Irish Firm; FastHouse based in Limavady, Co. Londonderry specialized in mass housing and infrastructure delivery conducted an MiC demonstration project in Ghana. The Irish Company recognized that the housing deficit in Ghana has both physical and economic dimensions. It was understood that a practical solution was to construct affordable houses within a shorter time span to outrun the spate of the deficit. As there are already housing developers in Ghana, the Irish company sought to be competitive and responsive in terms of cost, time, quality, and sustainability. FastHouse arrived at a conclusion that MiC is the technology to achieve a competitive advantage in all the adumbrated objectives. Consistent with the assembly line manufacturing technique popular in the automobile sector, MiC offered the firm with fast response time and the most cost-effective means of manufacturing mass houses at lower competitive prices using economies of scale. As such, FastHouse started a joint venture with Tradezone International Ghana Ltd to utilize "its offsite construction technology to manufacture housing from its Limavady facility, before being transported to Ghana for assembly" (Mulgrew, 2017). Using MiC as rapid building system of house construction, FastHouse put together a complete home in 15 days (Mulgrew, 2017). The demonstration project resulted in a 70% reduction in construction time. Again, the controlled factory environment associated with MiC resulted in improved health and safety standards, reduced waste and improved house quality (Mulgrew, 2017).

Case 2: Hilton Inc.'s First Modular Hotel in Africa: Hilton Garden Inn Accra

During the African Hotel Investment Forum (AHIF) in 2016, Hilton Worldwide Holdings Inc. declared the company's commitment to increase its footprint from 39 hotels in the continent to 80 hotels in the next 3-5years (Sturman, 2016). The multinational American hospitality company further revealed it First Africa's Modular Build Hotel; a 280 guest-room known as Hilton Garden Inn in the capital city (Accra) of Ghana. With over 50 years of driving hotels and resorts growth in Africa, Hilton Inc. wanted an innovative speedy construction technology, streamlined design and cost efficiencies, quicker return on investment and world-class hospitality hotel experience for guests in Ghana. As such, MiC was found to be capable of delivering such multifaceted project objectives. Hilton Inc. partnered with China International Marine Containers, CIMC (Group) LTD. The CIMC Modular Building Systems Holdings Co. Ltd. transported the partially assembled guest rooms and hallways from China to Accra for final installation and completion at the construction site (Sturman, 2016). The modular solution reduced the construction time, construction risk, ensured consistent quality of rooms, accelerated the building schedule on site and offered a quicker return on investment. It was expected to be opened in 2018 under the management of Independence

Properties Ltd whose major shareholder is Trasacco Estates Development Company Ltd. Although this project is a hotel project, it demonstrates the feasibility and potential of MiC and industrialized housing systems in Ghana.

Potential Barriers to the Adoption of MiC in Ghana

Although there are greater potentials in deploying MiC and IHS to rescue the housing crisis in Ghana, there are also potential barriers, constraints, challenges and risk factors which may hinder the adoption of MiC. Table 3 shows some of the most reported barriers to the adoption of MiC in developing countries (Kamar et al., 2014; Mao et al., 2014; Zhang et al., 2014). Although these barriers were identified in China and Malaysia, they are also widely reported in developed countries. As such, they will most likely be applicable to the Ghanaian context. In the absence of bespoke studies on the barriers to the adoption of MiC in Ghana, Table 3 summarizes some potential challenges which may be confronted in the implementation of MiC.

Table 3. Latent Barriers to the Adoption of MiC in Ghana

Barrier	Factor descriptions
Industry structure and supply chain	Fragmented industry structure
	Resistance from customers and professionals
	Lack of experience and knowledge on MiC from local projects
	Lack of local MiC designers, manufacturers, suppliers, and contractors
	Total dependence on traditional construction methods and entrenched practices
	Negative historic stigma associated with post-war prefabricated housing
Technological Innovation	Reluctance to change entrenched practices and pursue innovation
	Lack of technology and testing equipment for modular equipment
	Insufficient mobile cranes, and lifting equipment
	Inadequate hoist equipment capacity
Policies and regulations	Absence of a legal framework
	Lack of design codes and standards for modular components
	Lack of explicit government support, regulations and incentives
	Lack of bespoke modular construction guidance and information
	Complex code compliance and inspection process
Cost and investment	Higher initial capital cost and investment
	Higher cost pressure without immediate economies of scale
	Longer period required to realize break-even point
Market	Uncertain market demand for modular projects
	Complex supply chain structure
	Modular manufacturing capacity and quality uncertainties
	Absence of reliable local modular components manufacturers

Typically, the lack of substantial experience with MiC coupled with the failure of previous industrialized housing systems initiatives will trigger scepticism and reluctance among clients and professionals (Wuni et al., 2019). Additionally, there is currently no explicit MiC implementation framework at the national level in Ghana. Thus, there are no bespoke modular construction guidance and information, design codes and standards for modular components, and explicit government support or incentives. Besides, the higher initial capital requirement associated with MiC will make it impossible for the small-to-medium construction enterprises to fully implement the technology in projects without financial support. Though there are several PBCCs in Ghana (Table 2), the market (demand side) for MiC and industrialized housing systems is surrounded with uncertainties. Meanwhile, the absence of reliable local modular components manufacturers and a lack of well-established market demand for modular projects constitute potential barriers to the implementation of MiC (Kamar et al., 2014; Mao et al., 2014; Zhang et al., 2014).

Conceptual Framework for the Implementation of MiC in Ghana

MiC is a disruptively innovative technology in the construction industry (Wuni and Shen, 2019a). The adoption and implementation of MiC in Ghana is a classical problem of innovation diffusion. According to the innovation diffusion theory, the five stages of the innovation adoption process included knowledge, persuasion, decision, implementation, and confirmation (Rogers, 1983). Based on the knowledge of the potential barriers to the adoption of MiC, the feasibility of industrialized housing systems and the prevailing favorable opportunities for MiC in Ghana, a conceptual framework is proposed to enhance the decision to implement MiC. The framework grossly clusters the MiC stakeholders into government, industry practitioners, researchers, and clients. The framework also emphasizes the critical role of policymakers in MiC implementation because government spearheads the MiC revolution in Sweden, UK, China (including HKSAR), Singapore, Canada, Malaysia, among others (Wuni and Shen, 2019b).

Similarly, the implementation of MiC (Figure 2) must be driven by government and supported by other stakeholders. The government of Ghana is responsible for public or social housing and if MiC is to be deployed to deliver mass affordable housing, the government must explicitly recognize the technology, develop a legal framework to guide its implementation and provide leadership by undertaken demonstration projects. The government should create financial support and incentives for private developers to adopt the technology and secure long-term financing models such as public-private partnership to sustain the housing production process. Since MiC is largely an innovation in the Ghanaian construction sector, there is less expertise available to champion its excellence. As such, both government and industry practitioners (e.g. GREDA) must collaborate to provide relevant MiC knowledge to contractors, developers, architects, engineers, manufacturers etc. through training programs.

Industry practitioners need to establish MiC implementation teams and expertise towards establishing a positive attitude about MiC and encouraging standardization to improve MiC projects' quality and productivity. Researchers in Ghana must have to collaborate with researchers in countries with developed MiC technologies to generate bespoke information in Ghana to guide the MiC policy discourse. They will also need to develop best practice frameworks for implementing MiC in Ghana to minimize project failures and may also develop Aristotelian rhetoric strategies including Ethos, Logos, and Pathos as persuasive discourse mechanisms to be deployed by actors in diffusing MiC into the construction industry. Finally, industry practitioners would need to work closely with clients to ensure that the latter are convinced to adopt MiC solutions in their construction projects.

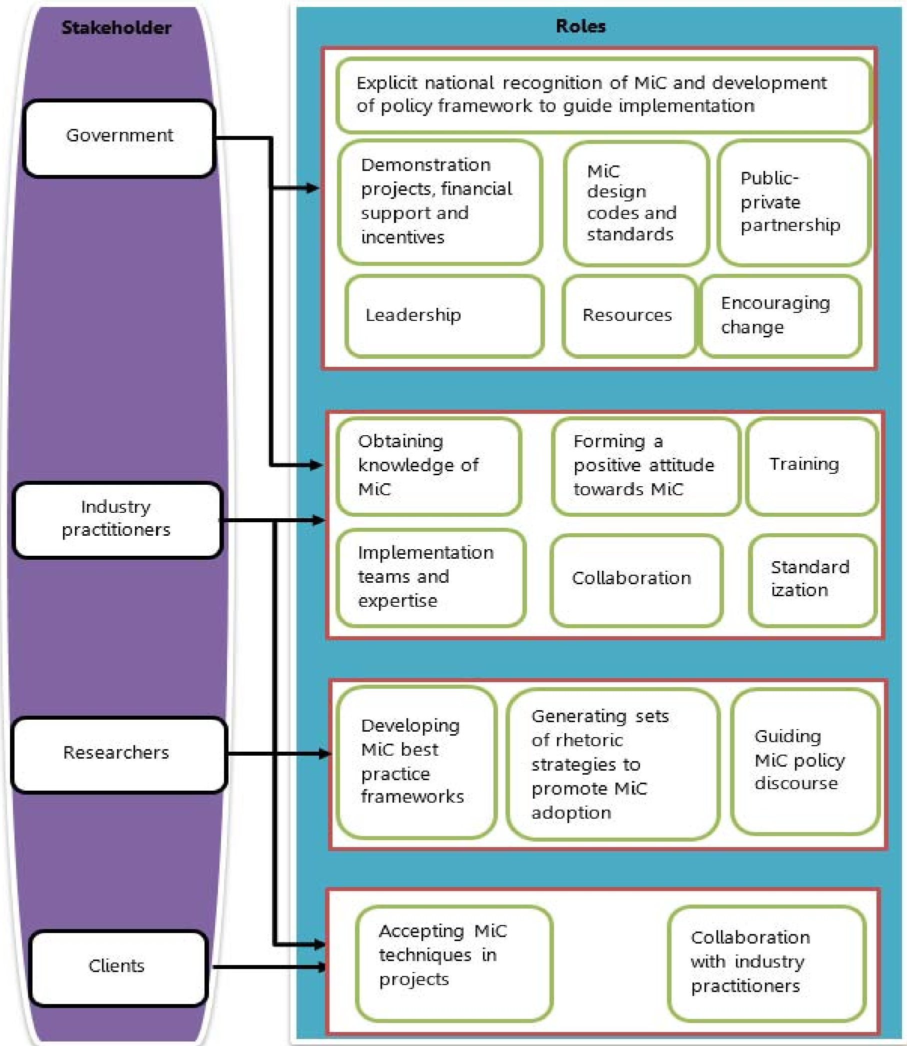

Figure 2: Multi-stakeholder framework for MiC implementation in Ghana

CONCLUDING REMARKS

The housing crisis in Ghana is associated with the combined physical housing deficit and the inability of many citizens to rent or purchase the available houses in the market. The affordability crisis is a product of the severe gap between wages and rents for the low- and middle-income families which have created a housing hardship of epic proportions. In addition, the rising shortfall in the supply of actually affordable housing overwhelms the traditional construction approach. Based on the experiences in many countries, modular integrated construction has proven to be capable of delivering quality affordable mass housing to match the pace of increasing shortfall. Drawing on literature review as a research methodology, this research found that the failures of the prefabricated housing construction initiatives in Ghana in the 50s and 70s were due to the lower level of industrialization, absence of well-defined housing market, poor infrastructure network, and less developed construction sector. It is further found that the implementation of industrialized housing systems in then Gold Coast was ill-informed and did not recognize the lower level of industrialization and the dominant self-build and incremental building models in the country. However, the presence of opportunities such as improved infrastructure and manufacturing power, the existence of prefabricated construction market, government recognition of innovative housing projects in Ghana and the available wealth of MiC experiences, lessons and best practices in other countries provide a useful reference for the implementation of MiC and IHS in Ghana. The research, however, found that the lack of MiC expertise, absence of policy framework, higher initial capital cost and the cloudy market for industrialized housing systems constitute potential barriers to the adoption of MiC in Ghana. Whether MiC will succeed as a panacea to the housing deficit in Ghana remains to be seen. However, for the housing ordeals and plights of the low- and middle-income households in Ghana, the government, developers and industry practitioners must give the technology a chance. As a unique contribution to policy discourse, the paper proposed a multi-stakeholder framework for implementation of MiC in Ghana. However, the authors recommend that the choice of modular option and solution to be implemented in Ghana must be informed by the prevailing conditions, dominant income levels of the homeless, political climate, dominant house building models, level of industrialization and the capacity of the available social infrastructure to support the technology. Thus, the paper contributes to the policy discourse in seeking a lasting solution to the housing deficit in Ghana and initiates a debate for rethinking housing supply in Ghana and West Africa.

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