DEVELOPING A MODEL FOR BRIDGING THE GAP BETWEEN SUSTAINABLE HOUSING AND AFFORDABLE HOUSING (LOW-COST HOUSING) IN THE GHANAIAN HOUSING MARKET

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Developing a Model for Bridging the Gap Between Sustainable Housing and Affordable Housing (Low-Cost Housing) in the Ghanaian Housing Market

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CERTIFICATE OF ORIGINALITY

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DEDICATION

I dedicate this thesis to the Almighty God, my family and friends.

ABSTRACT

Approximately over a billion of the world's urban population do not have access to adequate housing and therefore live in slums and squatter buildings. Most of these victims of homelessness and inadequate access to housing are low-income earners. While policy makers such as the United Nations (UN), World Bank and most governments have acknowledged the importance of housing as a basic right aside its economic benefits to every nation, this acknowledgement is yet to be translated into effective policies to mitigate the global housing affordability crisis.

Review of extant literature shows that besides inadequate policies from governments to improve housing supply, most developers in the housing sector still consider housing supply to low-income earners as an uninviting business segment due to risks and barriers. On the demand side, the limited low-cost housing facilities that are supplied are mostly unsatisfactory in meeting the true needs of the targeted household, which often leads to housing overhang. Considering these supply and demand challenges and the fact that Africa is the most urbanizing continent, Africa's housing affordability crisis demands the utmost attention. As such, there is a need for low-cost housing that meets the needs of the present and future generations while ensuring optimum economic, social and environmental balance. Though studies have been conducted on affordable or low-cost housing provision, ensuring sustainability attainment in such facilities remains a topical issue in most African countries and the world at large. Therefore, bridging the gap between affordable housing and sustainable housing is germane.

This study seeks to develop a model for bridging the gap between sustainable housing and affordable housing (SAH) using Ghana as a case study. To achieve this aim, five objectives were set, namely, (1) identify critical success criteria (CSC) for sustainable affordable housing

(SAH) development in Ghana; (2) determine critical risk factors (CRFs) to sustainability attainment in affordable housing (3) identify critical barriers to sustainability attainment in affordable housing; (4) identify critical success factors (CSFs) for sustainability attainment in affordable housing; and (5) develop a model for SAH in the Ghanaian housing market.

To this end, a comprehensive literature review was first conducted followed by questionnaire surveys among construction professionals with experience in affordable housing or public housing or low-cost housing and sustainable housing. To pilot test the questionnaire, a broader survey was first conducted among international housing professionals and some professionals from the Ghanaian housing market. Subsequently, the main questionnaire survey was carried out among professionals in the Ghanaian housing market. The garnered data were analyzed using quantitative techniques. Concerning critical success criteria (CSC) for SAH, results of the survey revealed that 'quality performance' was ranked the highest followed by the indicator 'end users' satisfaction'. 'Price affordability' was ranked third while 'maintainability of housing facility (maintenance cost)' and 'rental affordability' were ranked fourth and fifth, respectively. However, 'reduce occurrence of disputes and litigations' and 'technology transfer' were ranked relatively low.

On modelling the CSC for sustainability assessment of affordable housing, the fuzzy model showed that 'household-satisfaction' (with a sustainability index = 26.3%) has the highest contribution to the overall sustainable development in housing, followed by 'housing and transportation' (H+T with a sustainability index = 25.3%), then 'quality-related' (sustainability index=24.9%) and 'efficient stakeholder-management' (sustainability index = 23.6%). This model does not only aid policymakers to objectively and comprehensively assess sustainability performance in affordable housing but it also serves as a baseline for calibrating future projects and for benchmarking success levels of comparable housing projects.

Concerning risk factors to SAH, 30 risk factors were established and grouped into five categories, namely, 'political-related risk', 'financing-related risk factors', 'procurement-related risks factors', 'design & construction related risk factors' and 'operation and maintenance risk factors'. The five topmost risk factors identified include: 'delay payments by governments / clients', 'fluctuation in exchange rate', 'fluctuating financing cost', 'cost overruns' and 'risks associated with land acquisition'. On barriers to SAH, 'high interest rates', 'high upfront cost of materials and technologies', 'high cost of serviced land', 'policy instability on housing / abandoned public housing facilities or projects by succeeding government' and 'inadequate incentives for private investors' were the top five critical barriers to SAH. Confirmatory factor analysis revealed that 12 underlying barriers were successively loaded into 'cost-related barriers', 'incentive-related barriers' and 'retrofit-related barriers'. Partial Least Square Structural Equation Modelling (PLS-SEM) analysis on the impact of barriers on SAH showed that 'incentive-related barriers' have medium effect size (0.192) on 'sustainable housing' while 'retrofit-related barriers' have high effect size (0.430) on 'sustainable housing'. Furthermore, 'incentive-related barriers' have a significant impact on 'retrofit-related barriers'. 'Cost-related barriers' only had a significant impact on 'incentive-related barriers'. Accordingly, 'cost-related barriers' are secondary barriers to sustainable housing. Besides, adequate incentives for a holistic retrofit of existing housing facilities could yield greater impact on sustainable housing.

Regarding critical success factors (CSFs) for SAH, the five top CSFs include 'political will and commitment to SAH'; 'access to low-interest housing loans among developers'; 'improved supply of low-cost developed land by government'; 'use of environmentally friendly materials for construction'; 'adequate accessibility to social amenities / improved accessibility'. Through confirmatory factor analysis, 14 CSFs were successively loaded into 'developers' enabling factors', 'household enabling factors', 'mixed-used development factors' and 'land-use planning factors'. The PLS-SEM revealed that only 'developers' enabling' and 'mixed-use development' success factors are significant for sustainable housing. Though 'household-enabling factors' had no significant impact, they have high performance / index value on sustainable housing. Moreover, there was no significant impact regarding the 'land-use planning factors'. For significant impact on sustainable housing through 'household enabling factors', essential policies include: monitoring housing conditions / performance for retrofitting; efficient allocation of subsidies and adaptable housing design. Policies targeting utility subsidies could be pro-poor. Sustainable housing through 'land-use planning' could be achieved if the delivery of land among family heads, chiefs, skins and Wulomei is regulated while the Land and Spatial Planning Authorities are adequately provided with financial and human resources to strictly execute their duties.

Results of the various objectives were integrated to develop a model for SAH. The developed model was subsequently validated by selected professionals in the Ghanaian housing market. Essentially, the study findings could inform decision makers on the potential risk factors, barriers and the possible strategies for sustainable housing. Besides, findings of the study seek to apprise policymakers of the indicators that are relevant for defining the scope of SAH in the Ghanaian housing sector. In general, the findings could be essential to other African countries that have similar socio-economic characteristics as pertaining to Ghana's, while providing the basis for further empirical studies in Ghana and beyond.

Keywords: Public Housing; Affordable Housing; Low-cost Housing; Criteria; Sustainable Housing; Assessment criteria; Indicators; Risks; Barriers; Success Index; PLS-SEM; Ghana

LIST OF RESEARCH PUBLICATIONS

The following are a set of research publications that the author of this thesis published during his Ph.D. study, and, as shown within the text, chapters of this thesis have been fully or partially published in those that are directly relevant to this thesis.

A. Refereed Journal papers (Published / Accepted)

1. **Adabre, M.A.** and Chan, A.P.C. (2018). The ends required to justify the means for sustainable affordable housing: A review on critical success criteria. *Sustainable Development*, 26, 1-14.

2. Chan, A.P.C., & **Adabre, M. A.** (2019). Bridging the gap between sustainable housing and affordable housing: The required critical success criteria (CSC). *Building and Environment*, *151*, 112-125.

3. **Adabre, M. A.**, & Chan, A. P. C. (2019). Critical success factors (CSFs) for sustainable affordable housing. *Building and Environment*, *156*, 203-214.

4. **Adabre, M. A.,** Chan, A.P.C., Darko, A., Osei-Kyei, R., Abidoye, R., & Adjei-Kumi, T. (2020). Critical Barriers to Sustainability Attainment in Affordable Housing: International Construction Professionals' Perspective. *Journal of Cleaner Production*, 119995.

5. **Adabre, M.A.,** and Chan, A.P.C. Towards a Sustainability Assessment Model for Affordable Housing Projects: The Perspective of Professionals in Ghana. *Engineering, Construction and Architectural Management.* Manuscript ID: ECAM-08-2019-0432.R1.

6. **Adabre, M.A.,** and Chan, A.P.C. Forthcoming. Modelling the Impact of Barriers on Sustainable Housing in Developing Countries. *Urban Planning and Development.* 10.1061/ (ASCE)UP.1943-5444.0000639

7. **Adabre, M. A.,** Chan, A. P., & Darko, A. (2021). A Scientometric Analysis of the Housing Affordability Literature. *Journal of Housing and the Built Environment*, 1-33.

8. **Adabre, M. A.,** Chan, A. P., Edwards, D. J., & Adinyira, E. (2021). Assessing Critical Risk Factors (CRFs) to Sustainable Housing: The Perspective of a sub-Saharan African Country. *Journal of Building Engineering*, 102385.

B. Refereed Journal Papers (Under Review)

1. **Michael, A.A.** and Chan, A.P.C. To Build or Not to Build, that is the Uncertainty: Risk-Assessment for Sustainable Housing Supply in Cities of a Developing Country. *Cities.* Manuscript ID: JCIT-D-21-00463

C. Refereed Journal Papers (Pending Submission)

1. **Adabre, M.A.,** and Chan, A.P.C. A Sustainable Housing Model for Sustainable Cities: The Perspective of a sub-Saharan African Country.

2. **Adabre, M.A.,** and Chan, A.P.C. A Fuzzy Synthetic Evaluation of Barriers to Sustainable Housing in the Case of a Developing Country – Ghana

3. **Adabre, M.A.,** and Chan, A.P.C. Modelling the Impact of the Quadripartite Categories of Barriers on Sustainable Housing: The Case of Ghana

D. Refereed Conference Papers

1. **Adabre, M.A.,** and Chan, A.P.C. Success Factors (SFs) for Sustainable Affordable Housing: A Review Study. *CIB World Building Congress 2019 Hong Kong*.

2. **Adabre, M.A.,** and Chan, A.P.C. Critical Barriers (CBs) to Sustainable Affordable Housing (SAH): Views of Experts from Developing and Developed Countries. *Sustainability and Development Conference 18 October 2019, Michigan, United States of America*

3. Osei-Kyei, R., Chan, A. P., De-Graft, O. M., **Atafo, A. M.**, & Ameyaw, E. E. (2019). Public-private partnership for affordable housing delivery in Ghana: experience of the Ghana National Housing Project and policy implications. In *Proceedings of the 43rd Australasian Universities Building Education Association (AUBEA) Conference: Built to Thrive: Creating Buildings and Cities that Support Individual Well-being and Community Prosperity, 6-8 November 2019, Noosa QLD, Australia* (pp. 26-39).

E. Conference Pending (Abstracts have been submitted)

1. **Adabre, M.A.,** and Chan, A.P.C. Towards a Sustainability Assessment Model for Affordable Housing Projects: The Case of Developed Countries. *Housing Culture, Environment and Urban Development, 10-13 August 2020, Malaysia*

2. **Adabre, M.A.,** and Chan, A.P.C. Assessing the Effectiveness of Success Factors for Sustainable Housing in the Case of a Developing Country – Ghana. *15th International Housing and Home Warranty Conference (IHHWC), Building Homes for Tomorrow, 20th to 25th September 2020, Ireland.*

3. **Adabre, M.A.,** and Chan, A.P.C. A Fussy Synthetic Evaluation on Barriers to Sustainable Housing in the Case of a Developing Country – Ghana. *44th Annual Conference of the Australasian Universities Building Education Association (AUBEA), 28-30 October 2020, Australia.*

F. Refereed Journal papers (Published / Accepted) for which I co-authored

1. Darko, A., Chan, A. P., **Adabre, M. A.,** Edwards, D. J., Hosseini, M. R., & Ameyaw, E. E. (2020). Artificial intelligence in the AEC industry: Scientometric analysis and visualization of research activities. *Automation in Construction*, *112*, 103081.

2. Abidoye, R. B., Puspitasari, G., Sunindijo, R., & **Adabre, M.** (2020). Young adults and homeownership in Jakarta, Indonesia. *International Journal of Housing Markets and Analysis*.

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CHAPTER 1: INTRODUCTION[1]

1.1 INTRODUCTION

Housing is a basic human need as well as a human right, and it plays a significant role for individual's and national development (Salvi Del Pero et al., 2016). To the individual, it improves their living conditions and increases their stake in their community (Shadiya et al., 2015). To a nation, housing plays a monumental role in tackling poverty and promoting social mobility (McKee, 2012). Conversely, lack of access to housing is related to negative externalities such as social exclusion, poor educational outcome of children and poor access to normal health and housing services (Salvi Del Pero et al., 2016). Therefore, ensuring affordability of housing remains a priority to all governments (Golubchikov and Badyina, 2012).

Affordability is concerned with securing some given standard of housing at a given price or rent which does not impose in the eye of a third party (usually government) an unreasonable burden on household incomes. Studies on economic criteria for assessing affordability have

[1] This chapter is largely based upon the following publications:

Adabre, M.A. and Chan, A.P. (2018). The ends required to justify the means for sustainable affordable housing: A review on critical success criteria. *Sustainable Development*, 26, 1-14.

Chan, A. P., & Adabre, M. A. (2019). Bridging the gap between sustainable housing and affordable housing: The required critical success criteria (CSC). *Building and Environment*, *151*, 112-125.

Adabre, M. A., & Chan, A. P. (2019). Critical success factors (CSFs) for sustainable affordable housing. *Building and Environment*, *156*, 203-214.

Adabre, M. A., Chan, A. P., Darko, A., Osei-Kyei, R., Abidoye, R., & Adjei-Kumi, T. (2020). Critical Barriers to Sustainability Attainment in Affordable Housing: International Construction Professionals' Perspective. *Journal of Cleaner Production*, 119995.

Adabre, M.A., and Chan, A.P.C. Towards a Sustainability Assessment Model for Affordable Housing Projects: The Ghanaian Perspective. *Engineering, Construction and Architectural Management.* Manuscript ID: ECAM-08-2019-0432.R1.

Adabre, M.A., and Chan, A.P.C. Forthcoming. Modelling the Impact of Barriers on Sustainable Housing in Developing Countries. *Urban Planning and Development.* 10.1061/(ASCE)UP.1943-5444.0000639 received burgeoning attention amidst unresolved debates. The conventional price ratio criterion defines affordability in terms of the ratio of housing cost to incomes. Using this criterion, ***affordable housing is defined as that which does not exceed 30% of the income of household*** (Bodgen and Turner, 1993). However, according to Bogdon and Can (1997), the percentage of income measure of affordability does not account for actual pecuniary constraints confronted by individual households. Accordingly, affordability must encompass whether a household has enough income left over for other needs of life after paying for housing bills. If the household cannot meet its non-housing needs such as food, medical care and clothing at a minimum level of adequacy after paying for housing bill then the household is 'shelter poor' (Stone, 2006).

Therefore, as an improvement on the percentage of income measure, Stone (1994) suggested that the focus should rather be based on residual income after expenditure on housing is deducted, whether the residual income is enough to meet other expenses or basic needs. Consequently, Stone (2006) coined the term "shelter-poverty" which is an assessment of household income to cover cost of housing and non-housing costs, while ensuring that household maintains a decent living standard. Yet, these two affordability measures have a drawback. They do not control for the taste or preference of the household. So, another indicator such as "quality-based" measure has been proposed. Nevertheless, this approach has been criticized as being more difficult to compute and problematic to use as compared to the price-to-income approach (Bogdon and Can, 1997).

Though diverse criteria for measuring housing affordability exist, they all point to the same ubiquitous conclusion – there is a global housing stress or cost burden on middle and low-income earners. For instance, among OECD countries, 0.471% of the population were homeless in Australia in the year 2011. In the same year, the homeless population for Canada, Chile, Denmark and Ireland were 0.435%, 0.071%, 0.095% and 0.083%, respectively. In 2012, Hungary and Norway recorded 0.108% and 0.125% of the population as homeless while 0.200%, 0.357%, 0.006%, 0.222% and 0.347% share of the total population were homeless as recorded in the United States, Sweden, Japan, France and Germany, respectively (Golubchikov and Badyina, 2012). Though these percentages are small, they still represent a significant number of homeless people. For example, the estimates for Canada’s homeless population is 150,000 and that for the United States is almost 634,000 (Salvi Del Pero et al., 2016).

More severe affordability crises have been reported among developing countries such as India, Malaysia, China and African countries (Ram and Needham, 2016; Tan, 2012; Zou, 2014; Keivani and Werna, 2001). Urban slums in developing countries in 2010 were estimated at 199.5 million in sub-Saharan Africa; 190.7 million in Southern Asia; 189.6 million in Eastern Asia; 110.8 million in Latin America and the Caribbean; 88.9, 36, 11.8 and 0.6 million in South-Eastern Asia, Western Asia, North Africa and Oceania, respectively (Golubchikov and Badyina, 2012). In general, it has been estimated that the number of poor people living in slums and sub-standard housing in developing countries is 828 million. Speculations are that this number will rise to 1.4 billion by 2020 (Al-Saadi and Abdou, 2016; Desai, 2012). Moreover, the anticipation of the world’s population growth from 3.6 billion to 6.3 billion in 2050 implies the need for housing facilities to meet the present generation and future generations (Pullen et al.,2009; 2010).

Amidst the global affordability crisis, the situation in the African continent is growing worst. With an urbanization rate of 3.31%, Africa is one of the highest urbanizing continent in the world though it is currently the least urbanized (Obeng-Odoom, 2010; Cobbinah and Niminga-Beka, 2017). At this rate, it is estimated that by 2030, the urban population of Africa (748 million) will be higher than the total population of Europe (685 million). Besides, statistics shows that there is high level of poverty in both urban and rural areas in Africa, about 43% in urban areas and 59% in rural areas. Furthermore, with more than 50% of people classified as poor, sub-Saharan Africa is the world's highest regarding urban poverty (Obeng-Odoom, 2010). Housing is among the commodities that form a high proportion of household budget thereby worsen the poverty level in sub-Saharan African cities (Fuseini and Kemp, 2016).

Accordingly, many affordable housing policies have been initiated globally. However, whether the housing affordability of middle and low-income earners has been improved remains a debate. Though prior study by Stone (2006) has focused on the economic measure - price affordability - for accessing the success or improvement of housing policies, by solely focusing on the economic measure, real estate developers, planners, architects and governments have encountered challenges of low demand and abandonment of housing in the provision of affordable housing (Susilawati and Armitage, 2005; Adabre and Chan, 2018). For example, in a developing country China, it was stated that the average housing price-to-income ratio for many major cities was 10.2 in 2013, which situated China in a group of severely unaffordable housing market (Zhang et al., 2016). However, public rental housing which were less than 30% of market rents were abandoned by applicants in Shenzhen, Wuhan, Nanjing, Zhengzhou and Shanghai (Lin, 2012). Consequently, 90% vacancy rate was reported in the case of Shenzhen (Yuan et al., 2018). In Malaysia, a study indicated the need for affordable housing for low and middle-income earners (Abdul-Aziz and Kassim, 2011). Yet, affordable housing that were supplied to these income categories were left vacant leading to housing overhang (Teck-Hong, 2012). A Similar situation of housing abandonment has been reported in a developed country United Kingdom (Mulliner et al., 2013).

Some of these challenges could be common among most neoliberal economies in sub-Saharan Africa where self-built is mostly dominant. Affordable housing facilities that are developed in peri-urban areas could receive low-take up rate. A typical case of this is the Angola's Chinese-built ghost town. In Ghana for instance, "although 1,500 housing units, built under the Saglemi housing project, near Tsopoli in the Ningo-Prampram District in the Greater Accra Region have been completed, these units remained unoccupied almost two years after the facility had been inaugurated" (Graphic Online, 2018). Grant et al. (2019) described the potential fate of this housing project as a ghost city in the worst-case scenario, a similar fate of the Chinese-Angola ghost town. Furthermore, notwithstanding the housing crisis in a Ghanaian city – Kumasi, a study by Agyemang et al. (2018) revealed a low-social acceptability of high-rise apartment among households. In most of these cases, the low-take up rate of the houses were attributed to other criteria beyond price affordability. Thus, these paradoxes of housing needs amidst housing overhangs buttress the fact that not all that is affordable will meet the needs of potential households.

Moreover, the housing sector is the major energy consumer and contributor to the global greenhouse gas emissions. For example, heating and hot water provision among private households in Europe account for 40% of the total energy consumption and greenhouse gas emission (Lechtenböhmer & Schüring, 2011). In a developing country – Ghana – 54% of electricity is used to run homes (Asumadu-Sarkodie and Owusu, 2016). The resource consumption pattern of the housing sector has detrimental effects on the environment, the economy and the society. Left unbridled, the effects could be exacerbated. Through the adoption of appropriate sustainability practices, Lechtenböhmer & Schüring (2011) reported that about 80% reduction in energy consumption is attainable in building. Hence, the global demand for sustainable housing to improve the quality of life of middle and low-income households as well as to protect the environment is indispensable (Golubchikov and Badyina, 2012). Therefore, bridging the gap between sustainable housing and affordable housing is exigent. Furthermore, the global impact of the construction of housing facilities on the environment has necessitated the worldwide need for sustainability attainment in low-cost or affordable housing (low-cost housing).

1.2 SUSTAINABILITY ATTAINMENT IN AFFORDABLE HOUSING

Sustainable affordable housing (SAH) can be defined as ***"housing that meets the needs and demands of the present generation without compromising the ability of future generations to meet their housing needs and demands"*** (Pullen et al., 2010 p. 13). Various concepts such as 'low-carbon', 'zero-energy', 'green building' and 'high performance' have been used to describe sustainable housing. Households need SAH for health benefits, comfort and economic benefits from energy and water efficient technologies and reduced commuting cost / distance. Indeed, the lack of energy efficient technologies in the housing facilities of low-income earners means that some of these households incur higher utility bills relative to their income and ability to pay. Studies have espoused the triple-bottom-line (TBL) approach to explain the concept of sustainability. The TBL principle includes the social, economic and environment aspects of sustainable development (Yang & Yang, 2015). Thus, sustainable housing seeks to optimize the environmental, economic and social goals. Additionally, contemporary studies have advocated for an institutional or governance element as the fourth dimension to facilitate execution of sustainable housing.

1.2.1 Social sustainability

Social sustainability in affordable housing development can be defined as ***"development that is compatible with the harmonious evolution of civil society, fostering an environment that encourages social integration, with improvements in the quality of life for all segments of the population"*** (Polèse and Stren, 2000 p. 15-16). Besides, it entails the just distribution and consumption of housing resources (Trudeau, 2018). Bramley et al. (2006) indicated that it involves the overlapping concepts of social capital, social cohesion and social inclusion. Social capital includes the qualities of social organization such as networks, norms and trust which support co-operation for communal benefits. Social capital is essential for meeting the safety needs as well as preference and belonging needs of households (Trudeau, 2018). Concerning social cohesion, it refers to the need for a shared sense of morality and common purpose, social interaction within communities or families, a sense of belonging to a place and social solidarity and reductions in wealth disparities. Social inclusion ensures that individuals, families and neighbours have access to resources for efficient participation in the social, economic and political activities of a community.

1.2.2 Economic sustainability

Enhancing housing affordability of middle and low-income earners is one of the main objectives of affordable housing (Gan et al., 2017). Economic sustainability in affordable housing involves consideration of price / rental cost, cost of transportation and house operation cost (e.g. energy bills) (Chan and Adabre, 2019). Reduced operation and transportation costs prevent tradeoff in the budget of households to meet shelter needs to the detriment of meeting other basic needs (e.g. access to quality health care). Ultimately, for economically sustainable housing, households' residential take-up for such houses should be high (Pullen et al., 2010). Furthermore, economic sustainability should consider developers' needs for ensuring housing supply (Gan et al., 2017).

1.2.3 Environmental sustainability

Environmental sustainability involves matters relating to climate change and reduction of greenhouse gas emission. It ensures land use efficiency, energy efficiency, effective utilization of resources and reduction of greenhouse gas emission from housing facilities (Chan et al., 2017; Gan et al., 2017). It entails optimum land utilization strategies such as mixed-use development of land and compact development (i.e. high-rise development). These strategies ensure reduction of peri-urban land loss and reduced commuting distance of households to complementary facilities (i.e. healthcare centers, schools, markets, community centers), which could lead to reduction in vehicular emissions. Moreover, environmental sustainability requires the efficient utilization of materials to reduce wastage and to ensure circular economy (Adabre and Chan, 2020).

1.2.4 Institutional sustainability

It is predominantly argued that any analysis of sustainability issues needs to be connected to broader themes such as social, economic and environmental sustainability (Mulliner et al., 2013; Gan et al., 2017). However, by solely focusing on these three themes, the institutional / regulatory structure that is fundamental for attaining the three themes is often neglected. Thus, the development of SAH requires a more holistic understanding and convergent policy approaches along social, economic, environmental and institutional / regulatory goals (Sullivan and Ward, 2012). Institutional / regulatory sustainability entails policy actions that ensure sensitive planning controls and zoning that will encourage commitment to and participation in sustainable housing practices.

1.3 RESEARCH SCOPE AND PROBLEM STATEMENT

Among sub-Saharan African countries, Ghana is the targeted study area. Previously a British Colony named as Gold Coast, Ghana is surrounded by Burkina Faso on the north; Togo on the east; Côte d’Ivoire on the west and the Atlantic Ocean on the south (as shown in Fig. 1.1). With an estimated population size of 24,652,402 as of 2012, dominated by females (51%), the population density of the country is 78 persons per square kilometres. The mostly densely populated areas are the two principal cities in the southern part – Kumasi and Accra. About 70% of the population lived in this part of the country as of 2012. Consequently, access to housing facilities has been a problem among most middle- and low-income earners as evinced in high rental charges or high prices of housing facilities (Arku et al., 2012).

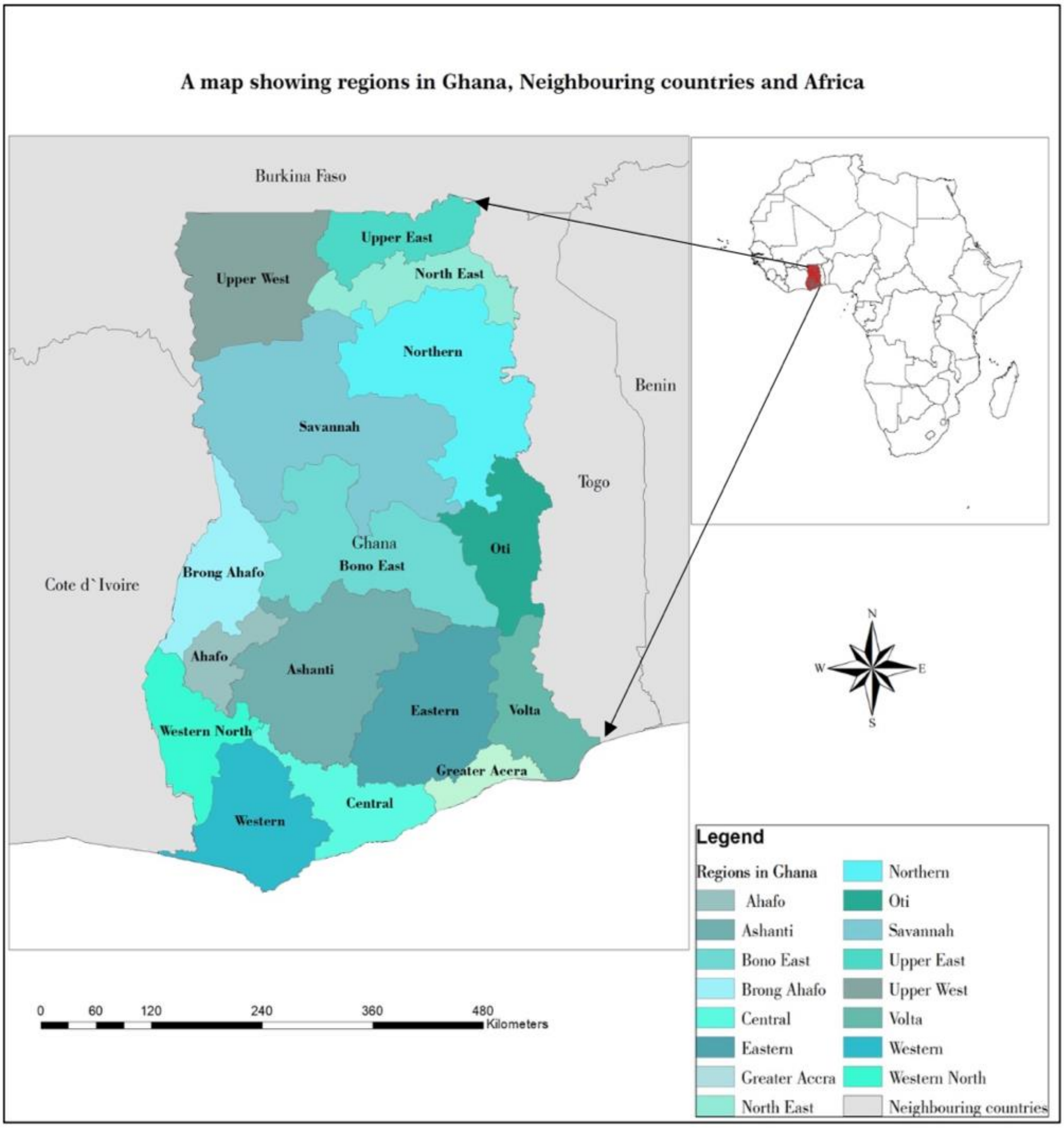

Fig. 1. 1: Map of Ghana (source: Ehwi, 2020)

The liberalization ideologies have been embraced by most economies in the 1980s and 1990s and Ghana is no exception. Ever since, the Ghanaian housing sector has undergone fundamental transition. Unlike previous pattern of state provision of housing, the state currently provides facilitative roles while the private sector provides housing facilities for rentals and ownership (Arku, 2009). State funding for housing reduced from 10-12 per cent range in the 1950 to 1-2 per cent in 1990. Multinational organizations such as World Bank and international aid agencies also provided support to augment the supportive role of the government. By devolving responsibilities to the private sector, these organizations believed that the supply of housing could be improved (Keivani & Werna, 2001). Besides, this transition was triggered by many institutional challenges faced by the public sector such as failure of government housing programmes, declining state resources and poor performance of state-owned organizations.

At the dawn of liberalization, many policies have been initiated by governments to provide aid for efficient operation of the private sector concerning affordable housing supply. Financial incentives such as tax enticements have been offered to potential investors to promote participation and competition among investors in the housing market. Aside the reduction of corporate tax from 55 per cent to 45 per cent, a five-year tax holiday and Stamp Duty exemption on the sales of houses were provided to real estate developers. Moreover, developers could apply for other incentives from the Ghana Investment Promotion Centre (GIPC). Even suppliers of locally produced building materials were granted tax reduction on sales from 20 per cent to 10 per cent. These policies encouraged the participation of the private sectors in the housing market. As at 1995, eight real estate companies were registered with Ghana Investment Promotion Centre. By the year 2005, a total of 81 were registered (Arku, 2009).

Despite these initiatives, the withdrawal of the public sector from housing supply has negatively affected most state housing providing institutions. For example, state-own housing enterprises such as State Housing Corporation (SHC) and Tema Development Corporation (TDC) had to rely on private finance to operate on commercial basis. Consequently, this negatively affected the level of finance and the quantity of housing supplied. Quasi-government institution such as State Insurance Company (SIC) and government owned institution – Social Security and National Insurance, have withdrawn from housing supply and have focused exclusively on insurance business and social security payments on workers' retirement, respectively (Arku, 2009). Rent control policies as a disincentive to curb exorbitant rents and the sales of public rentals (Grant & Yankson, 2003) to sitting tenants have further reduced the number of available private and public rental housing facilities to meet the growing number of households. Though the number of real estate developers have increased significantly, "the rise of private developers has led to housing units being produced by profit-oriented developers, and prices are extremely high, especially in urban areas such as Accra, Tema and Kumasi" (Arku, 2009, p.268). Unfortunately, income of households has not risen in likewise manner as prices of housing. For instance, it has been stated that about 37 per cent of Ghanaians live below the poverty line while 27 per cent live in extreme poverty (GPRS, 2003). Accordingly, housing is unaffordable to many low-income and middle-income earners in most urban areas in Ghana. Even among the highly paid workers, price to income ratios of housing were estimated at 1: 67 and 1:86 for senior servants and university professor, respectively (Konadu-Agyemang, 2001).

The housing deficit in Ghana has been estimated at between 750, 000 and 1.3 million units (Arku et al., 2012). Accra, the nation's capital, suffers the greatest housing shortage because of a continual flow of migrants and current influx of non-Ghanaian residents (Luginaah et al. 2010). The inadequate supply of housing has led to a high level of overcrowding, mainly in the poorest neighborhoods (Arku et al., 2012). Approximately 60 per cent of the residents in Accra live in slums (Awanyo, 2009). A study conducted by Arku et al. (2012) revealed the crisis in Ghana's rental market of which tenants expressed profound concerns about long-term advance rents, rising rental costs, threats of eviction, breaches of rental agreements and long searches for units.

The unaffordable housing crisis has culminated in a bifurcated housing supply system among self-builders and real estate developers. At one end of supplied housing are adequate residential facilities that are self-built or bought from developers by most high-income earners. Yet, at the other end is a high number of poorly serviced informal facilities (slums) mostly owned by low-income self-builders (Gaisie et al., 2019). By 2011, about 45% of Accra's population, almost 1.7 million residents, resided in 78 densely populated informal settlements. These were at varying stages of development, including makeshift, consolidated, and mature settlements that are overcrowded with room occupancy rates at 3.8 persons per room (Accra Metropolitan Assembly & UN-Habitat, 2011; Obeng-Odoom, 2011) cited in (Gaisie et al., 2019). Other ripple effects of the increasing slum development are traffic congestion, waste management challenges, flooding, erratic service delivery and cholera pandemic.

Reactively, successive governments in the past decades have made commitments to improve affordable housing provision by forming state housing enterprises. However, Arku et al. (2012) acknowledged that such commitments faltered since the early 1990s. As such, it has been pressing on current and successive governments to embark on innovative measures of housing supply to meet the increasing Ghanaian population in most cities especially Accra. However, risk and barriers have contributed to the debacles of most public housing projects and public-private housing projects. For instance, the Ghana Housing Project which was initiated in 2009 failed due to, in part, financial challenges (Securities Africa, 2012). Besides, the STX Korea-Ghana joint venture housing project, 200,000 housing units, which aimed to provide accommodation for the country's security personnel never materialised (Osei-Kyei et al., 2019). Moreover, the abandonment of uncompleted public housing projects is prolific in major cities in Ghana. Typical examples of abandoned public housing projects include the Asokore-Mampong Housing Project in the Asante Region, Kpone Housing Project and Borteman Housing Project both in Accra and the Police Housing Project in Cape Coast (Twumasi-Ampofo et al., 2014).

Aside the abandonment of uncompleted public housing projects, some completed and furnished public affordable housing projects are usually not desirable even among civil servants (Grant et al., 2019; Agyemang et al., 2018). While some houses supplied are affordable, yet not adequate, other houses supplied are adequate yet not affordable (Obeng-Odoom, 2009). Therefore, bridging the gap between affordable housing that is inadequate and adequate housing that is unaffordable is principal for meeting household residential demand and for reducing housing overhang. This will ensure a productive society among low-income earners.

Compounding the housing affordability problems is the energy crisis in the Ghanaian housing sector. For instance, about 25% shortage of peak power was reported in 2014 -2015. Besides, though the annual energy demand growth is estimated to be 10%, the installed capacity of the country has grown by only 7% (Gyamfi et al., 2018). Partly responsible for this energy supply-demand hiccup is increasing burden on the national grid with inefficient electrical appliances by households (Gyamfi et al., 2018). Consequently, there is an imbalance between demand and supply of electric power. This is evinced in the current frequent interruptions in electric power supply (load shedding) and total blackout in some occasions (Diawuo et al., 2019). Moreover, rapid economic development in Ghana towards middle-income status has led to increase per capital income (Gyamfi et al., 2018). Therefore, the number of households that can afford major appliances is expected to increase (Diawuo et al., 2019). About 54% of electricity is used to run home (Asumadu-Sarkodie and Owusu, 2016). Speculatively, the energy gap between supply and demand could even be wider due to the economic development and population growth.

Considering the residential energy and housing affordability crises, governments' strides to provide sustainable housing could have immense benefits. In addition to alleviating the negative effects of the country's energy crisis, housing price affordability challenges and greenhouse gas emissions (evinced in climate change), sustainable low-cost housing could improve the quality of life and enhance residents' health. It could also lead to cost saving to households over the lifecycle of the housing facility (Birkeland, 2012). Attributed to these benefits, there is a clarion call for sustainable development in housing globally. For instance, the pursuit for sustainable housing is evinced in the United Nations (UN) policy goal. Target 11.1 of the Sustainable Development Goal II states: 'By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums'.

Therefore, from the perspective of a developing country Ghana, this study explores the following core issues of sustainability attainment in affordable housing (low-cost housing): (1) critical success criteria; (2) critical risk factors; (3) critical barriers; (4) critical success factors (CSFs). For the purpose of this study and based on the scope of the study, affordable housing and low-cost housing are synonymous and they include public affordable housing or public low-cost housing and self-built housing among middle- and low-income earners.

1.4 RESEARCH AIM AND OBJECTIVES

1.4.1 AIM

This research study seeks to develop a model for sustainable affordable housing provision in Ghana.

1.4.2 OBJECTIVES

To achieve the overall aim, the following objectives are framed

1. To identify critical success criteria (CSC) for sustainability attainment in affordable (SAH) and to develop a sustainability assessment model for affordable housing in Ghana
2. To identify critical risk factors (CRFs) to Sustainability attainment in affordable housing
3. To identify critical barriers (CBs) to Sustainability attainment in affordable housing
4. To determine critical success factors (CSFs) for Sustainability attainment in affordable housing
5. To develop an integrated model for sustainable affordable housing in the Ghanaian housing market

1.5 RESEARCH PROCESS

The research process adopted for this study is divided into various stages. The first stage includes the establishment of the research background, the research problem, the research aim and objectives. The development of this preliminary stage of the study was achieved through a detailed literature review and discussions with academic supervisor and research colleagues.

In the second stage of the research study, a theoretical background (systematic review of extant literature) was conducted on CSC, CRFs, critical barriers and CSFs for sustainability attainment in affordable housing (low-cost housing).

The third stage of the research study involves a detailed description of the research methodology. This entails the research philosophy; the research strategy and approach; the research technique and method.

In the fourth stage, an international survey was conducted on the identified factors from the systematic literature (including CSC, CRFs, critical barriers and CSFs) for the purposes of piloting the questionnaire and to find out the views of international experts on these factors in order to draw inferences for the Ghanaian housing market. Besides, findings of the international survey were relevant for modelling the various forms of constructs of the sustainable affordable housing framework in the case of Ghana. Following the international survey and further pilot study in Ghana, the questionnaire was administered to professionals in the Ghanaian housing market. Some of these professionals include respondents from the Ghana Real Estate Developers Association (GREDA), Ministry of Water Resources, Works and Housing (MWRWH), Public Works Department (PWD), State Housing Cooperation (SHC), Tema Development Cooperation (TDC), Social Security and National Insurance Trust (SSNIT) and some Consultancies / Research Institutes (herein referred to as formal or controlled or regulated sector of the Ghanaian housing market).

Stage five entails quantitative analysis of the data from the survey. This helped to fully achieve objective one, two, three and four. Statistical techniques that were employed include mean score ranking method, factor analysis, fuzzy synthetic evaluation and partial least square structural equation modelling (PLS-SEM).

Stage six is the final phase of the study. This stage involves the development of the sustainable affordable housing (low-cost housing) model by integrating the findings from objectives one, two, three and four. It also includes the validation of the study findings among experts in the Ghanaian housing market. A summary of the research framework for the study is shown in Fig. 1. 2. It reveals the various stages of the study and the chapters of the entire study.

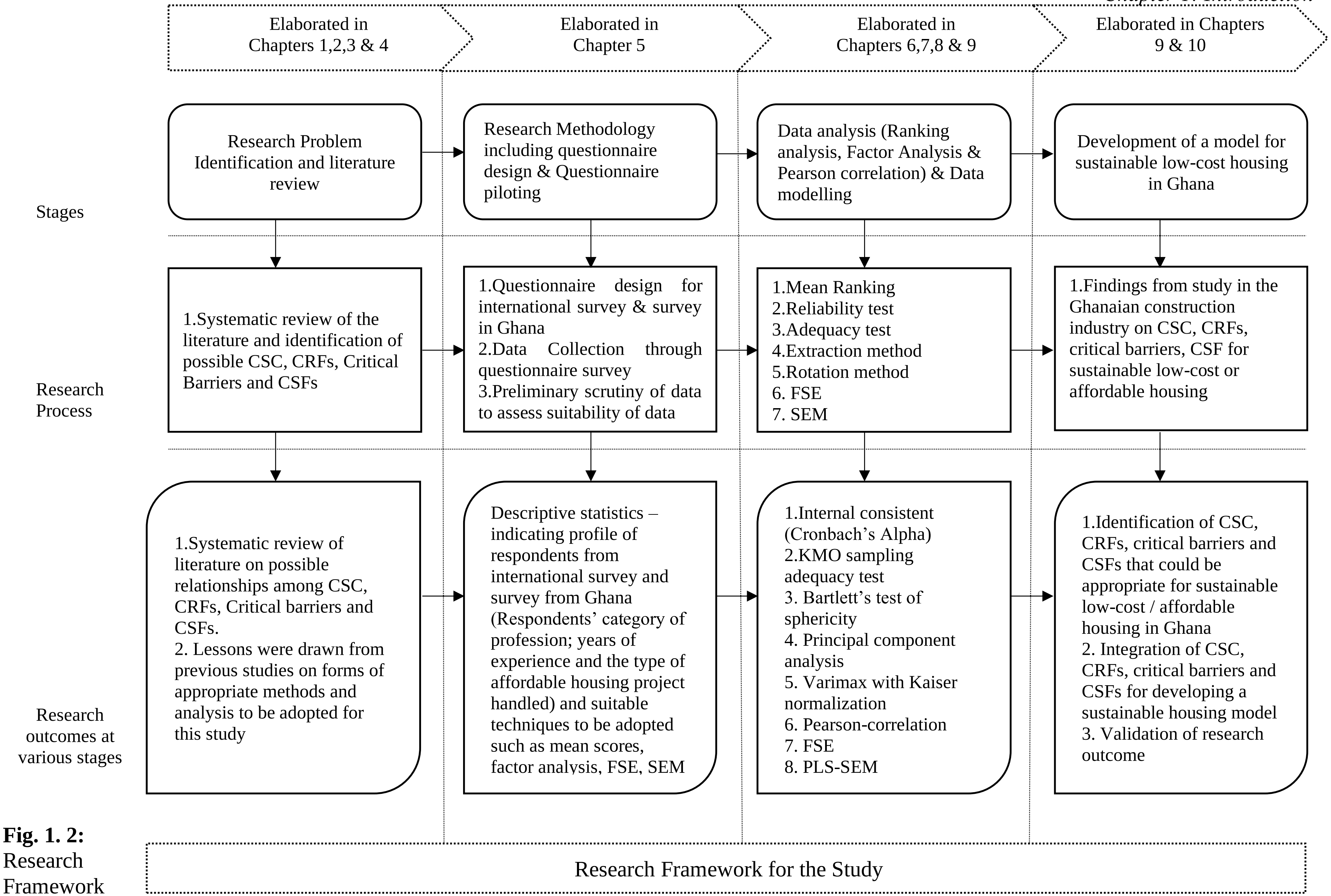

Fig. 1. 2: Research Framework

1.6 STRUCTURE OF THESIS

This thesis is organised into ten chapters. Chapter 1 consists of an introduction of the research, the scope and problem statement of the research, the aim and objectives of the research and an overview of the research process. In Chapter 2, a comprehensive literature review was conducted on sustainability attainment in affordable housing (SAH). Subsequently, a literature review on CSC was offered. Chapter 3 provides a comprehensive literature review on the risks and barriers while Chapter 4 proffers CSFs for SAH. Chapter 5 entails the research methodology that was deployed to achieve the objectives and the overall aim. Chapter 6 entails statistical analyses on CSC while Chapter 7 contains statistical analyses on barriers and success factors for sustainability attainment in housing from an international perspective. This provides the basis for conducting the PLS-SEM on the data obtained from Ghana. Chapter 8 and subsequent chapters present statistical analysis of the data from the Ghanaian perspective. In Chapter 8, the data were analysed to identify CSC towards developing a sustainability assessment model for affordable housing from the Ghanaian Perspective. Besides, Chapter 8 includes statistical analysis of CRFs using the Fussy Synthetic Evaluation (FSE). Chapter 9 entails results and discussion of the PLS-SEM analysis. It offers a PLS-SEM results on the impact of barriers on CSC of SAH. It also provides PLS-SEM results of the impact of CSFs on CSC for SAH. At the end of Chapter 9, a SAH model is developed by integrating findings on the CSC, CRFs, critical barriers and CSFs for SAH. The validation of the study findings, the conclusion, significance, recommendation and limitation of the study and future research directions are proffered in Chapter 10.

1.7 CHAPTER SUMMARY

This chapter first presented an introduction to the study. The concept of sustainability attainment in affordable housing (low-cost housing) (SAH) was expounded. Then, the research scope and problem statement; aim and objectives were offered. The housing affordability crisis especially in major cities (i.e. Accra, the country's administrative capital) and the country-wide energy crisis were identified as key problems in the Ghanaian housing market. It is based on these problems that the research aim and objectives were established. After which the research process and research framework of the entire thesis were presented. Finally, the structure of the thesis was described.

CHAPTER 2: LITERATURE REVIEW – CRITICAL SUCCESS CRITERIA (CSC) FOR SAH [2]

2.1 INTRODUCTION

The previous chapter expounded the background study together with the problem statement, research aim, objectives and brief research process of the study. This present chapter entails a review of the literature on CSC for sustainability attainment in affordable housing.

CSC are the set of principles or standards through which judgement can be made whereas critical success factors (CSF) are the set of circumstances, facts or influences which affect / contribute to the results or CSC (Lim and Mohammed, 1992 p.243). For instance, 'accessibility to shops' and 'access to health services' are examples of CSFs (factors) whereas 'reduced commuting cost or time' could be used as a CSC (criterion / outcome) which is influenced by the CSFs. Furthermore, 'availability of green public space' is a CSF whereas 'household / stakeholders' satisfaction' and 'quality housing' could be used as CSC (Torbica and Stroh, 2001; Ahadzie et al., 2008). Moreover, 'the construction method for a housing facility' and 'materials used for construction' are CSFs which could influence CSC such as 'maintainability of a housing facility'; 'technical specification of a housing facility' and 'environmental performance of a housing facility' (Torbica and Stroh, 2001; Rankin et al., 2008). Finally, 'the type of communication among project stakeholders' could be a CSF which influences criteria

[2] This chapter is largely based upon the following publications:

Adabre, M.A. and Chan, A.P. (2018). The ends required to justify the means for sustainable affordable housing: A review on critical success criteria. *Sustainable Development*, 26, 1-14.

Chan, A. P., & Adabre, M. A. (2019). Bridging the gap between sustainable housing and affordable housing: The required critical success criteria (CSC). *Building and Environment*, *151*, 112-125.

such as ‘reduced occurrence of disputes and litigation among project stakeholders’ and ‘technology transfer’ in construction projects (Adinyira et al., 2014).

Knowledge on CSC is required for the development of sustainable and affordable housing policies to improve the current and anticipated affordability crises. Besides, real estate developers, governments and international organizations need to be apprised of the effective and appropriate CSC to identify affordability challenges and innovate measures for successful housing delivery. Moreover, CSC serve as measures to guide developers and governments to enhance efficient allocation of the limited resources to meeting the residential needs of the household (Chua et al., 1999). Finally, the categorization of the various CSC will help governments and international policy makers on strategies required to bridge the gap between sustainable housing and affordable housing.

2.2 CSC FOR SAH

The identification of key project CSC is important so that construction managers, project managers and policymakers can appropriately plan resource allocation (Chua et al., 1999). Irrespective of the type of construction projects, the iron triangle of time, cost and quality have been widely recognized as the fundamental CSC in many studies (Atkinson, 1999; Bassioni et al., 2004; Chan and Chan, 2004). However, it is a fact that some determinants of success are likely to be distinctive among projects. Moreover, studies have revealed that the iron triangle criteria are non-exhaustive (Lim and Mohamed, 1999; Pinto and Pinto, 1991; Pocock et al.,1996). Therefore, studies have been conducted to comprehensively identify CSC for project monitoring and control in the construction industry (Lim and Mohammed, 1999; Baccarini, 1999; Ahadzie et al., 2011; Al-Tmeemy et al., 2011).

In general construction project, Lim and Mohamed (1999) explored the criteria of project success from different perspectives of stakeholders. The identified criteria were grouped into two categories. These included the macro and micro perspectives. Project completion and satisfaction were the criteria that defined the macro viewpoint of project success while the micro viewpoint was solely defined by the completion criterion. Thus, the classification by Lim and Mohamed (1999) highlighted an overlap between the categories. For instance, the completion criterion was common to both the macro and micro viewpoints. The other criterion – satisfaction – was more focused on the owner and user of the project. Therefore, they failed to provide detail criteria for construction companies or contractors (Al-Tmeemy et al., 2011). In Baccarini (1999), the criteria of project success were grouped into product success and project management success based on the goal, purpose, output and input. The product success deals with goals and purpose while the project management success deals with output and inputs. Although Baccarini (1999) flagged some key criteria applicable to construction companies and contractors in the project management success criteria, contractors' goals such as revenue and profit, market share and competitive advantage were not explicitly stated. Based on this knowledge gap, Al-Tmeemy et al. (2011) conducted a study on developing a framework to categorize project success for building projects from contractors' perspectives. While maintaining the classification of Baccarini (1999), Al-Tmeemy (2011) added another category of success – market success. Therefore, three classes of project success were identified from the study of Al-Tmeemy et al. (2011). These included: the project management success which consists of adherence to quality targets, schedule and budget; the product success such as customer satisfaction, functional requirement and technical specification; market success such as revenue and profit, market share, reputation and competitive advantage. The market success criteria emphasised on the strategic goals of construction companies.

Although the identified criteria from previous studies (Lim and Mohammed, 1999; Baccarini, 1999 and Al-Tmeemy et al., 2011) are comprehensive and applicable to most construction projects, not all might be relevant for housing projects due to differences in project characteristics. For instance, according to Ahadzie et al. (2008) on mass housing, housing projects involve the construction of domestic residence. Moreover, mass housing projects are speculative in nature since decisions on land acquisition, design and construction of such houses are mostly made without a specific customer in mind. Therefore, on housing projects, Ahadzie et al. (2008) developed four clusters of CSC for mass housing projects, namely, environmental impact, customer satisfaction, quality and overall cost and time. These CSC could be appropriate for affordable housing projects based on the similarities between mass housing and affordable housing. Like mass housing, affordable housing projects involve the construction of domestic residence and are also speculative in nature. Despite the similarities in project characteristics, definitional difference between them suggests that the CSC for mass housing are not comprehensive CSC for affordable housing projects. In Ahadzie et al. (2008 p. 678), mass housing is defined as “the design and construction of speculative standardized house-units usually in the same location and executed within the same project scheme.” However, “affordable housing is housing that is reasonably adequate in standard and location for a lower or middle-income household and does not cost so much that such a household is unlikely to be able to meet other basic living costs on a sustainable basis (National Summit on Housing Affordable, 2006). The rule-of-thumb is that housing is affordable if low income household spent less than 30% of their income on housing. Therefore, mass housing projects are affordable provided they meet the affordability criteria / requirements. Otherwise, mass housing cannot be considered affordable housing and therefore different CSC maybe required for assessing the sustainability of affordable housing.

Findings of the study by Ahadzie et al. (2008) cannot be considered as complete CSC for affordable housing projects. For example, price of housing and rental cost of housing in relation to household income which are important criteria for affordable housing (Mulliner et al., 2013) were not considered among the criteria in their study. Besides, transportation cost in relation to the income of households (Isalou et al., 2014) was not listed among the criteria identified in their study. Based on these caveats, it is necessary to find out the exclusive CSC for sustainable affordable housing projects. Studies have been conducted on identifying these specific criteria. The traditional ratio criterion measures affordability in terms of the ratio of housing cost to income. However, Chaplin et al. (1994) and Bogdon and Can (1997) stated that though the ratio approach is simple to compute and widely used, it is not adequate to assess the affordability situation of households. Affordability must involve whether a household has enough income left over for other needs of life after paying housing bills. If the household cannot meet their non-housing needs such as food, medical care and clothing at some minimum level of adequacy after paying for housing bill, then the household is 'shelter poor'. Thus, unlike the ratio criterion which looks at housing affordability only as a matter of housing cost, the 'shelter poor' or 'residual' approach considers the full amount required for housing and other basic needs (Stone, 2006). However, the residual income approach and the shelter poverty concept have a practical challenge of being translated into an operational affordability scale. It is a problem setting the minimum standard of adequacy for non-shelter items (Bogdon and Can, 1997). Moreover, the conventional ratio and residual approaches focus more on the economic issues of price affordability of housing. This solely does not bridge the gap between sustainable housing and affordable housing. For example, though the prices of a housing facility might be affordable, it is not truly affordable if it located in a remote area with high transportation cost (Golubchikov and Badyina, 2012). In a study conducted by Isalou et al. (2014), it was found out that suburban household spent about 57% of their income on housing and transportation which was significantly higher compared to 45% of housing and transportation expenditure spent by households in the urban areas.

Yet, the price of a housing facility and transportation cost do not give a complete view of the required CSC for measuring the success of sustainable affordable housing projects (Mulliner et al., 2013; Gan et al., 2017). According to Mulliner et al. (2013 p. 270), to improve quality of life and community sustainability, aside the economic assessment criteria, "the environmental and social sustainability of housing must be taken into consideration". Using the COPRAS method of Multi-Criteria Decision Making (MCDM), twenty-one criteria were used to assess the affordability of an area. These criteria in descending order of their mean scores include: house price in relation to income, rental costs in relation to income, interest rates and availability of mortgages, social and private rented accommodation availability, homeownership products availability, access to employment opportunities, public transport services accessibility, quality school accessibility, access to shops, access to health services, access to child care, open green public space accessibility, quality of housing, energy efficiency of housing, availability of waste management facilities, appeal of neighborhood area, deprivation in area and presence of environmental problems. It was concluded that considering social and environmental criteria can critically influence the estimation of the affordability in an area as compared to focusing solely on the financial criteria. Although Mulliner et al. (2013) broadened the scope of sustainable affordable housing criteria and contributed significantly, they failed to differentiate critical success criteria (CSC) from critical success factors (CSFs). Out of the twenty-one criteria, only five criteria namely, house price in relation to income, rental costs in relation to income, safety (crime), quality of housing and energy efficiency can be termed as critical success criteria. However, the other 16 criteria are critical success factors (Lim and Mohamed, 1999).

Similarly, Gan et al. (2017) aimed at identifying key sustainability performance indicators (KSPIs) from three stakeholder groups such as developers, government and academics. Using the fuzzy set theory and variance analysis, 24 KSPIs were conclusively highlighted from 42 sustainability indicators of affordable housing. Among the KSPIs, some of the CSC include affordable price / rent, reduced transport cost, cost effectiveness and energy efficiency. However, like in previous study by Mulliner et al. (2013), some of the 24 identified indicators are possibly critical success factors rather than critical success criteria. For instance, 'providing human resource for economic development', 'ensure balance housing market', 'availability of green public space and adequate living space within small size unit' are critical success factors (Lim and Mohamed, 1999).

Table 2. 1: Potential CSC for Sustainable Affordable Housing

No.	CSC for Sustainable Affordable Housing	References
CSC01	Timely completion of project	Chan and Chan (2004); Bassioni et al. (2004); Ahadzie et al. (2008)
CSC02	Construction cost performance of housing facility	Al-Tmeemy et al. (2011); Osei-Kyei and Chan (2017)
CSC03	Quality performance of project	Atkinson (1999); Lim and Mohamed (1999); Cox et al. (2003)
CSC04	Safety performance	Wai et al. (2012); Kylili et al. (2016); Ngacho and Das (2014)
CSC05	End user's satisfaction with the housing facility	Torbica and Stroh (2001); Bryde and Robinson (2005)
CSC06	Project team satisfaction with the housing facility	Yan et al. (2018)
CSC07	Environmental performance of housing facility (Eco-friendly)	Lim and Mohamed (1999); Atkinson (1999); Rankin et al. (2008)
CSC08	Reduce life cycle cost of housing facility	Wai et al. (2012); Ahadzie et al. (2008)
CSC09	Maintainability of housing facility	Wai et al. (2012)
CSC10	Energy efficiency of housing facility	Wai et al. (2012); Ahadzie et al. (2008)
CSC11	Reduced occurrence of disputes and litigation	Osei-Kyei and Chan (2017)
CSC12	Reduced public sector expenditure on managing housing facility	Osei-Kyei and Chan (2017)
CSC13	Functionality of housing facility	Chan and Chan (2004); Chan et al. (2002)
CSC14	Technical specification of housing	Chan and Chan (2004); Osei-Kyei and Chan (2017);
CSC15	Aesthetically pleasing view of completed house	Chan and Chan (2004)
CSC16	House price in relation to income	Mulliner et al. (2013); Ahadzie et al. (2008)
CSC17	Rental cost in relation to income	Mulliner et al. (2013)
CSC18	Commuting cost from the location of housing to public facilities	Hamidi et al. (2016)
CSC19	Technology transfer / innovation	Ahadzie et al. (2008)
CSC20	Waiting time of applicants before being allocated a housing unit	Chiu (2007)
CSC21	Take up rate of housing facility (marketability of housing facility)	Pullen et al. (2010)

2.3 STAGES TO SUCCESS IN THE PROVISION OF SAH

Identifying the stages to success of a product could be different from assessing the various stages of success of a product. For example, to ensure successful affordable housing, we argue that the stages to success should start from needs assessment of the intended users. Based on these needs assessment, the next stage is the management of the process or activities towards achieving the needs and other needs beyond the intended users' needs. This stage is the process domain known as project management (Pheng & Chuan, 2006). Finally, managing the process domain well leads to project success – successful affordable housing project (Cooke-Davies, 2002). However, since measuring success is mostly carried out to monitor and control, it is possible that assessment of the process domain would be conducted before assessment of the product success because the former precedes the latter in the construction of an affordable housing project. Therefore, regarding the stages of success, assessment of the project management success comes first followed by the assessment of the product success.

The CSC at each stage are elaborated with the support of a framework shown in Fig. 2.1. Project success in affordable housing can be conceptualised as product success and project management success. According to Al-Tmeemy et al. (2011), product success focuses on the effects of the final product. In the case of affordable housing, these effects should be to ensure the satisfaction of the household and the project team members regarding the completed house (Torbica & Stroh, 2001). Though previous study by Ahadzie et al. (2008) did not consider the life cycle cost of buildings (cost of maintenance, energy cost and other cost of building operation), it is relevant to consider reduced life cycle cost and reduced public-sector administrative cost (especially in the case of rental housing) as critical for assessing success of a housing facility - product success. High life cycle cost could increase public-sector administrative cost as well as lead to shelter poverty among low-income earners (Stone, 2006).

The price of housing, rental cost and transportation cost in relation to household income are also germane in measuring the economic viability of housing (Mulliner et al., 2013). Ultimately, the marketability of the housing facility is very important in determining its success (Al-Tmeemy et al., 2011). A proxy measure for marketability of housing facility could be the take up rate or the renting or purchasing rate of the housing facility.

After assessing success criteria at the product level, the next stage is project management success. This involves success at the delivery or process stage of an affordable housing project. Project management of affordable housing include managing for cost performance, quality performance, safety performance, productivity / efficiency, risk containment and technology transfer (Ahadzie et al., 2008; Al-Tmeemy et al., 2011; Atkinson, 1999). According to Baccarini (1999), the success at the project management stage leads to product success. For example, in an empirical study, Ibem and Amole (2013) noted that quality affordable housing at the project delivery is directly related to household satisfaction- an attribute of product success. Similarly, in Al-Tmeemy et al. (2011), when quality targets are met, the functional requirement and technical specification of the product can be achieved. Therefore, aside the other criteria of project management success, product success in an affordable housing project is a key element of project management success. Thus, integrating product success into project management success shows that the achievement of product success could be influenced by project management success. This is shown in the framework (Fig.2.1) as product success being a subset of project management success.

Finally, project success can be measured using the waiting time applicants are expected to spend before they could be allocated to a housing unit (Chiu, 2007) and how an affordable housing project leads to the attainment of sustainable development (Ibem and Azuh, 2011).

Besides, integrating product success and project management success leads to project success – successful affordable housing supply in meeting household demands. The three stages of success in affordable housing projects are presented in the framework in Fig.2.1 in the form of circles for the various phases. The inner circle represents product success, the middle circle represents project management success and the outermost circle represents project success. Thus, for success in sustainable affordable housing projects, product success is a precursor of both project management success and then project success.

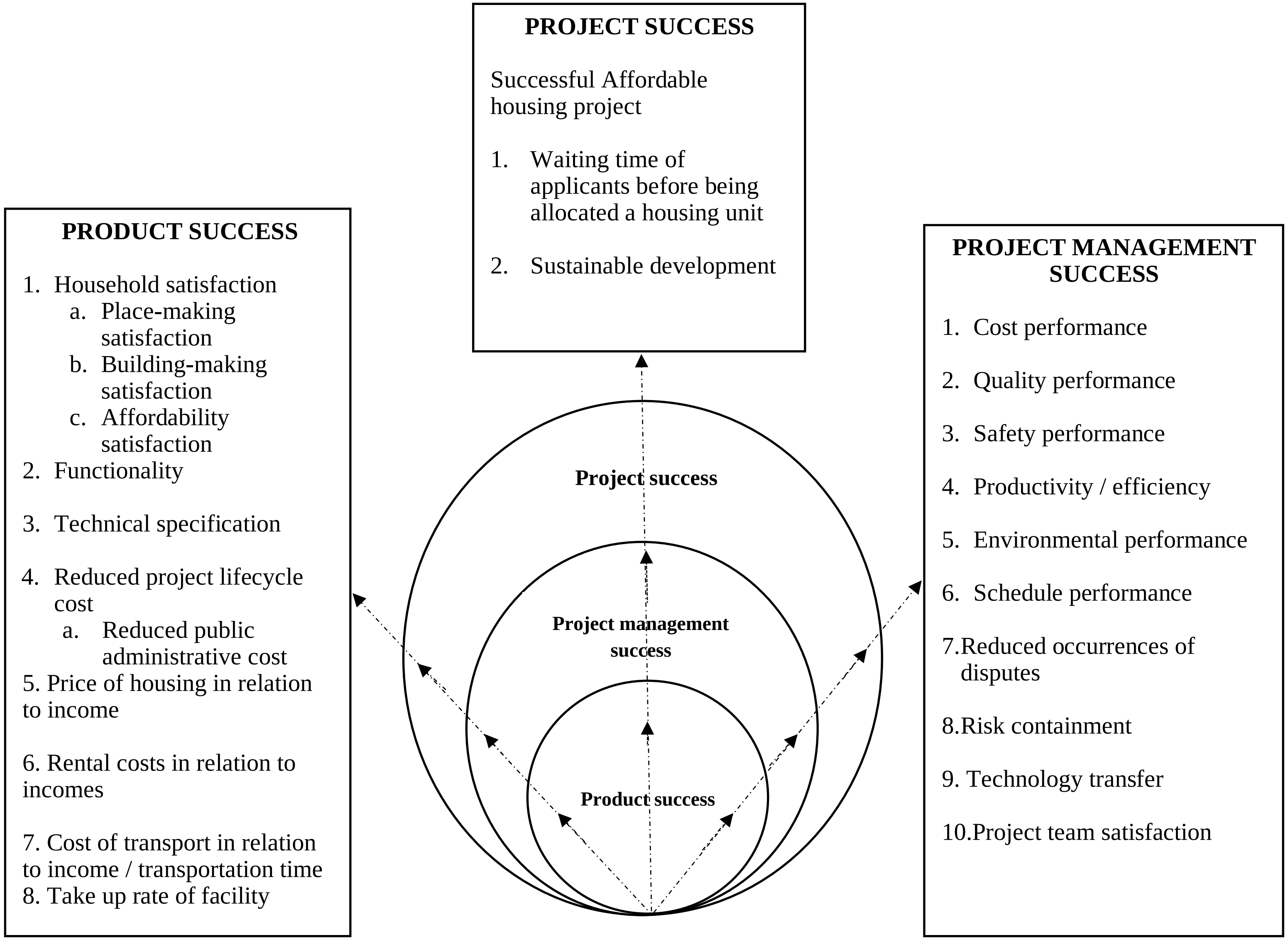

Fig. 2. 1: A Conceptual Framework of CSC for Sustainable Affordable Housing Projects (Adopted from Adabre & Chan, 2018)

2.4 KNOWLEDGE GAPS IDENTIFIED IN THE LITERATURE

It can be concluded from the above literature review that studies on CSC for bridging the gap between sustainable housing and affordable housing are limited. Therefore, a comprehensive investigation on CSC for performance assessment of sustainability attainment in affordable housing is worthwhile.

It can also be concluded from review that current studies on assessment of affordable housing have progressed from using price of housing to housing price plus transportation cost. However, this criterion is not adequate since it does not include qualitative criteria. Although GBRSs and advanced GBRSs tools such as neighbourhood sustainability assessment tools include some qualitative criteria, a major challenge is the subjectivity in the scoring and weighting of the criteria. This is attributed to the differences in the priorities and interests of the various stakeholders involved in rating these criteria. Based on this problem, Sharifi & Murayama (2013) recommended that the utilization of fuzzy technique is appropriate to tackle the issues of subjectivity of weightings. Besides, since the tools and models have been developed in different context and scope, it is preferable to develop country-specific model from the Ghanaian perspective. This could be an appropriate strategy to abreast policy-makers of a reliable level of sustainable development on affordable housing. Therefore, this study focuses on developing a sustainability assessment model for affordable housing in the Ghanaian perspective using fuzzy synthetic evaluation (FSE) technique.

2.5 CHAPTER SUMMARY

To ensure sustainability attainment in affordable housing, it is primal to identify the CSC for evaluating sustainability. This chapter is a systematic review on the CSC for SAH. From the review, 21 CSC were identified for bridging the gap between sustainable housing and affordable housing. It is this set of 21 CSC that is used for developing part of the questionnaire for data collection. Besides, the 21 CSC formed the basis for identifying the potential CRFs, critical barriers and success factors that influence SAH. Without the CSC, it would have been ardent for survey respondents to rate the CRFs, barriers and CSFs for SAH. Aside identifying the set of CSC, this chapter also identified the knowledge gap in previous studies vis-à-vis inadequate assessment criteria for evaluating SAH as well subjectivity in the rating of some CSC among existing tools (i.e. Green Building Rating Systems). Accordingly, as part of its objectives, this research aims to address these knowledge gaps in the literature. The following chapter is a systematic review on potential CRFs and critical barriers to SAH.

CHAPTER 3: LITERATURE REVIEW – RISK FACTORS & BARRIERS TO SAH

3.1 INTRODUCTION[3]

Regarding the residential energy and housing affordability crises, the Ghanaian governments' strides to provide sustainable housing could have immense benefits. In addition to alleviating the negative effects of the country's energy crisis, housing price affordability challenges and greenhouse gas emissions, sustainable housing could improve the quality of life and enhance residents' health. It could also lead to cost saving to households over the lifecycle of the housing facility (Birkeland, 2012). However, attaining the potential benefits of sustainable housing has been marred by risk factors and barriers. In subsequent sections, a literature review is conducted on risk factors and barriers to SAH. This review culminates in the development of a conceptual framework of barriers to SAH as well as identification of the research knowledge gap.

3.2 RISK FACTORS TO SUSTAINABLE HOUSING

Studies on projects performance have concluded that in most cases, not all the project goals are achieved because projects are fraught with risks (Adabre et al., 2020). According to El-Sayegh & Mansour (2015), "risk is defined as an uncertain event or condition that, if it occurs, has a positive or negative effect on at least one project objective or goal such as time, cost, scope, or quality". For this study, risks entail factors that, if not appropriately managed, could

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[3] This chapter is largely based upon the following publication:

Adabre, M. A., Chan, A. P., Darko, A., Osei-Kyei, R., Abidoye, R., & Adjei-Kumi, T. (2020). Critical Barriers to Sustainability Attainment in Affordable Housing: International Construction Professionals' Perspective. *Journal of Cleaner Production*, 119995.

Adabre, M.A., and Chan, A.P.C. Forthcoming. Modelling the Impact of Barriers on Sustainable Housing in Developing Countries. *Urban Planning and Development.* 10.1061/ (ASCE)UP.1943-5444.0000639 affect the goals or outcome of the project or could culminate in barriers that lead to project failures. Thus, risks are precursors of barriers. Risk is a joint function of both likelihood and severity and therefore should be assessed as such (Yu et al., 2017).

Various risk factors have been identified from prior studies. Some of these risk factors could be general and are applicable in most countries and projects. For instance, key risk factors identified by Ameyaw & Chan (2015) in the Ghanaian construction industry include: 'foreign exchange rate fluctuation', 'corruption', 'political interference', 'high operational costs', 'inflation and interest rates volatility', 'construction time and cost overruns', 'poor contract design', 'supporting utilities / infrastructure risk', 'design and construction deficiencies' and 'land expropriation risk'. Similarly, in a comparative study between Hong Kong and Ghana on general infrastructure procurement through public-private partnership, findings of Osei-Kyei & Chan (2017) confirmed most of these risk factors. In the United Arab Emirates, El-Sayegh and Mansour (2015) concluded that the most significant risks include 'quality and integrity of design', 'delays in approvals' and 'delays in land expropriations'. In Singapore, 'currency and interest rate volatility', 'inflation rate fluctuation', 'poor construction quality' and 'risk of design changes' are confirmed in studies by Hwang et al. (2017) and Zhao et al. (2016). Although most of these risk factors pertain to varied projects, they also affect housing projects. In a comparative by Fernandez-Dengo et al. (2013) on risk assessment in housing market, 'monetary inflation', 'economic growth', 'bureaucratic delays', 'social conflicts (e.g. demonstration, strikes, street violence)' and 'financing risks' were ranked relatively high by both Mexican and U.S. firms. Furthermore, most of these risk factors were established in Sanda et al. (2020) on housing projects in Nigeria and in Yu et al (2017) as social risks in housing demolition in China. Additionally, Lundin et al. (2015) identified 'contractor financial crisis', 'difficulties with payments' and 'litigations' as the reasons for delays in public housing projects in Ghana. It is worth noting that the applicability of these risk factors to housing projects could be attributed to the varied characteristics of housing projects. Considering that housing facility could be public facility that must be procured transparently, housing projects could be affected by political-related risks and inefficiencies in the procurement process. Besides, given that it could be a public or private investment, which requires extensive financial resources for construction, housing projects are influenced by financial related risks (macroeconomic factors and availability of fiscal resources) and inherent risks in project design and construction.

As a product for accumulation of wealth, housing could be affected by policy inefficiencies or risk inherent in policies. For instance, in Hong Kong, Ho (2004) and Zheng et al. (2017) concluded that public housing privatization stands the risk of exacerbating the inequitable distribution of housing resources. Similarly, Fields & Uffer (2014, p. 1486) revealed that 'financialization heightened existing inequalities in housing affordability and stability, and rearranged spaces of abandonment and gentrification in both New York and Berlin'. However, focusing solely on Berlin, Kitzmann (2017) concluded that following privatization of housing in Germany, private companies provided more housing facilities to the socially disadvantaged than Berlin's state-housing companies. Strategic measures such as avoidance of high vacancy rate, changes in policies of Berlin's state housing companies to market-oriented to increase return and guidelines on transfer payments and housing cost were stated as reasons for the different impact of privatization outcomes in Berlin as compared to that in Hong Kong, New York and London. In the Ghanaian housing sector, privatization of housing entails the transfer of the state's role of housing supply to the private sector and the sales of state housing facilities to existing household that can afford the prices of such facilities. 'Limited fiscal resources' and 'operation and maintenance cost burden' were identified for the former and latter form of privatization, respectively. Irrespective of the form of privatization, rising inequality has also been identified in most developing countries with neoliberal policies for housing supply in China and Ghana (Taruvinga & Mooya, 2018).

Furthermore, as a facility for providing daily shelter needs, belonging and esteem needs, housing could be affected by risks from households' preference. For example, while Hong Kong and some economies show high demand for housing facilities, 'low-take up rate of housing facilities' has been identified as a risk factor in Malaysia (Teck-Hong, 2012) and Mainland China (Yuan et al., 2018). In the case of Ghana, Agyemang et al. (2018) identified low-social acceptability as a risk factor to high-rise apartment. Concerning the Saglemi housing project, Grant et al. (2019) identified related risk factors such as socio-spatial segregation and inadequate infrastructural supply. Moreover, in the case of Australia, Susilawati (2009) found that developers agreed that risk of community rejection of low-cost housing projects is among the main risk factors to developers. Similar risk factor of opposition to low-cost housing projects has been identified in the U.S. with associated risk factors such as 'declining values of neighbouring housing facilities' and 'congestion on existing amenities / infrastructure due to new households' (Tighe, 2010). Although the former has not been highlighted in Ghana, Avogo et al. (2017) identified 'congestion on existing amenities' due to transformation of Government constructed housing at Madina Estates in Accra. Concerning opposition, Awanyo et al. (2016) stated that 'opposition to large public-private housing project' was one of the risk factors for the cancelation of the STX housing project. Unlike the case of U.S., Awanyo et al. (2016, p. 50) attributed the cancelation to housing as product for wealth accumulation. Disagreement over accumulation and opposition by the capitalist real estate developers and their political-class collaborators were highlighted by Awanyo et al. (2016).

In identifying the various forms of risk factors, both qualitative techniques (Ho, 2004; Susilawati, 2009; Fields & Uffer, 2014) and quantitative techniques (El-Sayegh and Mansour, 2015; Kitzmann, 2017) have been deployed. Yet, these techniques could yield different outcomes even within same country and same project. For instance, while Fields & Uffer (2016) concluded that privatization could contribute to housing unaffordability and inequality in Berlin using qualitative data (interviews), Kitzmann (2017) concluded that privatization in Berlin has rather led to the housing of the socially disadvantaged more than Berlin state housing-companies. Notwithstanding other reasons for the disparity in the results, it is worth noting that the results could be influenced by subjectivity and biases based on the data collection and statistical analysis techniques. Qualitative data analysed using qualitative techniques could yield subjectivity and biases in results and likewise quantitative descriptive statistical analysis using means scores and relative importance index. This could influence the outcome of risk assessment. Therefore, Zhao et al. (2016) recommended the fuzzy synthetic evaluation (FSE) technique as a robust tool in multi-criteria decision making. The FSE provides an objective and bias-free results regarding multivariate (multiple variables) decision-making among multi-stakeholders. Since housing projects involves multi-stakeholders (such as architects, quantity surveyors, developers), risk assessment by these stakeholders is prone to uncertainties.

It can be concluded from the literature review that risk is a multivariate factor that consists of varied forms. Table 3.1 is a summary of the varied forms and categorizations of the risk that could affect sustainable housing. Thus, as a public or private investment, housing could be affected by ‘political-related’, ‘financing-related’ and ‘procurement’ risk factors. As a construction product, it is influenced by ‘design and construction related risk factors. As a facility for providing daily shelter needs, belonging and esteem needs, housing facility could be affected by ‘operation and maintenance risk factors’. Though most of these risk factors are identified qualitatively, there is dearth study on providing an objective and quantitative assessment of the impact of these risk factors on sustainable development in housing. Such a study is germane to unravel CRFs and to enhance policy formulation and implementation among government and private developers for mitigating risks for effective housing supply in Ghana.

Table 3. 1: Potential Critical Risk Factors (CRFs) to SAH

Risk Categories	No.	Risk Factors	References												
			1	2	3	4	5	6	7	8	9	10	11	12	13
Political-Related Risk	PRF01	Political continuity risks / Change in government	√		√		√						√		
	PRF02	Risk associated with land acquisition / land expropriations for housing	√		√					√			√		
	PRF03	Risk associated with opposition to large public-private housing projects						√			√				
	PRF04	Risk due to policy instability / political opposition to public housing projects	√			√	√						√		
	PRF05	Risk due to delays in project permit approval / delays in obtaining construction permits or issuance of documents	√										√		
Financing-Related Risk	FRF01	Inflation rate volatility (price fluctuation of materials & labour & sustainable technologies)	√	√		√	√						√		√
	FRF02	Fluctuations in exchange rate	√	√	√								√		√
	FRF03	Fluctuating cost of finance (interest rates)	√				√						√		√
	FRF04	Changes in government financing strategies or project financing	√										√		
	FRF05	Poor / inadequate financial market	√			√							√		√
	FRF06	Increasing tax rates and fees on developers	√	√	√										
	FRF07	Delays in payments by governments / clients	√	√			√			√					
	FRF08	Litigations over claims payment		√						√					
Procurement Risks Factors	CRF01	Corruptions in project procurement	√			√							√		
	CRF02	Inadequate competition during project tendering													
	CRF03	Errors and omissions in tender documents (i.e. inaccurate cost estimation)			√								√		
Design & Construction Related Risk Factors	DRF01	Construction time overruns	√										√	√	
	DRF02	Construction cost overruns	√										√	√	
	DRF03	Construction deficiencies / defects											√		

			1	2	3	4	5	6	7	8	9	10	11	12	13
	DRF04	Resource unavailability risks (local skill labour & sustainable technologies and materials)													
	DRF05	Design and construction variation orders / alteration and rework due to construction variations				√	√								
	DRF06	Technical complexity risk associated with project		√		√									
	DRF07	Force majeure (unforeseen adverse conditions at project site)				√	√			√					
	DRF08	Construction accidents and injuries		√		√	√			√					
Operation & Maintenance Risk Factors	ORF01	Fluctuating market demand or preference / low take-up rate of housing facilities							√			√			
	ORF02	Operation / maintenance cost overruns on public budget	√										√		
	ORF03	Congestion on existing amenities / infrastructure due to new households									√				
	ORF04	Utilities / infrastructure supply risks											√	√	
	ORF05	Socio-spatial segregation												√	
	ORF06	Privatisation risk (privatization of public housing stock)													√

References: 1= Osei-Kyei & Chan (2017); 2= Zhao et al. (2016); 3= Fernandez-Dengo et al. (2012); 4= Hwang et al. (2017); 5= Chileshe et al. (2012); 6= Awanyo et al. (2016); 7= Sanda & Anigbogu (2016); 8= El-Sayegh & Mansour (2015); 9= Tighe (2010); 10= Teck-Hong (2012); 11= Ameyaw & Chan (2015); 12= Grant et al. (2019); 13= Taruvinga & Mooya (2018)

3.3 BARRIERS TO SUSTAINABILITY ATTAINMENT

3.3.1 Barriers to Social Sustainability

The attainment of social sustainability in affordable housing is trammeled by various barriers. For instance, Trudeau (2018) and Nguyen et al. (2013) stated that 'community opposition to affordable housing projects' is one of the main barriers to its realisation. Similarly, in the UK, Sturzaker (2011) asserted that there is high community opposition to social housing. Besides, income segregation among households is a barrier that affects social cohesion and social inclusion (Massey et al., 2009). Furthermore, Bramley et al. (2006) indicated that lack of / inadequate infrastructure development is a noted cause of social exclusion. Moreover, the culture and attitude of a community could negatively affect the attainment of social sustainability (Sullivan and Ward, 2012). For instance, 'negative culture towards mortgage' (Sidawi & Meeran, 2011) and 'high mortgage default rates' (Boamah, 2010) do not broaden and strengthen participation by financial institutions for sustainable housing supply. Similarly, 'poor maintenance culture of existing affordable housing' could affect the quality of life of households and consequently lower one's needs of place belonging. Finally, Sulemana et al. (2019) identified income inequality as one of the fundamental barriers to affordable housing.

3.3.2 Barriers to Economic Sustainability

There are challenges that could inhibit economic sustainability attainment in affordable housing projects. Zhang et al. (2016) identified inadequate public funding as one of the barriers. In Huang et al. (2015) and Hwang et al. (2017), high cost of the factors of housing production such as high cost of serviced land and high cost of sustainable housing materials / technologies, respectively, were stated as the causes of the colossal housing prices. Furthermore, Love et al. (2011) identified inadequate government incentives as one of the main impediments to sustainable development (green building). Obeng-Odoom and Amedzo (2011) pointed out that high inflation rate of construction materials and other factors of production was a key barrier to attaining economic sustainability in affordable housing. Moreover, Boamah (2010) stated that 'high interest rates' and 'tight credit conditions' are some of the challenges that negatively affect the affordable housing market. On rental affordability, Obeng-Odoom (2010) contended that though rent control policies are important to control housing rent escalation, they could create a 'black market' leading to the paradox of higher rents. Similarly, Duvier et al. (2018a) and Duvier et al. (2018b) elaborated on how quality data could improve the quality of housing services offered to low-income earners. However, rent control policy was identified as one of the barriers that could lead to loss of revenue and subsequently affect investment on quality data among social housing owners (Duvier et al., 2018b).

3.3.3 Barriers to Environmental Sustainability

Environmental sustainability attainment is beset with various barriers. Obeng-Odoom (2010) indicated that inadequate access to secure land is among the barriers. Furthermore, zoning restrictions on land for affordable housing projects (such as restriction on multifamily housing and compact development) and low-rise affordable housing do not ensure efficient utilization of land for SAH (Mondal & Das, 2018). Moreover, Winston (2010) stated that the sitting and construction of new affordable housing units in outskirts of towns and cities encourages sprawl development which leads to a faster use-up of land. Consequently, longer commuting has negative economic implication on household income and could also lead to the emission of more greenhouse gases.

3.3.4 Barriers to Institutional Sustainability

Upon reviewing the literature, some institutional / regulatory barriers to SAH were identified. According to Alam et al. (2019), lengthy planning and approval process is among the barriers to sustainable construction practices. Besides, Winston (2010) identified inadequate skilled labor as one of the barriers that hinder sustainable housing development. In Agyemang and Morrison (2018), 'weak enforcement of planning system control on land development'; 'inadequate affordable housing policy / guidelines' and 'inadequate autonomy of local authorities due to high central government interference or conflicting policies between local authorities and central government on planning' were identified as barriers that can affect the operation of an institution for SAH. Similarly, Czischke & van Bortel (2018) and Bardhan et al. (2018) identified 'inadequate policy / guidelines' as a barrier to affordable housing. According to Boamah (2010), 'inadequate mortgage institution' is one of the main barriers that affect financing of housing projects. Twumasi-Ampofo et al. (2014) and Gooding (2016) identified 'abandoned management of public housing facilities or projects by government' as a barrier that hinders SAH.

Table 3.2 shows the list of barriers identified from the literature review. In summary, the systematic literature review culminated in the development of a conceptual framework of barriers to SAH (shown in Fig. 3.1). This framework shows that there exist relationships or associations among the barriers in each group. Thus, these barriers do not exist in isolation but could have effects on or are correlated with one another. The hypothetical relationships among the barriers are represented by the double-arrow curved lines that connect one group of barriers to another group of barriers.

Table 3. 2: List of Potential Barriers to Sustainable Affordable Housing

Code	Barriers	References*	Countries / Jurisdictions Affected by Barrier
B01	Inadequate affordable housing policy / guidelines	[1]; [2]; [46]; [47]; [50]	Ghana; Dublin; Malaysia; United Kingdom; India
B02	Inadequate public funding	[3]; [4]; [5]; [47]	China; Australia; United Kingdom
B03	Income inequality	[6]; [7]; [8]	Most Sub-Saharan African Countries; China
B04	High cost of serviced land	[9]; [10]; [11]; [36]	Ghana; China; Hong Kong; Nigeria
B05	Income segregation	[12]; [13]; [32];	United States of America; Australia; South African
B06	Inadequate infrastructure development / supply	[14]; [15]; [32]; [51]; [56]	Ghana; South Africa; India
B07	Zoning restrictions on land for affordable housing projects	[17]; [18]	United States of America
B08	Poor maintenance culture / inadequate retrofitting of existing housing facilities	[19]; [20]; [21]; [22]	Russia; Italy; Hong Kong; Australia
B09	Delays in government approval process	[23]; [24]; [22]; [36]; [51]; [52]	Hong Kong; Australia; Ghana; Nigeria; India; Singapore
B10	Tight credit conditions	[25]; [21]; [22]	United Kingdom; Hong Kong; Australia
B11	Inadequate access to land for housing	[2]; [26]; [36]; [49]; [51]; [53]; [55]	Ghana; Hong Kong; Nigeria; China; India; Mauritius; Latin American Countries
B12	High cost of sustainable building materials / technologies	[27]; [28]; [29]; [30]	Canada; United States of America; Australia; Ghana; Malaysia; Hong Kong; Singapore
B13	Lack of policies on land use planning system for housing supply	[2] ; [59]	Most Sub-Saharan African countries; Dubai
B14	Abandoned management of public housing facilities / projects by government	[31]; [32]; [53]	Ghana; Mauritius
B15	Community opposition to affordable housing projects	[33]; [34]; [35]; [53]; [58]	United States of America; Dublin; Mauritius; UK
B16	High approval cost due to high taxes and fees on developers	[36]; [51]	Nigeria; India
B17	Inadequate mortgage / financing institutions	[36]; [37]; [38]; [41]; [51]; [54]	Nigeria; Ghana; India; Most Latin American countries
B18	High interest rates	[25]; [36]; [39]	United Kingdom; Nigeria; Ghana
B19	Inadequate incentive for private investors	[40]; [41]; [45]; [47]; [48];	Ghana; United States of America; Canada; Australia; UK; Singapore
B20	High inflation rate	[36]; [42]; [43]	Ghana; Nigeria
B21	Conflicting policies between local authorities and central government on planning	[2]; [22]; [56]	Ghana; Australia; New Zealand
B22	Rent control policies	[26] ; [44]	Ghana; United Kingdom
B23	Limited private partnership	[36]; [45]	Nigeria; Ghana
B24	Shortage of skilled labour	[15]; [22]; [23]	Dublin; Australia; Hong Kong
B25	High mortgage default rates by client	[37]	Ghana

B26	Negative culture towards mortgage	[39]	Kingdom of Saudi Arabia

*[1] Czischke & van Bortel (2018); [2] Agyemang and Morrison (2018); [3] Liu et al. (2015); [4] Zhang et al. (2016); [5] Hu & Qian (2017); [6] Chen et al. (2016); [7] Liddle (2017); [8] Sulemana et al. (2019); [9] Arku (2009); [10] Wen and Goodman (2013); [11] Huang et al. (2015); [12] Massey et al. (2009); [13] Randolph & Tice (2014); [14] Power (2008); [15] Winston (2010); [16] Oyebanji et al. (2017); [17] Hui & Soo (2002); [18] Mondal & Das (2018); [19] Paiho et al. (2015); [20] Gianfrate et al. (2017); [21] Tan et al. (2018); [22] Alam et al. (2019); [23] Lam et al. (2009); [24] Taylor (2011); [25] McKee (2012); [26] Obeng-Odoom (2010); [27] Ibem (2011); [28] Ahn et al. (2013); [29] Yang & Yang (2015); [30] Chan et al. (2018); [31] Twumasi-Ampofo et al. (2014); [32] Muringathuparambil et al. (2017); [33] Tighe (2010); [34] Winston (2010); [35] Trudeau (2018); [36] Makinde (2014); [37] Boamah (2010); [38] Bangdome-Dery et al. (2014); [39] Sidawi & Meeran (2011); [40] Susilawati and Armitage (2005); [41] Chan et al. (2018); [42] Marks & Sedgwick (2008); [43] Sulemana et al. (2019); [44] Duvier et al. (2018b); [45] Kwofie et al. (2016); [46] Winston (2010); [47] Sourani & Sohail (2011); [48] Yin et al.(2018); [49] Hu and Qian (2017); [50] Bardhan et al. (2018); [51] Ram & Needham (2016); [52] Hwang & Ng (2013); [53] Gooding (2016); [54] Blanco et al.(2016); [55] Echeverry et al. (2007); [56] Murphy (2016); [57] Daniel & Hunt (2014).
[58] Sturzaker (2011); [59] Alawadi et al. (2018)

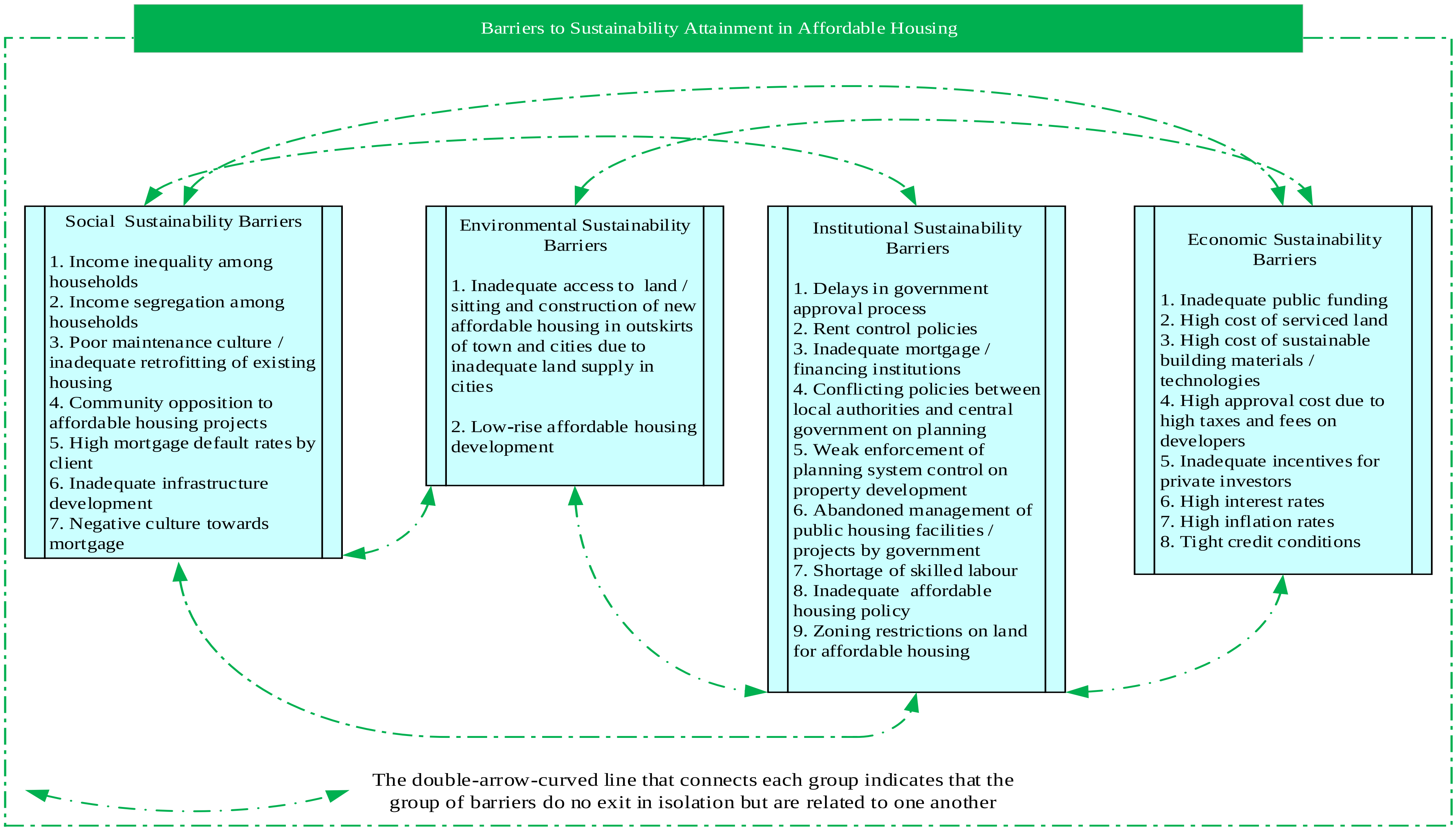

Fig. 3. 1: A Conceptual Framework on Barriers (Adopted from Adabre et al., 2020)

3.4 KNOWLEDGE GAPS IDENTIFIED IN THE LITERATURE

From the literature review, most prior studies concentrated on residential facilities of high-income earners while studies on sustainability attainment in affordable housing are insufficient. The notional reason is that sustainability and affordability are two diametric terms – one cannot be achieved without compromising on the other. Consequently, there is dearth empirical study on critical barriers for the gap between sustainable housing and affordable housing. An impetus for this study is that the largest area of residential development in most developing countries such as Ghana are to be found in low-income settlements (Obeng-Odoom, 2010). Therefore, if significant achievement on sustainable housing is to be made in Ghana, it is vital to figure out strategies of making low-income residential facilities sustainable. This could be achieved by first identifying the critical barriers that hinder SAH.

3.5 CHAPTER SUMMARY

Through a systematic review, this chapter concluded that there are various risk factors and barriers that hindered SAH sustainability attainment in affordable housing. On risk factors to SAH, the review resulted in the identification of 30 potential critical risk factors. Knowledge gaps on subjectivity of assessing the risk factors and the impact of the risk factor on the CSC were identified. This study aims to address these knowledge gaps. Concerning barriers, twenty-six potential critical barriers were identified and classified into four main groups, namely, economic sustainability, social sustainability, environmental sustainability and institutional sustainability attainment barriers. There is the need for an empirical study to provide manageable classifications / groupings for the various barriers. Besides, the review revealed that barriers to SAH are context specific and therefore, there is need to identify the critical barriers that pertain to SAH in the Ghana since studies on this topic are limited. Furthermore, prior studies did not investigate the impact of the barriers on the CSC. In the following chapter, a review is conducted on potential critical success factors (CSFs) for SAH.

CHAPTER 4: LITERATURE REVIEW – POTENTIAL CRITICAL SUCCSS FACTORS (CSFs) FOR SAH[4]

4.1 INTRODUCTION

Appropriately, there has often been a renewed interest among governments and other policy-makers such as the United Nations (UN) and the World Bank to address the growing housing deficits in these times of rapid urban growth (Buckley et al., 2016). In pursuit of the objective of access to sustainable housing, these policy makers employ various sets of success factors (interventions) in their housing policies (Salvi Del Pero et al., 2016). However, some of the success factors might lead to "contrasting objectives and goals, with loss of efficiency and potentially wider negative effects on the economy" (Salvi Del Pero et al., 2016 p. 11). Evidently, there are controversies on the criticality of success factors regarding the identification of a list of critical success factors (CSFs) for aspects of sustainable affordable housing markets (Hui, 2004; Huang et al., 2015; Deakin, 1989; Pendall, 2002). According to Rockart (1980 p. 4), "CSFs are the few key areas of an activity in which favorable results are absolutely necessary for a particular manager to reach his or her goals". Similarly, Boynton and Zmud (1984) defined CSFs as those few things that must go well to ensure success for a manager or organization and so, they represent those managerial or enterprise areas that must be given special and continual attention to bring about high-performance. A comprehensive review is first conducted to establish a list of the potential CSFs for SAH in subsequent sections.

[4] This chapter largely based upon the following publication:
Adabre, M. A., & Chan, A. P. (2019). Critical success factors (CSFs) for sustainable affordable housing. *Building and Environment*, *156*, 203-214.

4.2 CSFs FOR SAH

In this time of increasing greenhouse gas emissions and incessant housing supply deficit, sustainable development is the main measure of success in affordable housing (Ibem and Azuh, 2011; Chan and Adabre, 2019). Sustainable development is the attainment of a better quality of life through the efficient use of resources, which realizes continued social progress whilst maintaining stable economic growth and caring for the environment (Oyebanji et al., 2017). Sustainable development in affordable housing seeks to achieve the following three main goals: economic, environmental and social goals. Arising from these goals of sustainable affordable housing is often the question of what policy framework and interventions can better support these outcomes of success (Gurran et al., 2015).

Generally, the achievement of project success involves the interaction of several success factors. Lists of success factors have been proliferated in the literature, however, no general agreement can be made. With the abundance of different success factors for projects, Rockart (1980) believed that there were some success factors among the many factors, which were most important for the attainment of project success. Using the information system and through extensive interviews with nine reputable companies, Rockart (1980) felt that by zeroing in on those areas of an activity perceived by the executives to be most important for the organization well-being, the pertinent issues and tasks to be dealt with by managers could be targeted. From this perception, the concept of "critical success factors (CSF)" emerged.

After its introduction by Rockart (1980), the concept of CSFs has been widely adopted in many scopes of general construction industry and with, however, an altered meaning. In previous studies (Rockart, 1980; Boynton and Zmud, 1984), CSFs were applied to managerial or enterprise areas which required special attention. However, in many construction project studies, CSFs refer to the selected few factors from the many factors, which are extremely important for project success. For instance, Sanvido et al. (1992) concluded that among seven factors for project success, four were deemed critical. These included: a cohesive team to direct, organize, design and manage the project; a series of contracts that permit and support the various specialists to work as a team without conflicts of interest; experience in design, planning and managing construction and operation; well-timed, valuable information from the user, designer and contract. For budget performance of construction projects, Chua et al. (1997) stated that out of 27 success factors, eight were critical. Furthermore, using neural network analysis on 27 success factors, Kog et al. (1999) asserted that five success factors were critical for project schedule performance. On critical success factors for various sections of construction projects, Kog and Loh (2011) identified 10 CSFs from 67 success factors. The concept of CSFs has also been applied in PPP (Li et al., 2005; Zhang, 2005; Chan et al., 2010), knowledge management in small and medium enterprises (Yew Wong, 2005) and affordable housing projects (Kwofie et al., 2016; Oyebanji et al., 2017; Mukhtar et al., 2017).

Studies on success factors for affordable housing projects are prolific with controversies on the criticalities of these factors being very common. In Hong Kong, for example, due to housing shortage, the government initiated a plan to increase the supply of residential land in order to increase the housing supply. A study by Hui (2004) argued that such a policy is an efficient strategy to ameliorate the housing deficit. However, by analyzing time-series data, Huang et al. (2015) concluded that new housing supply in Hong Kong is independent of the land supply by the government. Thus, the policy of increasing land supply to increase housing supply may be inefficient. Accordingly, decreased internal rate of return attributed to high land price led to reduction in housing supply by developers (Huang et al., 2015). Besides, while some studies have concluded that urban containment policies (such as increasing densities for affordable housing development) have an incremental effect on housing prices and are therefore inefficient governmental policies and controls (Pollakowski and Wachter, 1990; Fischel, 1989; Dawkins and Nelson, 2002), a review study by Deakin (1989) stated that the price increment on housing is caused by other inefficiencies. Additionally, Pendall (2002) stated that urban containment policies prevent urban sprawl, preserve agricultural land and encourage higher density affordable housing development. Furthermore, the impact of financial subsidies on housing supply has not been left unquestioned. For instance, in South Africa, the government adopted subsidy payment as a method of financing affordable housing to ensure that houses are allocated to beneficiaries. However, a study by Ganiyu et al. (2017) revealed that this subsidy system was ill-treated by beneficiaries through the illegal sales of houses below market value. This led to an incessant building of sheds and an enlarged number of people on the waiting list. Similarly, Angel (2000: 110) notes, "the most important aspect of subsidies is that they can modify and sometimes inadvertently distort the behavior of consumers and producers by affecting the prices of housing inputs, units and services". Similarly, Guran et al. (2015) stated that though government grants, subsidies and taxes could be aimed at improving housing affordability, they could rather inflate prices or rents. Moreover, the importance of infrastructure supply to affordable housing has been acknowledged in Hui (2004), however, infrastructure supply without regulations could rather be capitalised in land and housing values making housing unaffordable (Guran et al., 2015; Agyemang and Morrison, 2017; Obeng-Odoom, 2010). Other policies such as land planning policies, mandatory inclusion or incentives for inclusion of affordable housing have received varied opinions on their effectiveness in ensuring the provision of affordable housing (Paris, 2007; Lerman, 2006). Though the varied opinions reflect variations among countries, it is worth noting that even within a country, differences in opinions are expressed on the effectiveness of some of these policies in ensuring affordable housing market (Hui, 2004; Huang et al., 2015).

4.2.1 CSFs for SAH in Ghana

From the Ghanaian perspective, various policies have been stipulated to achieve the UN Sustainable Housing Goals (SDGs) albeit limitations in policy implementation and policy inefficiencies. At the inception of the neoliberal approach, policies have been initiated by governments to provide aid for efficient operation of the private sector concerning housing supply. Financial incentives such as tax enticements have been offered to potential investors to promote participation and competition among investors in the housing market. Aside the reduction of corporate tax from 55 per cent to 45 per cent, a five-year tax holiday and Stamp Duty exemption on the sales of houses were provided to real estate developers. Moreover, developers could apply for other incentives from the Ghana Investment Promotion Centre (GIPC). These policies encouraged the participation of the real estate developers in the housing market (Arku, 2009). However, Arku (2009, p. 268) noted that, "the rise of private developers has led to housing units being produced by profit-oriented developers, and prices are extremely high for middle- and low-income earners, especially in urban areas such as Accra". Therefore, while few high-income earners have become the target of most real estate developers, the majority middle- and low-income earners could get their shelter needs met through self-built housing.

Self-built housing facilities have been a major form of housing supply in Ghana. As such, government policies have also been focused on enabling households to achieve sustainable housing. For instance, to ensure affordable energy, subsidy is provided to all residential consumers for the first 50kWh of electricity. Besides, partial retrofitting activities were implemented to ensure energy efficient housing. The government of Ghana through the Energy Commission replaced all incandescent bulbs with compact fluorescent lamps (CFL). Furthermore, through refrigerator rebate scheme, all households' second-inefficient refrigerators were to be replaced with those that are more energy efficient (Kumi, 2017). On affordable housing supply, collective self-help approaches to housing have been facilitated. Gillespie (2018) stated that as part of the country's commitment for upgrading slum and providing shelter for low-income households, policymakers provided expedited permit approval for the Amui Dzor Housing Cooperative within Ashaiman in Accra. However, while some self-built facilities are adequately constructed and well-serviced, others are poorly constructed, lack supplementary facilities and often result in proliferation of slums. Therefore, the effectiveness and adequacy of policies for enabling households has been questioned. For instance, Kumi (2017) impugned the relevance of the utility subsidies for sustainable housing. Thus, one of the issues at hand is to assess the efficiency and sufficiency of household policies for sustainable housing.

In reaction to urban sprawl, policies channelled towards mixed-used development have been established in some cities to regulate the uncoordinated expansion and to provide accommodation to more households within cities. For example, the Town and Country Planning Department (TCPD) in Kumasi initiated a standard building height of four storey minimum within the Central Business District (CBD) in 1990 to accommodate more households and businesses (Agyemang et al., 2018). Similar policies such as mixed development of housing and commercial facilities, appropriately siting / locating public housing facilities within cities and adequate infrastructure for accessibility have been considered as important for preventing traffic congestion, loss of peri-urban and for decreasing vehicular emission (Cobbinah & Amoako, 2012). Certainly, some of these policies such as 'high-rise housing facilities' and 'mixed development of housing and commercial facilities' have proven as successful policy for sustainable housing in most Asian economies such as Singapore and Hong Kong. However, considering the cultural difference of low-rise, single-family housing on peripheries of Ghanaian cities, the question worth asking is how impactful and how significant are mixed development policies for sustainable housing in Ghana?

Moreover, government's interventions through redistributive policies (such as taxes) have been suggested as strategies for controlling income inequality in urban areas and for providing housing to low-income earners. According to Stilwell (2011), "increasing urbanization leads to widespread use of land for roads and for other infrastructure development that are provided by the state or public". Based on this, Agyemang & Morrison (2018) asserted that there is an opportunity cost to the state for not capturing the increase in the value of land that results from state's infrastructural supply. Therefore, using the UK as a quintessential case, Agyemang & Morrison (2018) concluded that tax policies could be adopted in Ghana and other sub-Saharan African countries to capture increases in land values attributed to infrastructure supply. It was averred that revenues from such policies could be deployed to augment housing supply in most cities. Despite the significant contributions of their study, it is worth noting that the land tenure system in Ghana is different from that of the UK. In fact, land ownership structure in Ghana is dominated by the customary system. Besides, while UK is a developed economy and could have well-structured and mature institutions, most sub-Sharan African countries are still developing economies with incipient institutions. Therefore, recommending land-use policies for Ghana begs the question of how significant are such policies for the sustainable housing goals.

In summary, various policies have evolved with questionable limitations on their implementation or efficacy concerning housing development in Ghana. The policies, as revealed in the literature, can be categorised into four main constructs of success factors, namely, 'developers' enabling'; 'household enabling'; 'mixed-used development' and 'land-use planning'. These groupings are inveterate categories from the analysis of data from the international survey on critical success factors (CSFs) (as shown in Chapter 7). Table 4.1 shows a list of success factors (SFs) from the literature.

Table 4. 1: List of Success Factors (SFs) for Sustainable Affordable Housing Market

Code	Success Factors	References
SF01	Access to low interest housing loan to developers	Kwofie et al. (2016); Boamah (2010)
SF02	Mixed land development	Gan et al. (2017)
SF03	Linking commercial development approval to funding for affordable housing	Alawadi et al. (2018); Agyemang and Morrison (2017)
SF04	Stable macro-economic system	Kwofie et al. (2016)
SF05	Effective private sector participation	Kwofie et al. (2016); Whitehead (2007)
SF06	Incentives for developers to include affordable housing / sustainable designs	Klug et al. (2013); Ponce (2010); Morrison and Burgess (2014)
SF07	Governments providing guarantees to developers	Kwofie et al. (2016)
SF08	Improved supply of low cost developed land by government	Huang et al. (2015); Balmer and Gerber (2017)
SF09	Political will and commitment to affordable housing	Oyebanji et al. (2017); Mukhtar et al. (2017)
SF10	Stable political system	Kwofie et al. (2016); Cao and Keivani (2013)
SF11	Formulation of sound housing policies	Whitehead (2007)
SF12	Governments' provision of housing subsidies to households	Ganiyu et al. (2017); Whitehead (2007)
SF13	Good location for housing projects	Mukhtar et al. (2017)
SF14	Adequate accessibility to social amenities	Gan et al. (2017); Oyebanji et al. (2017)
SF15	Mandatory inclusion of affordable unit policy in developer's projects	Klug et al. (2013)
SF16	Adaptable housing design and construction	Adinyira and Anokye (2013)
SF17	Transparency in housing allocation	Mukhtar et al. (2017)
SF18	Adequate maintenance of existing houses	Gan et al. (2017)
SF19	Monitoring conditions / performance of completed houses	Winston (2010)
SF20	High density affordable housing development	Gan et al. (2017); Massyn et al. (2015)
SF21	Increase tax rate to discourage long holding period of vacant land	Obeng-Odoom (2010)
SF22	Adequate infrastructure supply by government	Oyebanji et al. (2017)
SF23	Compliance with quality targets	Oyebanji et al. (2017)
SF24	Adherence to project schedule	Mukhtar et al. (2017)
SF25	Compliance with project budget	Mukhtar et al. (2017)
SF26	Good coordination among project participants	Sanvido et al. (1992)
SF27	Adequate staffing of public housing agencies	Mukhtar et al. (2017); Agyemang and Morrison (2017)
SF28	Speculative measures on property sales through taxes	Mohd Thas Thaker and Chandra Sakaran (2016)
SF29	Taxation on property or capital gains for housing supply	Agyemang and Morrison (2017); Obeng-Odoom (2010)
SF30	Time limited planning approval / bonuses on land development	Gurran et al. (2015)

4.3 KNOWLEDGE GAPS IDENTIFIED IN THE LITERATURE

From the literature review, it can be concluded that most of the polemics in the literature on the criticality of the success factors are focused mostly on price affordability in the housing market with little regard to how these factors could generally improve the sustainability of affordable housing. Moreover, concerning sustainable affordable housing development, both the developed and developing countries are in the infancy stage (Choi, 2010).

Since international policy makers often seek to implement worldwide affordable housing policies (Keivani and Werna, 2001), it is important to find out the opinion of affordable housing experts around the world on the criticalities and categorization of these success factors for a sustainable affordable housing market. This is a gap is the literature. As such, a general knowledge on construct formation, either reflective or formative constructs for critical success factors for SAH is not empirically investigated in the previous studies. Therefore, an international study will provide basis for further studies in the Ghanaian housing market.

Moreover, since current and successive governments in Ghana seek to implement policies for not only price / rental affordability of housing facilities but for a holistic economic, social and environmental sustainability attainment, it is important to find out the opinion of housing experts in the Ghanaian housing market on the criticalities of the identified success factors (shown in Table 5.1) towards achieving the sustainable development goals as stated in Target 11.1 of the United Nations (UN) policy goal. Furthermore, the findings could be relevant in guiding decision making on resource allocation for sustainable housing towards sustainable cities development. Theoretically, the findings could serve as benchmarks to guide further study in other sub-Saharan African countries. Besides, future study in other sub-Saharan Africa countries could adopt and implement some of the findings.

4.4 CHAPTER SUMMARY

The thorough review of the literature culminated in the identification of 30 potential CSFs for SAH. Besides, the knowledge gap in prior studies was pointed out through the systematic review. It was revealed that some of the potential CSFs might lead to "contrasting objectives and goals, with loss of efficiency and potentially wider negative effects on the economy" (Salvi Del Pero et al., 2016 p. 11). Therefore, there is the need for an empirical investigation into the set of 30 success factors to identify CSFs for SAH. The following chapter presents the research methodology that was deployed to achieve the various objectives and to ultimately achieve the aim of the study.

CHAPTER 5: RESEARCH METHODOLOGY[5]

5.1 INTRODUCTION

In previous chapters (Chapters 2,3 & 4), a literature review on CSC, CRFs, CBFs and CSFs was elaborated. Although the relevance of the research knowledge gaps as evinced in the literature review give credence for the study, the "how" to achieve the aim and objectives of the study was not much expatiated. Therefore, this chapter seeks to elucidate the methodology adopted for achieving the stated aim and objectives of the study. First in this chapter is a description of the philosophical assumption / paradigm for the research study. Then, the various stages of the adopted research paradigm are stated with explanation on each of them. Finally, the research techniques for data collection and analysis are discussed.

5.2 PHILOSOPHICAL ASSUMPTION

A research assumption is a set of believes that guide an action or within which theories and practices operate (Guba & Lincoln, 2004). These assumptions include epistemology – philosophy of knowledge or how we know – which is associated with ontology and methodology. Establishing how these three terms are related, Krauss (2005) stated that

[5] This chapter largely based upon the following publications:
Adabre, M.A. and Chan, A.P. (2018). The ends required to justify the means for sustainable affordable housing: A review on critical success criteria. *Sustainable Development*, 26, 1-14.
Chan, A. P., & Adabre, M. A. (2019). Bridging the gap between sustainable housing and affordable housing: The required critical success criteria (CSC). *Building and Environment*, *151*, 112-125.
Adabre, M. A., & Chan, A. P. (2019). Critical success factors (CSFs) for sustainable affordable housing. *Building and Environment*, *156*, 203-214.
Adabre, M. A., Chan, A. P., Darko, A., Osei-Kyei, R., Abidoye, R., & Adjei-Kumi, T. (2020). Critical Barriers to Sustainability Attainment in Affordable Housing: International Construction Professionals' Perspective. *Journal of Cleaner Production*, 119995.
Adabre, M.A., and Chan, A.P.C. Towards a Sustainability Assessment Model for Affordable Housing Projects: The Ghanaian Perspective. *Engineering, Construction and Architectural Management.* Manuscript ID: ECAM-08-2019-0432.R1.

ontology includes the philosophy of reality, epistemology concerns how one comes to know that reality while methodology pinpoints the specific practices adopted to achieve knowledge of reality. Moreover, epistemology poses the question “what is the relationship between the knower and what is known? How do we know what we know? What counts as knowledge?” (Krauss, 2005 p. 759).

From the ontological assumption, affordability crisis is a reality that is globally recognized (Salvi Del Pero et al., 2016; Golubchikov & Badyina, 2012). Stakeholders such as governments, real estate developers and low-income earners face many challenges and are unable to initiate and implement pragmatic policies to mitigate the affordability challenges as well as achieve sustainable housing goals. This has, therefore, led to the observed reality – unaffordable housing and energy crises. This reality is mostly critical in cities of sub-Saharan African countries (Arku, 2009), from which Ghana is selected for a case study. Epistemologically, the researcher can further investigate the observed reality by using any of the following three assumptions: positivism, constructivism / interpretivism or realism (post-positivism).

Concerning the positivism paradigm, objectiveness of the researcher is the main presuppositions. Appositely, knowledge of the observed reality – the need for sustainability attainment in affordable (low-cost housing) in Ghana – could be discovered and verified through direct observation or measurement. Accordingly, empiricism is the core believe of the positivist. Thus, observation and measurement form the basics of an objective or scientific attempt of studying the crisis (Trochim and Donelly, 2001). Positivism seeks to explain and predict a happening in the society by searching for regularities and causal relationship between its constituents (Krauss, 2005 p. 759). To establish causal relationships, quantitative techniques are adopted for the elimination of subjective bias since positivism presupposes the existence of an objective reality.

From the constructivism / interpretivism perspective, knowledge about the unaffordable housing crisis in Ghana can be established through the meaning attached to the phenomena being studied. The researcher interacts with survey respondents through interviews to obtain data. According to the constructivism approach, the data obtained is time and context dependent. Thus, meaning from the data depends on cognition and not on external objects (Lythcott & Duschl, 1990). Constructivism assumption presupposes multiple realities of the Ghanaian unaffordable housing and energy crises that can be studied through qualitative techniques.

Regarding realism, it is a philosophical paradigm that has features of both positivism and constructivism. Realism hinges on the belief of multiple perception (the constructivism perspective) under a single reality (the positivism perspective) (Healy & Perry, 2000). From an axiological perspective, while the positivism and constructivism are value-free and value-laden, respectively, realism is value cognizant. Thus, while relying on reality, it recognizes how reality could be influenced by the value of the human system (Lincoln & Guba, 1985).

Considering the three stated epistemologies, the philosophical assumption for this study leans towards the positivism for the following two reasons: first, it is worth noting that the type of research paradigm adopted for a study depends on the aim and research objectives. The aim of this research is to develop a potential model for SAH in Ghana. It seeks to explain causal relationships among CSC, CRFs, critical barriers and CSFs in relation to the Ghanaian housing affordability crisis. Second, this study adheres to only what the researcher can observe and measure in order to draw generalizations of the findings. Therefore, both stated objectives are features of the positivism paradigm (Krauss, 2005; Lythcott & Duschl, 1990). Accordingly, this study adopts the positivism paradigm.

5.3 RESEARCH METHODOLOGY

The selected research methodology is influenced by the adopted philosophical assumption. Selection of the right research methodology ensures that the aim and objectives of the study are achieved (Steele, 2000). This section consists of various selections of parts of the methodology, namely, selection of the research approach; adoption of research methods; data collection techniques; questionnaire development; questionnaire survey and statistical analysis techniques.

5.3.1 RESEARCH APPROACH

Research approach deals with the use of theory. According to Saunders et al. (2009), there are two main research approaches: the deductive approach and inductive approach. The deductive approach concerns developing a theory or hypothesis, which is then followed by the design of a research strategy to test the theory or hypothesis. However, the inductive approach concerns collecting data and developing a theory based on results of data analysis (Malalgoda et al., 2013). This study is an explanatory science since its core purpose is to develop valid knowledge (a model) to explain an objective reality (unaffordable housing and energy crises). This commences with acquaintance with the research problem, highlight of the problem-solving strategies and performance measure (Vaishnavi & Kutcher, 2004). Similarly, the identification of the unaffordable housing crisis (i.e. barriers and risks) and the problem-solving strategies and performance measure (i.e. CSFs and CSC) are first drawn from existing theory or knowledge. Then, hypotheses are developed concerning the unaffordable housing situation in Ghana. Subsequently, at the investigation stage, the relevance of the factors in the hypothesis is tested by soliciting for the views of respondents for a better understanding of the nature and solutions to the Ghanaian unaffordable housing challenges mostly in cities. Thus, the research approach for this study is the deductive approach since its end results is the development of a theory (a model) beginning from a broader perspective of literature review, structured methodology and data collection.

5.3.2 RESEARCH METHOD

Research method is a broad term encompassing data collection and data analysis. Due to variability among studies on research objectives, different methods have been adopted in various studies. Thus, there are no strict research methods, there are only justifiable research methods (Yin, 2009). Besides, the dictates of research objectives on the research method type, the significance and replicability of the research findings also play a major role (Alwaer and Clements-Croome, 2010). Rigorous and appropriate research methods lead to significant contribution to knowledge in academia while advancing industrial practices (Walker, 1997). Typical research methods include experiment, survey, case study, action research, ethnography, grounded theory and archival research (Malalgoda et al., 2013).

Experiments are deployed to study the relationship between two or more variables in which the outcome of a control group is compared with the outcome of an uncontrolled group (Saunders et al., 2009). Experimental method is not suitable for this study since the researcher has no control over the observed problem – the unaffordable housing and energy crises. Furthermore, as deliberated under the research philosophical assumption and approach, this research adopts the positivism stance and uses a deductive approach. As such, research methods such as case study, action research, ethnography, grounded theory and archival research are not related to this study since they are more appropriate for the constructivism philosophical stance (Krauss, 2005). Therefore, survey is the appropriate research method since it is suitable for positivism research and deductive study (Collis and Hussey, 2009; Saunders et al., 2009). Additionally, Yin (2009) stated that a researcher must consider two aspects when selecting a research method. First is the type of research question asked, second is the extent of control the researcher has on the real behavioural events and the degree of focus on contemporary versus historical events. This study is focused on answering 'what' and 'how' forms of research questions. Some of these questions include 'what are the CSC, CRFs, critical barriers and CSFs for SAH?'; 'what are the impacts of CSFs and critical barriers on SAH?' and 'how can the findings on CSC, CRFs, critical barriers and CSFs be integrated to provide a model for sustainability attainment in affordable / low-cost housing? To answer these questions, survey research method is the most suitable (Yin, 2009). Moreover, per the positivism epistemological stance, this study falls under quantitative strategy. Accordingly, quantitative strategy is adopted for this study. This strategy emphasises quantification over words in data collection and analysis (Bryman and Bell, 2015).

5.3.3 TIME HORIZON

The chosen type of time horizon determines the type of data to be collected. It is also important for planning the research study (Malalgoda et al., 2013). The two main types of time horizons considered for research studies include: cross-sectional studies and longitudinal studies. Cross-sectional study involes a 'snapshot' of events taken at a particular time. However, longitudinal study entails collecting data to study changes and development over time. Since this research does not seek to study changes and development of SAH in Ghana over time, it falls under a cross-sectional study.

5.3.4 DATA COLLECTION TECHNIQUES

Data collection techniques enable the systematic gathering of information about the object of study while taking into consideration the setting of the information gathering. In choosing the data collection method, it is important that the depth and scope should be taken into consideration (Fellows and Liu, 2015). Survey covers a wide scope of study objects by using questionnaire surveys, structured observations and interviews to collect quantitative data. Representative sample data could be collected economically with the use of survey. Since this research seeks to collect data from a wide scope of respondents from the industry and academia, questionnaire survey is the most appropriate data collection technique (Fellows and Liu, 2015).

5.3.5 COMPREHENSIVE LITERATURE REVIEW

A comprehensive literature review was conducted on CSC, CRFs, critical barriers and CSFs for SAH. Details of the literature review are provided in subsequent chapters. Review on CSC is detailed in Chapter 2, CRFs and critical barriers in Chapter 3 and CSFs in Chapter 4. In addition to other relevance of the literature review, the various factors for developing the questionnaire were identified from the review.

5.3.6 QUESTIONNAIRE SURVEY

Questionnaire survey has many advantages that make it suitable for this study. Notwithstanding the advantages, challenges such as selection bias and low response rate have been acknowledged in questionnaire surveys (Akadiri, 2011). Yet, in the light of the merits and demerits, questionnaire survey stands out as the best option for data collection. Through content analysis during the systematic literature review, various factors were identified for the questionnaire design. The factors identified covered four main areas such as CSC, CRFs, critical barriers and CSFs. These factors were used to develop questionnaires for data collection from respondents in the formal sector of the Ghanaian housing market such as respondents in the Ghana Real Estate Developers Association (GREDA), GhIS, employees at Public Works Department (PWD), Tema Development Cooperation (TDC), Ministries of Works and

Housing and respondents from academic institutions, Architectural Engineering and Service Limited (AESL), private consortium and other real estate developers from both public and private sectors. Table 5.1 is a summary of the research objectives and the deployed methods.

Table 5. 1: Research Objectives and Their Methods

Research objectives	Research Methods					
	Data Collection Methods		Data Analysis Methods			
	Extensive literature review	Questionnaire survey	Mean score ranking	Factor analysis	FSE	PLS-SEM
To identify critical success criteria for SAH in Ghana	√	√	√	√	√	√
To identify critical risk factors to SAH	√	√	√		√	
To identify critical barriers to SAH	√	√	√	√		√
To identify success factors for SAH	√	√	√	√		√

5.3.7 QUESTIONNAIRE DEVELOPMENT

A questionnaire containing various sections was designed for data collection. The first part of the questionnaire labelled "Section A" contains questions on respondent's organization, years of industrial and / or research experience in housing projects, professional background, the type and number of housing projects that a respondent has handled. The second section tagged as "Section B" contains questions on the identification of the CSC, CRFs, critical barriers and CSFs for SAH. In the first part of "Section B", respondents are asked to rate the level of importance of the various CSC regarding SAH. On the barriers, respondents were requested to indicate their level of agreement or disagreement on how the set of barriers affect SAH. In Section B, respondents were also asked to rate the likelihood of occurrence and severity of impact of some risks factors to SAH. The final part entailed the rating of success factors for sustainable housing. Thoughtfully, since the list of factors might not be exhaustive, spaces were provided for the respondents to list and rate other CSC, CRFs, critical barriers and CSFs for SAH, that might not have been included. A sample of the questionnaire is provided in appendix

A for reference. Except for "Section A", all the questions in "Section B" required respondents to rate the various factors on a rating scale.

5.3.8 RATING SCALES

Various rating scales have been adopted in the general field of construction industry for questionnaire design. These scales range from a 5- point Likert scale to a 11-point Likert scale. Due to its pithy nature and brevity, the 5-point Likert scale has mostly been adopted to encourage high response rate (Chan et al., 2016; Osei-Kyei and Chan, 2015). According to Chan et al. (2016), because of the tight schedules of professionals in the construction industry, a 5-point rating scale ensures rapid responses since there are fewer rating scores for experts to go through before choosing their responses. Similarly, Pitt et al. (2009) stated that lengthy rating scale such as 7-point Likert scale and 11-point scale could result in low-response rate. Though acquiescence bias is common with a 5-point Likert scale, it is worth noting that the quality of the responses from a 5-point Likert scale is not compromised (Revilla et al., 2014). Tables 5.2 and 5.3 show the rating scales that were adopted for the various sections of the questionnaire for the international and Ghanaian surveys, respectively.

Table 5. 2: Rating Scales for An International Survey

Rating Score	Critical Success Criteria and Success Factors	Barriers
1	Not important	Strongly disagree
2	Less important	Disagree
3	Neutral	Neutral
4	Important	Agree
5	Very important	Strongly agree

Table 5. 3: Rating Scales for Questionnaire Survey in Ghana

Rating Score	Critical Success Criteria and Success Factors	Barriers	Risks Occurrence and Severity of Impact
1	Not important	Strongly disagree	Very low
2	Less important	Disagree	Low
3	Neutral	Neutral	Medium
4	Important	Agree	High
5	Very important	Strongly agree	Very High

5.3.9 PILOT STUDIES

Piloting of the questionnaire was conducted. Essentially, questionnaire pretesting helped to refine its content for clarity and brevity before the actual survey. Part of the questionnaire was pre-tested to refine its content for clarity and brevity before the actual survey. Though a pilot study does not guarantee success in the final survey, it does increase the likelihood of success (Van Teijling and Hundley, 2001). It could mitigate the risk of low response rate. Therefore, the essence of this pilot is to solicit the opinions of the experts on the appropriateness of questionnaire vis-à-vis the lucidity of definitions and questions, wording of the questions, relevance or suitability of factors, structure and length of the questionnaire (Oyedele, 2010). The questionnaire was sent out to experts in the industry and academia. Eight experts (using respondents' publication profile and through social referral networks) were selected from the academia and industry; the questionnaires were then emailed to these selected experts. Four experts participated in the pilot survey.

The suggestions from the experts helped to improve the structure of the questionnaire. For instance, per the constructive comments of experts, some of the wordings of the questionnaires were reworded for clarity while other factors added for comprehensiveness. For example, on the question concerning CSC, one of the experts (a professor) suggested the addition of "waiting time of applicants before being allocated a housing unit". After the pilot studies, an international survey on the questionnaire was conducted to solicit expert opinion on the importance of some of the criteria and factors (i.e. CSC, critical barriers and CSFs). The international survey further helped in strengthening the clarity of the questionnaire before the main survey in the Ghanaian housing market.

5.3.10 POPULATION AND SAMPLING TECHNIQUES

For this study, the population of housing experts in the formal sector of the Ghanaian housing market. They include registered members of GREDA, members of the Ghana Institution of Surveyors (GhIS) who are employees of housing supplying institutions, researchers (housing lecturers in some of the public universities), public and private consortia such as Architectural Engineering and Service Limited (AESL). Employees at Public Works Department (PWD) and Ministries of Works and Housing, Tema Development Corporation (TDC), SSNIT, State Housing Corporation (SHC) were also included as part of the survey population. Not all housing developers or experts are registered with GREDA. As such, it was a herculean task to clearly define the sample frame. Therefore, a random sampling technique could not be employed for the selection of respondents. However, a non-probability sampling could be used to select representative sample in this situation (Chan et al., 2016). Thus, non-probability sampling techniques – purposive and snowball – were deployed in this study. The respondents were selected based on purpose of the study and the willingness of respondents to participate in the survey. The purposive sampling technique enables the selection of respondents based on their expertise for achieving the purpose of the study. With snowball sampling, respondents were identified through referral or social networks.

5.4 DATA ANALYSIS TECHNIQUES

Various statistical analysis techniques were utilized for analyzing the garnered data. These techniques are described in subsequent subsections.

5.4.1 MEAN SCORE RANKING TECHNIQUE

Mean score ranking is mostly used to rank the criticality or importance of a set of factors on a Likert scale (Chan & Adabre, 2019). In this study, mean scores were used to rank the criticalities of the CSC, CRFs, barriers and CSFs of the responses from professionals in the Ghanaian housing market. The following formula was used to calculate the mean score:

$$B_i = \frac{\sum_{j=1}^{n} a_{ij}}{n} \quad \text{..eqn. (5.1)}$$

Where n= the total number of respondents; a_{ij}= the importance/criticality of the factor *i* rated by the respondent *j*; and B_i = the mean score of the importance/criticality of the factor *i*, which could take any of the scores on the 5-point Likert scale from one to five.

5.4.2 CRONBACH'S ALPHA RELIABILITY TEST

Since various factors such as CSC, CRFs, critical barriers and CSFs have been put into scales, it is important to test the exhaustiveness, stability and reliability of each scale. The Cronbach's Alpha coefficient (α) provides such measure whether in repeated administration of the survey instrument, the factors will be reliable. Thus, the Cronbach's Alpha measures the reliability by determining the internal consistency of the factors. Against this backdrop, the Cronbach's Alphas for the various scales of the CSC, CRFs, critical barriers and CSFs for SAH were determined using the Statistical Package for Social Science (SPSS). The Cronbach's Alpha coefficient value can also be determined mathematically using eqn. (5.2)

$$\alpha = \frac{k\overline{r}}{1+(K-1)\overline{r}} \quad \text{..eqn. (5.2)}$$

Where k = the number of scale items; $\overline{r}$ = the average correlation among the scale items. The value of $\overline{r}$ is the product of the average variance and covariance of the scale items.

5.4.3 FACTOR ANALYSIS

Factor analysis is a useful statistical tool for investigating the relationship among variables or for establishing patterns in a scale (Field, 2009). With factor analysis, concepts that are not easily measured directly can be investigated. This is achieved through the grouping of variables into few interpretable underlying factors. It is mostly used in construction management due to its relevance in reducing large number of variables into smaller sets of easily and adequately manageable sets of principal factors (Chan and Adabre, 2019). Though there are different forms of factor analysis, Principal Component Factor Analysis (PCFA) is the appropriate option for this study. With the PCFA, data on CSC, critical barriers and CSFs from the international surveys were categorized into underlying groupings. Categorization of the variables into factors requires four steps (Chan et al., 2004, p. 192):

1. Establishing the relevant factors (CSC, critical barriers and CSFs) in sustainability attainment in affordable housing
2. Computing the correlation matrix for the factors
3. Extracting and rotating every factor; and
4. Interpreting and naming the principal factors as underlying constructs

Before conducting the factor analysis, two basic tests – Bartlett's test of sphericity and Kaiser-Meyer-Olkin (KMO) test – must be conducted to determine the suitability of the data. The adequacy of a sample for factor analysis is measured by the KMO while the Bartlett's test of sphericity determines whether the population correlation matrix is an identity matrix or not. For suitability of the data for factor analysis, the Bartlett's test of sphericity should be significant (p-value < 0.05) and KMO index should be above 0.5 (Kaiser, 1974; Field, 2009).

After preliminary examination of the suitability of the data, the main tasks in factor analysis include factor extraction and rotation. Factor solutions were obtained through factor extractions. The first factor solution explains the largest variance with the remaining variance distributed among other factor solutions. After which, the factors were rotated. Rotation of the factors simplifies the structure of the factors for interpretability. Though different rotations are available, varimax rotation was adopted because this form of rotation is developed as an incremental improvement upon prior algorithms: quartimax and equamax (Osborne, 2015). To limit the number of factors to manageable factor solution, the eigenvalue is mostly used as the limitation criterion. Eigenvalue for a given factor measures the variance in all the variables which is accounted for by the factor. It is obtained as the sum of the squared factor loadings of the factors (Field, 2009). Based on previous studies (Chan & Adabre, 2019; Adabre & Chan, 2019), only factors with eigenvalues higher than one will be retained.

5.4.4 FUZZY SYNTHETIC EVALUATION (FSE) FOR AN ASSESSING MODEL

Decision-makers and practitioners often encounter challenges in assessing the sustainability of projects (Haider et al., 2018). After the selection of CSC, appraising the non-quantifiable CSC has always been a problem in establishing a sustainability assessment model for a project. Benchmarks from CSC defined on linguistic scale as 'not important', 'less important', 'neutral', 'important' and 'very important' aid respondents to qualitatively assess the criticalities of the CSC. However, Haider et al. (2018) indicated that such benchmarks may contain inherent uncertainties as a result of vague non-mathematical claims and subjectivity in experts' opinion. Besides, multi-criteria decision making (decision making on qualitative data with many CSC and many decision-makers) are prone to uncertainties and are often arduous to be assessed.

Therefore, Zadeh (1965) developed the fuzzy synthetic evaluation (FSE) technique as a robust tool for handling such uncertainties (i.e. data limitations and linguistic scale for CSC that are prone to subjectivity). The FSE is a modelling technique for quantifying multi-attributes and multi-variates (Osei-Kyei & Chan, 2017). It is appropriate for aggregating scores of CSC towards developing an overall sustainability index. Therefore, by converting respondents' subjective opinions into mathematical indices, FSE provides an objective and quantitative assessing model for sustainable affordable housing projects. The FSE has been applied in studies of different fields for developing sustainability assessment model for small-size urban neighbourhood (Haider et al., 2018); mathematical models of project success for public-private partnership (Osei-Kyei & Chan, 2017) and project risk assessment model in construction projects (Tah & Carr, 2000).

Fuzzy Synthetic Evaluation Procedure

In this study, FSE was utilized to develop a sustainability assessment model for affordable housing (detailed in Chapter 8) and for modelling the impact of risks on sustainable affordable housing (also detailed in Chapter 8). The step-by-step guidelines for developing the model using FSE technique include the following (Osei-Kyei & Chan, 2017):

FSE Procedure for Sustainability Assessment Model

Stage 1: First, a set of fundamental assessment CSC (hereafter referred to as indicators, I) is developed. $I = \{I_1, I_2, I_3 \ldots I_n\}$; where n represents the number of indicators

Stage 2: Then, labels for the set of grade alternatives are established as $L = \{L_1, L_2, L_3 \ldots L_n\}$. For this study, the 5-point Likert scale is the set of grade alternatives. Therefore, L_1 = not important, L_2 = less important, L_3 = neutral, L_4 = important, L_5 = very important

Stage 3: Afterwards, the weighting for each indicator is established. The weighting (W) could be determined from the survey results using eqn. (5.3).

$$W_i = \frac{M_i}{\sum_{i=1}^{k} M_i}, \ 0 < W_i < 1, \text{ and } \sum_{i=1}^{k} W_i = 1 \quad \text{……………………………eqn. (5.3)}$$

Where W_i = weighting; M_i = mean score of an indicator; K= number of indicators within a criterion; $\sum W_i$ = summation of weightings

Stage 4: Furthermore, a fuzzy evaluation matrix for each grouping is established. This matrix is expressed as $R_i = (r_{ij})_{m \times n}$, where r_{ij} is the degree to which alternative L_j satisfies the criterion C_j

Stage 5: Moreover, the final FSE results for the evaluation are determined through the weighting vector and the fuzzy evaluation matrix as expressed in eqn. (5.4):

$$D = W_i \circ R_i \qquad \text{eqn. (5.4)}$$

Where D is the final FSE evaluation matrix; and " º " is the fuzzy composition operator.

Stage 6: Finally, the FSE evaluation matrix is normalized to develop the sustainability assessment index (SAI) by using eqn. (5.5):

$$SAI = \sum_{i=1}^{5} D \times L \qquad \text{eqn. (5.5)}$$

5.4.5 FUZZY SYNTHETIC EVALUATION (FSE) FOR ESTABLISHING CRFS

According to Zhao et al. (2016), risk assessment using the fuzzy synthetic evaluation requires three main elements, namely,

(1) A set of fundamental factors / risk attributes $R = \{R_1, R_2, R_3 \ldots R_n\}$; where n represents the number of risk factors or attributes

(2) A set of grade alternatives $G = \{G_1, G_2, G_3 \ldots G_n\}$. For this study, the 5-point Likert scale is the set of grade alternatives. Therefore, G_1 = very low, G_2 = low, G_3 = medium, G_4 = high, G_5 = very high

(3) A fuzzy evaluation matrix for each set of risk attribute groupings. This matrix is expressed as $R_i = (r_{ij})_{m \times n}$, where r_{ij} is the degree to which alternative G_j satisfies the criterion R_j

After establishing these three basic elements, three systematic steps are required for assessing the risks at the individual level (level 1 which is achieved in step 1), group level (level 2 which is achieved in step 2) and overall risk level (level 3 which is achieved in step 3). These steps include:

(1) Calculating the likelihood of occurrence (LO), severity of impact (SI) and magnitude of impact (MI) of risk factors
(2) Calculating the likelihood of occurrence (LO), severity of impact (SI) and magnitude of impact (MI) of various categories of risk factors
(3) Calculating the likelihood of occurrence (LO), severity of impact (SI) and magnitude of impact (MI) of all the categories of risk factors

Step 1. Estimating the LO, SI and MI of Risk Factors (Level 1)

To assess the likelihood of occurrence, severity of impact and magnitude of impact (MI) of the various risk factors, respondents were asked to rate the various set of risk factors using a 5-point Likert scale. Therefore, the set of grade alternative for both the likelihood of occurrence and severity of impact of the risk factors includes the various elements of the scale such as G_1 = very low, G_2 = low, G_3 = medium, G_4 = high, G_5 = very high.

These responses can be expressed as membership functions regarding the LO in the following equation forms

$$R_{(\mathrm{LO})1} = \frac{LO_1}{G_1} + \frac{LO_2}{G_2} + \cdots + \frac{LO_5}{G_5}$$

$$R_{(\mathrm{LO})1} = \frac{LO_1}{\text{very low}} + \frac{LO_2}{\text{low}} + \frac{LO_3}{\text{medium}} + \frac{LO_4}{\text{high}} + \frac{LO_5}{\text{very high}}$$

$$R_{(\mathrm{LO})1} = \frac{LO_1}{1} + \frac{LO_2}{2} + \frac{LO_3}{3} + \frac{LO_4}{4} + \frac{LO_5}{5}$$

Similarly, the responses on the severity of risk impact could be expressed in the membership function as follows:

$$R_{(\mathrm{SI})1} = \frac{SI_1}{G_1} + \frac{SI_2}{G_2} + \cdots + \frac{SI_5}{G_5}$$

$$R_{(\mathrm{SI})1} = \frac{SI_1}{\text{very low}} + \frac{SI_2}{\text{low}} + \frac{SI_3}{\text{medium}} + \frac{SI_4}{\text{high}} + \frac{SI_5}{\text{very high}}$$

$$R_{(\mathrm{SI})1} = \frac{SI_1}{1} + \frac{SI_2}{2} + \frac{SI_3}{3} + \frac{SI_4}{4} + \frac{SI_5}{5}$$

In FSE, the "+" denotes a notation and not an addition (Ameyaw & Chan, 2015). Thus, the equation for the membership functions for both the likelihood of risk occurrence and the severity of impact of the risk factors can also be expressed as $(LO_1, LO_2, LO_3, LO_4, LO_5)$ and $(SI_1, SI_2, SI_3, SI_4, SI_5)$, respectively.

After determining the membership functions, both the LO and the SI can be calculated using the following equations as stated in Zhao et al. (2016) and Osei-Kyei. & Chan (2017).

$$\mathrm{LO_i} = \sum_{i=1}^{5} (G_i \text{ X } R_{(LO)1}) \quad \text{……eqn. (5.6)}$$

$$\mathrm{SI_i} = \sum_{i=1}^{5} (G_i \text{ X } R_{(\mathrm{SI})1}) \quad \text{……eqn. (5.7)}$$

The criticality of each risk variable is calculated as a square root of a product of the likelihood of risk occurrence (LO) and the severity of risk impact (SI) as shown in eqn. (5.8).

$$\mathrm{MI}_i = \sqrt{\mathrm{LO_i} \text{ X } \mathrm{SI_i}} \quad \text{……eqn. (5.8)}$$

Step 2. Estimating the LO, SI and MI of Each Risk Category (Level 2)

The LO and SI of each category of risk factors are estimated by first determining the weightings of the various risk factors in the category. This is achieved by using eqn. (5.9) and eqn. (5.10):

$W_{LOi} = \frac{\mathrm{LO_i}}{\sum_{i=1}^{n} \mathrm{LO_i}}$, 0 < W_{LOi} < 1, and $\sum_{i=1}^{n} W_{LOi} = 1$……………………………..…..…...eqn. (5.9)

$W_{SIi} = \frac{\mathrm{SI_i}}{\sum_{i=1}^{n} \mathrm{SI_i}}$, 0 < W_{SIi} < 1, and $\sum_{i=1}^{n} W_{SIi} = 1$...…………………………......…....eqn. (5.10)

Where W_{LOi} = weighting of the likelihood of occurrence of a risk factor i; W_{SIi} = weighting of the severity of impact of a risk factor i; $\sum W_{LOi}$ = summation of all weightings of the risk factors under the category (level 2) concerning likelihood of occurrence; $\sum W_{SIi}$ = summation of all weightings of the risk factors under the category (level 2) concerning severity of impact and n is the number of risk factors within a category.

The LO and SI of each category of risk factors are obtained by using the weighting vector and the fuzzy evaluation matrix which can be expressed as

D = $W_i \circ R_i$ ………………………………………………...…………...……… eqn. (5.11)

Where W_i represents the weighting of all risk factors within a category and R_i is the fuzzy evaluation matrix.

Given that $X_{1\mathrm{LO}\,n}$ is the element of the fuzzy matrix which is one of the weighting elements of risk factors, then the fuzzy evaluation matrix can be obtained by using the weighting function set of a category of risk factors as follows:

$$R_{(LO)i} = \begin{bmatrix} MF_{LO1} \\ MF_{LO2} \\ MF_{LO3} \\ MF_{LO4} \\ MF_{LO5} \\ \cdots \\ MF_{LOn} \end{bmatrix} = \begin{bmatrix} X_{1LO1} & X_{2LO1} & X_{3LO1} & X_{4LO1} & X_{5LO1} \\ X_{1LO2} & X_{2LO2} & X_{3LO2} & X_{4LO2} & X_{5LO2} \\ X_{1LO3} & X_{2LO3} & X_{3LO3} & X_{4LO3} & X_{5LO3} \\ X_{1LO4} & X_{2LO4} & X_{3LO4} & X_{4LO4} & X_{5LO4} \\ X_{1LO5} & X_{2LO5} & X_{3LO5} & X_{4LO5} & X_{5LO5} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ X_{1LOn} & X_{2LOn} & X_{3LOn} & X_{4LOn} & X_{5LOn} \end{bmatrix}$$

$$D_{LOi} = (W_{i1}, W_{i2}, \ldots, W_{in}) \text{ x } \begin{bmatrix} X_{1LO1} & X_{2LO1} & X_{3LO1} & X_{4LO1} & X_{5LO1} \\ X_{1LO2} & X_{2LO2} & X_{3LO2} & X_{4LO2} & X_{5LO2} \\ X_{1LO3} & X_{2LO3} & X_{3LO3} & X_{4LO3} & X_{5LO3} \\ X_{1LO4} & X_{2LO4} & X_{3LO4} & X_{4LO4} & X_{5LO4} \\ X_{1LO5} & X_{2LO5} & X_{3LO5} & X_{4LO5} & X_{5LO5} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ X_{1LOn} & X_{2LOn} & X_{3LOn} & X_{4LOn} & X_{5LOn} \end{bmatrix}$$

Therefore, the membership functions of LO and SI of a particular category of risk factors, C, are calculated as follows:

$$D_{LOc} = \sum_{i=1}^{n} (W_i \text{ X } R_{(LO)i}) \quad \ldots\ldots \text{ eqn. (5.12)}$$

$$D_{SIc} = \sum_{i=1}^{n} (W_i \text{ X } R_{(SI)i}) \quad \ldots\ldots \text{ eqn. (5.13)}$$

Using the estimated membership function of LO and SI from eqn. (5.12) and eqn. (5.13) for a category of risk factors, C, the LO, SI and magnitude of impact (MI) of the category can be estimated using eqn. (5.14), eqn. (5.15) and eqn. (5.16), respectively.

$$LO_c = \sum_{i=1}^{5} (G_i \text{ X } D_{LOC}) \quad \ldots\ldots \text{ eqn. (5.14)}$$

$$SI_C = \sum_{i=1}^{5} (G_i \text{ X } D_{SIc}) \quad \ldots\ldots \text{ eqn. (5.15)}$$

$$MI_c = \sqrt{LO_c \text{ X } SI_C} \quad \ldots\ldots \text{ eqn. (5.16)}$$

Step 3. Estimation of the Overall LO, SI and MI of All Risk Category (Level 3)

The overall LO, SI and MI of all the risk factors are calculated by first determining the weights of each category of risk factors. This is obtained by dividing the LO_c and the SI_C by the summation of LO and SI of all the categories of risk factors, respectively. Given that there are k number of categories of risk factors, the estimation could be expressed mathematically as follows:

$$W_{LOc} = \frac{\mathrm{LO_c}}{\sum_{c=1}^{k} \mathrm{LO_c}}, 0 < W_{LOc} < 1, \text{ and } \sum_{c=1}^{k} W_{LOc} = 1 \quad \text{.......... eqn. (5.17)}$$

$$W_{SIc} = \frac{\mathrm{SI_c}}{\sum_{c=1}^{k} \mathrm{SI_c}}, 0 < W_{SIc} < 1, \text{ and } \sum_{c=1}^{k} W_{SIc} = 1 \quad \text{.......... eqn. (5.18)}$$

Then, using the estimated $\mathrm{W_{LOc}}$ and $\mathrm{W_{SIc}}$, the overall membership functions of LO and SI, respectively, represented as $\mathrm{D_{LOoverall}}$ and $\mathrm{D_{SIoverall}}$ are calculated as follows:

$$\mathrm{D_{LOoverall}} = \sum_{c=1}^{k} (\mathrm{W_{LOc}} \times \mathrm{R_{(LO)c}}) \quad \text{.......... eqn. (5.19)}$$

$$\mathrm{D_{SIoveral}} = \sum_{c=1}^{k} (\mathrm{W_{SIc}} \times \mathrm{R_{(SI)c}}) \quad \text{.......... eqn. (5.20)}$$

Using the grade point alternatives, G_i, with the $\mathrm{D_{LOoverall}}$ and $\mathrm{D_{SIoverall}}$ obtained from eqn. (5.19) and eqn. (5.20), the overall likelihood of risk occurrence ($\mathrm{LO_{overall}}$); overall severity of risk impact ($\mathrm{SI_{overall}}$) and overall magnitude of risks impact ($\mathrm{MI_{overall}}$) could be estimated as follows:

$$\mathrm{LO_{overall}} = \sum_{i=1}^{5} (G_i \times \mathrm{D_{LOoverall}}) \quad \text{.......... eqn. (5.21)}$$

$$\mathrm{SI_{overall}} = \sum_{i=1}^{5} (G_i \times \mathrm{D_{SIoveral}}) \quad \text{.......... eqn. (5.22)}$$

$$\mathrm{MI_{overall}} = \sqrt{\mathrm{LO_{overall}} \times \mathrm{SI_{overall}}} \quad \text{.......... eqn. (5.23)}$$

5.4.6 PARTIAL LEAST SQUARE STRUCTURAL EQUATION MODELLING

To determine the impact of one or more independent variables on a dependent variable, the traditional multiple regression analysis (MRA) could be used. However, in a situation where the dependent variables are more than one, the MRA is not applicable. Besides, MRA is not appropriate for simultaneously examining the relationships among independent variables on one hand and the relationships between independent variables and dependent variables on the other hand. Moreover, MRA does not offer validation or reliability test for assessing latent variables (Aibinu et al., 2010). In this study, the dependent variables (CSC of SAH) are more than one. Hence, a more robust multivariate method known as structural equation model (SEM) is espoused in this study. SEM allows a concurrent evaluation of a set of relationships among constructs of critical barriers or CSFs (independent constructs) on one hand and relationships between one or more constructs of barriers and the sustainable housing construct (CSC, dependent construct), on the other hand.

Prior to using SEM, it is essential to specify two main variables, namely, latent variables and observable variables. Latent variables are variables that are not directly measured but are inferred or measured indirectly from observable variables. However, observable variables can be measured directly. Relating these two types of variables to this study, sustainable housing is a latent variable that can be inferred from the set of CSC (i.e. energy efficiency, rent charges, water efficiency etc.). These set of CSC are referred to as observable variables (henceforth referred to as indicators). Similarly, various groups of the critical barriers and CSFs are all latent variables while the underlying variables in each group are observable variables (hereafter referred to as indicators / items of barriers or success factors).

Generally, SEM involves two forms of equation models: the measurement model and the structural model. The measurement model shows the relationship between a construct and its indicators. For instance, a relationship between sustainable housing and its indicators or a category of barrier or success factor and its indicators is a measurement model while a relationship between constructs (i.e. 'sustainable housing' and 'barriers' or 'success factor') is a structural model. SEM could be conducted using covariance-based SEM (CB-SEM) or variance-based partial least square structural equation modelling (PLS-SEM).

The choice between CB-SEM and PLS-SEM depends on the sample size and the nature of the data. A large sample size (about 200) that is normally distributed is required to accurately assess model fitness in CB-SEM (Lee et al., 2011). However, the PLS-SEM is suitable for a relatively small number of responses that are non-normally distributed. Due to these characteristics of the PLS-SEM, it is widely employed in construction management and sustainable development studies. For example, with a sample size of 43 professionals, Darko et al. (2018) utilized the PLS-SEM to evaluate the relationships among promotion strategies, barriers, drivers and the adoption of green building technologies in Ghana. Hence, smart-PLS version 3.2.7 was adopted for this study, Results of the PLS-SEM are presented in Chapter 9 which is dedicated for data analysis.

5.4.7 IDENTIFICTION OF INTERNATIONAL SURVEY RESPONDENTS

These experts were selected based on two major criteria as used in previous studies (Ke et al., 2011; Osei-Kyei and Chan, 2017).

1. Respondents who had broad research and / or industrial experience in affordable housing were selected.

2. Respondents who have in-depth knowledge on affordable housing projects were contacted to participate in the survey.

Considering the selection criteria for experts, it is believed that these experts will offer insight on the relevance of the CSC, critical barriers and CSFs for sustainable affordable housing projects.

The targeted respondents for this survey included experts in academia, contractors or developers and consultants. Experts were sourced and identified from affordable housing related publications in top-tier academic refereed journals and databases (member directories) of affordable housing experts. Like snowballing, potential respondents of the questionnaire were implored to forward the questionnaire to any affordable housing expert they deemed suitable to answer the questionnaire. Therefore, it will be a difficult task to state the exact number of questionnaires administered. However, approximately 200 questionnaires were administered. Emails were sent to the participants with the questionnaire attached together with a web-link option for responding to the questionnaire through a “survey monkey”. These flexibility options provided convenient means for experts to respond to the questionnaire to enhance the response rate. Experts were asked to rate on a five-point Likert scale (1= not important, 2= less important, 3= neutral, 4= important, 5= very important) the level of importance of each CSC and CSFs for sustainability attainment in affordable housing projects. Besides, a five-point Likert scale (1= strongly disagree, 2= disagree, 3= neutral, 4= agree, 5= strongly agree) was provided for respondents to indicate their level of agreement regarding the rating of the critical barriers to SAH. Fifty-three responses were received. However, two respondents skipped most of the questions on the CSC, CSFs and critical barriers and were, therefore, excluded from the number of responses, lowering the number of responses to 51 with a corresponding response rate of 26%. Despite the low response rate, the sample size is deemed appropriate for further analysis when compared with the response rate of previous study. Besides, low response rate is not unusual with online questionnaire surveys. For instance, Osei-Kyei and Chan (2017) received 42 responses out of 310 participants (a response rate of 18%). As argued in Chan et al. (2018), a minimum sample size of 30 is regarded as representative of the population. Moreover, despite the small sample size, the aim of the study could be achieved. Table 5.4 shows the number of responses received from various countries. It shows that most of the responses are from the United States of America, Australia, Malaysia and Italy.

Table 5. 4: Responses from Various Countries

Countries	Number of Responses
USA	12
Australia	5
Malaysia	5
Italy	4
Hong Kong	3
Sweden	3
China	3
Canada	3
Ghana	2
New Zealand	2
Singapore	2
Brazil	1
India	1
Spain	1
South Africa	1
Japan	1
Norway	1
Papua New Guinea	1
Total	51

5.4.8 PROFILE OF INTERNATIONAL SURVEY RESPONDENTS

Table 5.5 is a summary of the profile of respondents. Most of the respondents (72.5%) are in the category of academia/research institute followed by respondents in the consulting firms (9.8%). About 5.9% and 3.9% of the respondents are in public sector agencies and private developers/contractors, respectively. Regarding profession, most of the respondents are researchers (54.9%) as shown in Table 5.5. Many of the respondents (41.2%) had over 20 years of experience in affordable housing projects. Generally, all the respondents indicated that they have been involved in affordable housing research and/or have industrial experience in affordable housing projects.

Table 5. 5: Respondents' Profile

Category, Profession, years of experience and housing type handled	Number of Response	Percent
Category		
Academia/research institute	37	72.5
Consulting firm	5	9.8
Public sector agency/department	3	5.9
Private developer/contractor	2	3.9
Others	4	7.8
Profession		
Academic/researcher	28	54.9
Architect	9	17.6
Quantity Surveyor	3	5.9
Project/Construction manager	2	3.9
Engineer	1	2.0
Others	8	15.7
Years of Experience		
1-5 years	9	17.6
6-10 years	11	21.6
11-15 years	6	11.8
16-20 years	4	7.8
> 20 years	21	41.2
Housing Type Handled		
Social housing	37	40.2
Public housing	35	38.0
Cooperative housing	14	15.2
Others	6	6.5

5.4.9 PROFILE OF SURVEY RESPONDENTS FROM GHANA

A three-month questionnaire survey was launched in 10th January 2019. In the absence of a comprehensive sampling frame for registered housing experts, purposive sampling and snowballing were the two non-probability sampling techniques adopted to identify potential respondents. A brochure containing the addresses of some real estate developers was obtained from the Ghana Real Estate Developers Association (GREDA). The real estate developers were contacted on phone and were introduced to the research topic and purpose of the study before craving for their partaking in the survey. Subsequently, emails with an attached questionnaire were sent to those who showed interest in the survey. In the emails, the real estate developers were politely requested to either forward the emails to their colleagues or suggest contact addresses of other real estate developers. Furthermore, the questionnaires were administered personally to members of the Ghana Institution of Surveyors at the 50th Annual General Meeting, which was held at GIMPA on 2nd March 2019. Only surveyors who are employees in the formal sector of the Ghanaian housing market were included. Finally, other experts were identified and contacted through referral or social networks from the parastatal organizations. A total of 110 questionnaires were administered personally. Forty-nine answered questionnaires were received in all from the various forms of questionnaire administration. However, two questionnaires were excluded due to incompleteness. Therefore, 47 returned questionnaires were deemed valid. The corresponding response rate for the 47 responses is 42.7%. This response rate compares favourably with past study on green buildings in Ghana with 43 responses (i.e. Darko et al., 2018).

Table 5.6 is a summary of the respondents' profile. On the types of institution, most of the participants (47.9%) are in the public sector or department followed by 35.4% respondents in the academic/research institution and 16.7% respondents as private developers or contractors. On profession, most of the participants (55.3%) are quantity surveyors while 19.2% and 12.8% indicated that they are architects and construction managers, respectively. Concerning the number of housing projects handled by respondents, majority of the respondents (52.2%) have handled more than two housing projects in the Ghanaian housing market. Among the various housing projects handled, most (55.1%) are public housing projects followed by social housing projects (34.7%) and then cooperative housing projects (6.1%). It is worth noting that though vulnerable groups such as the youth, women, the unemployed and people who are HIV positive could have been housed in social facilities, per the country's legal provisions, majority of the respondents stated that no social housing exists in Ghana. However, since some of them indicated that they have been involved in social housing, it is possible that these few respondents have participated in such projects that are carried out beyond the scope of Ghana. It is also not surprising that low number of respondents have been involved in cooperative housing since it is still emerging in the Ghanaian housing sector. About 63.9% of the respondents have over 1-5 years of work experience in the Ghanaian housing market. From the profile of the respondents, it can be concluded that the survey participants are abreast of the Ghanaian housing market and could provide relevant data for developing a sustainable housing model towards ensuring sustainable cities and beyond in Ghana.

Table 5. 6: Profile of Respondents

Category	Characteristics	Number of Responses	Percentage
Company Type	Academic/Research institutions	17	35.4
	Public sector agency/department	23	47.9
	Private developers/contractors	8	16.7
Profession	Architect	6	12.8
	Project / construction manager	9	19.1
	Engineer	3	6.4
	Quantity surveyor	26	55.3
	Researcher	2	4.3
	Others	1	2.1
Number of Housing projects handled	0 project	5	10.9
	1-2 projects	17	37.0
	3-4 projects	9	19.6
	5-6 projects	3	6.5
	7 and above projects	12	26.1
Housing Type Handled	Public housing	27	55.1
	Social housing	17	34.7
	Cooperative housing	3	6.1
	Others	2	4.1
Years of Experience	1-5 years	17	36.2
	6-10 years	13	27.7
	11-15 years	10	21.3
	16-20 years	3	6.4
	Above 20 years	4	8.5

5.5 CHAPTER SUMMARY

This chapter has proffered in detail the following aspects of the thesis: the philosophical assumption of the study; the research methods and background data of both the international survey and the specific survey in Ghana. The research methodology was described based on how the research objectives could be achieved. Discussion on the research methodology can be classified broadly into three categories: data collection method; data analysis and data modelling (FSE and PLS-SEM). A questionnaire survey is the sole data collection tool for this study. It entails five sections related to respondents' background information, CSC, CRFs, critical barriers and CSFs. The questionnaire was first developed from lists of factors obtained from a comprehensive literature review. The questionnaire was revised and finalized for data collection in Ghana after receiving constructive comments from pilot survey participants and from international survey. Statistical methods such as mean scores, factor analysis, FSE and PLS-SEM, which are the adopted and adapted techniques, were elaborated in this chapter.

Descriptive statistics of respondents' data covered institution types, profession, number of housing projects handled, housing type handled and years of experience of respondents. Concerning the international survey respondents, about 82% of the respondents indicated that they have more than five years of working experience on public, social and cooperative housing. Regarding data from the Ghanaian respondents, about 74% of the respondents have more than five years of working experience in various housing-related projects. The relatively high years of working experience of the respondents suggest that respondents have experiential knowledge and proficiency to merit the reliability of the study (Ameyaw, 2008).

In the next chapter, analysis of the data is conducted on critical success criteria (CSC). These CSC are relevant for bridging the gap between sustainable housing and affordable housing and for assessing sustainability attainment in affordable housing (low-cost housing) projects.

CHAPTER 6: DATA ANALYSIS AND RESULTS – CRITICAL SUCCESS CRITERIA (CSC) FOR SUSTAINABLE AFFORDABLE HOUSING[6]

6.1 INTRODUCTION

In previous chapters, an introduction of the study, literature review and research methodology were described. The present chapter reports part of the findings from an international perspective on the CSC for sustainable affordable housing. This chapter seeks to identify from international respondents the comprehensiveness and relevance of the CSC for SAH, from which essential CSC that pertain to the Ghanaian housing market can be identified in subsequent analysis. Besides, the aim of the international survey is to provide basis for comparison regarding the CSC. This could unearth differences among countries and enable policy transfer or enhance policy formation in the Ghanaian housing market. In the present chapter, the findings are presented and discussed based on two forms of analysis that were conducted. First is a descriptive analysis using mean scores in which the findings are grouped into developed and developing economies. This helped to identify any differences in the ranking of the CSC between the two categories of economies. Then, factor analysis and Pearson correlation analysis were carried out for categorization of the CSC and for determining the level of correlation among the CSC, respectively. Pearson correlation analysis is relevant to inform the type of measurement model – reflective or formative – during subsequent analysis of data from Ghana. The findings from this chapter are relevant to policymakers for identifying suitable locations for affordable housing projects. Furthermore, by using the identified CSC

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[6] This chapter largely based upon the following publication:
Chan, A. P., & Adabre, M. A. (2019). Bridging the gap between sustainable housing and affordable housing: The required critical success criteria (CSC). *Building and Environment*, *151*, 112-125.

from this study, policy makers could be informed on the success level of projects and possible improvement on policies to reduce low take up rate of housing facilities.

6.2 DESCRIPTIVE ANALYSIS ON CSC FOR SAH

The CSC were ranked based on their mean and standard deviation values (shown in Table 6.1). The ranking is first based on the mean values of the CSC. However, if two or more CSC have the same mean, the CSC with the lowest standard deviation is ranked the highest. The top five CSC for responses from all economies include house price in relation to income (CSC16), rental cost in relation to income (CSC17), maintainability of housing facility (CSC9), end user's satisfaction with housing facility (CSC5) and functionality of housing facility (CSC 13) with mean scores of 4.833, 4.771, 4.553, 4.417 and 4.333, respectively.

The high ranking of price and rental cost of housing implies that though the other criteria are necessary for sustainable affordable housing, priority is most centered on price and rental affordability. Similarly, in Gan et al. (2017) price and rental affordability were highly ranked by different stakeholders, namely, government agencies, developers and academics. Therefore, improvement in any of the CSC that is likely to increase price and rental affordability of housing could be resisted. This was confirmed in a study conducted by Chan et al. (2018) of which increase in cost was among the main reasons for the low adoption of green building technologies in both developed and developing economies. Therefore, Chan et al. (2018) concluded that cheaper and efficient green building technologies should be adopted to improve the level of success of the other criteria in housing projects (i.e. reduce life cycle cost of housing facility and energy efficiency of housing facility) without increasing price and rental cost of housing. The five least ranked CSC from all responses include: reduced public sector expenditure on house management (CSC12), reduced occurrence of disputes and litigation

(CSC11), project team satisfaction (CSC6), technical specification of housing (CSC14) and technology transfer (CSC 19) which all had mean values below 3.700. Similarly, in Ahadzie et al. (2008) technology transfer was the least ranked critical success criterion.

Furthermore, the means, standard deviation and ranking were calculated separately for both developed and developing economies. Classification into developed and developing economies was done by means of their GDP per capita with reference to data from Mandelli et al. (2016). China, Malaysia, Ghana, Papua New Guinea, South Africa, India and Brazil were grouped as developing economies while USA, Australia, Italy, Hong Kong, Sweden, Canada, New Zealand, Singapore, Spain, Japan and Norway were classified as developed economies. Among the developed economies, priority was given first to rental cost of housing and then house price. However, in developing economies, price of housing was ranked first while rental cost was ranked forth. In Gilbert (2016), it was stated that the privatization of public housing due to abysmal low rents, self-help housing and the cultural preference for ownership among developing economies could be the reasons for the preference of price affordability over rental affordability. From the findings (as shown in Table 6.1), other CSC such as commuting cost from location of housing facility to public facilities, maintainability of housing facility and reduced lifecycle cost were ranked relatively high among developed economies as compared to their rankings from developing economies. It is not surprising given the disparities in the ranking of these sustainability related criteria. This reflects the high priority devoted to these criteria from developed economies as compared to developing economies (Darko et al., 2018).

Table 6. 1: Ranking of CSC

Code	All Economies			Developed Economies			Developing Economies		
	Mean	SD	Rank	Mean	SD	Rank	Mean	SD	Rank
CSC16	4.833	.429	1	4.857	.430	2	4.769	.439	1
CSC17	4.771	.425	2	4.857	.355	1	4.539	.519	4
CSC09	4.553	.503	3	4.559	.504	3	4.539	.519	4
CSC05	4.417	.613	4	4.343	.639	4	4.615	.506	3
CSC13	4.333	.724	5	4.286	.750	6	4.462	.660	8
CSC03	4.313	.689	6	4.171	.707	10	4.692	.480	2
CSC02	4.313	.748	7	4.286	.789	5	4.385	.650	9
CSC04	4.292	.544	8	4.200	.531	9	4.539	.519	6
CSC08	4.250	.700	9	4.229	.690	7	4.308	.751	14
CSC18	4.250	.758	10	4.200	.797	8	4.385	.650	9
CSC10	4.167	.694	11	4.086	.612	12	4.385	.870	12
CSC20	4.167	.883	12	4.086	.951	11	4.385	.650	9
CSC01	4.042	.898	13	3.886	.932	13	4.461	.660	7
CSC21	4.000	.905	14	3.882	.946	14	4.364	.674	13
CSC07	3.854	.684	15	3.800	.719	15	4.000	.577	18
CSC15	3.833	.753	16	3.743	.741	16	4.077	.760	17
CSC12	3.688	1.095	17	3.543	1.146	17	4.078	.862	16
CSC11	3.583	.964	18	3.429	.948	18	4.000	.913	20
CSC06	3.575	.853	19	3.412	.857	19	4.000	.707	19
CSC14	3.521	.875	20	3.286	.789	20	4.154	.801	15
CSC19	3.065	1.020	21	2.971	.937	21	3.333	1.231	21

6.3 FACTOR ANALYSIS

Factor analysis was conducted to group the 21 CSC into components. This was necessary to identify the underlying structures of CSC for sustainable affordable housing projects. The Principal Component Analysis (PCA) was adopted for the factor analysis. Prior to conducting the analysis, the suitability of the data for factor analysis was assessed. The Kaiser-Meyer-Olkin (KMO) Sampling Adequacy Test and Bartlett's Test of Sphericity were carried out to determine the data appropriateness. KMO measures the sampling adequacy as a ratio of the squared correlation between the variables to the squared partial correlation between the variables (Field, 2013). KMO value of 0 is an indication of the unsuitability of data for factor analysis while a value of 1 indicates that the data are suitable and will yield reliable and distinct factors in the factor analysis. A KMO value above 0.5 is deemed appropriate (Field, 2013).

Table 6.2 shows the test results. The KMO measure of sampling adequacy was 0.63. Thus, this was considered acceptable. Besides, the Bartlett Test of Sphericity was conducted to check if the original correlation matrix is an identity matrix. For data suitability for factor analysis, the Bartlett's test of sphericity must be large with a small associated significance level (Pallant, 2013). The Bartlett's test of Sphericity was 483.120 at a significance level of 0.000. This indicates that the population correlation matrix was not an identity matrix (Larose, 2006; Field, 2013). Therefore, the test results of the KMO and Bartlett's Test suggested that the data were suitable for factor analysis.

With the selection of the Varimax Rotation, the Principal Component Analysis was then carried out to identify the fundamental structures of CSC. Conventionally, only variables with eigenvalue and factor loading at cut-off points of 1.0 and 0.50, respectively, were retained. Since the factor loadings for all the CSC exceeded 0.50 (Shown in Table 6.4), all the 21 CSC were retained. "The relatively high values of the loading factors (0.6 for more than four variables) lend support to the favorability of the sample size for the analysis" (Ahadzie et al. 2008 p. 681). Six components were extracted (as shown in Table 6.4). The total variance explained by each component (as shown in Table 6.4) are as follows: Component 1 (29.377%); component 2 (13.103%); component 3 (10.317%); component 4 (7.868%); component 5 (6.790%) and component 6 (5.271%). In sum, the components explained 72.726% of the total variance.

Depending on the underlying variables in each component, the components were named as follows: component 1 was named 'Household satisfaction CSC'; component 2: Stakeholders' satisfaction CSC; component 3: House operation cost CSC; component 4: Time measurement CSC; component 5: Location affordability cost CSC; component 6: Quality-related CSC.

Table 6. 2: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.630
Bartlett's test of sphericity	Approximate chi-square	483.120
	df.	210
	Sig.	0.000

Table 6. 3: Correlation Matrix of CSC

CODE		CSC01	CSC02	CSC03	CSC04	CSC05	CSC06	CSC07	CSC08	CSC09	CSC10	CSC11	CSC12	CSC13	CSC14	CSC15	CSC16	CSC17	CSC18	CSC19	CSC20	CSC21
CSC01	**r**	**1.000**																				
CSC02	**r**	.392**	**1.000**																			
CSC03	**r**	.116	.343*	**1.000**																		
CSC04	**r**	.105	.189	.433**	**1.000**																	
CSC05	**r**	.161	.174	.441**	.521**	**1.000**																
CSC06	**r**	.361*	.047	.124	.230	.393**	**1.000**															
CSC07	**r**	-.094	-.200	.370**	.231	.402**	.365*	**1.000**														
CSC08	**r**	.051	.173	.232	.140	.397**	.393**	.389**	**1.000**													
CSC09	**r**	-.005	.269	.293*	.415**	.487**	.206	.415**	.559**	**1.000**												
CSC10	**r**	.193	.020	.200	.263	.233	.442**	.590**	.569**	.384**	**1.000**											
CSC11	**r**	.414**	.155	.072	.358*	.192	.365*	.132	.284	.156	.297*	**1.000**										
CSC12	**r**	.252	.252	.076	.192	.040	.082	-.062	.271	.208	.098	.479**	**1.000**									
CSC13	**r**	.240	.314*	.469**	.450**	.591**	.084	.186	.210	.459**	.226	.264	.080	**1.000**								
CSC14	**r**	.540**	.429**	.430**	.389**	.301*	.597**	.272	.339*	.352*	.449*	.364*	.204	.324*	**1.000**							
CSC15	**r**	.136	.019	.389**	.433**	.200	.455**	.447**	.363*	.422**	.420**	.313*	.116	.104	.490**	**1.000**						
CSC16	**r**	-.202	.033	-.108	.030	-.135	-.200	-.157	.142	-.057	.095	.034	.339*	-.160	-.274	-.022	**1.000**					
CSC17	**r**	-.253	-.239	-.041	.111	.048	-.219	-.044	.125	.009	.132	-.082	-.112	.115	-.302*	-.122	.369**	**1.000**				
CSC18	**r**	.172	.122	.255	.438**	366*	-.030	.113	.281	.303*	.243	.349*	.507**	.426**	.056	.186	.261	.248	**1.000**			
CSC19	**r**	.263	.291	.254	.206	-.008	.323*	.274	.327*	.232	.305*	.495**	.437**	.033	.518**	.483**	.026	-.227	.150	**1.000**		
CSC20	**r**	.045	-.145	.192	.339*	.498**	.354*	.358*	.344*	.367*	.231	.333*	.231	.111	.106	.426**	.075	.161	.350*	.160	**1.000**	
CSC21	**r**	-.045	-.102	.226	.458**	.404**	.150	.331*	.214	.101	.249	.312*	.115	.193	.116	.273*	.341*	.325*	.398**	.218	.640**	**1.000**

r =Value for Pearson correlation.
p= Value of the significance
*Correlation is significant at the 0.05 level (2-tailed)
**Correlation is significant at the 0.01 level (2-tailed)

(**CSC01** = Timely completion of projects; **CSC02** = Construction cost performance of housing facility; **CSC03** = Quality performance of project; **CSC04** = Safety performance; **CSC05** = End user's satisfaction with the housing facility; **CSC06** = Project team satisfaction with the housing facility; **CSC07** = Environmental performance of housing facility (Eco- friendly); **CSC08** = Reduced life cycle cost of housing facility; **CSC09** = Maintainability of housing facility; **CSC10** = Energy efficiency of housing facility; **CSC11** = Reduced occurrence of disputes and litigation; **CSC12** = Reduced public sector expenditure on managing housing facility; **CSC13** = Functionality of housing facility; **CSC14** = Technical specification of housing; **CSC15** = Aesthetically pleasing view of completed house; **CSC16** = House price in relation to income; **CSC17** = Rental cost in relation to income; **CSC18** = Commuting cost from the location of housing to public facilities; **CSC19** = Technology transfer; **CSC20** = Waiting time of applicants before being allocated a housing unit; **CSC21** = Take up rate of housing facility (marketability of housing facility))

Table 6. 4: Rotated Component Matrix

Extraction Method: Principal Component Analysis; **Rotation method**: Varimax with Kaiser Normalization

Code	CSC for Sustainable Affordable Housing	Components Loading					
		1	2	3	4	5	6
Component 1: Household Satisfaction CSC							
CSC13	Functionality of housing facility	0.839	–	–	–	–	–
CSC5	End user's satisfaction with the housing facility	0.812	–	–	–	–	–
CSC9	Maintainability of housing facility	0.641	–	–	–	–	–
CSC4	Safety performance (crime)	0.610	–	–	–	–	–
Component 2: Stakeholders' Satisfaction CSC							
CSC1	Timely completion of project	–	0.788	–	–	–	–
CSC6	Project team satisfaction	–	0.688	–	–	–	–
CSC11	Reduced occurrence of disputes and litigation	–	0.607	–	–	–	–
Component 3: Housing Operation Cost CSC							
CSC10	Energy efficiency of housing facility	–	–	0.856	–	–	–
CSC8	Reduced lifecycle cost of housing	–	–	0.842	–	–	–
CSC7	Environmental performance of housing facility (Eco-friendly)	–	–	0.530	–	–	–
Component 4: Time Measurement CSC							
CSC21	Take up rate of housing facility (marketability of housing facility)	–	–	–	0.802	–	–
CSC20	Waiting time of applicants before being allocated housing unit	–	–	–	0.716	–	–
CSC2	Construction cost performance of housing facility	–	–	–	-0.555	–	–
Component 5: Location affordability Cost CSC							
CSC12	Reduced public sector expenditure on house management	–	–	–	–	0.818	–
CSC16	House price in relation to income	–	–	–	–	0.649	–
CSC18	Commuting cost from the location of housing to public facilities	–	–	–	–	0.631	–
CSC17	Rental cost in relation to income	–	–	–	–	0.506	–
Component 6: Quality-Related CSC							
CSC3	Quality performance of project	–	–	–	–	–	0.686
CSC15	Aesthetically pleasing view of completed house	–	–	–	–	–	0.665
CSC19	Technology transfer	–	–	–	–	–	0.658
CSC14	Technical specification of housing	–	–	–	–	–	0.600
Eigenvalue		6.169	2.752	2.167	1.652	1.426	1.107
Variance (%)		29.377	13.103	10.317	7.868	6.790	5.271
Cumulative Variance (%)		29.377	42.480	52.797	60.665	67.455	72.726

6.4 RESULTS OF PRINCIPAL COMPONENT ANALYSIS AND DISCUSSION

6.4.1 Component 1: Household Satisfaction CSC

The underlying CSC in this component highlight the criteria that lead to household satisfaction in a housing facility. This component is characterized by four main criteria. These four CSC, together with the percentages of their loading in bracket include: functionality of housing facility (83.9%); end user's satisfaction with housing facility (81.2%); maintainability of housing facility (64.1%) and safety performance (61.0%). This component explains most of the variance among the six components, about 29.377% (please refer to Table 6.4 for loading and for the variance).

The correlation matrix (shown in Table 6.3) revealed significant associations among the various CSC in this component. For example, the correlation between 'functionality of housing facility' and 'end user's satisfaction' was significant (r=0.591, p=0.01); between 'functionality of housing facility' and 'maintainability of housing facility' (r= 0.459, p=0.01) and 'functionality of housing facility' and 'safety performance' (r=0.450, p=.0.01). Therefore, the association among these CSC is coherent since they measure the same factor – household satisfaction.

Similarly, in Ahadzie et al. (2008), household satisfaction with housing facility emerged as one of the components for mass housing projects. To bridge the gap between sustainable housing and affordable housing, meeting household satisfaction is very important. Household satisfaction is defined as an assessment of the degree to which the current dwelling of the household and quality of the environment are close to the expectations of their favorite one (Galster, 1985). Ensuring functionality of housing according to aspirations, safety performance (i.e. security provision features) and ease of housing facility maintenance are relevant for household satisfaction. Functionality is considered a consequence of the facility. It includes the performance output and the benefits of the facility to the household. Performance output of housing facility measures the quality of the housing while the benefit of the housing functionality is a measure of the household satisfaction (Jusan, 2007). Functionality can be measured by the level of conformance to client's expectation, with the goal of achieving fitness for purpose (Chan et al., 2002). Functionality should be assessed at the post construction phase, when the facility is completed and is in use (Chan et al., 2002).

Moreover, several features of a house ensure residential satisfaction. For instance, separate bedrooms for parents and children contribute to more private space and residential satisfaction (Ren and Folmer, 2017). Similarly, Pearson's correlation conducted by Mohit et al. (2010) revealed that residential satisfaction is highly and positively correlated with dwelling unit features followed by the social environment, dwelling support services and public facilities. Among planning policies, neighborhood interaction and safety were dominant predictors of residential satisfaction. Moreover, maintainability of a housing facility ensures household satisfaction. In Torbica and Stroth (2001), low-cost maintenance features of house and ease of home maintenance were identified as contributory variables to household satisfaction.

Although Riazi and Emami (2018) found that design principles on residential satisfaction had a significant value of 0.183, most of the design features were related to safety and security provisions. Some of these features include lighting of public areas, safety of car parking, safety of outdoor parking, safety of indoor space and security for children in public areas. Personal security was identified as a feature that first-time homebuyers look out for in making purchasing decision. Crime rate in the neighborhood and whether a neighborhood is gated are significant factors that influence residential satisfaction and the likelihood of home ownership among first-time homebuyers (Teck-Hong, 2012). Safety community together with good leisure facilities promote residential satisfaction (Ren and Folmer, 2017).

6.4.2 Component 2: Stakeholders' Satisfaction CSC

This component consists of 'timely completion of project' (78.8%), 'project team satisfaction' (68.8%) and 'reduced occurrence of dispute and litigation' (60.7%). These three CSC explained about 13.10% of the total variance (as shown in Table 6.4).

The construction of an affordable housing project involves many stakeholders including the targeted households, governments, developers, design team, suppliers and the people in the neighborhoods of the project. Stakeholders receive and execute the success criteria. Therefore, they have the potential to impact the outcome of sustainable affordable housing project (Yan et al., 2019). Findings of the study showed that there is a statistically significant correlation between 'timely completion of project' and 'reduce occurrence of disputes' (r=0.414, p=0.01) (as shown in Table 6.3). According to Sambasivan and Soon (2007), most disputes in construction projects are the effects of project delays. Timely completion of projects prevents construction disputes that could arise from construction claims. Besides, decrease in property values due to affordable housing projects is one of the causes of public protest which has caused the failure of many affordable housing projects (Nguyen et al., 2013; Tighe, 2010). Delays and complete abandonment of projects due to political reasons could affect the values of neighboring housing facilities. Such projects are often used as hideouts by criminals. As such, households in the neighborhood might live in fear of insecurity. Therefore, potential tenants and buyers might perceive such surroundings as unsafe. This could lower the rent and price of the neighboring facilities. This leads to dissatisfied neighborhoods who may disrupt and protest the construction of subsequent affordable housing project. Accordingly, timely completion of affordable housing projects ensures stakeholders' satisfaction by preventing negative social impacts. It also ensures project team satisfaction (Rashvand and Zaimi Abd Majib, 2013). This is evident in the statistically significant correlation (as shown in Table 6.3) between 'timely completion of project' and 'project team satisfaction' (r=0.361, p=0.05). Similarly, ‘reduced occurrence of disputes’ and ‘project team satisfaction’ have a statistically significant association (r=0.365, p=0.05).

6.4.3 Component 3: Housing Operation Cost CSC

The total variance accounted by component 3 is 10.3% (as shown in Table 6.4). The respective criteria and the percentage of the factor loadings in this component include energy efficiency (85.6%), reduced lifecycle cost of housing facility (84.2%) and environmental performance of housing facility (53.0%) (as shown in Table 6.4). The criteria showed significant correlation among themselves. The correlation (as shown in Table 6.3) between energy efficiency and reduced lifecycle cost of housing was significant (r=0.569, p=0.01); the correlation between energy efficiency and environmental performance was also significant (r=0.590, p=0.01). Similarly, reduced life cycle cost and environmental performance of housing facility revealed a significant correlation (r=0.389, p=0.01). These significant associations among these criteria are not surprising because according to Ruparathna et al. (2016), the environmental impact of a housing facility is determined from its lifecycle and its energy consumption. Since all these criteria measure the operation cost or impact of a housing facility (Pacheco et al., 2012), this component was, accordingly, named as housing operation cost CSC.

For sustainable affordable housing, the operations cost of housing is worth considering due to its cost saving benefits to low-income household and the environment. Minimizing the operation cost of affordable housing projects could be achieved through energy efficient housing. The fundamental principle of energy efficient housing is to use the minimum energy for operation (such as cooling, lighting, heating etc.) without impacting residents’ health and comfort (Ruparathna et al., 2016). Improving energy efficiency of affordable housing is key to abating the environmental effects – greenhouse effects – due to CO_2 emissions. It also reduces the energy use and therefore provides economic benefits such as savings to low-income earners. Moreover, energy efficient affordable housing is a requirement to prevent fuel poverty – low income household spending beyond 10% of their income on domestic energy (Mattioli et al., 2018).

Studies have been conducted on energy efficient technologies that can be adopted to provide sustainable affordable housing without rendering household shelter poor (Allouhi et al., 2015; Morrissey et al. 2011; Nikolaidis et al., 2009). On the mechanical components of a housing facility, heating, ventilation and air conditioning (HVAC) system is the most energy consumption component of a housing facility (Perez-Lombard et al., 2011). Using thermal solar systems for a substitute of an electric water heater leads to 80% saving of the cost of heating water as well as ensuring environmental protection (Nikolaidis et al., 2009). By changing from air-cooled to water cooled air-conditioning system, substantial electricity consumption could be reduced (Yik et al. 2001).

Regarding lighting system, about 15% of the total energy of a building is spent on lighting. However, installing better luminous efficacy lamps and linking daylight to lighting systems could reduce electricity consumption on lighting. Moreover, changing to light emitting diode (LED) light system, replacing incandescent lamps with low energy fluorescent lamps and installing automated lighting system can reduce the amount of electricity demanded for lighting (Ruparathna et al., 2016). Another important area for energy efficient housing is the building envelope. Improved Insulation minimizes the heat gain or loss from a building thereby enhancing the thermal performance of the housing facility (Ruparathna et al., 2016). Reflective paint and coating on roofs and walls or insulating paint with low conduction can be used to improve the thermal performance of a building. In a location of high temperature difference between day and night, coating of the external surface of the housing facility provides better thermal function. However, in locations of low temperature difference between daytime and nighttime, housing facilities with interior insulation do better (Huang et al., 2013).

Building codes set the lowest requirement for energy efficiency in buildings. Notable ones include BREEAM, Leadership in Energy and Environment (LEED) and Green Star. These codes may target one of the following building energy concepts: low energy building, passive houses, zero energy building, zero carbon building (Allouhi et al., 2015). By making building energy code mandatory, it was stated that the yearly electricity consumption, for example in Hong Kong, can be lowered by 7.9% (Lee and Yik, 2002). Therefore, through the development of localized codes or adoption of internationally recognized codes, affordable housing would be energy efficient and thus sustainable.

The shape of a housing facility affects the amount of solar radiation that the building receives, which consequently influences its total energy consumption (Mingfang, 2002). The higher the solar radiation received by a housing unit, the higher the energy required to cool it (Elasfouri et al., 1991). According to Aksoy and Inalli (2006), 36% of heat energy savings can be obtained by combining the optimization of orientation and shape of a building. For instance, on quantifying the effects of a building shape on the amount of energy required to heat and cool a building, Florides et al. (2002) concluded that the best orientation to maximize the solar benefits of a rectangular building is for the lengthiest wall of the housing unit to face the south. The southern orientation is best for heat gain during wintertime and for regulating solar radiation during summer (Pacheco et al., 2012). Shading on buildings also affects the amount of solar radiation gain by a building. For instance, overhangs over windows prevent the direct entry of solar radiation through the window, therefore, it regulates the entry of excessive heat and daylight. However, since overhangs are mostly designed to remain fixed, they could favor energy savings in certain times while hindering energy saving at a different time. Thus, mobile shading devices provide better energy saving benefits than immovable shading devices (Bouchlaghem, 2000). Using the net present value appraisal on a uniform evaluation period, Nikolaidis et al. (2009) found that insulation of the roof of a building provides better intervention concerning heat insulation than with the replacement of windows and doorframes, which yielded low returns on investment.

Moreover, though mud / baked bricks cannot be used to construct structural elements, its use for the construction of non-loading bearing walls could offer energy saving benefits. According to Chel and Tiwari (2009), internal temperatures of mud houses are moderate throughout the year. This leads to potential energy savings. Mud houses have yearly heating and cooling energy saving of about 1481KWh/year and 1813kWh, respectively. Moreover, mud-houses can alleviate 5.2 metric tons per year of CO_2 emission into the atmosphere.

6.4.4 Component 4: Time Measurement CSC

The extracted CSC with their factor loading for this component include ‘take up rate of housing facility (marketability)’ (80.2%), ‘waiting time of applicants before being allocated housing unit’ (71.6%) and ‘construction cost performance of housing facility’ (-55.5%). This cluster explained about 7.87% of the total variance (as shown in Table 6.4) and was named time measurement CSC.

The correlation matrix (shown in Table 6.3) revealed that significant correlations exist among the criteria in this component. For example, the correlation between ‘take up rate of housing facility’ and ‘waiting time of applicant before being allocated a housing unit’ was significant (r=0.640, p= 0.01). Since both criteria measure the time taken for a household to move into a housing facility, the significant correlation between them is logical.

Aside building affordable housing, it is important to measure how supplied housing is reducing the time spent by low-income earners in the 'waiting line' before being allocated affordable housing unit. Besides, assessing how affordable housing supplies are meeting the needs of household is very critical. This can be measured using the take-up rate of housing facilities. Houses that are affordable but not adequate or sustainable are likely to receive low take-up rate by low-income earners (Teck-Hong, 2012). Take up rate of an affordable housing facility is significantly associated with household's satisfaction (r=0.404, p=0.01). The correlation between take up rate and household's satisfaction indicates that high expectation for household satisfaction leads to high take-up rate of a housing facility. However, high cost of housing facility beyond the affordability range of the household could lead to low take up rate of the housing facility and increase waiting time of applicants for housing unit allocation.

6.4.5 Component 5: Location Affordability Cost CSC

The principal component 5 contains four CSC: reduced public sector expenditure on housing management (81.8%); house price in relation to income (64.9%); commuting cost from the location of housing to public facilities (63.1%) and rental cost in relation to income of household (50.6%) (as shown in Table 6.4). This component accounted for 6.79% of the total variance (as shown in Table 6.4). Studies have stated that affordability should be measured as location affordability, that is taking into consideration housing affordability cost and cost of transportation or accessibility (Kramer, 2018; Mattioli et al., 2018; Fan and Huang, 2011). Therefore, this component was labelled location affordability cost CSC.

As shown in the correlation matrix in Table 6.3, a statistically significant correlation exists between 'house price in relation to income' and 'rental cost in relation to income' (r=0.369, p=0.01). This association between the two criteria is reasonable since both are used to measure the same item – housing affordability. Similarly, there was a significant correlation between the criteria 'reduced public sector expenditure on house management' and 'commuting cost from the location of housing to public facilities' (r=0.507, p=0.01).

Previous studies have elaborated on the importance of housing affordability (Adinyira et al., 2014; Ahadzie et al., 2008). However, an important cost factor which was overlooked in measuring affordability is the cost of transportation. Location affordability incorporates both the cost of housing and transportation. A study conducted by Saberi et al. (2017), revealed that neighbourhoods that seem to be affordable concerning only housing cost are not definitely affordable when transportation cost is factored in. Housing facilities at the urban peripheral or in low-residential density areas may appear more affordable yet might suffer from inadequate access to various amenities and incur high cost on transportation to access the amenities. Thus, the low housing cost is mostly offset by the high commuting cost which leads to transport poverty. A household might be transport poor based on three conditions: if the household spends more than 10% of their income on car running costs, if the household lives more than one mile from the closest bus or station and if it takes more than one hour to access a number of important services by cycling, walking and public transport (Sustrans, 2012 cited in Mattioli et al., 2018). Transportation poverty has many effects. Individuals can be rendered unemployed due to inability to afford ownership of cars / commuting cost. Besides, most households that can afford do trade-off transport expenditure against spending on other necessities (Mattioli et al., 2018).

It is recommended that policies and plans for housing affordability should consider transportation infrastructure supply (Saberi et al., 2017). Three main factors influence transportation affordability namely the built environment, policy environment and the socio-demographics of households (Fan and Huang, 2011). The socio-demographics of the household defines the influence of household income on transportation affordability. The built environment (defined by the land use) and urban design influence the transportation affordability. There is an association between the built environment and travel behavior. For instance, low residential density and mono-functional use of land are related to more car travel. However, high density areas such urban as centers where the buildings are closer, walking and cycling would be encouraged among many households especially low-income earners (Mattioli et al., 2018). It is worth noting that extreme cases of compact city and urbanization could increase traffics on the roads thereby increasing the time spent on travelling. Thus, an affordable house is not sustainable if the cost and time of transportation are very high.

6.4.6 Component 6: Quality-Related CSC

Lastly, the sixth principal component contains four CSC. These CSC together with their factor loading are ‘quality performance of project’ (68.6%), ‘aesthetically pleasing view of completed house’ (66.5%), ‘technology transfer’ (65.8%) and ‘technical specification of housing’ (60.0%). This component explains 5.3% of the total variance and is named quality-related CSC.

The findings revealed that some of the four CSC in this component showed statistically significant correlation among themselves. For instance, the correlation matrix (as shown in Table 6.3) revealed a significant relationship between quality performance of project and aesthetically pleasing view of completed house (r=0.389, p=0.01). Besides, the correlation between quality performance of project and technical specification of housing was significant (r=0.430, p=0.01). Moreover, the correlation matrix revealed a significant association between ‘technology transfer’ and ‘technical specification of housing’ (r=0.518, p=0.01). Likewise, the association between technology transfer and aesthetically pleasing view of completed house is significant (r=0.483, p=0.01).

The significant association between quality performance and aesthetically pleasing view of completed house could be attributed to the fact that the conventional description of quality is based on issues such as 'how well a housing facility blends into its environment', 'the facility's psychological impacts on its inhabitants', 'the ability of landscaping plan to match the theme of nearby structures' and 'the use of intriguing novel design models that capture people's imaginations' (Stasiowski and Burstein, 1994). Since the aesthetic definition of quality is subjective, there is often no consensus on whether quality affordable housing has been achieved or not (Arditi and Gunaydin, 1997). However, quality performance of housing facility can also be defined objectively as meeting technical specification of the designer, owner and regulatory organizations (Ferguson and Clayton, 1988).

Due to the subjective and objective assessment of quality, it is important to differentiate 'quality in perception' and 'quality in fact'. A housing facility that meets client's and household's expectation attains quality in perception while a housing facility that meets the technical specification attains 'quality in fact' (Arditi and Gunaydin, 1997). 'Quality in fact' can be achieved by meeting two main requirements: product quality and process quality (Arditi and Gunaydin, 1997). Whereas product quality is ensuring suitable construction materials, equipment and technology required for the construction of a housing facility, process quality involves attaining quality regarding the design and construction of the housing facility.

Achieving both forms of quality is very important. The neglect of quality in perception has often resulted in abandoned affordable housing facilities (Arditi and Gunaydin, 1997; Teck-Hong, 2012). Therefore, it is suggested that prior to the construction of any housing facility, a pilot study should be conducted to assess the needs of the intended households. Regular assessment of the needs of the intended households is important since household needs are ephemeral (Adabre and

Chan, 2018). This assessment will ensure that the expected quality of a household is met. Though quality is considered a latent variable, it could be achieved based on the housing design features. Design principles such as interior layout (i.e. size of living room, arrangement of rooms, size of kitchen, availability of storage room) and privacy of living space (i.e. number of bedrooms, size of bedrooms and number of bathrooms) are considered very important among low-income households (Opoku and Abdul-Muhmin, 2010). Among interior design features such as number of bedrooms, bathrooms and living rooms, living space was the indicator of quality that had the highest loading and reliability (Ren and Folmer, 2017). Thus, these quality features should be taken into consideration for sustainable affordable housing projects to meet household needs.

The significant positive correlations among technology transfer, technical specification and aesthetically pleasing view of housing (as shown in Table 6.3) are logical. In Adinyira et al. (2014) technology transfer emerged together with cost of individual units. Accordingly, it was stated that the benefits of technology transfer could improve the price affordability of housing facilities. In this study, technology transfer emerged together with quality performance of housing project, aesthetically pleasing view of completed house and technical specification of housing. This implies that aesthetically pleasing view and technical specification could be improved through technology transfer.

6.5 CHAPTER SUMMARY

The meaning of success, most often, changes from project to project. Determining whether an affordable housing project is sustainable and therefore a success or a failure is far more complex. This is because there are inadequate studies on identifying a comprehensive list of CSC for assessing the sustainability and success of affordable housing projects. Consequently, affordable housing is mostly assessed based on the price or rental cost, which creates a gap between affordable housing and sustainable housing. Bridging this gap requires sustainable CSC. This chapter analyzed CSC required for the provision of sustainable affordable housing. A questionnaire of 21 CSC was administered globally to affordable housing experts. Ranking, factor analysis and Pearson correlation were employed for data analysis.

Findings of this chapter revealed that though there is high interest on other CSC (such as energy efficiency of housing facility, reduced lifecycle cost of housing facility and environmental performance of housing facility), price and rental cost CSC are the most highly ranked among developed and developing countries. Besides, some of the identified CSC are significantly correlated with one another. Furthermore, six factors were developed for bridging the gap between sustainable housing and affordable housing: (1) household satisfaction CSC, (2) stakeholder's satisfaction CSC, (3) housing operation cost CSC, (4) time measurement CSC, (5) location affordability cost CSC and (6) quality-related CSC.

CHAPTER 7: DATA ANALYSIS AND RESULTS – BARRIERS AND SUCCESS FACTORS FOR SUSTAINABILITY ATTAINMENT IN AFFORDABLE HOUSING[7]

7.1 INTRODUCTION

The previous chapter entails an analysis on the CSC for SAH from an international perspective. Similarly, the present chapter first reports on barriers to SAH from an international perspective towards identifying barriers that require much attention from respondents in developed and developing economies. Factor analysis and correlation analysis were conducted to determine the level of correlation among the barriers. These analyses were conducted using the SPSS 21. The results on the comparison are relevant to international organizations (UN and World Bank) on the barriers that require much attention to achieve global sustainable development as advocated for among these international organizations. Besides, the outcome of the factor analysis and the Pearson correlation analysis informed the potential type and formation of barrier constructs – reflective or formative construct – to be established during modelling of the data from Ghana, the study area.

The second part of this Chapter is data analysis on success factors required to mitigate barriers and thus promote SAH. Similarly, an international survey was conducted among 51 respondents. The main aim of this analysis is to identify the underlying success factors for SAH, which could form the fundamental constructs for developing the sustainable affordable housing model for the Ghanaian housing market. Factor analysis was conducted from which four main components were

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[7] This chapter largely based upon the following publication:

Adabre, M. A., Chan, A. P., Darko, A., Osei-Kyei, R., Abidoye, R., & Adjei-Kumi, T. (2020). Critical Barriers to Sustainability Attainment in Affordable Housing: International Construction Professionals' Perspective. *Journal of Cleaner Production*, 119995.

Adabre, M. A., & Chan, A. P. (2019). Critical success factors (CSFs) for sustainable affordable housing. *Building and Environment*, *156*, 203-214.

established. These components form the key constructs in the PLS-SEM analysis in developing a SAH model from the Ghanaian perspective, as detailed in Chapter 9. Besides, by classifying these factors, policymakers are informed of the underlying groupings of CSFs which could be implemented concurrently. Moreover, successful implementation of these CSFs will ensure a holistic sustainable affordable housing market.

7.2 CRITICAL BARRIERS TO SUSTAINABILITY ATTAINMENT IN HOUSING

The means, standard deviations (SD) and normalization scores for all the 26 barriers (stated in Chapter 3) were computed for responses from both developing and developed economies (see, Table 7.1). Using the normalized scores, 18 barriers were identified as critical (barriers with normalization scores ≥ 0.50) from experts of developing economies. The top five critical barriers to sustainable affordable housing according to the normalized scores include: B04 – high cost of serviced land – was ranked first (score = 1.00). The second critical barrier is B06 – inadequate infrastructure development (score = 0.95) – followed by both B05 – income segregation (score = 0.90) and B18 – high interest rates (score = 0.90) while B13 – lack of policies / weak enforcement of policies on land use planning system for housing supply – ranked as the fifth critical barrier (score = 0.84). However, from the views of experts in developed economies, 15 critical barriers were identified. The top five critical barriers include: B01 – inadequate affordable housing policy – was ranked as the most critical barrier (score = 1.00). The second most critical barrier was B02 – inadequate public funding (mean = 0.95) followed by B03 – income inequality – as third (mean = 0.88) and then B05 – income segregation – as fourth (score = 0.85). Finally, B04 – high cost of serviced land – was ranked as the fifth critical barrier (mean = 0.84) (in Table 7.1).

Table 7. 1: Ranking of Potential Critical Barriers to SAH

Code	Developing Economies				Developed Economies			
	Mean	SD	Normalization	Rank	Mean	SD	Normalization	Rank
B01	4.286	0.611	0.79[b]	12	4.333	0.802	1.00[b]	1
B02	4.357	0.929	0.84[b]	9	4.233	0.817	0.95[b]	2
B03	4.357	1.008	0.84[b]	10	4.100	0.923	0.88[b]	3
B04	4.571	0.851	1.00[b]	1	4.000	0.900	0.84[b]	5
B05	4.429	0.756	0.90[b]	3	4.033	1.159	0.85[b]	4
B06	4.500	0.760	0.95[b]	2	3.667	0.922	0.67[b]	8
B07	3.786	0.975	0.42	19	3.900	0.960	0.79[b]	6
B08	4.143	1.099	0.68[b]	15	3.548	1.091	0.61[b]	10
B09	4.143	0.893	0.68[b]	14	3.484	1.061	0.58[b]	13
B10	4.357	0.745	0.84[b]	6	3.533	0.973	0.61[b]	10
B11	4.071	0.917	0.63[b]	16	3.516	0.926	0.60[b]	12
B12	4.214	0.864	0.74[b]	13	3.567	0.898	0.62[b]	9
B13	4.357	0.633	0.84[b]	5	3.419	1.119	0.55[b]	15
B14	4.357	0.842	0.84[b]	8	3.452	1.207	0.57[b]	14
B15	3.357	1.447	0.11	25	3.800	1.157	0.74[b]	7
B16	4.357	0.842	0.84[b]	6	3.000	0.910	0.34	17
B17	4.214	0.802	0.74[b]	11	2.900	1.062	0.30	18
B18	4.429	0.756	0.90[b]	4	2.733	1.048	0.21	22
B19	4.000	0.961	0.58[b]	18	2.839	1.128	0.27	19
B20	4.000	0.679	0.58[b]	17	2.655	0.857	0.17	25
B21	3.786	0.975	0.42	19	2.742	1.210	0.22	20
B22	3.714	0.994	0.37	21	2.613	0.989	0.15	24
B23	3.429	1.222	0.16	24	2.690	1.004	0.19	23
B24	3.286	0.914	0.05	26	2.742	1.154	0.22	21
B25	3.500	1.224	0.21	23	2.567	1.000	0.13	26
B26	3.214	0.893	0.00	27	2.300	0.837	0.00	27

7.3 FACTOR ANALYSIS (FA) WITH PEARSON CORRELATION (PC)

Only barriers that were deemed critical from the perspective of developing or developed economies were considered for subsequent analysis. In all, 20 critical barriers were considered for FA and PC. PC was conducted for better interpretation of the results of the FA and to determine the associations among the barriers as postulated in the literature. Table 7.2 shows the correlations among the barriers. For FA, the KMO and Bartlett's test were conducted. The KMO obtained is 0.527. This value is acceptable since it satisfies the 0.50 threshold (Chan et al., 2018). The value of Bartlett's test of sphericity was large (600.551) with a high level of significance (0.000). Thus, the results of the KMO and the Bartlett's test give credence of the suitability of the data for FA.

Consequently, the principal component analysis was selected with further selection of the varimax rotation to identify the underlying groups of barriers. Table 7.3 is a summary of the FA results with only 19 barriers successfully loaded (the loading of these barriers ≥ 0.50). Five underlying components were extracted, which explain 64.989% of variance. The variance compares approvingly with 62.82% of variance in a recent study (Chan et al., 2018). These five components explain the highest percentage (> 50) of variance. Therefore, a model with these five components can be used to satisfactorily represent the data from developing and developed economies. The components were named based on a common theme of their underlying barriers.

Table 7. 2: Pearson Correlation (PC) Matrix of Critical Barriers

CODE		B01	B02	B03	B04	B05	B06	B07	B08	B09	B10	B11	B12	B13	B14	B15	B16	B18	B19	B20
B01	r	1.000																		
B02	r	.185	1.000																	
B03	r	.413**	.207	1.000																
B04	r	.223	.086	.160	1.000															
B05	r	.122	.086	.237	.044	1.000														
B06	r	.274	.013	.061	.263	.337*	1.000													
B07	r	.000	-.028	.243	.193	.141	.106	1.000												
B08	r	.205	.061	.331*	.193	.608**	.523**	.185	1.000											
B09	r	.241	.203	.296*	.015	-.007	-.168	.129	.169	1.000										
B10	r	.053	.215	.080	.231	.250	.305*	-.001	.385**	.141	1.000									
B11	r	.293*	.193	.032	.133	-.033	.098	.160	-.012	.609**	.329*	1.000								
B12	r	-.060	.218	-.210	-.059	-.107	-.151	.247	-.181	.398**	.111	.322*	1.000							
B13	r	.267	.029	.237	.293*	.390**	.502**	-.078	.400**	.131	.391**	.069	.159	1.000						
B14	r	.260	.214	.173	.104	.211	.333**	-.031	.422**	.185	.559**	.292*	.161	.500**	1.000					
B15	r	.349*	.123	.481**	.076	.007	-.014	.528**	.194	.289	.018	.119	.033	-.071	.103	1.000				
B16	r	-.109	.093	-.010	.095	.287	.592**	.242	.161	.256	.160	.078	.417**	.245	.152	-.173	1.000			
B18	r	-.078	-.031	-.060	.345*	.235	.503**	-.076	.303*	.191	.594**	.259	.230	.484**	.284	-.307*	.469**	1.000		
B19	r	-.025	-.106	.050	.270	-.090	.173	.048	.096	.522**	.235	.453**	.450**	.262	.100	-.105	.223	.363*	1.000	
B20	r	-.084	-.021	-.032	.228	.127	.358*	-.228	.235	.257	.492**	.242	.221	.514**	.420**	-.378**	.442**	.789**	.451**	1.000

r =Value for Pearson correlation.
p= Value of significance
*Correlation is significant at 0.05 level (2-tailed)
**Correlation is significant at 0.01 level (2-tailed)

(**B01**= Inadequate affordable housing policy / guidelines; **B02** = Inadequate public funding; **B03** = Income inequality; **B04** = High cost of serviced land; **B05** = Income segregation; **B06** = Inadequate infrastructure development; **B07** = Zoning restrictions on land for affordable housing projects; **B08** = Poor maintenance culture / inadequate retrofitting of existing housing facilities; **B09** = Delays in government approval process; **B10** = Tight credit conditions; **B11**= Inadequate access to land for housing; **B12** = High cost of sustainable building materials / technologies; **B13** = Lack of policies / weak enforcement of policies on land use planning system for housing supply; **B14** = Abandoned management of public housing facilities / projects by government; **B15** = Community opposition to affordable housing projects; **B16** = High approval cost due to high taxes and fees on developers; **B18** = High interest rates; **B19** = Inadequate incentive for private investors; **B20** = High inflation rate**)**

Table 7. 3: Rotated Component Matrix

Codes	Barriers to Sustainable Affordable Housing	Components				
		1	2	3	4	5
Component 1	**Green retrofit -related Barriers**					
B14	Abandoned management of public housing facilities / projects by government	0.796	–	–	–	–
B10	Tight credit conditions	0.781	–	–	–	–
B08	Poor maintenance culture / inadequate retrofitting of housing facilities	0.639	–	–	–	–
B05	Income segregation	0.522	–	–	–	–
Component 2	**Land market-related Barriers**					
B13	Lack of policies / weak enforcement of policies on land use planning system for housing supply	–	0.707	–	–	–
B04	High cost of serviced land	–	0.636	–	–	–
B18	High interest rate	–	0.573	–	–	–
B20	High inflation rate	–	0.554	–	–	–
Component 3	**Incentive-related Barriers**					
B12	High cost of sustainable building materials / technologies	–	–	0.780	–	–
B09	Delays in government approval process	–	–	0.749	–	–
B11	Inadequate access to land	–	–	0.709	–	–
B19	Inadequate incentives for private investors	–	–	0.635	–	–
Component 4	**Housing market-related Barriers**					
B15	Community opposition to affordable housing projects	–	–	–	0.802	–
B03	Income inequality	–	–	–	0.716	–
B01	Inadequate affordable housing policy / guidelines	–	–	–	-0.555	–
Component 5	**Infrastructural-related Barriers**					
B07	Zoning restrictions on land for affordable housing projects	–	–	–	–	0.758
B16	High approval cost due to high taxes and fees on developers	–	–	–	–	0.736
B06	Inadequate infrastructural development	–	–	–	–	0.539
B02	Inadequate public funding	–	–	–	–	-0.779
Eigenvalue		7.172	3.049	2.444	1.632	1.299
Variance (%)		29.884	12.706	10.185	6.802	5.413
Cumulative variance (%)		29.884	42.589	52.775	59.576	64.989

Extraction method: Principal Component

Analysis Rotation method: Varimax with Kaiser Normalization

7.3.1 Component 1: Green retrofit-related Barriers

The underlying barriers in this component emphasize the challenges associated with retrofitting or maintenance of affordable housing facilities. Accordingly, this component is named 'green retrofit-related barriers'; it is the most dominant among the five components and explains the highest level of variance (29.9%). The constituents of this component consist of four barriers. These barriers together with their loadings include: 'abandoned management of public housing facilities / projects by government' (79.6%); 'tight credit condition' (78.1%); 'poor maintenance culture / inadequate retrofitting of existing housing facilities' (63.9%) and 'income segregation' (52.2%) (see Table 7.3 for variance and loading values).

The correlation matrix (in Table 7.2) shows some significant relationships / associations among some of the critical barriers as postulated in Fig 4.1 in the literature review section. For instance, there are significant correlations between 'abandoned management of public housing facilities / projects by governments' (B14) and 'tight credit conditions' (r= 0.559, p =0.01); between 'abandoned management of public housing facilities / projects by governments' (B14) and 'poor maintenance culture / inadequate retrofitting of housing facilities' (B08) (r= 0.422, p =0.01); between 'tight credit conditions' (B10) and 'poor maintenance culture / inadequate retrofitting of housing facilities' (B08) (r= 0.385, p =0.01); and finally between 'poor maintenance culture / inadequate retrofitting of housing facilities' (B08) and 'income segregation' (B05) (r = 0.608, p=0.01).

There is an increasing trend of the proportion of aged residential buildings to the total number of buildings as observed in most countries (Tan et al., 2018; Power, 2008). Consequently, debates abound on whether to demolish or refurbish older housing facilities to achieve reduction in greenhouse gas emission as well as reduce energy consumption in homes. Power (2008) reckoned that refurbishing older housing facilities to high environmental standards is more feasible in achieving the stated goals in addition to a significant carbon reduction. For instance, an estimated 80% cut in energy used has been achieved in renovated homes in Germany (Power, 2008). Similarly, in Italy, the maintenance of low energy houses contributed to a saving of 26% - 35% residential energy consumptions (Blengini and Carlo, 2010). Moreover, refurbishment encourages façade retention, encourages neighborhood renewal, generates more employment opportunities than new housing construction and are socially more satisfactory with less environmental impact and reduction in fuel poverty.

Therefore, most existing affordable housing facilities can be made sustainable through retrofit or green retrofit (Tan et al., 2018; Curado & de Freitas, 2019; Casquero-Modrego & Goñi-Modrego, 2019). Retrofit is the replacement of elements or components of a building. In a broader perspective, the U.S. Green Building Council (USGBC) defined green retrofit as "any kind of upgrade at an existing building that is wholly or partially occupied to improve energy and environmental performance, reduce water use and improve comfort and quality of the space in terms of natural light, air quality and noise – all done in a way that it is financially beneficial to the owner." Green retrofit of aged affordable housing facilities could offer an alternative measure to reduce household energy consumption and greenhouse gas emissions (Tan et al., 2018). Besides, since retrofitted buildings provide more comfort to residents, they enhance social sustainability in housing. Thus, it can improve environmental, social and economic sustainability of aged affordable housing facilities.

Yet, the rate of retrofit to upgrade existing affordable housing to sustainability standards is low (Chiang et al., 2015; Tan et al., 2018). Green retrofit implementation is plagued with some barriers, namely, 'abandoned management of public housing facilities / projects by government', 'tight credit conditions' and 'poor maintenance culture / inadequate retrofitting of housing facilities'. High upfront cost of retrofitting, limited budget and high fiscal burden on government have often resulted in the abandonment of public affordable housing or poor maintenance of aged affordable housing facilities (Liang et al., 2016). Liu et al. (2015) noted that public involvement in energy saving retrofitting of housing facilities is often neglected. Consequently, poor living environments are often associated with older buildings that exist without proper management and maintenance (Chiang et al., 2015). Furthermore, poor maintenance and abandonment of affordable housing facilities could lead to value decline of adjacent buildings in the neighborhood. Therefore, there can be a domino effect on the type of households who leave the neighborhood (increase in high-income household mobility rate) and low-income households who may have no option of affording other housing facilities except to stay in that neighborhood. This could eventually cause income segregation within a neighborhood.

7.3.2 Component 2: Land market-related Barriers

This component consists of four barriers and it explains 12.06% of the total variance. The barriers and the percentage of their loadings in bracket include: 'lack of policies / weak enforcement of policies on land use planning system for housing supply' (70.7%); 'high cost of serviced land' (63.6%); 'high interest rates' (57.3%) and 'high inflation rate' (55.4%) (see, Table 7.3 for variance and loadings).

Some significant correlations exist among the barriers. For instance, (in Table 7.2), there are significant correlations between 'lack of policies / weak enforcement of policies on land use planning system for housing supply' (B13) and 'high interest rates' (B18) (r=0.484, p=0.01); between 'lack of policies / weak enforcement of policies on land use planning system for housing supply' (B13) and 'high inflation rates' (B18) (r=0.514, p=0.01); between 'lack of policies / weak enforcement of policies on land use planning system for housing supply' (B13) and 'high cost of serviced land' (B04) (r=0.293, p=0.05); between 'high cost of serviced land' (B04) and 'high interest rate' (B18) (r=0.345, p=0.05); between 'high interest rate' (B18) and 'high inflation rate' (B20) (r=0.789, p=0.01). The significant correlations among these barriers indicate that they are directly or indirectly related to supply and demand of land. Therefore, this component is labelled as 'land market-related barriers'.

'Lack of policies / weak enforcement of policies on land use planning system for housing supply' could lead to land price escalation (Agyemang and Morrison, 2018). Infrastructure supply within a community reduces the land available for housing development while increasing the desire among potential households to live in that community. This increases demand for land thereby increasing prices of land. The increase in the land price / value could be attributed to the infrastructure supply, mostly provided by the state. Without adequate planning control, increase in land price / value is freely captured by landowners and developers. According to Agyemang and Morrison (2018 p.2640), there is an "opportunity cost in not attempting to extract some form of economic rent from private investors for affordable housing provision". Lack of policies / weak policies enforcement of planning control on infrastructural development could lead to an uplift in land value and an upsurge in land prices. Consequently, 'lack of policies / weak enforcement of policies on land use planning system for housing supply' leads to high cost of serviced land. Besides, general inflation rate of a country is one of the macroeconomic variables that affect land prices. The relative price of land is positively linked to the expected inflation rate, as shown in the positive correlation between them (r=0.514, p=0.01). An increase in the expected inflation rate triggers an instant increase in the relative price of such 'store of value' real assets (i.e. land) (Feldstein, 1980).

Furthermore, high cost of serviced land impedes sustainable affordable housing development. For example, Huang et al. (2015) concluded that housing deficit and high housing prices in Hong Kong are due to high cost of land. Besides, the findings of Huang et al. (2015) revealed that land in areas of high land prices will experience longer holding periods than land in areas with low prices. The effect of high cost of serviced land is the postponement of housing development which leads to inflations in the prices of existing housing or supply of housing at high prices. Consequently, supplied houses may not be economically sustainable in terms of price affordability. Besides, at high cost of serviced land, developers may borrow from financial institutions for land purchase. On borrowed capital for land purchase, the effect is high cost of financing. This ultimately increases the overall land price and the cost of housing development. For example, Wen and Goodman (2013) found a direct positive relationship between housing price and land price. Though they concluded that housing price has a greater influence (0.7109 elasticity of housing price) on land price than land price does on price of housing, the elasticity of land price was estimated at 0.1698 which means the increment is 4.19 times that of land price on housing price.

7.3.3 Component 3: Incentive-Related Barriers

The total variance accounted by this component is 10.2%. The underlying barriers and their percentage factor loadings include: 'high cost of sustainable building materials / technologies' (78.0%); 'delays in government approval process' (74.9%); 'inadequate access to land' (70.9%) and 'inadequate incentives for private investors' (63.5%) (shown in Table 7.3).

In Table 7.2, there exist statistical significant correlations between 'high cost of sustainable building materials' (B12) and 'inadequate incentives for private investors' (B20) (r=0.450, p=0.05); between 'inadequate incentives for private investors' (B20) and 'delays in government approval process' (B09) (r=0.522, p=0.01); between 'inadequate incentives for private investors' (B20) and 'inadequate access to land' (B11) (r=0.453, p=0.01); between 'high cost of sustainable building materials' (B12) and 'delays in government approval process' (B09) (r=0.398, p=0.01) and between 'high cost of sustainable building materials' (B12) and 'inadequate access to land' (r=0.322, p=0.01).

The significant correlations among these barriers are coherent since they measure the same problem. This component is labelled as 'incentive-related barriers'. Studies have shown that developers are trammeled by barriers to sustainable affordable housing. For instance, in the USA higher cost of sustainable building materials (green products) and inadequate government incentives were identified as some of the barriers that thwart sustainable development (Ahn et al., 2013 and Chan et al., 2016). In the case of UK, Parsons et al. (2010) highlighted some importance of rainwater and storm water collection for a sustainable resource utilization. However, findings of their study revealed a substantial shortage of interest in installing rainwater harvesting system in most houses. Attributable to the shortage of interest were financial and economic constraints of which the absence of incentives was significant.

Similarly, Chan et al. (2018) identified higher initial cost as among the barriers to the adoption of green building technologies among developing and developed countries. Elaborating on the cost, Van Bueren and Priemus (2002) stated that strategies for sustainable affordable housing mostly require few raw materials and more labor than conventional modes of construction of affordable housing. For example, it is estimated that depending on the project site, sustainable practices could increase the cost of the initial design, extra design services, certain green features and commission as much as 2-7% (Alwaer and Clements-Croome, 2010). Though some sustainable housing technologies (such as passive water heaters, energy efficient lighting, reflecting foil on exposed windows to reduce solar gains and shading devices / overhang) could be achieved at a minimal cost of two-figure sum in dollars, other sustainable materials / technologies could be expensive.

For example, photovoltaic (solar) panels which can reduce household energy consumption by 80 percent can be costly (Sullivan and Ward, 2012). Therefore, integrating some of these technologies into housing facilities could make the housing facilities unaffordable to low-income earners.

Furthermore, delays in project approval is one of the identified barriers to sustainable affordable housing. Taylor (2011) estimated that review and approval procedure for development could be 18 months duration. So, the implementation of sustainable technologies in affordable housing may increase the complexity of construction because there could be additional submissions and approvals as compared to traditional form of construction (Lam et al., 2009). For example, in Singapore and Hong Kong, lengthy preconstruction process or delays caused by green requirements was identified as one of the barriers that affect the successful implementation of green construction (Hwang and Ng, 2013; Lam et al., 2009). As direct construction cost is linked to time, any delay in workflow due to review and approval would have economic effects (Lam et al., 2009).

7.3.4 Component 4: Housing market-related Barriers

The extracted barriers with their factor loadings include 'community opposition to affordable housing' (80.2%); 'income inequality' (71.6%) and 'inadequate affordable housing policy / framework' (55.5%). This cluster explains 6.8% of the total variance (shown in Table 7.3) and is named 'housing market-related barriers'.

The correlation matrix shows some statistical significant associations among the barriers. There are significant correlations between 'community opposition to affordable housing projects' (B15) and 'income inequality' (B03) (r=0.481, p=0.01); between 'community opposition to affordable housing projects' (B15) and 'inadequate affordable housing policy' (B01) (r=0.349, p=0.05) and between 'income inequality' (B03) and 'inadequate affordable housing policy / guidelines' (B01) (r=0.413, p=0.01) (shown in Table 7.2).

'Inadequate affordable housing policy / guidelines' as a critical barrier could result from fiscal burden on the budget of most governments. Due to pressure on budgets of governments, the scarce resources are often allocated for the provision of other basic needs. Thus, housing provision could be relegated to the market. In a typical market-dominant model, housing is commodified and provided to those who are willing and able to pay (Drudy and Punch, 2002). Considering the incremental cost of adopting sustainable technologies and the predominance of the market-model, supplied sustainable housing are often beyond the income capacity of most low-income earners, without governments' intervention. The consequence of the dominance of a market model is an inadequate affordable housing policy / guideline for low-income earners. This could lead to 'income inequality' and 'community opposition to affordable housing'.

The market-dominance model has various outcomes regarding efficiency, quality and equity. For instance, since housing could be a consumption good and an investment, high-income earners could purchase more houses in anticipation of making profit soon (Drudy and Punch, 2002). As high-income earners earn profit from such investments, from the perspective of partial equilibrium, there is an outward shift in their demand curve with a corresponding increase in their demand for more housing, *ceteris paribus*. If supply is inelastic, the market equilibrium price increases correspondingly. This heightens the income inequality (gap) between high-income earners and low-income households. Thus, 'inadequate affordable housing policy' is associated with income inequality (r=0.413, p=0.01, as shown in Table 7.2). Income inequality could lead to rent increase, decrease housing consumption and decrease residual income among low-income households (Dewilde and Lancee, 2013). For instance, an increase in the market equilibrium price results in a decrease in the quantity of housing consumed among low-income earners. A study by Matlack and Vigdor (2008) revealed a continual significant relationship between inequality and crowding among low-income households. This is because low-income tenants respond to increasing inequality by reducing consumption to the point where expenditures on housing remain roughly steady. It was suggested in Matlack and Vigdor (2008) that allowing for product differentiation in housing could possibly alter the effects of income inequality. However, product differentiation could lead to community opposition depending on the "degree of product differentiation in the housing market".

"Opposition to affordable housing is often motivated by homeowners' fear that their property values will decline" (Nguyen, 2005 p. 15). Reasons for opposition to affordable housing include low quality designs of affordable housing facilities, which are often linked to the fear of declining property values of neighbouring facilities. Upon a critical review of hedonic price studies, Nguyen (2005) concluded that proximally located affordable housing can negatively affect neighbouring property values. This could be attributed to inadequate affordable housing development policy such as low-quality design and poor management and maintenance, low compatibility between affordable housing and residential facilities of the host neighbourhood and high concentration of affordable housing within a specific area. Community opposition causes spatial segregation of low-income residential facilities, which leads to homogenous community development. This does not encourage social mix – a requirement for social sustainability.

7.3.5 Component 5: Infrastructural-related Barriers

Lastly, component 5 consists of four barriers: 'zoning restrictions on land for affordable housing projects' (75.8%); 'high approval cost due to high taxes and fees on developers' (73.6%); 'inadequate infrastructural development' (53.9%) and 'inadequate public funding' (77.9%) (in Table 7.3). This component explains 5.4% of the total variance and is named 'infrastructural-related barriers'. The correlation matrix (in Table 7.2) shows only one significant association between 'high approval cost due to high taxes and fees on developers' (B16) and 'inadequate infrastructure development' (B06) (r=0.592, p=0.01).

Owing to zoning restrictions on land, most affordable housing facilities are constructed at the outskirts of towns and cities (Winston, 2010). Consequently, infrastructure such as roads are required to provide transport link among the housing facilities and social amenities. However, key infrastructure frequently arrives after affordable housing development and occasionally not at all. Funding is mostly reduced in large scale building programs on account of cost overruns and construction variations which may alter the product usually far from the initial proposal (Power, 2008). Subsequently, inadequate transport link among infrastructure could increase commuting distance and cost. This makes affordable housing projects not economically and environmentally sustainable due to high greenhouse gas emissions that could be linked to longer commuting distance (Power, 2008).

Besides, inadequate infrastructural supply could be a barrier to the sitting and construction of affordable housing within cities. For instance, one of the main reasons for zoning restrictions on land for affordable housing projects is to avoid possible congestion on existing limited social amenities (Tighe, 2010). Due to tight budget, most governments try to resolve the problem of inadequate infrastructure by increasing taxes and approval fees on developers so that the realised revenue could be used to augment infrastructure provision. However, when developers incur high taxes and permit fees for housing development, the taxes and permit fees are invariably transferred onto potential households in the form of higher house prices, thus making housing prices very high and economically unsustainable.

To avoid the problems of inadequate infrastructural supply, high-density development and mixed-land use are crucial. These developments encourage proximity to infrastructure. Proximity to infrastructure and services has relevant outcomes such as vehicle emission reduction and the wellbeing of citizens. These forms of development are key elements for an efficient access to local services and for promoting fairer transport models. They promote a walkable and cycling community. These alternatives of transport are considered as fundamental ingredients in an integrated, intermodal transportation system and they offer households transportation options and provide continuity from home to destination (Southworth, 2005). Walking and cycling gain merits as sustainable means of transport since they are "energy efficient and low pollutant" (Marquet and Miralles-Guasch, 2015). Besides, communal facilities should be provided in addition to housing facilities to promote social contact (Winston, 2010).

Although high-density development is important, Turok (2016) noted that extreme high-density development could have detrimental effects. High-density development could increase traffic congestion. Consequently, this could increase the travelling time of households and associated difficulties in pedestrian movement which could discourage brief walking trips (walking trips that take no more than 10 minutes). Similarly, a study conducted by Marquet and Miralles-Guasch, (2015 p.263) revealed that "as density increases from the more dispersed areas to the denser ones, so does the use of the neighborhood for brief trips. However, once a certain density threshold is surpassed, proximity utilization no longer varies significantly. For areas above the 35.00 inh / km^2, density ceases to be found as significant for proximity use."

7.4 DATA ANALYSIS AND RESULTS – CRITICAL SUCCESS FACTORS FOR SUSTAINABILITY ATTAINMENT IN AFFORDABLE HOUSING[8]

7.4.1 MEAN SCORE RANKING OF SUCCESS FACTORS

The statistical mean, standard deviation and normalization values for each SF were computed (as shown in Table 7.4). Two of the factors: 'High density affordable housing development' (SF20) and 'Speculative measures on property sales through taxes' (SF28) with the same mean value of 3.458 but different standard deviations of 1.051 and 1.129, respectively, were the lowest ranked factors. Based on the calculated normalization values, 13 CSFs were identified (normalization values ≥ 0.50) as shown in Table 7.4. The top six CSFs among the identified CSFs include "political will and commitment to affordable housing" (SF09), "formulation of sound housing policies" (SF11), "access to low interest housing loans to developers" (SF01), "adequate accessibility to social amenities" (SF14), "good location for housing projects" (SF13) and "monitoring condition / performance of completed houses" (SF19).

[8] This chapter largely based upon the following publication:
Adabre, M. A., & Chan, A. P. (2019). Critical success factors (CSFs) for sustainable affordable housing. *Building and Environment*, *156*, 203-214.

Table 7. 4: Ranking of Potential CSFs for Sustainable Affordable Housing

Code	Respondents (All)			
	Mean	SD	Normalization	Rank
SF09	4.766	0.598	1.00[a]	1
SF11	4.575	0.542	0.85[a]	2
SF01	4.468	0.687	0.77[a]	3
SF14	4.362	0.819	0.69[a]	4
SF13	4.319	0.911	0.66[a]	5
SF19	4.277	0.743	0.63[a]	6
SF12	4.261	0.801	0.61[a]	7
SF24	4.222	0.441	0.58[a]	8
SF08	4.213	0.999	0.58[a]	9
SF22	4.208	0.922	0.57[a]	10
SF06	4.192	0.947	0.56[a]	11
SF15	4.192	1.014	0.56[a]	12
SF17	4.188	0.960	0.56[a]	13
SF04	4.085	0.747	0.48	14
SF25	4.083	0.739	0.48	15
SF10	4.044	0.788	0.45	16
SF26	4.042	0.746	0.45	17
SF23	4.042	0.849	0.45	18
SF30	4.000	0.918	0.41	19
SF27	3.957	0.779	0.38	20
SF02	3.938	1.040	0.37	21
SF16	3.872	0.992	0.32	22
SF24	3.792	0.898	0.26	23
SF29	3.729	0.983	0.21	24
SF05	3.717	1.129	0.20	25
SF21	3.604	1.026	0.11	26
SF03	3.575	1.175	0.09	27
SF07	3.511	1.140	0.04	28
SF20	3.458	1.051	0.00	29
SF28	3.458	1.129	0.00	30

Note: SD = Standard deviation
Normalized value = (mean – minimum mean) / (maximum mean – minimum mean)
[a] The normalized value indicates that the success factor is critical (normalized ≥ 0.50)

7.4.2 FACTOR ANALYSIS

7.4.2.1 Internal Reliability

The Cronbach alpha was used to assess the internal consistency of the 13 CSFs. Cronbach alpha coefficient (α) value ranges from 0 to 1. A high alpha value indicates high internal consistency / reliability of a set of factors in a scale. An alpha coefficient (α) of 0.724 was computed using the SPSS software. The alpha value shows that the 13 CSFs are internally consistent or reliable (Santos, 1999).

The obtained value for the KMO is 0.597 which is above the required minimum of 0.50. The Bartlett's test of sphericity result of 164.253 with a significance level of 0.00 indicated that the correlation matrix is not an identity matrix. Therefore, the data are suitable for factor analysis. Factor analysis was, therefore, conducted. First, factor extraction was carried out using the principal component analysis to identify the relevant variables. The eigenvalue, which measures the contributions of a variable to the principal components, was used as the criterion to determine the relevance of a variable. Judging from previous study (Chan et al., 2018), only variables with eigenvalues greater than one should be retained. Consequently, only 13 CSFs with eigenvalues above 1 were retained. Then, the Varimax rotation was conducted on the 13 CSFs which yielded four underlying components which explain 62.65% of the total variance (as shown Table 7.5). Only 11 CSFs were successfully loaded into the four underlying components. Two of the CSFs namely 'political will and commitment to affordable housing' (SF09) and 'transparency in allocation of houses' (SF17) were excluded because their loading values were below 0.50. The factor loading measures the correlation coefficient between an original variable and an extracted component. Normally, factor loadings higher than 0.5 are regarded significant and contribute to the components interpretation. Otherwise, it is regarded insignificant (Li et al., 2011). Table 7.5 shows the variables with factor loadings above 0.50. The four factors were renamed and summarized as follows:

Table 7. 5: Results of the Factor Analysis

Code	CSFs for Sustainable Affordable Housing	Components			
		1	2	3	4
Component 1	**Developers' Enabling CSFs**				
SF15	Mandatory inclusion of affordable unit policy in developer's projects	0.770	–	–	–
SF01	Access to low interest housing loan to developers	0.750	–	–	–
SF06	Incentives for developers to include affordable housing / sustainable designs	0.743	–	–	–
SF08	Improved supply of low cost developed land by government	0.661	–	–	–
Component 2	**Household-demand Enabling CSFs**				
SF19	Monitoring conditions / performance of completed houses	–	0.827	–	–
SF12	Governments' provision of housing subsidies to households	–	0.774	–	–
SF24	Adherence to project schedule	–	0.652	–	–
Component 3	**Mixed Land Use CSFs**				
SF14	Adequate accessibility to social amenities	–	–	0.794	–
SF13	Good location for housing projects	–	–	0.767	–
Component 4	**Land Use Planning CSFs**				
SF22	Adequate infrastructure supply by government	–	–	–	0.740
SF11	Formulation of sound housing policies	–	–	–	0.616
Eigenvalue		3.389	1.965	1.647	1.144
Variance (%)		17.850	17.802	13.685	13.313
Cumulative variance (%)		17.850	35.652	49.337	62.649

Extraction method: Principal Component Analysis
Rotation method: Varimax with Kaiser Normalization

7.4.3 RESULTS AND DISCUSSION OF PRINCIPAL COMPONENT ANALSIS

7.4.3.1 Component 1: Developers' Enabling CSFs

Component 1 consists of four underlying factors: 'mandatory inclusion of affordable unit policy in developer's projects', 'access to low interest housing loan to developers', 'incentives for developers to include affordable housing / sustainability designs (strategies) in their projects' and 'improved supply of low cost developed land by governments'. All these factors are closely related to enhancing sustainable affordable housing supply among developers. Therefore, this component is named 'developer's enabling CSFs'. The total variance accounted by this component is 17.850% (as shown in Table 7.5). Inclusion of affordable housing in developer's project could be made mandatory for affordable housing supply. However, incentives such as the allocation of land and the provision of loan at low interest rates will also ensure lower housing prices (Whitehead, 2007). Thus, these policies lead to economic sustainability through price affordability. In the UK, for example, mandatory policies through section 106 (S106) are implemented. Conversely, in Australia and New Zealand, incentives such as low interest finances are provided for inclusionary affordable housing projects (Berry, 2004). In Singapore where there is strong public ownership of land, land allotment system has been an effective instrument in providing affordable housing. Among other incentives that could enhance developers' sustainable affordable housing supply are design flexibility, density bonus, fast-tracking processing, fee deferral, fee reduction, fee waiver and growth-control exemption (Garde, 2016). Design flexibility such as relaxations on maximum floor design, number of stories and number of units could have comparatively positive impact on sustainable affordable housing supply. Therefore, policy makers could use these design flexibilities as incentives to enable developers to improve on sustainable affordable housing provision (Hui and Soo, 2002). Aside the attainment of economic sustainability, these policies could also ensure social sustainability.

Mandatory or incentives for inclusionary housing policies enable socially integrated forms of affordable housing. This leads to a form of mixed income housing thus preventing segregation of households, which could lead to the attainment of social sustainability (Adabre and Chan, 2018). For instance, in South Africa, inclusionary housing policy was initiated to remedy the divided apartheid community (Klug et al., 2013). Although developers can set aside 25% of land or the money equivalence for social housing, as witnessed in Bogota and Columbia, it is worth noting that in such approach, mix housing is traded off against housing supply (Mallach, 2010). To ensure maximum achievement of the inclusionary housing policies, the policies should be a combination of a voluntary pro-active deal-driven component and an obligatory but incentive-linked regulation-based component (Klug et al., 2013).

Previous studies have evaluated the effectiveness of these policies in achieving price affordability with little regard to other economic and environmental sustainability goals. In many affordable housing projects, these sustainability factors can be achieved significantly through the implementation of energy efficient strategies. Strategies such as energy efficient lighting system, energy-efficient heating, ventilation and air condition (HAVC) systems, solar water heating technology, installation of water-efficient appliances (low-flow toilets), rainwater harvesting technology and grey water recycling techniques are active strategies that could be adopted for sustainable affordable housing (Nelms et al., 2005). Besides, improvement to the housing envelope elements – known as passive strategies – can be implemented for energy efficient housing. Different kinds of walls could be adopted in sustainable affordable housing construction. Typical examples are solar walls (i.e. trombe wall, insulated trombe wall, unventilated solar wall and composite solar wall); transwalls; white washing external walls and ventilated or double skin walls (Sadineni et al., 2011). These walls are sensitive to weather factors and therefore perform better under certain climatic conditions and designs. For instance, insulated trombe walls or composite solar walls are suitable in zones with briefer heating seasons to prevent overheating during cooling seasons. However, unventilated solar walls or trombe walls are appropriate in zones with lengthier heating seasons (Sadineni et al., 2011). In zones where there is high differential in atmospheric air temperature between days and nights, thermal mass as a passive strategy is more efficient. Ventilated walls also improve passive cooling of a facility thus saving on energy consumption. Though the energy saving benefits of ventilated walls increase with increase in the size of the air gap, increases after 0.15m yield diminishing returns (Ciampi et al., 2003). On fenestration such as windows, 1.5m overhangs and wind walls and reflective coated glass window glazing to all windows are some recommendable passive strategies (Cheung et al., 2005). Roof architecture such as white-washed exterior roof, doomed and vaulted roofs, green roofs and double roofs are some examples of passive cooling strategies that can be adopted in tropical climates (Sadineni et al., 2011).

Integrating these strategies into affordable housing projects could lead to incremental costs of projects (Nelms et al., 2005). For instance, higher cost was identified as the major barrier to the adoption of some of these strategies in Ghana, USA, Canada and Australia (Chan et al., 2018). However, one of the most effective approaches to promote their integration into affordable housing construction is to incentivize the affordable housing market (Taylor, 2011). Incentives motivate developers to integrate sustainability techniques into projects (DuBose et al., 2007). These incentives could either be external or internal. On external incentives, beneficiaries must fulfil specified conditions or obligations to benefit from an incentive.

However, the internal incentives allow beneficiaries to be incentivized out of their own desire due to the appeal of the benefits of sustainable construction (Olubunmi et al., 2016). External incentives can be classified into two categories: financial and non-financial (structural) incentives. Financial incentives (such as tax incentives, rebates, direct grant, low interest loans and development contribution remission) can be provided by government to alleviate the economic barriers of incorporating both passive and active strategies into housing projects. For instance, with tax incentives, developers that integrate these strategies in affordable housing could be offered tax deductions or completely exempted from tax payment (Azis et al., 2013). Most often, financial incentives can be paired with non-financial incentives for sustainable affordable housing supply.

With non-financial incentives, a government mostly grants developers the right or additional rights that are beyond the normally allowable when specific conditions are accomplished. At no or low cost, sustainable affordable housing construction can be made more appealing to developers (Taylor, 2011). Typical among the non-financial incentives include: Floor-to-Area density (FAR), expedited permitting, planning assistance and technical assistance. For example, the FAR allows developers who incorporate sustainable construction technologies into a proposed development to construct more building than are allowed by the usual zoning. In Singapore, for instance, the Green Mark Gross Floor Area Incentive scheme is offered to developers who accomplish the highest Green Mark Platinum or Green Mark Gold Plus rating for an extra floor area up to 2% of the total gross floor area of the project (Gou et al., 2013). Though the FAR is a non-financial incentive, additional rentable / saleable space resulting from the FAR bonuses could help developers to completely or partially recoup the expenditure on sustainability strategies incorporated into the housing facilities (Olubunmi et al., 2016). Furthermore, it has been estimated that review and permitting procedure for development could take up to 18 months (Taylor, 2011). In project delivery for marketing or for occupation, time is essential. A significant reduction in project duration promotes project cost and risks reduction for the developer (Perkins and McDonagh, 2012). Through a shift in permitting priority, expedited permitting could be used to significantly save developers time in permit approval process in exchange for the developer committing to stated sustainable affordable housing strategies (Perkins and McDonagh, 2012; Choi, 2009).

Studies have been conducted in comparing the different incentives mechanisms – financial incentives, non-financial incentives (administrative incentives) and density-bonuses – to identify incentives which contribute most to sustainable housing development. Findings of a study by Sauer and Siddiqi (2009) indicated that density bonus (i.e. zoning ordinances), which allows projects to achieve a higher unit density, was the main cause for higher construction of LEED certified multi-unit residential buildings. Furthermore, administrative incentives (such as expedited permitting, fee remission, or fee waiver as well as free consultation) have a more substantial impact on the adoption of sustainable construction measures by developers than financial incentives (i.e. tax credits). Therefore, it was concluded that non-financial incentives are the most effective at encouraging sustainable construction (i.e. green building development) among developers. Similarly, a study by Choi (2009) confirms this assertion since monetary / financial incentive was found not to have effectively promoted sustainability practices in buildings. Rather, regulations and administrative incentives are strong tools for sustainable construction. Choi (2009) argued that it is possible that financial incentives have not been adequate to offset the cost of sustainable construction.

7.4.3.2 Component 2: Household-demand Enabling CSFs

Component 2 includes three factors: 'monitoring conditions / performance of completed houses', 'governments' provision of housing subsidies to households' and 'adherence to project schedule'. These factors emphasize strategies for meeting households' demand in an affordable housing market and are therefore termed 'household-demand enabling CSFs'. The total variance accounted by this component is 17.802%.

'Monitoring conditions / performance of completed houses' is essential for housing maintenance. It keeps a facility in a condition suitable for use. It also improves the quality of a building. One challenge in achieving maintenance of building projects is inadequate information about the building structure and performance. However, through automatic monitoring, routine inspections and feedback from users, data could be collected for the appropriate type of maintenance. Various forms of maintenance could be applied to housing facilities based on the conditions at hand. Corrective maintenance is recommended when the effect of failure is insignificant. With the possibility of a colossal cost due to failure, preventive maintenance is more appropriate (Sadineni et al., 2011; Lind and Muyingo, 2012). Preventive maintenance means circumstances where repair and / or replacement is carried out without the incidence of any fault. It could be condition-based whereby various elements of a facility are inspected on a regular basis and the elements serviced or replaced based on certain noticed conditions. It could also be time-based whereby maintenance tasks are executed at a frequency based on the passage of time, irrespective of the condition of the elements of the housing facility (Lind and Muyingo, 2012). Due to high cost of over-maintenance, conditioned-based maintenance would be preferred to time-based maintenance for sustainable affordable housing facilities since it is more possible to make repairs only when needed. Another cost-effective maintenance strategy is opportunistic maintenance. It includes maintenance of various elements or components of a building if there arises an 'opportunity' to carry out certain activities in a cost-effective way (Lind and Muyingo, 2012).

There is the need for a considerable amount of opportunistic maintenance in existing affordable housing projects to meet sustainability requirements. A study conducted by Nikolaidis et al. (2009) recommended opportunistic maintenance for energy efficient residential buildings. It was found that the most effective energy saving methods are the improvement of lighting, the insulation of the roof of the building and installation of an automatic temperature control system (Nikolaidis et al., 2009). Among the alternative domestic light sources – incandescent lamps, compact fluorescent light (CFL), tungsten-halogen lighting and light emitting diode (LED) – Jacob (2009) stated that LED's are possibly the ideal replacement for the most widely use incandescent lamps, having a long lifespan and discrete appearance. Besides, Nikolaidis et al. (2009) recommend that replacing electric water heaters with thermal solar system could lead to 80% saving of the cost of heating water in addition to promoting environmental protection. Furthermore, replacing air-cooled with water-cooled air condition system could lead to substantial reduction in electricity consumption (Yik et a., 2001). Moreover, household appliances (i.e. refrigerators) could be replaced with low CFC and high energy efficient refrigerators to limit ozone depletion and to promote energy efficiency over time.

It is worth noting that long term energy efficiency would be achieved only through an integration of several energy efficient measures (Costolanski et al., 2013). For instance, in Ethiopia, CFL bulb distribution program contributed significantly to energy saving in the country. However, due to rebound effect on the CFL bulb distribution program, about 20% of the initial energy savings disappeared in 18 months after the implementation of the program. This finding was stated as not surprising because of high estimated income elasticity. As the economy grows, demands for other electrical appliances and electricity increase. Appropriately, it was recommended that for long term energy savings, the CFL bulb distribution program should be integrated with other energy efficient measures (Costolanski et al., 2013).

The least energy-efficient households are most likely to be lower-income residents. Yet, considering the net benefits of energy efficient measures, the take-up responses of these measures are very low and disappointing (Clinch and Healy, 2000). In a study by Zhao et al. (2012), it was found that although half of the respondents were interested in energy-efficient and renewable energy products, high investment cost was a major barrier that hindered purchases among income groups including low-income earners. However, subsidies programs such as tax credits, purchasing rebates and interest-free loans can be developed to promote the adoption of these measures. Taylor (2011) argued that revolving loans could be established to provide low-interest loans to low-income households who seek to renovate their residency to sustainability standards. However, between tax credits and interest-free loans, a study by Zhao et al. (2012) found that because of indebtedness concerns, households were not very attracted to loan subsidies (including interest-free loans). Rather, households are more disposed to take tax credits than interest-free loans, which may be attributable to the fact that tax credits cutback the actual purchase cost. Tax credits at higher rates are required for expensive products such as solar panels and for drawing interest from lower income households (Zhao et al. 2012) for opportunistic replacement of most of the energy inefficient appliances in a housing facility.

7.4.3.3 Component 3: Mixed use Development CSFs

Component 3 comprises two factors: ‘adequate accessibility to social amenities’ and ‘good location for housing projects’, which accounts for 13.685% variance. Both accessibility and location efficiency can be achieved through mixed land use (Aurand, 2010). Therefore, component 3 was named ‘mixed land use CSFs’.

"Mixed land use is defined as a mixture of commercial, residential and industrial land uses within a specified geographical area as opposed to the segregation of residential land uses from non-residential uses" (Aurand, 2010 p. 1023). According to advocates of smart growth, one of the ways of better meeting the housing needs of low-income earners is by mixed land use than by neighborhood of single-family homes dominance (Kalinosky, 2001). 'Mixed land use' is one of the key planning principles among contemporary planning strategies. It is a planning strategy that ensures mix of shops, apartments, offices and homes for the attainment of sustainability goals. For instance, mixture of complimentary land use promotes transit-supportive development, encourages walkability and bicycle travel, builds a sense of community, expedites a more economic arrangement of landscape amenities and reserves open space. Consequently, this leads to reduce energy consumption, improved access to services and facilities and enables agglomeration economies (Koster and Rouwendal, 2012). Conversely, the isolation of employment, services and shopping from housing facilities has often led to substantial distance between residential neighborhoods and jobs or services. Arguably, this separation has led to excessive commuting time, air pollution, traffic congestion, job housing imbalance, inefficient utilization of energy which are some of the causes of increase pollution emission due to long traveling distance by vehicles and increase financial burden on household as a result of high commuting cost (Song and Knaap, 2004). Therefore, 'mixed land use CSFs' directly ensures environmental sustainability and economic sustainability while indirectly promoting social sustainability through household satisfaction (Adabre and Chan, 2018; Chan and Adabre, 2019).

7.4.3.4 Component 4: Land use Planning CSFs

Component 4 has two variables: 'adequate infrastructure supply by government' and 'formulation of sound affordable housing policies'. The provision of infrastructure leads to the appreciation in the value of land. If these infrastructure facilities are supplied by the government then policies could be formulated which link the appreciation of land value to development of sustainable affordable housing. This system is termed as land use planning. Therefore, component 4 was named 'land use planning CSFs.' The total variance accounted by this component is 13.313%.

'Land-use planning' is a governing mechanism that seeks to increase the efficiency of the use of land in addition to ensuring greater equity in that use (Evans, 2008). Some of the reasons for the increased value of housing include agglomeration economies and the provision of public infrastructure (Whitehead, 2007). The former could be enhanced by the latter (Whitehead, 2007). When both scenarios occur, they result in the reduction of the total quantity of housing to be provided since an amount of the input for housing – land – is channeled into the provision of infrastructure. The planning and provision of infrastructure provide communal benefits which can increase the value of land (Crook, 1996). This may lead to an increase in affordability difficulties. Therefore, on fairness grounds, planning and capital gains to the maximum of the increase associated with the infrastructure development are levied on developers / owners of land in the form of taxes and distributed to assuage the housing affordability difficulties. The main rationale for capturing uplift in land values rests on redistribution policies (Agyemang and Morrison, 2018). The realized taxes could be distributed as subsidies. As argued by Whitehead (2007), in a political environment of tight funding with priority for affordable housing, the link should be established between the potential for taxation resulting from the land-use planning system and the need for affordable housing funding / finance. Generally, studies have concluded that a successful case study of the 'land use planning' system is the UK (Whitehead, 2007; Crook et al., 2001). The land use planning CSFs have several benefits. Some of which include mixed development or mixed communities. If efficiently implemented, the land use planning CSFs could promote economic and social sustainability (Chan and Adabre, 2019).

7.5 CHAPTER SUMMARY

This chapter contains an analysis of critical barriers that hinder sustainable affordable housing development. Through a questionnaire survey, data on barriers and success factors were collected from 51 affordable housing experts from various economies around the world. These experts are also knowledgeable in sustainable housing. The data were analysed using ranking analysis (mean and normalization scores) and factor analysis with Pearson correlation. Through factor analysis of the combined critical barriers from the perspective of developing and developed economies, five components were obtained, namely, green retrofit-related; land market-related; incentive-related; housing market-related and infrastructural-related barriers.

Moreover, factor analysis on the success factors indicated that the CSFs can be grouped into four underlying components: 'developers' enabling CSFs', 'household-demand enabling CSFs', 'mixed land use CSFs' and 'land use planning CSFs'. The findings of the chapter suggest the CSFs among the many success factors, that could be the pivotal interventions for sustainable affordable housing in both developing and developed countries. Besides, by classifying these factors, policymakers are informed of the underlying groupings of CSFs which could be implemented concurrently. Moreover, successful implementation of these CSFs will ensure a holistic sustainable affordable housing market. For instance, economic sustainability could be attained if 'developer's enabling CSFs' are implemented while social sustainability could be accomplished through the execution of 'household-demand enabling CSFs' and 'land use planning CSFs'. The implementation of the underlying component 'mixed land use CSF' ultimately leads to environmental sustainability. For further study, quantitative analysis towards establishing relationships among the identified critical barriers, CSFs and the success criteria of sustainable affordable housing project is a knowledge gap which will be explored in subsequent chapters.

Therefore, the groupings in this chapter provided guidelines for the categorization of the critical barriers for modelling the impact of the critical barriers on the critical success criteria for the case of Ghana, the study area of this research. Similarly, the chapter also offered a classification of the success factors for modelling the impact of the success factors on the critical success criteria in Ghana.

CHAPTER 8: DATA ANALYSIS AND RESULTS – AN ASSESSMENT MODEL FOR SAH & RISKS IMPACT ON SAH [9]

8.1 INTRODUCTION

In the previous chapters on data analysis, the data were sourced from respondents from an international perspective. However, in the present chapter and subsequent chapters, data were obtained and analyzed from only respondents in the Ghanaian housing market. The objectives of the present chapter are to identify the relevance of the CSC for SAH and to develop a sustainability assessment model for evaluating affordable housing or low-cost housing from the Ghanaian perspective. It also entails the assessment of risk impact on SAH. A questionnaire survey, as deployed in previous chapters, was employed for data collections. The data were first descriptively analyzed using mean scores and standard deviation for ranking the CSC. Next, a fuzzy synthetic evaluation (FSE) technique was used to develop the sustainability assessment model and to evaluate the impact of risk factors on SAH. Essentially, the findings of this chapter help to identify CSC that are important for sustainability attainment in affordable housing. By developing an assessment model, the findings seek to inform policymakers on resource allocation for affordable housing regarding the weights of the various categories of CSC. Furthermore, the assessment model could be used to monitor and control housing projects for ensuring sustainability attainment in such projects. Concerning the risk impact assessment, the data analysis revealed critical risk factors that required much attention for efficient resource allocation for SAH.

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[9] This chapter largely based upon the following publication:
Adabre, M.A., and Chan, A.P.C. Towards a Sustainability Assessment Model for Affordable Housing Projects: The Ghanaian Perspective. *Engineering, Construction and Architectural Management.* Manuscript ID: ECAM-08-2019-0432.R1.

8.2 TOWARDS A SUSTAINABILITY ASSESSMENT MODEL FOR AFFORDABLE HOUSING

8.2.1 RESULTS OF MEAN SCORE RANKING

Mean scores and standard deviations were estimated and subsequently used for ranking the sustainability indicators. If two indicators have the same mean scores, decision on their ranking is made based on their standard deviation values. A lower standard deviation of an indicator implies a high level of consistency among respondents in rating the indicator and vice-versa. Therefore, for two indicators with the same mean values, the indicator with lower standard deviation is ranked higher. Results of the mean score rankings are shown in Table 8.1. Based on the mean scores and the standard deviation values, 'quality performance' was ranked the highest followed by the indicator 'end users' satisfaction'. 'Housing price in relation to income of household' was ranked third while 'maintainability of housing facility (maintenance cost)' and 'rental cost of housing in relation to income of household' were ranked fourth and fifth, respectively. However, 'reduce occurrence of disputes and litigations' and 'technology transfer' were relatively ranked low (shown in Table 8.1).

In previous study by Chan & Adabre (2019), a comparison between developed and developing economies on the ranking of the indicators 'rental cost of housing' and 'price of housing' revealed that 'price of housing' was ranked higher among developing economies. This shows a higher preference for homeownership than for renting. However, among developed economies 'rental cost of housing' was ranked higher which implies higher preference for renting than for homeownership. Aside the prestige and esteem needs that are derived from homeownership over renting of houses, there are other possible reasons for the higher ranking of 'price of housing' (higher preference for homeownership) in the case of Ghana as a developing country. Due to limited investment options, the desire for homeownership as an investment could be relatively high in Ghana as compared to the case of developed countries. Thus, even among low and middle-income earners in Ghana, the propensity for homeownership is high for the purpose of real investment and to hedge against the escalating inflation rate and high advance rent charges especially in cities. These could possibly be the reasons for the relatively high rank of ‘price of housing in relation to household income’ (an indication of higher preference for homeownership) over ‘rental cost of housing in relation to household income’ (an indication of renting) among respondents in the Ghanaian housing market.

From Table 8.1, environmental sustainability-related indicators such as ‘energy efficiency of housing facility’, ‘eco-friendliness of housing facility’ and ‘commuting cost’ are ranked high (> 3.5) per their mean scores. However, indicators related to economic sustainability such ‘price of housing’ and ‘rental cost of housing’ are ranked higher than the environmental sustainability-related indicators. Yet, these economic assessment indicators are not considered in most of the widely adopted GBRSs such as BREEAM and LEED. Furthermore, social sustainability-related indicators such as ‘end user’s satisfaction of housing facility’, ‘functionality of housing facility’, ‘safety performance of housing facility’ and ‘quality performance of housing facility’ were ranked higher than some of the environmental sustainability-related indicators such as ‘energy & water efficiency of housing facility’ and ‘environmental performance/impact of housing facility’ (eco-friendliness)’. However, most of the internationally recognised GBRSs and neighbourhood sustainability assessment tools do not adequately consider these social sustainability indicators for evaluating sustainability of projects or housing facilities. Similarly, Ameen & Mourshed (2019) concluded that prominent GBRSs and neighbourhood sustainability assessment tools paid less attention to safety factors. This is evinced in the low weightings allocated to the safety indicator by BREEAM Community

(0%) and LEED-ND (1.9%) and 0.70% and 0.65% weightings from PCRS and GSAS, respectively. Nonetheless, safety is a crucial indicator for not only social sustainability attainment but for general sustainable development. It includes the right to be safe in addition to adopting security measures and adaptations to prevent future harm and casualties (Eizenberg & Jabareen, 2017).

Therefore, though most of the GBRSs are more inclined towards the environment than to the social and economic aspects of sustainability, it is worth noting that priority on sustainability indicators vary among schemes. Regarding affordable housing schemes, socio-economic assessment indicators featured highly from the perspective of respondents from the Ghanaian housing market. The inadequate consideration of this disparity in the rating of these indicators among recognized rating tools and frameworks may reduce their effectiveness in promoting sustainable development across affordable housing schemes. Accordingly, subsequent improvement in GBRSs should pay more attention to these socio-economic indicators to enhance the coverage and thorough sustainability assessment in housing.

Table 8. 1: Mean Score Ranking of the Indicators

Code	Indicators (I)	Mean (M_i)	Standard Deviation (SD)	Rank
I 1	Rental cost of housing facility in relation to household income	4.196	0.824	5
I 2	Housing price in relation to income of household	4.298	0.749	3
I 3	Maintainability of housing facility	4.283	0.851	4
I 4	End users' satisfaction	4.319	0.980	2
I 5	Functionality of housing facility	4.174	0.789	6
I 6	Other life cycle cost of housing facility	3.933	0.918	11
I 7	Safety performance of housing facility	4.085	0.803	8
I 8	Commuting cost from the location of housing facility to public facilities	3.787	0.999	14
I 9	Quality performance	4.343	0.644	1
I 10	Energy & water efficiency of housing facility	3.915	0.880	12
I 11	Environmental performance of housing facility (Eco-friendly)	4.085	0.803	8
I 12	Aesthetic view of completed housing facility	3.913	0.717	13
I 13	Reduce occurrence of disputes and litigations	3.660	1.027	15
I 14	Stakeholders' satisfaction with housing facility	3.957	0.833	10
I 15	Technical specification of housing facility	4.128	0.824	7
I 16	Technology transfer	3.468	0.856	16

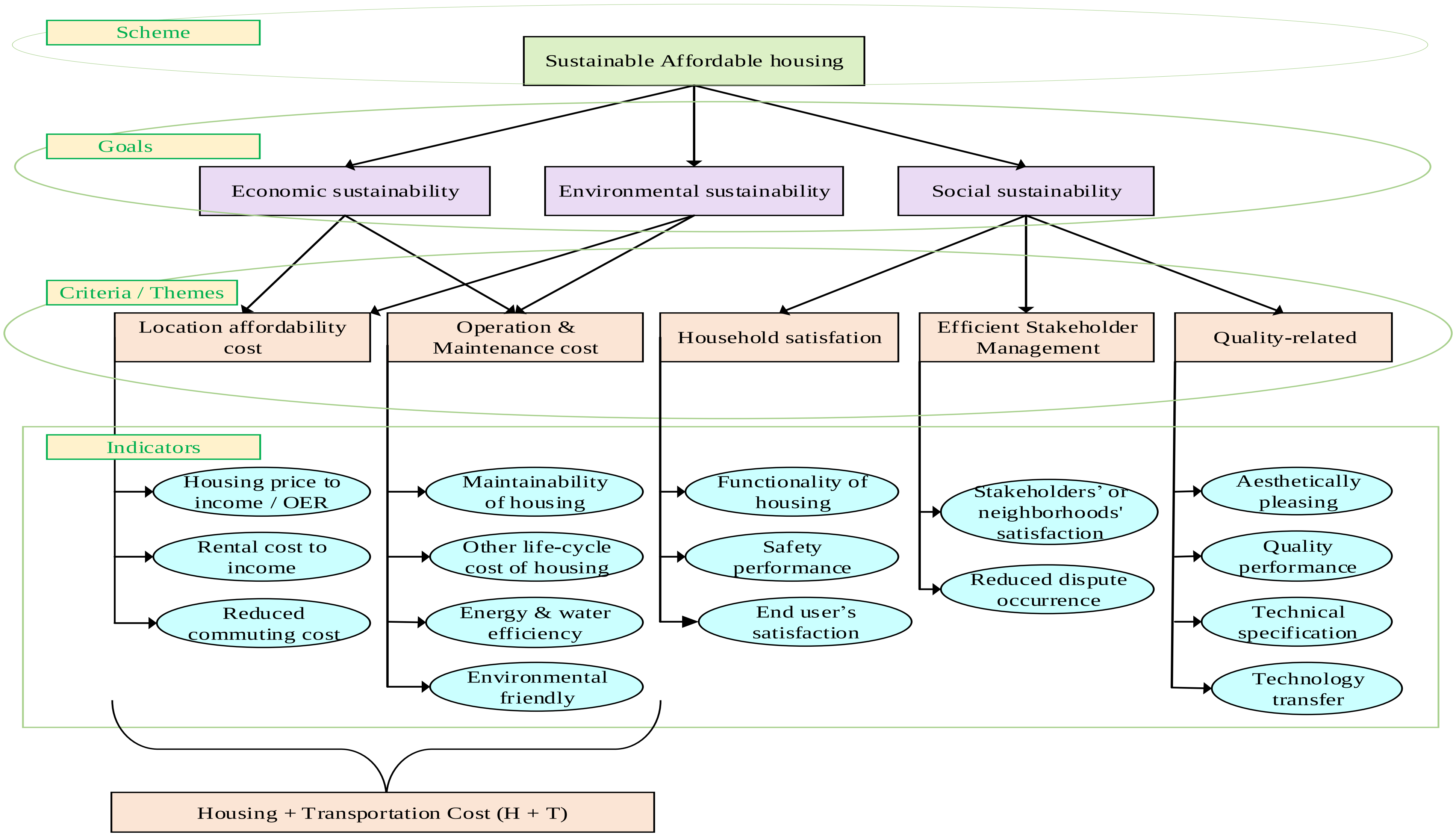


Fig. 8. 1: Conceptual Framework of Sustainability Assessment Model for Affordable Housing (Adopted from Adabre & Chan, 2020)

8.2.2 DEVELOPING A SUSTAINABILITY ASSESSMENT MODEL

In this study, the FSE technique is the main tool used for developing the sustainability assessment model. Prior to using the FSE, two different levels were established based on the groupings of the various indicators as shown in Fig. 8.1. The four main criteria/groupings, namely, housing and transportation (H+T); household satisfaction, efficient stakeholder management and quality-related criteria are defined as the first level constructs and are represented as C_{H+T}, C_{HSC}, C_{ESM} and C_{QRC}, respectively. However, the indicators under each criterion are termed as second level or secondary constructs (Osei-Kyei & Chan, 2017; Owusu et al., 2019). Both levels could be expressed as follows:

$C_{H+T} = \{I_{(H+T)1}, I_{(H+T)2}, I_{(H+T)3}, I_{(H+T)4}, I_{(H+T)5}, I_{(H+T)6}, I_{(H+T)7}\}$

$C_{HSC} = \{I_{HSC1}, I_{HSC2}, I_{HSC3}\}$

$C_{ESM} = \{I_{ESM1}, I_{ESM2}\}$

$C_{QRC} = \{I_{QRC1}, I_{QRC2}, I_{QRC3}, I_{QRC4}\}$

The variables of the secondary level are the input variables for the fuzzy synthetic analysis. For instance, $I_{(H+T)1}$ is an input variable that represents the indicator 'rental cost of housing facility in relation to household income'. It is under the criterion 'housing and transportation' that is denoted as C_{H+T}.

8.2.2.1 Determining Input Variables' Weightings

The weightings of an indicator (input variable) denotes its relative significance as rated by the survey respondents. The weightings of the input variables within each of the criteria groupings were estimated using eqn. (8.1):

$$W_i = \frac{M_i}{\sum_{i=1}^{k} M_i}, 0 < W_i < 1, \text{and} \sum_{i=1}^{k} W_i = 1 \quad \text{eqn. (8.1)}$$

From eqn.8.1, the explanation of the variables is given as follows: w_i represents the calculated weighting of an indicator within a grouping. This is obtained by dividing the mean score, represented as M_i, of an indicator by the sum of all the means scores within that grouping. For instance, using the 'H+T criterion', the weighting for the indicator 'rental cost in relation to household income' is given as

$$W_i = \frac{4.196}{4.196+4.298+3.787+4.283+3.933+3.915+4.085} = \frac{4.196}{28.497} = 0.147$$

Similarly, the weighting of a criterion is calculated by dividing the mean score of that criterion (obtain by summing mean scores of all the indicators under the criterion) by the summation of the mean scores of all the criteria. For instance, the weighting for the 'H+T criterion' is given as

$$W_c = \frac{28.497}{28.497+12.578+7.617+15.852} = \frac{28.497}{64.544} = 0.442$$

Therefore, the weightings of all the other indicators and criteria (shown in Table 8.2) are calculated using the same approach

Table 8. 2: Calculated Weightings of Indicators and Criteria

Criteria and their Underlying Indicators	Code	Mean (M_i)	Weightings of Indicator (W_i)	Total Mean of each Criterion (M_c)	Weightings of each Criterion (W_C)
Criterion 1: H + T					
1. Rental cost in relation to household income	I 1	4.196	0.147		
2. Housing price in relation to income of household	I 2	4.298	0.151		
3. Commuting cost from the location of housing to public facilities	I 8	3.787	0.133		
4. Maintainability of housing facility	I 3	4.283	0.150		
5. Other life-cycle cost of housing facility	I 6	3.933	0.138		
6. Energy & water efficiency of housing facility	I 10	3.915	0.137		
7. Environmentally friendliness of housing facility	I 11	4.085	0.143	28.497	0.442
Criterion 2: Household Satisfaction					
1. End user's satisfaction with housing facilities	I 4	4.319	0.343		
2. Functionality of housing facility	I 5	4.174	0.332		
3. Safety performance (crime rate)	I 7	4.085	0.325	12.578	0.195
Criterion 3: Efficient Stakeholder Management					
1. Stakeholders' satisfaction with housing facility (neighborhood satisfaction)	I 14	3.957	0.519		
2. Reduced occurrence of dispute and litigation	I 13	3.660	0.481	7.617	0.118
Criterion 4: Quality-Related					
1. Quality performance of project	I 9	4.343	0.274		
2. Aesthetically pleasing view of completed house	I 12	3.913	0.247		
3. Technical specification of housing facilities	I 15	4.128	0.260		
4. Technology transfer	I 16	3.468	0.219	15.852	0.246
Total mean and total weighting values				64.544	1.000

8.2.2.2 Determining the Membership Functions of Indicators

Membership functions (i.e. the degree of an element's membership in a fuzzy set) normally ranges between 0 and 1. They are derived from Level 2 to Level 1 (Ameyaw & Chan, 2016). This implies that the membership functions of the indicators are obtained first before calculating the membership functions for each of the criteria. Membership functions are obtained from the ratings provided by the respondents in the survey regarding the 5-point Likert scale (i.e. L_1 = not important to L_5 = very important) (Osei-Kyei & Chan, 2017). For instance, 26.1% of the respondents were neutral regarding rating on 'rental cost of housing in relation to household income'. 28.3% of the respondents rated it as important and 45.7% as very important. Given that $X_{\mathrm{I(H+T)1}}$ is the percentage of responses received per each rating, then the membership function ($MF_{\mathrm{I(H+T)1}}$) for this indicator is given as follows:

$$MF_{\mathrm{I(H+T)1}} = \frac{X_{1\mathrm{I(H+T)1}}}{L_1} + \frac{X_{2\mathrm{I(H+T)1}}}{L_2} + \cdots + \frac{X_{5\mathrm{I(H+T)1}}}{L_5}$$

$$MF_{\mathrm{I(H+T)1}} = \frac{X_{1\mathrm{I(H+T)1}}}{\text{not important}} + \frac{X_{2\mathrm{I(H+T)1}}}{\text{less important}} + \cdots + \frac{X_{5\mathrm{I(H+T)1}}}{\text{very important}}$$

Thus,

$$MF_{\mathrm{I(H+T)1}} = \frac{0.00}{L_1} + \frac{0.00}{L_2} + \frac{0.26}{L_3} + \frac{0.28}{L_4} + \frac{0.46}{L_5}$$

In FSE, the "+" denotes a notation and not an addition (Ameyaw & Chan, 2016). Therefore, the membership function can also be expressed as (0.00, 0.00, 0.26, 0.28, 0.46). Using the same procedure, the membership functions of the remaining 15 indicators can be obtained (shown in Table 8.3).

8.2.2.3 Determining the Membership Functions of the Criteria (the Groupings)

Establishing the membership functions of the indicators at Level 2 is the precursor for calculating the membership function for each criterion at Level 1. To do so, eqn. (8.2) is deployed.

$D = W_i \circ R_i$ .... eqn. (8.2)

Where W_i = weightings of all indicators within a criterion and R_i is the fuzzy evaluation matrix.

For example, using 'H + T criterion', its fuzzy matrix R_i can be expressed as:

$$R_\mathrm{i} = \begin{bmatrix} MF_{\mathrm{I(H+T)1}} \\ MF_{\mathrm{I(H+T)2}} \\ MF_{\mathrm{I(H+T)3}} \\ MF_{\mathrm{I(H+T)4}} \\ MF_{\mathrm{I(H+T)5}} \\ MF_{\mathrm{I(H+T)6}} \\ MF_{\mathrm{I(H+T)7}} \end{bmatrix} = \begin{bmatrix} X_{1\mathrm{I(H+T)1}} & X_{2\mathrm{I(H+T)1}} & X_{3\mathrm{I(H+T)1}} & X_{4\mathrm{I(H+T)1}} & X_{5\mathrm{I(H+T)1}} \\ X_{1\mathrm{I(H+T)2}} & X_{2\mathrm{I(H+T)2}} & X_{3\mathrm{I(H+T)2}} & X_{4\mathrm{I(H+T)2}} & X_{5\mathrm{I(H+T)2}} \\ X_{1\mathrm{I(H+T)3}} & X_{2\mathrm{I(H+T)3}} & X_{3\mathrm{I(H+T)3}} & X_{4\mathrm{I(H+T)3}} & X_{5\mathrm{I(H+T)3}} \\ X_{1\mathrm{I(H+T)4}} & X_{2\mathrm{I(H+T)4}} & X_{3\mathrm{I(H+T)4}} & X_{4\mathrm{I(H+T)4}} & X_{5\mathrm{I(H+T)4}} \\ X_{1\mathrm{I(H+T)5}} & X_{2\mathrm{I(H+T)5}} & X_{3\mathrm{I(H+T)5}} & X_{4\mathrm{I(H+T)5}} & X_{5\mathrm{I(H+T)5}} \\ X_{1\mathrm{I(H+T)6}} & X_{2\mathrm{I(H+T)6}} & X_{3\mathrm{I(H+T)6}} & X_{4\mathrm{I(H+T)6}} & X_{5\mathrm{I(H+T)6}} \\ X_{1\mathrm{I(H+T)7}} & X_{2\mathrm{I(H+T)7}} & X_{3\mathrm{I(H+T)7}} & X_{4\mathrm{I(H+T)7}} & X_{5\mathrm{I(H+T)7}} \end{bmatrix}$$

Where $X_{\mathrm{jI(H+T)\,n}}$ is the element of the fuzzy matrix; it is one of the weighting elements of an indicator. The fuzzy evaluation matrix is then obtained by using the weighting function set of the indicators in the 'H + T criterion' as follows:

$$\mathrm{D}_{\mathrm{H+T}} = (W_{i1}, W_{i2}, \ldots, W_{in}) \times \begin{bmatrix} X_{1\mathrm{I(H+T)1}} & X_{2\mathrm{I(H+T)1}} & X_{3\mathrm{I(H+T)1}} & X_{4\mathrm{I(H+T)1}} & X_{5\mathrm{I(H+T)1}} \\ X_{1\mathrm{I(H+T)2}} & X_{2\mathrm{I(H+T)2}} & X_{3\mathrm{I(H+T)2}} & X_{4\mathrm{I(H+T)2}} & X_{5\mathrm{I(H+T)2}} \\ X_{1\mathrm{I(H+T)3}} & X_{2\mathrm{I(H+T)3}} & X_{3\mathrm{I(H+T)3}} & X_{4\mathrm{I(H+T)3}} & X_{5\mathrm{I(H+T)3}} \\ X_{1\mathrm{I(H+T)4}} & X_{2\mathrm{I(H+T)4}} & X_{3\mathrm{I(H+T)4}} & X_{4\mathrm{I(H+T)4}} & X_{5\mathrm{I(H+T)4}} \\ X_{1\mathrm{I(H+T)5}} & X_{2\mathrm{I(H+T)5}} & X_{3\mathrm{I(H+T)5}} & X_{4\mathrm{I(H+T)5}} & X_{5\mathrm{I(H+T)5}} \\ X_{1\mathrm{I(H+T)6}} & X_{2\mathrm{I(H+T)6}} & X_{3\mathrm{I(H+T)6}} & X_{4\mathrm{I(H+T)6}} & X_{5\mathrm{I(H+T)6}} \\ X_{1\mathrm{I(H+T)7}} & X_{2\mathrm{I(H+T)7}} & X_{3\mathrm{I(H+T)7}} & X_{4\mathrm{I(H+T)7}} & X_{5\mathrm{I(H+T)7}} \end{bmatrix}$$

Thus, $\mathrm{D}_{\mathrm{H+T}}$ of 'H + T criterion', can be calculated as follows:

$$D_{H+T} = (0.147, 0.151, 0.133, 0.150, 0.138, 0.137, 0.143) \text{ x } \begin{bmatrix} 0.00 & 0.00 & 0.26 & 0.28 & 0.46 \\ 0.00 & 0.00 & 0.17 & 0.36 & 0.47 \\ 0.02 & 0.09 & 0.23 & 0.40 & 0.26 \\ 0.02 & 0.02 & 0.07 & 0.44 & 0.46 \\ 0.02 & 0.02 & 0.27 & 0.38 & 0.31 \\ 0.02 & 0.02 & 0.23 & 0.47 & 0.26 \\ 0.00 & 0.04 & 0.15 & 0.49 & 0.32 \end{bmatrix}$$

= (0.01, 0.03, 0.20, 0.40, and 0.37)

Similarly, the membership function for the 'household satisfaction criterion' is calculated as follows:

$$D_{HSC} = (0.343, 0.332, 0.325) \text{ x } \begin{bmatrix} 0.02 & 0.04 & 0.11 & 0.26 & 0.57 \\ 0.00 & 0.04 & 0.11 & 0.48 & 0.37 \\ 0.02 & 0.00 & 0.13 & 0.45 & 0.41 \end{bmatrix}$$

= (0.00, 0.03, 0.12, 0.39, and 0.45)

Likewise, the membership function for 'efficient stakeholders' management criterion' can be estimated as follows:

$$D_{ESM} = (0.519, 0.481) \text{ x } \begin{bmatrix} 0.02 & 0.04 & 0.11 & 0.62 & 0.21 \\ 0.04 & 0.11 & 0.17 & 0.51 & 0.17 \end{bmatrix}$$

= (0.03, 0.07, 0.14, 0.57, and 0.19)

Lastly, the membership function for 'quality-related criterion' can be determined as follows:

$$D_{QRC} = (0.274, 0.247, 0.260, 0.219) \text{ x } \begin{bmatrix} 0.00 & 0.00 & 0.07 & 0.38 & 0.55 \\ 0.00 & 0.02 & 0.24 & 0.54 & 0.20 \\ 0.00 & 0.06 & 0.09 & 0.51 & 0.34 \\ 0.04 & 0.04 & 0.38 & 0.47 & 0.06 \end{bmatrix}$$

= (0.01, 0.03, 0.19, 0.47, 0.30)

Table 8. 3: Membership Function of Indicators and Criteria

Criteria	Code	Weightings of each Indicator	MF for Level 2	MF for Level 1	Criteria's Weightings
H + T					
	I 1	0.147	0.00,0.00,0.26,0.28,0.46	0.01,0.03,0.20,0.40,0.37	0.442
	I 2	0.151	0.00,0.00,0.17,0.36,0.47		
	I 8	0.133	0.02,0.09,0.23,0.40,0.26		
	I 3	0.150	0.02,0.02,0.07,0.44,0.46		
	I 6	0.138	0.02,0.02,0.27,0.38,0.31		
	I 10	0.137	0.02,0.02,0.23,0.47,0.26		
	I 11	0.143	0.00,0.04,0.15,0.49,0.32		
Household satisfaction					
	I 4	0.343	0.02,0.04,0.11,0.26,0.57	0.01,0.03,0.12,0.39,0.45	0.195
	I 5	0.332	0.00,0.04,0.11,0.48,0.37		
	I 7	0.325	0.02,0.00,0.13,0.45,0.41		
Efficient Stakeholder Management					
	I 14	0.519	0.02,0.04,0.11,0.62,0.21	0.03,0.07,0.14,0.57,0.19	0.118
	I 13	0.481	0.04,0.11,0.17,0.51,0.17		
Quality-Related					
	I 9	0.274	0.00,0.00,0.07,0.38,0.55	0.01,0.03,0.19,0.47,0.30	0.246
	I 12	0.247	0.00,0.02,0.24,0.54,0.20		
	I 15	0.260	0.00,0.06,0.09,0.51,0.34		
	I 16	0.219	0.04,0.04,0.38,0.47,0.06		

8.2.2.4 Determining a Sustainability Assessment Index for Each Criterion

After estimating the membership functions at level 1, the index for each criterion is determined using eqn. (8.3). For instance, the assessment index (AI) for 'H+T criterion' is calculated as follows:

$AI_{H+T} = D_n \times L_n = (D_1, D_2, D_3, D_4, D_5) \times (L_1, L_2, L_3, L_4, L_5)$ ………………….....eqn. (8.3)

Where $D_n = (D_1, D_2, D_3, D_4, D_5)$ is the fuzzy evaluation matrix or MF for level 1 and $L_n = (1, 2, 3, 4, 5)$ is the grade alternative. Thus, the assessment index (AI) for 'H+T criterion' is calculated as follows:

$AI_{H+T} = (0.01, 0.03, 0.20, 0.40, 0.37) \times (1, 2, 3, 4, 5)$

$= 4.087$

Using similar approach, the AI for the other three criteria are computed as follows (shown in Table 8.4):

$AI_{HSC} = (0.01, 0.03, 0.12, 0.39, 0.45) \times (1, 2, 3, 4, 5)$

$= 4.254$

$AI_{ESM} = (0.03, 0.07, 0.14, 0.57, 0.19) \times (1, 2, 3, 4, 5)$

$= 3.816$

$AI_{QRC} = (0.01, 0.03, 0.19, 0.47, 0.30) \times (1, 2, 3, 4, 5)$

$= 4.023$

Table 8. 4: Assessment Index for the Criteria

No.	Criteria	Criterion's Index	Coefficient[a]
Criterion 1	H+T	4.087	0.253
Criterion 2	Household Satisfaction	4.254	0.263
Criterion 3	Efficient Stakeholders' Management	3.816	0.236
Criterion 4	Quality-Related	4.023	0.249
Total		16.18	1.000

[a]Coefficient = (Criterion Index ⁄ Sum of Indices of all Criteria)

8.2.3 A SUSTAINABILITY ASSESSMENT MODEL (SAM) FOR HOUSING

In this study, a linear, additive approach is employed to establish a combined-criterion model for assessing sustainable development in affordable housing. A linear model is chosen to enable the calculation of a composite index or figure that depicts the level of sustainability attainment in an affordable housing facility or project with regard to ‘H+T criterion’; ‘household satisfaction criterion’; ‘efficient stakeholders’ management criterion’ and ‘quality-related criterion’. Similarly, previous studies (Osei-Kyei & Chan, 2017; Hu et al., 2016) developed an assessment index using the linear and additive approach. Prior to establishing the sustainability assessment model, the indices for all the criteria are normalized so that they sum to one (shown in Table 8.4). The normalized values are the coefficients in the model. Normalizing the indices is important to provide a better reflection of the relative criticality of each criterion in the sustainability assessment model (SAM). Besides, it allows various measurement scales for the criteria to be employed in the model for affordable housing assessment (Osei-Kyei & Chan, 2017). The SAM for affordable housing could therefore be expressed in the following equation:

SAM = 0.253(H+T) + 0.263(Households’ Satisfaction) + 0.236 (Efficient Stakeholders management) + 0.249(Quality-related) ……………..………. eqn. (8.4)

8.2.4 DISCUSSION OF RESULTS

In subsequent sections, a discussion is presented on the various criteria together with their indicators and how each criterion could be assessed.

8.2.4.1 Housing and Transportation (H+T)

This criterion has an index of 4.087 and a coefficient of 0.253 (as shown in Table 8.4). Current studies on assessment of affordable housing have developed a composite cost of housing (i.e. rental cost or mortgage or owner rental equivalent, utility cost and other life cycle cost) and transportation cost in relation to household income. Prior studies employed only 'rental cost/price of housing to household income ratio' for measuring housing affordability. The conventional benchmark of housing affordability was that low-income household would spend at most 30% of their income on housing. However, this measure of affordability is limited since it does not include the cost of transportation.

Therefore, with the adoption of the H+T criterion / index, policy makers such as planners could achieve additional sustainable development goals. It could be used to identify suitable locations for sitting affordable housing projects and to advice households on an appropriate housing location for affordable transportation cost. Concerning policies on price increases or decreases on fuel cost, the H+T criterion could be used to evaluate possible cost burden or saving, respectively, on household income. Thus, this criterion could lead to more sustainable development such as economic sustainability (i.e. reduced transportation cost), environmental sustainability (i.e. energy conservation and reduction in pollution emissions) and social sustainability (i.e. improved access to economic opportunities and reduction in accident risks) (Isalou et al., 2014).

To assess the 'H+T' performance on SAH, the Center for Neighborhood Technology (CNT) estimated that 15% of household income should be an achievable goal for transportation affordability. Combining the 15% benchmark for transport affordability with the conventional 30% of housing cost on household income results in a 45% benchmark for the H+T criterion (Dewita et al., 2018). The H+T index could be estimated using the following eqn. 8.5:

$$\text{H + T index} = \frac{(\text{housing costs} + \text{Transportation costs})}{\text{Income}} \text{ x } 100 \text{ ……………………eqn. (8.5)}$$

Housing costs are monthly accommodation expenses of the household. These include rent for tenants or mortgage payment, regular operation cost (including utility bill) and maintenance cost and other lifecycle cost (property tax, neighborhood maintenance fees). For the case of homeownership, the ‘owner equivalent rent (OER)’ is used in replace of rent for tenants. The OER is an expected rent value that owner-occupants would fetch in the competitive market for their houses. It is calculated by soliciting for the opinion of the owners on the amount they think their housing facility would rent for in the market (Dewita et al., 2018). Regarding transportation, transportation costs are calculated by adding all household’s expenses incurred in traveling to work, school, market or shopping, recreation and visiting of relatives or friends. After determining the housing cost and transportation cost, these cost variables are sum up and divided by the monthly household income. The result is then multiplied by 100 to convert the cost to percent. For households who spend at most 45% of their income on both housing and transportation, their housing facilities are considered affordable. Therefore, using the 45% limit as a benchmark, a percentage scale could be developed for allocating points in order to calculate the level of sustainability attainment by the H+T index. The percentage scale is developed based on pro-rata of the 45% benchmark (as shown in Table 8.5). An H+T that is ≤ 45% of household income is scored 100%. An estimated H+T that is 46-55% of household income, is rated 98-82%. The exact percentage is obtained on pro-rata basis. For instance, the range for 46-55 is calculated as follows:

45 -----> 100%

46 -----> ?

46 -----> 98%

Similarly,

45 -----> 100%

55-----> ?

55-----> 82%

After determining the points (%) to be allocated, its H+T index is obtained by multiplying the appropriate point (in %) by the estimated weight i.e. (0.253 x (H+T point in %)). For example, if a household spends ≤ 45% of their income on housing and transportation, the points (in %) to be allocated will be 100 and the overall sustainability attainment by the H+T criterion will be calculated as follows:

H+T Index = (0.253 x (H+T)) = (0.253 x (100%)) = 25.3%

Table 8. 5: Scale for Assessing H + T Index in SAH

Scale	Points (in %) to be awarded
≤ 45	100
46 - 55	98 - 82
56 - 65	80 - 69
66 - 75	68 - 60
76 - 85	59 - 53
≥ 86	≤ 52

However, based on its calculated index (shown in Table 8.4), the H+T criterion accounts for 25.3% of sustainability attainment in affordable housing. Therefore, much will not be accomplished on sustainable development in affordable housing if policymakers focus solely on the H+T criterion to the neglect of the other criteria.

8.2.4.2 Household Satisfaction

This criterion has the highest index of 4.254 and a coefficient of 0.263. Household satisfaction is one of the relevant and subjective criteria in post-construction evaluation of affordable housing facility. Assessing residential satisfaction enables decision makers to develop successful housing policies for the attainment of social sustainability (Riazi & Emami, 2018). The household satisfaction criterion consists of three main indicators: end user's satisfaction with the housing facility and infrastructure (or supplementary facilities), functionality of housing facility and safety performance (crime rate). These three main indicators account for

26.3% of sustainability attainment in affordable housing. The importance of this criterion is evinced in low take-up rate of housing facilities due to the neglect of end user's needs at the design stage of housing projects. This problem could be attributed to the speculative nature of affordable housing projects. Decisions on land acquisition, housing design and construction are mostly made without the participation of the target households (Ahadzie et al., 2008; Chan & Adabre, 2019).

To quantify this criterion, it is important to identify the variables which determine household satisfaction. Residential satisfaction of low-income households is derived from the availability of public facilities within the housing environs (Addo, 2016). Besides, safety and security of households influence residential satisfaction (Mohit et al., 2010; Tan, 2012). Variables such as 'safety of indoor space', 'safety of outdoor space', 'lighting of public areas', 'private open space' and 'the number of burglary/theft incidents in housing facilities or neighborhood' could provide adequate information for measuring the level of safety of households within their housing facility and their surroundings (Riazi & Emami, 2018; Hino & Amemiya, 2019). Moreover, the indicator – 'functionality of the housing unit' – could provide essential information for assessing household satisfaction. Functionality of a housing facility measures the adequacy of housing facility in meeting the current and evolving needs of households. It includes the availability of adequate physical amenities such as a sizable bathroom, sizable floor, adequate sanitary facilities (such as septic tank and garbage collection facility) (Acolin & Green, 2017). Adequate functionality of a housing facility could prevent residential mobility, which could lead to housing abandonment. Most households abandon or make housing relocation decision because of 'lack of fit' of housing facility to meet their needs. 'Lack of fit' challenges are caused by changes in households' demographic factors such as age, household size, prestige etc., which can lead to households' dissatisfaction with current housing facility (Riazi & Emami, 2018).

To determine the level of sustainability attainment by household satisfaction, households' as respondents could be asked to indicate their satisfaction level on facilities within their environment, satisfaction level on safety features in the housing facility and their environment and their satisfaction level on the functionality variables. Satisfaction level could be rated using a 5-point Likert scale from 1(very dissatisfied) to 5 (very satisfied). The satisfaction score can then be calculated by adding up all scores on the various features/variables from the ratings of respondents. Then, the total scores obtained from the Likert scale is divided by the maximum possible total score and the result is multiplied by 100 to obtain a percentage score for households' satisfaction (Ogu, 2002). Afterward, the level of sustainability attainment by the household satisfaction is obtained by multiplying the coefficient of the satisfaction criterion by the percentage score for household satisfaction i.e. (0.265 x Households' percentage satisfaction score). The satisfaction percentage score can be calculated by using eqn. (8.6) as provided in Ogu (2002):

$$\text{HSV} = \frac{\sum_{i=1}^{N} y^i}{\sum_{i=1}^{N} Y^i} \times 100 \qquad \text{eqn. (8.6)}$$

Where HSV is the household satisfaction value (in percent) of a respondent, N is the number of variables being scaled, y^i is the actual score by a respondent on the ith variable and Y^i is the maximum possible score that *i* could have on the scale used (Addo, 2016; Mohit, et al., 2010).

8.2.4.3 Efficient Stakeholder's Management

This criterion has the lowest index of 3.816 and has a coefficient of 0.236. Two main indicators were used to determine the weight of efficient stakeholders' management (i.e. project team/stakeholder satisfaction and reduce occurrence of dispute/litigations). Attaining these indicators in affordable housing accounts for 23.6% of sustainability performance in affordable housing facilities or projects. Without adequate policies to achieve this, low-income households could be isolated from one another or from their neighbors. This could negatively affect social sustainability attainment in affordable housing (Chan & Adabre, 2019).

Aside stakeholders (such as government, developers, design team and households), residents in the neighborhood where an affordable housing facility is sited play a significant role in social sustainability attainment. According to Berardi (2011), tackling the social dimension of sustainable development entails contextual design of housing facility and linking the housing facility to its neighbourhood. This could be achieved by providing adequate facilities within the housing environs to encourage interaction among households and their neighbours. 'Interaction with neighbours' could positively affect residential satisfaction. For instance, Riazi & Emami (2018) confirmed that among three determinants of residential satisfaction such as 'design principles', 'interaction with neighbours' and 'planning policies', 'interaction with neighbours' was the most dominant influencing factor. Besides, effective interaction among households and residents in the neighborhood enhances their health and well-being. Medical studies have revealed that one's participation in such social activity could reduce depression, dementia, disability, mortality and improve cognitive health of the elderly (Yung et al., 2017).

To assess this criterion, the availability and the design features of parks and open spaces in the environs of the housing facility should be assessed. Parks should be evaluated based on multiplicity of purpose with the following incorporated-relevant features: children play area, water features (splash ponds for children and fountains), fitness area/facilities, multi-purpose plaza, roller skating rink, pavilion, better integration of cultural heritage into design, cafeteria/refreshment kiosk, sanitary facilities, adequate lighting and Wi-Fi connections (Yung et al., 2016). Importantly, these amenities promote cross-generation integration in parks, which enhances social ties and satisfaction to a variety of stakeholders. Efficient stakeholder management could also be assessed by finding out the impact of an affordable housing facility on the neighboring housing facilities or community. Impact variables could include: effects of affordable housing facility on prices/rent of neighboring housing facilities or properties; possibilities of congestion on existing social amenities or infrastructure; crime rate within neighboring community; level of disputes/cordial interaction among residents in the neighborhood and households of the affordable housing facilities and fear of insecurity and noise level in the neighborhood.

The presence and impact level of various variables for ‘efficient stakeholder’s management’ (i.e. parks and open spaces, variables on ‘occurrence of dispute or litigation’ and impact variables of housing facility on neighborhood) could be rated on a Likert scale by some randomly selected residents in the neighborhood. Then, a percentage score of ‘efficient stakeholder management’ could be determined by using a similar approach as in eqn. (8.6). Afterwards, the level of sustainability attainment by efficient stakeholder management is obtained by multiplying its coefficient by the percentage score i.e. (0.236 x percentage score of efficient Stakeholder’s Management).

8.2.4.4 Quality-Related Criterion

This criterion has a success index of 4.023, and a coefficient of 0.249. The scores of four main indicators, namely, ‘quality performance’; ‘aesthetic view of housing facility’; ‘technical specifications or performance outputs' and 'technology transfer' were used to estimate an index of 4.023 for quality-related criterion. It accounts for 24.9% of sustainability attainment in affordable housing.

Housing quality can be assessed using both subjective and objective approaches. Subjective assessment includes perception and aspiration which are related to the psychosocial aspect of households (Mohit et al., 2010). The subjective description of quality is based on aesthetic of the housing facility. It could be assessed by finding out 'how well a housing facility blends with its environment', 'the psychological impact of the housing facility on the households, neighbouring residents and existing facilities' and 'the ability of landscaping plan to match the theme of nearby structures' and 'interesting design models that capture people's imagination' (Stasiowski and Burstein, 1994; Chan & Adabre, 2019). Aesthetic view of a housing facility enhances the pride/sense of place attachment and could encourage residential stability (Eizenberg & Jabareen, 2017). A housing facility that meets the aesthetic expectation / aspiration of a household attains quality in perception.

The objective assessment of housing quality entails evaluating the quality of the materials and the specification outputs (or performance output). A facility that attains its technical requirement/specification output is said to have achieved 'quality in fact' (Arditi & Gunaydin, 1997). By ensuring material/product quality and construction or process quality, 'quality in fact' can be achieved in affordable housing facilities (Arditi & Gunaydin, 1997). Whereas 'product quality' is ensuring appropriate equipment and technology for construction and the use of suitable construction materials, 'process quality' includes attaining quality on the design and construction of the housing facility (Chan & Adabre, 2019).

In assessing the quality of materials for SAH, emphasis should be placed on circular economy and environmental impact of the construction materials. Circular economy involves the production and consumption of construction materials in closed loop material flows that internalize environmental externalities linked to virgin resource extraction and waste production (including pollution) (Pomponi & Moncaster, 2017). It takes into consideration impact of resource consumption and impact of waste on the environment. Circular economy ensures that post-consumption construction products get reintegrated upstream into the manufacturing process. This ensures efficient management of resources, which leads to a reduction in energy usage, CO_2 emissions and waste production.

For circular economy, materials should be assessed based on ‘how easily they can be dismantled, demolished and recycled/reused’; ‘how effluent generated from demolition could serve as raw materials for other work’ and ‘how materials used for housing facilities could be recoverable for reuse’ (Sauvé et al., 2016; Pomponi & Moncaster, 2017). For instance, at the micro-level, manufactured products/components (e.g. blocks and façade elements) should be such that they can be dismantled without much waste generation. Besides, quality of material assessment should include environmental impact of the materials on greenhouse gas emission, human toxicity, eco-toxicity to water and soil acidification and eutrophication. Thus, by assessing the various variables concerning ‘aesthetic view of housing facility’, ‘quality of materials’, ‘technical specification or performance output’ and ‘technology transfer or innovation’ from experts (such as architects, developers and materials engineers), a percentage score for the ‘quality-related criterion’ could be computed using eqn. (8.6). Then, the level of sustainability attainment by the ‘quality-related criterion’ is estimated by multiplying its coefficient by its percentage score (0.249 x percentage score of quality-related criterion).

8.3 DATA ANALYSIS AND RESULTS – ASSESSING THE IMPACT OF RISK FACTORS ON SAH

8.3.1 APPLICATION OF THE FSE APPROACH TO DATA ANALYSIS

The evaluation matrix is established based on the rating of the respondents regarding the likelihood of occurrence and severity of impact of the risk factors. For example, on 'political continuity risks/change in government', 4% of the respondents indicated that its likelihood of occurrence (LO) is very low, 7% rated it as low, 27% as medium, 33% as high and 29% as very high. Similarly, 5% of the respondents indicated that the severity of impact (SI) of this risk factor is low, 5% rated it as low, 16% as medium, 32% as high and 42% as very high.

These responses can be expressed as membership functions with regard to the LO in the following equation forms

$$R_{(\mathrm{LO})1} = \frac{LO_1}{G_1} + \frac{LO_2}{G_2} + \cdots + \frac{LO_5}{G_5}$$

$$R_{(\mathrm{LO})1} = \frac{0.04}{\text{very low}} + \frac{0.07}{\text{low}} + \frac{0.27}{\text{medium}} + \frac{0.33}{\text{high}} + \frac{0.29}{\text{very high}}$$

$$R_{(\mathrm{LO})1} = \frac{0.04}{1} + \frac{0.07}{2} + \frac{0.27}{3} + \frac{0.33}{4} + \frac{0.29}{5}$$

Similarly, the responses on the severity of risk impact could be expressed in the membership function as follows:

$$R_{(\mathrm{SI})1} = \frac{SI_1}{G_1} + \frac{SI_2}{G_2} + \cdots + \frac{SI_5}{G_5}$$

$$R_{(\mathrm{SI})1} = \frac{0.05}{1} + \frac{0.05}{2} + \frac{0.16}{3} + \frac{0.32}{4} + \frac{0.42}{5}$$

In FSE, the "+" denotes a notation and not an addition (Ameyaw & Chan, 2015). Thus, the equation for the membership functions for both likelihood of risk occurrence and severity of risk factors can also be expressed as (0.04, 0.07, 0.27, 0.33, 0.29) and (0.05, 0.05, 0.16, 0.32, 0.42), respectively. Subsequently, the LO, SI and magnitude of impact (MI) are calculated as follows:

$$\mathrm{LO_i} = \sum_{i=1}^{5} (G_i \mathrm{\ X\ } R_{(LO)1}) = 1 \mathrm{\ X\ } 0.04 + 2 \mathrm{\ X\ } 0.07 + 3 \mathrm{\ X\ } 0.27 + 4 \mathrm{\ X\ } 0.33 + 5 \mathrm{\ X\ } 0.29 = 3.76$$

$$\mathrm{SI_i} = \sum_{i=1}^{5} (G_i \mathrm{\ X\ } R_{(\mathrm{SI})1}) = 1 \mathrm{\ X\ } 0.05 + 2 \mathrm{\ X\ } 0.05 + 3 \mathrm{\ X\ } 0.16 + 4 \mathrm{\ X\ } 0.32 + 5 \mathrm{\ X\ } 0.42 = 4.06$$

$$\mathrm{MI}_i = \sqrt{\mathrm{LO_i \ X \ SI_i}} = \sqrt{3.76 \mathrm{\ X\ } 4.06} = 3.91$$

The membership functions together with LO, SI and MI of each of the risk factors are calculated similarly as in the case of the risk factor 'political continuity risks/change in government'. The estimated values for each risk factor are shown in Table 8.6.

Table 8. 6: LO, SI and MI of Risk Factors (Level 1)

Risk Categories	No.	Risk factors	LO		SI		MI	Rank in Category
			Value	Membership function	Value	Membership function		
Political-Related Risks Category	PRF01	Political continuity risks / Change in government	3.76	0.04,0.07,0.27,0.33,0.29	4.06	0.05,0.05,0.16,0.32,0.42	3.91	2
	PRF02	Risk associated with land acquisition / land expropriations for housing	4.08	0.00,0.09,0.13,0.39,0.39	4.04	0.00,0.07,0.11,0.53,0.29	4.06	1
	PRF03	Risk associated with opposition to large public-private housing projects	3.37	0.04,0.16,0.28,0.43,0.09	3.35	0.07,0.13,0.27,0.44,0.09	3.35	5
	PRF04	Risk due to policy instability / government commitment to housing project / political opposition to public housing projects	3.72	0.00,0.11,0.24,0.47,0.18	3.84	0.00,0.09,0.22,0.46,0.23	3.78	3
	PRF05	Risk due to delays in project permit approval / delays in obtaining construction permits	3.36	0.06,0.13,0.33,0.35,0.13	3.37	0.09,0.02,0.41,0.30,0.18	3.37	4
Financing-Related Risks Category	FRF01	Inflation rate volatility (price fluctuation of materials & labour & sustainable technologies)	4.23	0.02,0.03,0.15,0.30,0.50	4.12	0.02,0.05,0.16,0.33,0.44	4.17	4
	FRF02	Fluctuations in exchange rate	4.40	0.00,0.04,0.09,0.30,0.57	4.38	0.00,0.04,0.07,0.36,0.53	4.39	2
	FRF03	Fluctuating cost of finance (interest rates)	4.37	0.00,0.00,0.11,0.41,0.48	4.31	0.00,0.00,0.11,0.47,0.42	4.34	3
	FRF04	Privatization risks (changes from government / public financing to private / market financing strategies)	3.45	0.07,0.02,0.41,0.39,0.11	3.64	0.07,0.04,0.27,0.42,0.20	3.54	7
	FRF05	Poor / inadequate financial market	3.94	0.00,0.02,0.23,0.52,0.23	3.93	0.01,0.02,0.21,0.55,0.21	3.94	6
	FRF06	Increasing tax rates and fees on developers	3.94	0.02,0.02,0.20,0.57,0.20	4.02	0.00,0.00,0.23,0.52,0.25	3.98	5
	FRF07	Delays in payments by governments / clients	4.46	0.00,0.01,0.09,0.33,0.57	4.40	0.00,0.02,0.05,0.44,0.49	4.43	1
	FRF08	Litigations over claims payment	3.74	0.04,0.09,0.22,0.39,0.26	4.03	0.02,0.07,0.15,0.38,0.38	3.88	8
Procurement Risks Category	CRF01	Corruptions in project procurement	4.04	0.07,0.04,0.04,0.48,0.37	4.00	0.04,0.04,0.16,0.40,0.36	4.02	1
	CRF02	Inadequate competition during project tendering	3.39	0.04,0.22,0.22,0.35,0.17	3.48	0.02,0.16,0.27,0.42,0.13	3.43	3
	CRF03	Errors and omissions in tender documents (i.e. inaccurate cost estimates) / inadequate project design	3.70	0.04,0.07,0.28,0.37,0.24	3.78	0.04,0.02,0.29,0.42,0.23	3.74	2
Design & Construction Risks Category	DRF01	Construction time overruns	4.00	0.00,0.04,0.20,0.48,0.28	4.08	0.02,0.04,0.20,0.32,0.42	4.04	2

	DRF02	Construction cost overruns	4.14	0.00,0.09,0.11,0.37,0.43	4.19	0.00,0.04,0.20,0.29,0.47	4.16	1
	DRF03	Construction deficiencies / defects (i.e. low quality of work)	3.35	0.09,0.11,0.33,0.30,0.17	3.63	0.09,0.04,0.29,0.31,0.27	3.49	4
	DRF04	Resource unavailability risks (local skill labour & sustainable technologies and materials)	3.08	0.15,0.16,0.30,0.24,0.15	3.35	0.09,0.16,0.24,0.33,0.18	3.21	7
	DRF05	Design and construction variation orders / alteration and rework due to construction variations	3.56	0.02,0.09,0.37,0.35,0.17	3.74	0.02,0.06,0.30,0.41,0.21	3.65	3
	DRF06	Technical complexity risk associated with project	3.49	0.05,0.07,0.33,0.44,0.11	3.62	0.02,0.04,0.40,0.38,0.16	3.55	5
	DRF07	Force majeure events	3.14	0.09,0.24,0.26,0.26,0.15	3.37	0.07,0.21,0.18,0.36,0.18	3.25	6
	DRF08	Construction accidents and injuries	3.19	0.01,0.26,0.33,0.33,0.07	3.17	0.04,0.20,0.38,0.31,0.07	3.18	8
Operation & Maintenance Risks Category	ORF01	Fluctuating market demand or preference / low take-up rate of housing facilities	3.62	0.04,0.04,0.33,0.44,0.15	3.76	0.04,0.05,0.25,0.43,0.23	3.69	1
	ORF02	Socio-spatial segregation	3.46	0.02,0.22,0.20,0.40,0.16	3.50	0.02,0.16,0.23,0.48,0.11	3.48	4
	ORF03	Operation / maintenance cost overruns	3.37	0.07,0.11,0.31,0.40,0.11	3.26	0.05,0.16,0.36,0.34,0.09	3.32	5
	ORF04	Utilities supply risks / Supporting utilities / infrastructure risk	3.54	0.02,0.15,0.30,0.33,0.20	3.60	0.04,0.13,0.27,0.31,0.25	3.57	3
	ORF05	Congestion on existing amenities / infrastructure due to new households	3.00	0.11,0.26,0.24,0.30,0.09	3.13	0.07,0.19,0.37,0.28,0.09	3.06	6
	ORF06	Privatization risk (privatization of existing public rental stock)	3.62	0.04,0.11,0.26,0.37,0.22	3.53	0.06,0.09,0.38,0.20,0.27	3.57	2

To evaluate the membership functions of each category of risk factors, the LO and SI weights of each risk factor within each risk category were first calculated using eqn. 8.7 and 8.8 (results of the calculation are shown in Table 8.7). For instance, the LO weight of the risk factor ‘political continuity risks/change in government’ which is among the five risk factors (n = 5) within the category named ‘political risk factors’ is calculated as follows:

$$W_{LOi} = \frac{\mathrm{LO_i}}{\sum_{i=1}^{n} \mathrm{LO_i}} \quad \text{.......eqn. (8.7)}$$

$$W_{LOi} = \frac{\mathrm{LO_i}}{\sum_{i=1}^{n} \mathrm{LO_i}} = \frac{3.76}{3.76+4.08+3.35+3.72+3.37} = \frac{3.76}{18.28} = 0.21$$

Similarly, the SI weigh of risk factor ‘political continuity risks/change in government’ can be calculated as follows

$$W_{SIc} = \frac{\mathrm{SI_c}}{\sum_{i=1}^{n} \mathrm{SI_i}} \quad \text{.......eqn. (8.8)}$$

$$W_{SIc} = \frac{\mathrm{SI_c}}{\sum_{i=1}^{n} \mathrm{SI_i}} = \frac{4.06}{4.06+4.04+3.35+3.86+3.37} = \frac{4.06}{18.68} = 0.22$$

Using the estimated LO and SI weights of each risk within a category, the LO and SI membership function of a risk category were calculated using eqns. (8.9) – (8.10) (as shown in Table 8.7 & 8.8). For example, the LO membership function for the risk category named ‘political continuity risks / change in government’ can be calculated as follows:

$$\mathrm{D_{LOc}} = \sum_{i=1}^{n} (W_i \text{ X } R_{(LO)i}) \quad \text{.......eqn. (8.9)}$$

$$\mathrm{D_{LOc}} = \sum_{i=1}^{n} (W_i \text{ X } R_{(LO)i}) = [0.21, 0.22, 0.18, 0.20, 0.18] \text{ X } \begin{bmatrix} 0.04 & 0.07 & 0.27 & 0.33 & 0.29 \\ 0.00 & 0.09 & 0.13 & 0.39 & 0.39 \\ 0.04 & 0.16 & 0.28 & 0.43 & 0.09 \\ 0.00 & 0.11 & 0.24 & 0.47 & 0.18 \\ 0.06 & 0.13 & 0.33 & 0.35 & 0.13 \end{bmatrix}$$

$$= (0.19, 0.19, 0.20, 0.19, 0.19)$$

Similarly, the SI membership function for the risk category 'political continuity risks / change in government' can be calculated as follows:

$D_{\text{SIc}} = \sum_{i=1}^{n} (W_i \text{ X } R_{(\text{SI})i})$ …………………………………………………......…eqn. (8.10)

$$D_{\text{SIc}} = \sum_{i=1}^{n} (W_i \text{ X } R_{(\text{SI})i}) = [0.22, 0.22, 0.18, 0.21, 0.18] \text{ X } \begin{bmatrix} 0.05 & 0.05 & 0.16 & 0.32 & 0.43 \\ 0.00 & 0.07 & 0.11 & 0.53 & 0.29 \\ 0.07 & 0.13 & 0.27 & 0.44 & 0.09 \\ 0.00 & 0.09 & 0.23 & 0.46 & 0.23 \\ 0.09 & 0.02 & 0.41 & 0.30 & 0.18 \end{bmatrix}$$

$= (0.19, 0.20, 0.20, 0.20, 0.19)$

Based on the D_{LOc} and D_{SIc} values, the LO_C, the SI_C and the MI_C of each risk category are estimated as shown in Tables 8.8 & 8.9. For example, using the risk category 'political continuity risks / change in government', the values are estimated as follows:

$LO_c = \sum_{i=1}^{5} (G_i \text{ X } D_{\text{LOC}}) = 1 \text{ X } 0.19 + 2 \text{ X } 0.19 + 3 \text{ X } 0.20 + 4 \text{ X } 0.19 + 5 \text{ X } 0.19 = 2.88$

$SI_C = \sum_{i=1}^{5} (G_i \text{ X } D_{\text{SIc}}) = 1 \text{ X } 0.19 + 2 \text{ X } 0.20 + 3 \text{ X } 0.20 + 4 \text{ X } 0.20 + 5 \text{ X } 0.19 = 2.94$

$MI_c = \sqrt{LO_c \text{ X } SI_C} = \sqrt{2.88 \text{ X } 2.94} = \sqrt{8.47} = 2.91$

Table 8. 7: LO and SI of Each Risk Category (Level 2)

Risk Categories	No.	LO				SI			
		Value	Total weight	Factor Weight	Group Weight	Value	Total weight	Factor Weight	Group Weight
Political-Related Risks Category	PRF01	3.76	18.29	0.21	0.17	4.06	18.66	0.22	0.17
	PRF02	4.08		0.22		4.04		0.22	
	PRF03	3.37		0.18		3.35		0.18	
	PRF04	3.72		0.20		3.84		0.21	
	PRF05	3.36		0.18		3.37		0.18	
Financing-Related Risks Category	FRF01	4.23	32.53	0.13	0.29	4.12	32.83	0.13	0.29
	FRF02	4.40		0.14		4.38		0.13	
	FRF03	4.37		0.13		4.31		0.13	
	FRF04	3.45		0.11		3.64		0.11	
	FRF05	3.94		0.12		3.93		0.12	
	FRF06	3.94		0.12		4.02		0.12	
	FRF07	4.46		0.14		4.40		0.13	
	FRF08	3.74		0.12		4.03		0.12	
Procurement-Related Risks Category	CRF01	4.04	11.13	0.36	0.10	4.00	11.26	0.36	0.10
	CRF02	3.39		0.30		3.48		0.31	
	CRF03	3.70		0.33		3.78		0.34	
Design & Construction Risks Category	DRF01	4.00	27.95	0.14	0.25	4.08	29.15	0.14	0.26
	DRF02	4.14		0.15		4.19		0.14	
	DRF03	3.35		0.12		3.63		0.12	
	DRF04	3.08		0.11		3.35		0.11	
	DRF05	3.56		0.13		3.74		0.13	
	DRF06	3.49		0.13		3.62		0.12	
	DRF07	3.14		0.11		3.37		0.12	
	DRF08	3.19		0.11		3.17		0.11	
Operation & Maintenance Risks Category	ORF01	3.62	20.61	0.18	0.19	3.76	20.78	0.18	0.18
	ORF02	3.46		0.17		3.50		0.17	
	ORF03	3.37		0.16		3.26		0.16	
	ORF04	3.54		0.17		3.60		0.17	
	ORF05	3.00		0.15		3.13		0.15	
	ORF06	3.62		0.18		3.53		0.17	
Summation of total weights			110.51				112.68		

2

The LO and SI membership function of the risk category (as shown in Table 8.8) were deployed to assess the overall risk level by first calculating the LO and SI weights of the risk category as shown in Table 8.9. The number of risk categories is five (k= 5). Using the 'political-related risk factors' category for example, the LO and SI weights are calculated as follows:

$$W_{LOc} = \frac{\mathrm{LO_c}}{\sum_{c=1}^{k} \mathrm{LO_c}} = \frac{2.85}{2.85+4.12+3.66+3.59+3.46} = \frac{2.85}{17.68} = 0.16$$

$$W_{SIc} = \frac{\mathrm{SI_c}}{\sum_{c=1}^{k} \mathrm{SI_c}} = \frac{3.00}{3.00+4.01+3.73+3.79+3.45} = \frac{3.00}{17.98} = 0.17$$

Then, the overall membership functions of LO and SI, respectively, represented as $\mathrm{D_{LOoverall}}$ and $\mathrm{D_{SIoverall}}$ are calculated as follows:

$$\mathrm{D_{LOoverall}} = \sum_{c=1}^{k} (\mathrm{W_{LOc}} \text{ X } \mathrm{R_{(LO)c}})$$

$$= [0.16, 0.23, 0.21, 0.20, 0.20] \text{ X } \begin{bmatrix} 0.19 & 0.19 & 0.19 & 0.19 & 0.20 \\ 0.02 & 0.03 & 0.18 & 0.40 & 0.38 \\ 0.05 & 0.10 & 0.17 & 0.40 & 0.26 \\ 0.05 & 0.13 & 0.28 & 0.36 & 0.20 \\ 0.05 & 0.15 & 0.28 & 0.38 & 0.15 \end{bmatrix}$$

$$= (0.07, 0.18, 0.22, 0.35, 0.24)$$

Similarly, the overall membership function of $\mathrm{D_{LOoverall}}$ for all the risk category is calculated as follows:

$$\mathrm{D_{SIoveral}} = \sum_{c=1}^{k} (\mathrm{W_{SIc}} \text{ X } R_{\mathrm{(SI)c}})$$

$$= [0.17,0.22,0.21,0.21,0.19] \text{ X } \begin{bmatrix} 0.20 & 0.20 & 0.20 & 0.20 & 0.19 \\ 0.02 & 0.03 & 0.15 & 0.42 & 0.36 \\ 0.03 & 0.07 & 0.24 & 0.41 & 0.24 \\ 0.04 & 0.08 & 0.28 & 0.35 & 0.27 \\ 0.05 & 0.13 & 0.31 & 0.34 & 0.17 \end{bmatrix}$$

=(0.06,0.10,0.23,0.35,0.25)

Using the grade point alternatives, G_i, with the $D_{LOoverall}$ and $D_{SIoverall}$ obtained, the overall likelihood of risk occurrence ($LO_{overall}$), overall severity of impact of risks ($SI_{overall}$) and overall magnitude of risk ($MI_{overall}$) could be estimated as follows:

$$LO_{overall} = \sum_{i=1}^{5}(G_i \text{ X } D_{LOoverall}) = 1 \text{ X } 0.07 + 2 \text{ X } 0.18 + 3 \text{ X } 0.22 + 4 \text{ X } 0.35 + 5 \text{ X } 0.24$$

$$LO_{overall} = 3.69$$

$$SI_{overall} = \sum_{i=1}^{5}(G_i \text{ X } D_{SIoveral}) = 1 \text{ X } 0.06 + 2 \text{ X } 0.10 + 3 \text{ X } 0.23 + 4 \text{ X } 0.35 + 5 \text{ X } 0.25$$

$$SI_{overall} = 3.60$$

$$MI_{overall} = \sqrt{LO_{overall} \text{ X } SI_{overall}} = \sqrt{3.69 \text{ X } 3.60} = \sqrt{13.28} = 3.64$$

Table 8. 8: Overall LO, SI and MI of All Risk Category (Level 3)

Risk Categories	LO			SI			MI	Rank
	Weight	Value	Membership function	Weight	Value	Membership function		
Political-Related Risks Category	0.16	2.88	(0.19,0.19,0.20,0.19,0.19)	0.16	2.94	(0.19,0.20,0.20,0.20,0.19)	2.91	5
Financing-Related Risks Category	0.23	4.12	(0.02,0.03,0.18,0.40,0.38)	0.23	4.09	(0.01,0.03,0.15,0.43,0.37)	4.10	1
Procurement-Related Risks Category	0.21	3.66	(0.05,0.10,0.17,0.40,0.26)	0.21	3.82	(0.03,0.07,0.24,0.42,0.25)	3.74	2
Design & Construction Risks Category	0.20	3.52	(0.05,0.13,0.27,0.35,0.20)	0.20	3.64	(0.04,0.09,0.27,0.34,0.25)	3.58	3
Operation & Maintenance Risks Category	0.20	3.51	(0.05,0.15,0.28,0.38,0.16)	0.19	3.50	(0.05,0.13,0.31,0.34,0.18)	3.50	4
Overall Risk Level (ORL)		3.69	(0.07,0.18,0.22,0.35,0.24)		3.60	(0.06,0.10,0.23,0.35,0.25)	3.64	

Table 8. 9: Interpretation of Various Risk Categories and Overall Risk Level

Risk Categories	Likelihood of Occurrence		Severity of Risk		Overall Magnitude of Risk		Ranking
	Index	Linguistic scale	Index	Linguistic scale	Index	Linguistic scale	
Political-Related Risks Category	2.88	Moderate	2.94	Moderate	2.91	Moderate	5
Financing-Related Risks Category	4.12	High	4.09	High	4.10	High	1
Procurement-Related Risks Category	3.66	High	3.82	High	3.74	High	2
Design & Construction Risks Category	3.52	High	3.64	High	3.58	High	3
Operation & Maintenance Risks Category	3.51	High	3.50	High	3.50	Moderately High	4
Overall Risk Level (ORL)	3.69	High	3.60	High	3.64	High	

8.3.2 DISCUSSIONS OF RESULTS

8.3.2.1 Risk Category 1 – Political-Related Risk Factors

Political-related risk category ranks fifth with a moderate risk level of 2.91. Its likelihood of occurrence and severity indices are both moderate values of 2.88 and 2.94, respectively (as shown in Table 8.9). The political risk category contains five risk factors of which 'risk associated with land acquisition / land expropriations for housing', 'political continuity risks / change of government' and 'risk due to policy instability / political opposition to public housing projects' are ranked high with magnitude of impact of 4.06, 3.91 and 3.78, respectively.

Most lands in Ghana are owned by customary institutions such as stools, skin, clans and families. However, through the invocation of eminent domain, the state can access land for public purpose (Larbi, 2008, p.21). Yet, governments' access to land/land expropriations is a major problem in Ghana as evinced in its high ranking (4.06). This concurs with findings of Larbi (2008) that land expropriation is a critical risk factor that has led to unresolved issues. Some of these issues are related to unpaid compensation on acquired land, encroachment on acquired land, problems on intergenerational equity and divestiture of state-owned enterprises to private enterprises. These issues have culminated in lack of trust between the state and customary landowners and have undermined tenure security on acquired land. As such, it is a herculean task for the state to acquire land for public private partnership for low-cost housing in major cities such as Accra and Kumasi. On problems related to intergenerational equity, the state faces challenges of starting or continuing projects due to protest from families, clan and community on expropriated land in the past. Some of the families and clan think that, even if compensations were paid to the earlier generation, the compensations are inadequate (Larbi, 2008).

To mitigate land expropriation risk, a partnership between landowners and developers or government is essential. For partnership between the government and the landowners, payment of lump sum amounts by governments as compensations should be discouraged. Instead, a portion of the lump sum could be paid to the landowners. Then, in addition to the partial payment to landowners, there could be an agreement such that a number of housing units are allocated to the landowners or the annual rents from a number of units is given to the landowners while the remaining housing units are allocated to the government for providing housing facilities to the public (low- and middle-income earners). This strategy could reduce the financial burden on governments concerning lump sum payment as compensation. Additionally, it could mitigate problems related to intergenerational equity.

Moreover, some of the risk factors that affect housing projects and are worth considering include 'political continuity risks/change of government' and 'risk due to policy instability/political opposition to public housing projects'. Similarly, Twumasi-Ampofo et al. (2014) concluded that 'lack of institutional structure that could ensure the continuation of projects when there is a change of government' and 'negative politics by governments' are among the reasons for abandoned public housing projects in Ghana. Typical abandoned public housing projects include the Asokore-Mampong Housing Project; Kpone Housing Project; Cape Coast Police Housing Projects and Borteman Housing Projects. Housing projects abandonment is attributed to some identified reasons (Twumasi-Ampofo et al., 2014). A political party that assumes incumbency mostly focuses on its campaign promises while initiated projects that are unfinished by past political parties are neglected/abandoned. Furthermore, contractors are mostly awarded contracts not based on competence but on political affiliation which partly contributes to low quality construction due to contractor's ineptitude. Moreover, there are no institutional or regulatory structures that serve as checks on successive governments for project completion when there is a change of governments.

To alleviate these risk factors, projects should be awarded based on competence. This could be achieved by ensuring tendering procedures are devoid of manipulations. Using electronic procurement system could be an effective strategy to ensure that contracts are awarded based on capability. Furthermore, there is the need for an independent regulatory structure to ensure continuation of housing projects when there is a change of government. This could be attained through the allocation of project budget to an independent body (such as consultancy firms) following detailed and meticulous estimation of project cost (Adabre et al., 2020).

8.3.2.2 Risk Category 2 - Financing-Related Risk

This risk category has the highest risk level of 4.10. Its likelihood of occurrence and severity indices are both high with 4.12 and 4.09, respectively (shown in Table 8.9). It consists of eight risk variables as shown in Table 8.6. Among them, the top five risk factors include 'delays in payments by governments / clients', 'fluctuation in exchange rate', 'fluctuating cost of finance (interest rates)', 'inflation rate volatility (price inflation of materials / labour and sustainable technologies)' and 'increasing tax rates and fees on developers'. These risk factors have a negative impact on project's cash flow, project funding and profitability (Ameyaw and Chan, 2015) and could dent sustainable development goals in housing projects / facilities.

Delay payments by government officials or clients has been highlighted in prior studies as a critical risk in the Ghanaian construction industry (Twumasi-Ampofo et al., 2014; Fugar & Agyakwah-Baah, 2010; Famiyeh et al., 2017). Without adequate measures to mitigate this risk, it could trigger other risk factors such as cost overruns, time overruns and compromise on quality of low-cost public housing projects. However, to curb this risk factor of delay payments, contractual scheme such as payment bond could be established in the Ghanaian construction industry. For instance, through payment bond, contractors could evoke the bond for payment of certified work if the clients or government officials fail to pay the contractors after a stipulated number of days.

‘Fluctuating cost of finance’ is not viable for sustainability attainment in housing (either public or private housing). ‘Fluctuating cost of finance’ is as a result of weakness in the Ghanaian financial system, risk of default loans among developers and rising commercial bank prime lending rates such as 18.20% and 25.10% in 2011 and 2012, respectively (Ameyaw and Chan, 2015). Due to hesitation among banks in Ghana, high interest rates are often charged on developers or contractors. This could influence the cost of procuring sustainable technologies and materials for sustainable housing among developers. Moreover, high base rate implies that financial institutions and the government could attract money from lenders by promising them high interest rates (higher than the base rates) using fixed deposits and treasury bills, respectively. Financial institutions (such as banks), in turn, lend to private developers at high interest rate. Consequently, to amortise these loans, developers may charge high rents or sell housing facilities at high prices, thus making these houses unaffordable to low- and middle-income earners.

8.3.2.3 Risk Category 3 - Procurement-Related Risk Factors

Procurement-related risks category ranks second with high magnitude of impact (3.74), high likelihood of occurrence (index =3.66) and high severity (index = 3.82). This risk category underlies three main risk factors among which ‘bribery and corruptions in project procurement’ and ‘errors and omissions in tender documents (i.e. inaccurate cost estimates)’ were ranked high with magnitudes of impact of 4.02 and 3.74, respectively (as shown in Table 8.9).

The high magnitude of impact (4.02) of 'bribery and corruption in project procurement' confirms findings of Ameyaw & Chan (2015) that corruption in the Ghanaian construction industry is still an importunate issue though the Public Procurement Act 2003 was enacted to ensure transparent procurement and corrupt-free practices in public procurement. Corruption in the Ghanaian construction industry is often caused by political connections, tenuous regulatory structure and dubious sole-sourcing of projects, and it is mostly manifested in various forms such as kickbacks (extortion), collusion and tender rigging, bribery, conflict of interest and fraud (Ameyaw & Chan, 2015). Contractors mostly pay 10-20% of the tender sum to obtain construction contracts (Ameer, 2015). Therefore, winning contractors may either inflate the contract sum to cover for the 10-20% payment or they may cut corners to recoup the 10-20% payment.

Consultants may also contribute to the corrupt practices by reducing the number of bidders at the tendering stage and certifying shoddy works and overvaluing works at the contract stage in exchange for monetary or personal gains. Thus, project cost could be inflated, quality could be reduced while project environmental safeguards could be ignored. Consequently, corruption could stifle economic, social and environmental sustainability attainment in low-cost or public housing projects (Ameyaw & Chan, 2015; Chan & Adabre, 2019).

To achieve sustainable housing for low-income and middle-income earners, it is not surprising that target 16.5 and target 16.6 of the UN Sustainable Development Goals demand a substantial reduction in corruption and bribery, on one hand, while ensuring effective, transparent and accountable institutions. In a project, consultants own clients/governments a fiduciary duty by ensuring ethical behaviour (such as honesty, integrity, fairness and accountability). Strict adherence to this duty on the part of consultants could prevent overvaluing of contractor's work. High ethical standards by professional bodies such as Ghana Institution of Surveyors (GhIS) and Ghana Institutes of Construction (GIOC) and regular seminars on approved ethics are essential in regulating the behaviour of members. Sanctions from these professional bodies could include blacklisting members involved in corrupt practices. Furthermore, on the part of clients, regular auditing of consultants by frequent site visits could ensure that contractors are paid based on works executed. Moreover, effective implementation of e-procurement could lessen corrupt practices and misuse of power. Ensuring that the various stages of procurement from purchase of tender documents, tendering and contractor's payment are conducted online could improve transparency at the various stages (Sohail & Cavill, 2008).

'Errors and omissions in tender documents (i.e. inaccurate cost estimates)' is also ranked high (> 3.50) as a critical risk factor to sustainable low-cost housing. This is attributed to the limited tenure of office of governments and public officials. Most public projects in Ghana are initiated when elections are approaching as means of canvasing for votes from the public. As such, consultants are mostly given short time to provide project designs and cost estimates which could lead to limited specifications in project design and inaccurate cost estimates. Therefore, it is a common practice for ad hoc quantities to be provided in such circumstances. Consequently, the complexities of public housing projects are often underestimated (Twumasi-Ampofo et al., 2014). Furthermore, environmental sustainability measures and quality of materials could be compromised. However, with the growing trend of digitization in construction (such as Building Information Modelling, BIM), incentives to enable consultants and contractors to adapt quickly to these technologies could improve project cost estimates and, therefore, reduce this risk factor.

8.3.2.4 Risk Category 4 - Design & Construction Risk Factors

With high risk level of 3.58, high likelihood of occurrence index (3.52) and high severity index (3.64), 'design & construction risk category' ranks second. It entails eight risk factors as shown in Table 8.9. Among the eight risk factors, the top four ranked factors include 'construction cost overruns', 'construction time overruns', 'design and construction variation orders/alteration and rework due to variations' and 'technical complexity / risk associated with project'.

Public housing projects have often come to a halt as a result of cost overruns, design and construction variations orders which have ripple effects on construction time overruns (Fugar & Agyakwah-Baah, 2010). These risk factors could decrease quality of housing projects and thus, affect social sustainability as well as decrease productivity through loss revenue or additional expenses. Though cost and time overruns are related and may be considered as one (as Ameyaw & Chan, 2015), the causes of these risk factors are different. In the Ghanaian construction industry, Famiyeh et al. (2017) revealed that cost overruns were caused by clients' financial difficulties, delays in payments to contractors and design variations while time overruns are caused by financial challenges, unrealistic estimation of project duration and poorly defined project scope. Similarly, in the Danish construction industry, lack of fund for project was identified as a key influential factor of time overruns; for cost overruns, it was negligence on consultant materials (Larsen et al., 2016). Because of the different causal variables, there is no strategy that is a panacea for these risk factors. To control them, there should be adequate planning of housing projects to accurately ascertain the cost, time and technical complexities of the project before the detailed design and construction. Contractual schemes such as liquidated and ascertained damages (LAD) could be reinforced to control time overruns caused by contractors. For an effective execution of LADs, contracts for public housing should be 'fixed-date'.

8.3.2.5 Risk Category 5 - Operation & Maintenance Risk Factors

This risk category ranked fourth with a moderately high level of 3.50. Its likelihood of occurrence index and severity index are both moderate values of 3.51 and 3.50, respectively. 'Operation & maintenance risk category' entails six risk factors (as shown in Table 8.9). Though the overall magnitude of impact of this risk category is moderate, 'fluctuating market demand or preference / low take-up rate of housing facilities', 'privatization risk' and 'utilities / infrastructural supply risks' are ranked high in Ghana.

'Fluctuating market demand or preference/low-take up rate of housing facilities' is among the risk factors that could affect public housing facilities. Public housing facilities are speculative in nature since decisions on land acquisition, design and construction of such houses are mostly made without a specific customer in mind (Ahadzie et al., 2008). Consequently, though the need for more affordable housing is pressing in Kumasi, surprisingly, there are problems of low-take up rates of high-rise rental facilities among government employees. This is often the case in the southern part of Ghana where *fufu* is the most popular food. As such, high-rise facilities that do not incorporate special areas in subsequent floors for the preparation of this food could receive low take-up rate among multi-family households.

Low take-up of housing facilities could be controlled through co-designing and co-production at the design stage of such housing facilities. Co-production involves an interaction between the design team and the potential households or user through the sharing of resources (including knowledge) and legitimacy (including power) for value creation. However, co-design envisages, plans and develops effective solutions to households/users for optimum attainment of form and function. Though both are inextricably linked, co-production is a precursor of co-design (Laitinen et al., 2018). Accordingly, co-production creates an enabling environment for co-design to occur. They both encourage potential households' participation in which the design team does not design housing facilities/project for households but with them "enabling them to control the design process" (Lee, 2008). Essentially, they ensure empathy between the design team and potential households, prevents information asymmetry between the design team and households. Co-production and co-design could promote households' satisfaction and stakeholder's satisfaction, which ultimately leads to social sustainability attainment in public housing projects (Chan & Adabre, 2019). Ensuring co-production and co-design could reduce low take-up of housing facilities in Ghana among civil servants. Besides, co-production and co-design could stimulate interest of local beneficiaries and, therefore, serve as a check on other stakeholders of public housing project in preventing abandoned, uncompleted housing projects in the case of Ghana.

Public housing privatization risk could occur as a result of the sale of public rental housing units to sitting tenants or other potential households (Ho, 2004). This form of privatization is still in vogue in Ghana and most sub-Saharan African countries albeit for political reasons. Though the motive for privatization is to improve housing ownership, this is often far from altruistic and could impose risks and barriers to sustainable housing in the Ghanaian construction industry. Privatization of public housing could lead to upgrading of public affordable housing facilities, rent increases, displacement of low-income households from privatised facilities in cities (as observed in the case of New York and London) and re-selling to wealthier households (Kitzmann, 2017; Fields & Uffer, 2014). Consequently, privatisation could cause financialization of housing whereby housing is treated as a commodity for accumulating wealth and as a security but not for shelter. This could contribute to the increasing inequality and poor living conditions in major cities (Suleman et al., 2019). To mitigate this risk in the case of Ghana, privatisation of state-owned rental facilities could be minimised. Besides, current and successive governments could focus more on the supply of public rental facilities. This will increase the rental facilities in the housing market and therefore reduce the increasing rental charges and high advance rent charges by private landlords (Arku et al., 2012; Akaaabre et al., 2018). Thus, the availability of adequate public rental facilities could serve as a buffer against increasing rent on private facilities and could prevent displacement of low-and middle-income civil servants from cities.

A holistic sustainable development requires complementary infrastructure/utilities. However, public housing facilities in Ghana are often developed at the peripheral of cities and towns. Complementary facilities such as basic educational facilities (nursery and primary school facilities), playground or recreational facilities for children, library, adequate accessibility to transportation, supermarkets or shopping facilities and healthcare facilities are mostly lacking or inadequate due to the colossal financial resources and time required for their supply. Besides, intermittent supply of utilities such as portable water and electricity is a major problem in the Ghanaian construction industry (Ameyaw & Chan, 2015). Without these facilities, social sustainability attainment could be hindered. Furthermore, increasing commuting distance to these facilities among low and middle-income household could increase vehicular emissions and increase fuel cost burden on households. Even if the housing facilities are price affordable, increasing commuting cost could annul the price affordability of housing facilities. Thus, although public housing facilities could be provided at affordable prices, these houses stand the risks of low take-up if complementary facilities or utilities are not adequately supplied and if houses are sited in remote areas far from cities.

8.4 CHAPTER SUMMARY

This chapter established a comprehensive model for assessing sustainability performance in affordable housing from the Ghanaian perspective. Besides, risk assessment was conducted to determine the impact of risk factors on SAH. The sustainability model is an evaluation tool which accounts for the economic, social and environmental goals for sustainable low-cost housing.

Through a questionnaire survey among respondents in the Ghanaian housing sector, data were collected and analyzed using mean score ranking and fuzzy synthetic evaluation (FSE) for both the sustainability assessment model and the risk impact assessment. On the sustainability assessment model for SAH, the research findings revealed that though environmental-related indicators (e.g. energy efficiency and eco-friendliness of housing facilities) are important, social sustainability indicators (i.e. end-users' satisfaction of housing facility, functionality of housing facility, safety, quality of housing) and economic sustainability indicators (i.e. price/rental cost of housing facilities) are rated higher concerning affordable housing. Besides, the indicators were used to develop a sustainability assessment model (SAM). The model consists of four main indices: housing and transportation (H+T) index; household satisfaction index; efficient stakeholder management index and quality-related index. These indices account for 25.3%, 26.3%, 23.6% and 24.9% of sustainability attainment in affordable housing, respectively. Among these indices, household satisfaction index accounts for the highest contribution to sustainability attainment in affordable housing from the Ghanaian perspective. A combined linear and additive model was developed to provide a composite sustainability index for SAH.

On the risk assessment impacts on SAH, data analysis through the FSE revealed that critical risk factors that hinder sustainable low-cost housing include: ‘Delays in payment by governments/clients’, ‘fluctuations in exchange rate’, ‘fluctuating cost of finance (interest rates)’, ‘construction cost overruns’, ‘inflation rate volatility (price fluctuation of materials, labour and sustainable technologies)’, ‘risk associated with land acquisition/land expropriations for housing’ , ‘corruption in project procurement’ and ‘construction time overruns’. Further analysis on the criticalities of the risk categories revealed that ‘financial-related risk category’ is the most critical followed by ‘procurement-related risk category’, ‘design & construction risk category’, ‘operation and maintenance risk category’ and ‘political risk category’.

The next chapter, Chapter 9, entails modelling the impact of barriers and success factors on sustainable development goals in housing. This will unearth critical barriers and critical success factors for SAH in the Ghanaian housing market.

CHAPTER 9: DATA ANALYSIS AND RESULTS – DEVELOPING A MODEL FOR SAH

9.1 MODELLING THE IMPACT OF BARRIERS ON SUSTAINABILITY ATTAINMENT IN AFFORDABLE HOUSING

9.1.2 CONCEPTUAL FRAMEWORK

Based on the literature review on the indicators of sustainable housing and barriers (in Chapters 2 & 3), a conceptual framework was developed. The barriers are categorised into three main groups, namely, 'cost-related', 'incentive-related' and 'retrofit-related' barriers. These three main groups are developed based on the theme of their underlying barriers while using findings from the international survey serve as a guide. These are also inveterate categories in previous studies (i.e. Gianfrate et al., 2017; Dowson et al., 2012). Cost-related barriers include 'delays in permit approval'; 'high upfront cost of materials and technologies for sustainable housing'; 'high cost of land'; 'high interest rates'; 'high inflation rate'; 'high cost of permit approval' and 'income inequality'. Though 'delays in permit approval' could be considered as an incentive-related barrier, it was considered as a cost-related barrier from the Ghanaian perspective. This is because high interest rates, as noted in the case of Ghana, increases cost of capital. Therefore, 'delays in permit approval' could further exacerbate the cost of capital and thus, increase cost of sustainable housing among developers. Regarding 'income inequality', as stated in Reardon (2011), housing facilities cost/rent high in high-income neighbourhood than in low-income neighbourhood. Thus, 'income inequality' is a key determinant of neighbourhood affordability and was therefore considered a 'cost-related barrier'.

Incentive-related barriers include eight underlying barriers: 'inadequate incentives for investors'; 'inadequate access to land among developers'; 'lack of planning control on land development'; 'inadequate subsidies on sustainable technologies'; 'poor location of housing facilities'; 'inadequate infrastructural development'; 'inadequate mortgage/financing schemes' and 'tight credit conditions' (shown in Fig.9.1). The underlying barriers under 'retrofit-related' include: 'low level or inadequate retrofitting (maintenance operation)'; 'inadequate standards/guideline and tools for retrofitting'; 'lack of routine maintenance / poor maintenance culture of housing facilities'; 'policy instability/abandoned public housing facilities or projects' and 'inadequate local professional skills' for retrofitting activities (i.e. Dowson et al., 2012).

9.1.3 DEVELOPMENT OF HYPOTHESES

Though the classification of the underlying barriers into the three groups is based on the themes and on the literature, their categorisation will be confirmed by a confirmatory factor analysis during data analysis. It is also worth noting that these categories of barriers have negative impact on one or more of the critical success criteria (CSC) of sustainable housing. Moreover, one group of barriers could influence another group as stated in Adabre et al. (2020). For instance, 'income inequality' could lead to mortgage redlining by banks. This could influence 'tight credit conditions', which is listed under 'incentive-related barrier'. Thus, based on these epistemological assumptions on how the groups of barriers interact with one another, on one hand, and between the CSC of sustainable housing, on the other hand, the following hypotheses were established.

Hypothesis 1: Cost-related barriers have a significant negative impact on 'incentive-related barriers'.

Hypothesis 2: Incentive related barriers have a significant negative impact on 'retrofit-related barriers'.

Hypothesis 3: Cost-related barriers have a significant negative impact on 'retrofit-related barriers'

Hypothesis 4: Cost-related barriers have a significant negative impact on 'sustainable housing development'.

Hypothesis 5: Incentive-related barriers have a significant negative impact on 'sustainable housing development'.

Hypothesis 6: Retrofit-related barriers have a significant negative impact on 'sustainable housing development'.

Fig. 9. 1: A Conceptual Model of the Impact of Barriers on Sustainable Housing

9.1.4 ANALYSIS AND RESULTS - DESCRIPTIVE STATISTICS

Prior to the descriptive analysis of the data, reliability analysis was conducted by evaluating the Cronbach alpha values for both the CSC of sustainable housing and the indicators of barriers. In both sets of data, Cronbach alpha values of 0.878 and 0.840 were obtained for all the CSC of sustainable housing and for all the items/indicators of the barriers, respectively (shown in Table 9.1). These values are higher than the 0.70 threshold recommended in similar sustainable housing studies (Chan & Adabre, 2019; Adabre & Chan, 2019). Therefore, the Cronbach alpha values indicate that the survey data are adequately reliable for subsequent analysis.

Sequentially, the mean values, standard deviations and ranks based on the mean values were estimated for the CSC of sustainable housing and for the indicators of the barriers to sustainable housing (shown in Table 9.1). Concerning the CSC of sustainable housing, the mean scores of the 21 CSC range from 4.468 (for 'construction cost performance of housing facility') to 3.468 (for 'waiting time of potential household before being allocated a housing unit'). Therefore, the respondents considered the 21 CSC as important for measuring the concept of sustainable housing since none of the mean values was within the category of '*less important'* (< 2). Besides, the low standard deviations (< 1) of most of the CSC suggest a relatively high consistency level among the different respondents who ranked the them.

On the barriers (also shown in Table 9.1), mean scores of the 21 barriers range from 4.761 (for 'high interest rates') to 3.255 (for 'lack of/inadequate local professional skills'). Most of the highly ranked barriers such as 'high interest rates', 'high inflation rate', 'high upfront cost of materials and sustainable technologies' and 'high cost of serviced land' are barrier items from the 'cost-related barriers' construct. The results show that 'cost-related barriers' are the most impediments to sustainable housing in Ghana. Besides, among the 'incentive-related barriers', 'tight credit conditions' 'inadequate mortgage institution', 'lack of planning control on land development', 'inadequate access to land', and 'inadequate infrastructure development' are ranked high (above 4.00). Furthermore, the barriers ranked high (above 4.00) under the 'retrofit-related barriers' include: 'policy instability/abandoned housing facilities or projects by succeeding government' and 'lack of routine maintenance/poor maintenance culture of public housing facilities'. Therefore, in addition to 'cost-related barriers', sustainable housing in Ghana could be hindered by 'incentive-related barriers' and 'retrofitting-related barriers'.

The values in the columns of 'Corrected Item-Total Correlation' and 'Cronbach's Alpha if Item Deleted' were used as guide to delete CSC/indicators that might not be relevant for further consideration in the PLS-SEM (Yuan et al., 2018). The conditions for deleting a CSC/indicator is that if the item's 'Corrected Item-Total Correlation' is less than 0.40 and its 'Cronbach's Alpha if Item Deleted' is greater than overall Cronbach's Alpha for all items (i.e. 0.878 for CSC of sustainable housing and 0.840 for barriers to sustainable housing), then the item should be deleted. Based on these conditions, the CSC 'take up rate of housing facility' (in Table 9.1) could be deleted before further analysis. Similarly, the barrier item 'inadequate local professional skills' for retrofitting activities (in Table 9.1) could be deleted

Table 9. 1: Descriptive Statistics of Constructs and Indicators of Barriers to Sustainable Housing

Constructs	Code	Observable Variables	Mean Score	Standard Deviation	Rank	Corrected Item-total correlation	Cronbach's Alpha if Item Deleted	Cronbach's Alpha
Sustainable Housing (Measured by Indicators of Sustainable Housing (CSC))								
CSC	CSC01	Timely completion of project	4.340	0.815	3	0.378	0.875	0.878
	CSC02	Construction cost performance	4.468	0.584	1	0.231	0.878	
	CSC03	Quality performance	4.343	0.644	2	0.496	0.872	
	CSC04	Safety performance (crime prevention)	4.085	0.803	10	0.654	0.867	
	CSC05	End user's satisfaction	4.319	0.980	4	0.646	0.866	
	CSC06	Stakeholders' satisfaction	3.957	0.833	12	0.385	0.875	
	CSC07	Environmental-friendly (Eco-friendly)	4.085	0.803	10	0.380	0.875	
	CSC08	Reduced lifecycle cost	3.933	0.918	14	0.502	0.872	
	CSC09	Maintainability of housing facility	4.283	0.851	6	0.566	0.869	
	CSC10	Energy efficient housing	3.915	0.880	16	0.547	0.870	
	CSC11	Reduced disputes and litigation	3.660	1.027	19	0.469	0.873	
	CSC12	Reduced public expenditure on housing management	3.851	0.932	17	0.377	0.876	
	CSC13	Technical specification	4.128	0.824	9	0.563	0.870	
	CSC14	Aesthetic view of housing facility	3.913	0.717	15	0.363	0.876	
	CSC15	Price of housing facility	4.298	0.749	5	0.393	0.875	
	CSC16	Rental cost of housing facility	4.196	0.824	7	0.472	0.872	
	CSC17	Commuting cost of household to facility	3.787	0.999	18	0.582	0.869	
	CSC18	Functionality of housing facility	4.174	0.789	8	0.567	0.870	
	CSC19	Technology transfer	3.468	0.856	20	0.621	0.868	
	CSC20	Take up rate of housing facility	3.936	0.818	13	0.264	0.879	
	CSC21	Waiting time of potential households	3.468	0.881	21	0.430	0.874	
Potential Critical Barriers to Sustainable Housing								
Cost-Related Barriers (CRB)	CRB1	Delays in government approval process	3.936	0.895	16	0.391	0.837	0.840
	CRB2	High upfront cost of materials and technologies for sustainable housing both new construction and retrofitting	4.467	0.544	2	0.395	0.838	
	CRB3	High cost of serviced land	4.467	0.710	3	0.386	0.837	
	CRB4	High inflation rate	4.404	0.712	6	0.414	0.836	
	CRB5	High interest rates	4.761	0.427	1	0.443	0.837	

	CRB6	High cost of permit approval (high taxes and fees on developers)	4.170	0.637	10	0.326	0.839
	CRB7	Income inequality among households	3.979	0.737	15	0.427	0.835
Incentive-Related Barrier (IRB)	IRB1	Inadequate incentive for private investors	3.872	0.924	19	0.553	0.829
	IRB2	Inadequate access to land among developers	4.043	0.908	13	0.437	0.835
	IRB3	Lack of planning control on land development	4.239	0.728	8	0.579	0.830
	IRB4	Inadequate subsidies/public funding for sustainable technologies	3.893	1.047	18	0.420	0.836
	IRB5	Poor housing location (Inadequate policies on situating housing development in cities / towns)	3.596	0.798	20	0.379	0.807
	IRB6	Inadequate infrastructure development	4.043	0.806	12	0.488	0.833
	IRB7	Inadequate mortgage/financing institutions	4.319	0.726	7	0.313	0.840
	IRB8	Tight credit conditions	4.404	0.680	5	0.397	0.837
Retrofit-Related Barriers (RRB)	RRB1	Low-level or inadequate retrofitting (maintenance operation)	3.935	0.818	14	0.527	0.831
	RRB2	Inadequate policies or sustainability assessment tools (standards or guidelines) for retrofitting housing facilities	3.894	1.047	17	0.673	0.822
	RRB3	Lack of routine maintenance/Poor maintenance culture of public housing facilities	4.213	0.907	9	0.493	0.832
	RRB4	Policy instability/abandoned or neglected management of public housing facilities or projects by succeeding governments	4.404	0.648	4	0.404	0.837
	RRB5	Inadequate local professional skills	3.255	1.170	21	0.134	0.855

9.1.5 RESULTS OF PLS-SEM – ESTIMATION OF MEASUREMENT MODEL

All the measurement items were specified as reflective indicators and not formative indicators. Reflective indicators are interchangeable and therefore omitting an item does not essentially change the nature of the underlying construct. However, for formative indicators, omitting an indicator is omitting a part of the underlying construct (Hair et al., 2014; Diamantopoulos & Winklhofer, 2001). Besides, reflective indicators have high correlations among themselves, as revealed in the international survey in Chapter Seven (7). Study by Chan & Adabre (2019) and Adabre et al. (2020) showed that there are high correlations among CSC of sustainable housing and indicators of the barriers. Therefore, the analysis was conducted after specifying all the measurement items as reflective indicators. It is recommended that factor loadings of the measurement items should be above 0.5. As suggested by Nunnally (1978), items with loading below 0.5 do not contribute significantly to the explanatory power of the constructs. Therefore, during the data analysis, measurement items / indicators whose factor loadings were below 0.5 were deleted and the analysis was repeated until a reliable and valid measurement model was obtained.

Results of the measurement model are shown in Table 9.2. Though, one of the underlying barriers 'income inequality' was classified as cost-related barriers, it was successfully loaded (loading ≥ 0.5) under 'incentive-related barriers'. From Table 9.2, the estimated composite reliability values and Cronbach's alpha values of all constructs are above the required threshold of 0.7, which indicate that internal consistent reliability is acceptable. Furthermore, the factor loadings and the average variance extracted (AVE) values are above the recommended 0.5, indicating a satisfactory level of convergent validity of the indicators and constructs, respectively.

Table 9. 2: Measurement Model Evaluation

Constructs	Indicators	Loadings[a]	AVE[b]	CR[c]	CA[d]
Sustainable Housing (Measured by CSC)	CSC10	0.715	0.504	0.876	0.812
	CSC16	0.572	–	–	–
	CSC17	0.701	–	–	–
	CSC19	0.691	–	–	–
	CSC04	0.694	–	–	–
	CSC05	0.832	–	–	–
	CSC06	0.741	–	–	–
Cost-Related Barriers	CRB1	0.821	0.502	0.799	0.734
	CRB2	0.735	–	–	–
	CRB3	0.647	–	–	–
	CRB4	0.613	–	–	–
Incentive-Related Barriers	IRB1	0.853	0.542	0.823	0.737
	IRB2	0.742	–	–	–
	CRB 7	0.573	–	–	–
	IRB3	0.749	–	–	–
Retrofitting-Related Barriers	RRB1	0.697	0.545	0.826	0.727
	RRB2	0.841	–	–	–
	RRB3	0.722	–	–	–
	RRB4	0.682	–	–	–

Items removed: indicator items below 0.5: - CSC01, CSC02, CSC03, CSC07, CSC09, CSC11, CSC12, CSC13, CSC14, CSC15, CSC18, CSC21, CRB5, CRB6; IRB5, IRB6, IRB7, IRB8, IRB9:

a. All indicator loadings > 0.5 means CSC / indicator reliability (Hulland, 1999).
b. All Average Variance Extracted (AVE) > 0.5 indicates Convergent Reliability (Fornell and Larcker, 1981).
c. All Composite Reliability (CR) > 0.7 indicates Internal Consistency (Gefen et al., 2001).
d. All Cronbach's Alpha (CA) > 0.7 indicates Indicator Reliability (Nunnally, 1978).

9.1.6 MEASUREMENT MODEL ASSESSMENT: DISCRIMINANT VALIDITY (VERTICAL COLLINEARITY)

9.1.6.1 Fornell and Lacker Criterion

After estimating the measurement model, the next step is to assess its vertical collinearity. This was done by estimating the discriminant validity using the Fornell & Lacker criterion. The criterion of assessment is that a construct should share more variance with its measures than it shares with other constructs in the model. Using the AVE, Fornell & Lacker stated that the AVE of constructs should be greater than the variance shared between the constructs and other constructs. From the results in Table 9.3, the highest correlation for a construct is the correlation between a construct and itself. These correlation values are the diagonal values as indicated in Table 9.3. The values are the square root of the AVE of the latent variable and indicate the highest in any column or row. Therefore, the discriminant validity was satisfactory using the Fornell & Lacker criterion (Chin, 1998).

Table 9. 3: Discriminant Validity (Fornell & Larcker Criterion)

Constructs	Sustainable Housing	Cost-Related barrier	Incentive-Related barrier	Retrofitting-Related barrier
Sustainable Housing	**0.710**	–	–	–
Cost-Related barrier	0.348	**0.709**	–	–
Incentive-Related barrier	0.126	0.464	**0.736**	–
Retrofitting-Related barrier	0.513	0.402	0.698	**0.738**

*The diagonals are the square root of the AVE of the latent variable and indicate the highest in any column or row

9.1.6.2 Indicators' Cross Loading

Another approach for estimating the discriminant validity of the measurement model is by evaluating the measurement items' cross loadings. As shown in Table 9.4, each measurement item had the highest factor loading on the construct it was theoretical identified to measure than any other constructs in the model. Therefore, this further buttresses the fact that the measurement model is valid and reliable for structural path modelling.

Table 9. 4: Indicators' Cross Loading

Indicators	Sustainable Housing	Cost-Related Barriers	Incentive-Related Barriers	Retrofitting-Related Barriers
CSC10	**0.715**	0.430	0.162	0.296
CSC16	**0.572**	0.275	0.089	0.292
CSC17	**0.701**	0.145	0.001	0.333
CSC19	**0.691**	0.100	0.147	0.383
CSC04	**0.694**	0.029	0.091	0.387
CSC05	**0.832**	0.412	0.126	0.467
CSC06	**0.741**	0.262	0.030	0.365
CRB1	0.344	**0.821**	0.540	0.425
CRB2	0.268	**0.735**	0.175	0.189
CRB3	0.187	**0.647**	0.134	0.198
CRB4	0.052	**0.613**	0.210	0.172
IRB1	0.125	0.291	**0.853**	0.599
IRB2	0.034	0.373	**0.742**	0.490
CRB7	-0.131	0.092	**0.573**	0.383
IRB3	0.219	0.498	**0.749**	0.550
RRB1	0.568	0.349	0.391	**0.697**
RRB2	0.315	0.498	0.793	**0.841**
RRB3	0.264	0.138	0.470	**0.722**
RRB4	0.383	0.062	0.276	**0.682**

9.1.6.3 Discriminant Validity (HTMT)

The measurement model was finally judged through the HTMT (shown in Table 9.5). Using the HTMT as a criterion to evaluate the discriminant validity entails comparing the HTMT with predetermined threshold. If the HTMT value is higher than the threshold, then there is a lack of discriminant validity (Henseler et al., 2015). Though the threshold for HTMT is debatable, Gold et al. (2001) and Teo et al. (2008) proposed a value of 0.90 ($HTMT_{0.90}$), which is the adopted threshold for this study. As shown in Table 9.5, since all the inter-construct correlations are below 0.90, the discriminant validity has been further established.

Table 9. 5: Discriminant Validity (HTMT)

Constructs	Sustainable Housing	Cost-Related Barrier	Incentive-Related Barrier	Retrofitting-Related Barrier
Sustainable Housing		–	–	–
Cost-Related Barrier	0.403		–	–
Incentive-Related Barrier	0.281	0.495		–
Retrofitting-Related Barrier	0.663	0.412	0.883	

9.1.7 ESTIMATION OF STRUCTURAL MODEL / PATH ANALYSIS

After the assessment of the measurement model on reliability, convergent validity and discriminant validity, it was concluded that the constructs are within the satisfactory limit for estimating the structural model (relationships among constructs). Therefore, path analysis was conducted (shown in Fig. 9.2). The values between constructs are the respective path coefficients. The higher the path coefficient between constructs, the stronger the influence of the independent construct on the dependent construct. As stated by Murari (2015), path coefficient values from 0.1 to 0.3 indicate weak influence, between 0.3 to 0.5 suggest moderate influence and 0.5 to 1.0 show strong influence.

The results (shown in Fig. 9.2) indicate that the path connecting the ‘cost-related barriers’ to the ‘incentive-related barriers’ shows a moderate influence (0.464). However, there is high influence (0.698) from ‘incentive-related barriers’ on ‘retrofitting-related barriers’ while the path linking ‘cost-related barriers’ to ‘retrofitting-related barriers’ revealed weak influence (0.105). Concerning the paths linking the constructs of the barriers to the sustainable housing construct, it was found that there is weak influence from ‘cost-related barriers’ on ‘sustainable housing’. In contrast, the path linking ‘incentive-related barriers’ to ‘sustainable housing’ indicates high influence (-0.556). Furthermore, ‘retrofitting-related barriers’ have high influence (0.783) on the ‘sustainable housing’ construct.

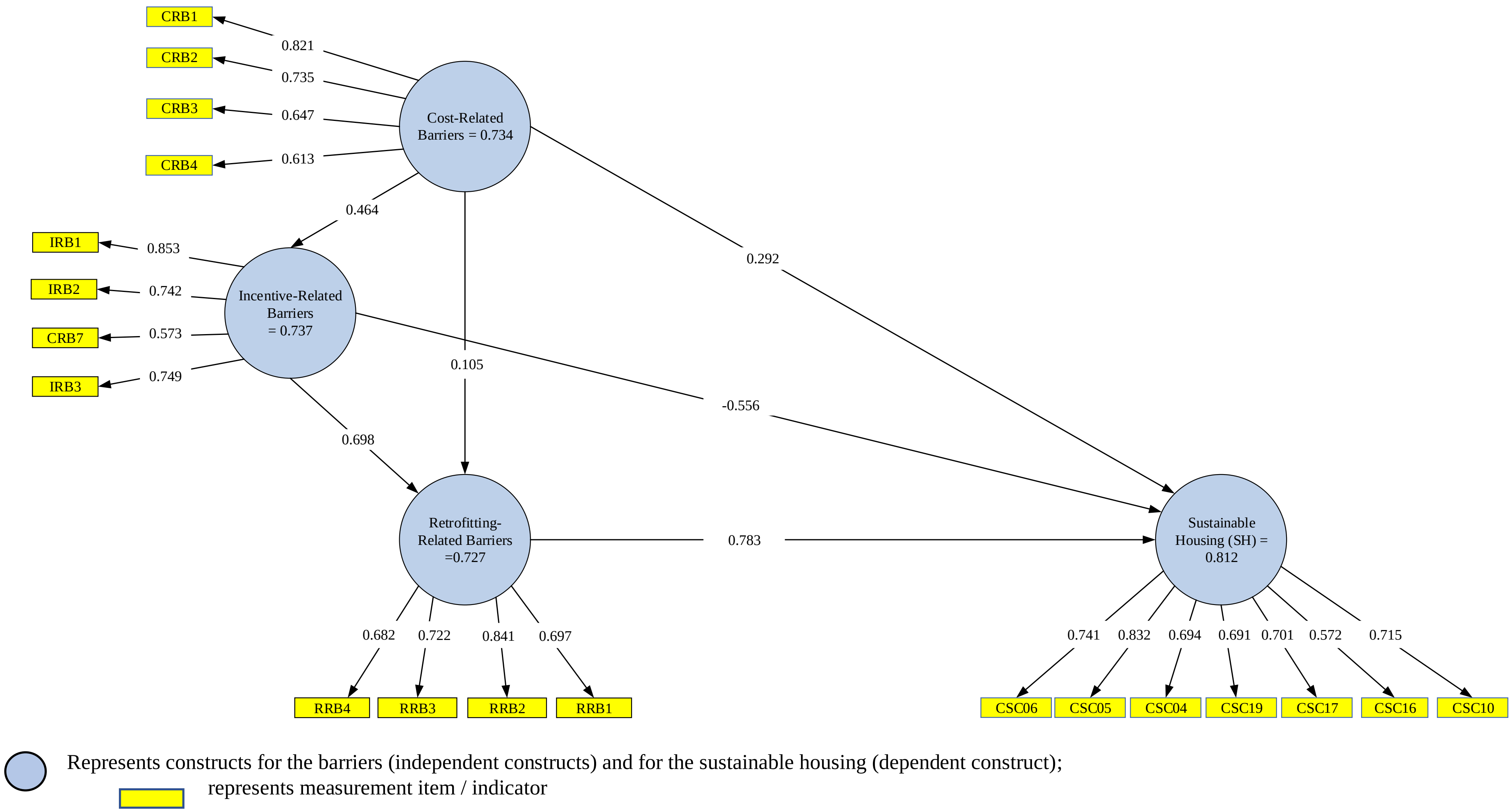


Fig. 9. 2: Structural Model of Construct of Barriers and Sustainable Housing Construct

9.1.8 ASSESSMENT OF THE STRUCTURAL MODEL

Assessment of the structural model includes: evaluating collinearity issues (using the inner variance inflation factor values), assessing the significance and relevance of the structural model relationships, assessing the coefficient of determination (R^2); assessing the effect sizes (f^2) and the predictive relevance (q^2).

9.1.8.1 Assessing the Structural Model for Multi-Collinearity

Multicollinearity in the structural equation model was judged using the inner variance inflation factor (VIF) values. If the VIF values are below 5, then there is no multicollinearity. As shown in Table 9.6, since all the inner VIF values are less than 5, the structural model has passed the test of multicollinearity.

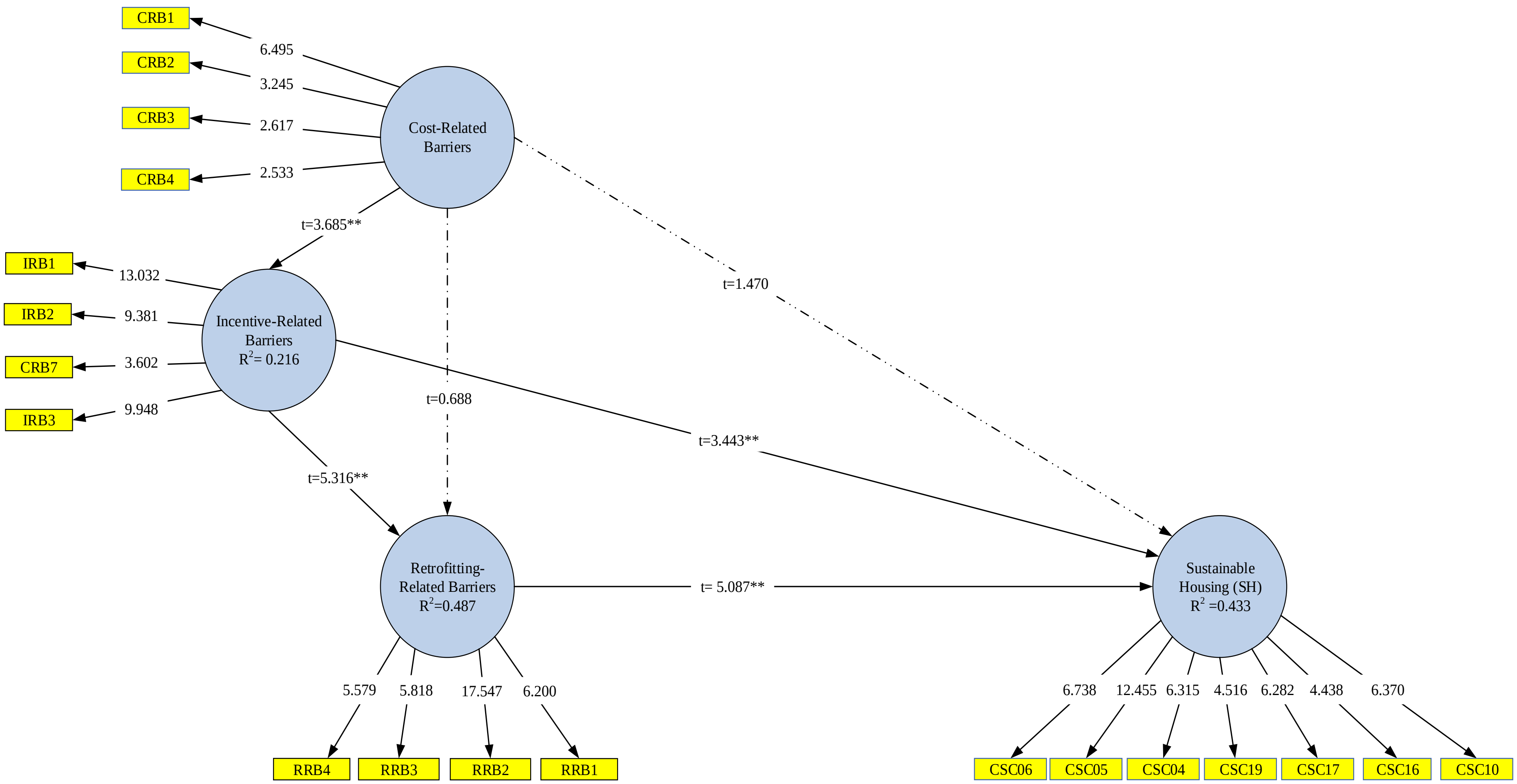
Table 9. 6: Inner VIF Values

Constructs	Sustainable Housing	Cost-Related Barrier	Incentive-Related Barrier	Retrofitting-Related Barrier
Sustainable Housing	–	–	–	–
Cost-Related Barriers	1.295	–	1	–
Incentive-Related Barriers	2.115	–	–	1
Retrofitting-Related Barrier	1.978	–	–	–

9.1.8.2 Assessing the Significance and Relevance of Structural Model (Bootstrapping)

Bootstrapping was conducted to assess the significance of the relationships among constructs. It estimates the spread, shape and bias of the sampling distribution of the population from which the sample under study was obtained. Prior to conducting the bootstrapping, the normality of the data was assessed using the Mardia's Multivariate skewness and kurtosis. The skewness value obtained was 8.81 while the kurtosis value was 38.96. Comparing the outputs of the skewness and the kurtosis with the cut offs (Mardia multivariate –skewness ±1; kurtosis ±20), it can be concluded that the data is not normally distributed since the estimated values are above the predetermined values (Chin, 1998). Hence bootstrapping was conducted for the data set. Bootstrapping analysis was used for statistical testing of the direct effects of all the hypothesized relationships. If $t_{0.05} > 1.96$ (for a 2-tailed test), hypothesis is supported (Peng & Lai, 2012; Hair et al., 2016).

Result of the bootstrapping is shown in Fig.9.3. The t-values are indicated on the various paths linking the constructs. The explanatory power of the structural model was evaluated by the coefficient of determination (R^2). R^2 measures the proportion of variance in the sustainable housing constructs explained by all the barrier constructs linked to it (Chin, 1988). It ranges between 0 and 1, with higher values indicating higher levels of predictive accuracy of the overall structural model. As shown in Fig.9.3, the R^2 for 'sustainable housing' is 0.433. This means that about 43% of the challenges in sustainable housing development are due to the three constructs of barriers. This value indicates a satisfactory level of the predictive accuracy and quality of the structural model (Hair et al., 2014).



Note: **p < 0.01, *p < 0.05

Indicates an insignificant path; Indicates a significant path

Fig. 9. 3: Bootstrapping Results on Impact of Barriers

9.1.9 VALIDATION OF THE HYPOTHESES

The hypotheses (hypotheses 1 to 6) were evaluated based on the structural model. Each path represents a hypothesis. Tests of the hypotheses were achieved by evaluating the statistical significance of the path coefficients. Table 9.7 is a summary of path analysis results and their corresponding t-values. For all the paths, a two-tail t-test was used (Aibinu & Al-Lawati, 2010). The hypotheses were considered based on the conventional significance levels 0.01 and of 0.05. Table 9.7 shows that out of the six hypotheses, four hypotheses were significant. The path coefficient between 'cost-related' and 'incentive-related' barriers (hypothesis1) is significant. Furthermore, the path linking 'incentive-related barriers' to 'retrofitting-related barriers' is significant (hypothesis 2). Moreover, the coefficient of the path linking 'incentive-related barriers' to 'sustainable housing' is statistically significant (hypothesis 5). Finally, hypothesis 6 (the path linking 'retrofitting-related barriers' to 'sustainable housing') is significant. Accordingly, hypothesis 1, hypothesis 2, hypothesis 5 and hypothesis 6 were accepted because their t-values are all greater than the 1.96 ($t_{0.05} > 1.96$).

9.1.9.1 Assessing the Effect Sizes (f^2)

The structural model was also assessed by calculating the effect sizes of the constructs. Effect size (f^2) measures how strongly one independent construct contributes to explaining a certain dependent construct in terms of R^2. The effect size was evaluated by investigating the changes in R^2 to find out if there is a substantive impact of any of the construct of barriers on the 'sustainable housing' construct. Then, based on the obtained R^2 value, the effect size was calculated using eqn. (9.1):

$f^2 = (R^2_{included} - R^2_{excluded}) / (1 - R^2_{included})$ ……………………………………..…..…eqn. (9.1) where $R^2_{included}$ and $R^2_{excluded}$ are the R^2 values of the dependent construct when a selected independent construct is included or excluded from the model. The change in the R^2 values is calculated by estimating the PLS path model twice: once with the independent construct included (yielding $R^2_{included}$) and the second time with the independent construct excluded (yielding $R^2_{excluded}$). The effect size of a construct is small if $0.02 \leq f^2 < 0.15$; medium if $0.15 \leq f^2 < 0.35$ and large if $f^2 \geq 0.35$ (Cohen, 2013). Table 9.7 shows the results on estimates of the effect size for some of the constructs that could be estimated.

From Table 9.7, 'cost-related barriers' have small effect size (0.034) on 'retrofitted-related barriers'. However, 'incentive-related barriers' have a high effect size (0.675) on 'retrofitting-related barriers'. Between the construct of barriers and sustainable housing construct, 'incentive-related barriers' have a medium effect size (0.192) on 'sustainable housing' while the effect size of 'retrofitting-related barriers' on 'sustainable housing' is large (0.430). The effect size of 'cost-related barriers' on 'sustainable housing' is small (0.086).

9.1.9.2 Assessing the Predictive Relevance (q^2)

The rigorousness or how well observed values are reproduced by the structural model was evaluated by calculating the predictive relevance. Predictive relevance (q^2) of exogenous constructs uses blindfolding procedure where every n^{th} data point in the dependent construct's indicators is omitted to estimate the parameters with the remaining data points (Henseler et al., 2009). While estimating parameters for a model under blindfolding procedure, this technique omits data for a given block of indicators and then predicts the omitted part based on the calculated parameters (Akter et al., 2011). Then, the predictive relevance can be estimated using eqn. (9.2). A construct's predictive relevance is small if $0.02 \leq q^2 < 0.15$; medium if $0.15 \leq q^2 < 0.35$ and large if $q^2 \geq 0.35$ (Cohen, 2013; Hair et al., 2014). Results of the constructs predictive relevance are shown in Table 9.7. The results indicate that the path linking 'incentive-related barriers' to 'retrofit-related barriers' has medium predictive relevance (0.210) and likewise the path linking 'retrofitting-related barriers' to 'sustainable housing' (predictive relevance 0.184). However, a small predictive relevance (0.053) was obtained for the path between 'incentive-related barriers' and 'sustainable housing' (shown in Table 9.7).

$$Q^2 = (Q^2_{included} - Q^2_{excluded}) / (1 - Q^2_{included}) \quad \ldots\ldots \text{eqn. (9.2)}$$
$$Q^2 = 1 - (\sum_D SSE_D) / (\sum_D SSO_D)$$

Where D is the omission distance, SSE is the sum of squares errors, and SSO represents the sum of squares total. To set D, the rule of thumb is $5 \leq D \leq 10$. Therefore, in conducting the blindfolding in smart PLS-SEM, a D value of 6 instead of 7 was selected considering that the total number of indicators in 21.

Table 9. 7: Direct Relationships for Hypothesis Testing

Hypothesis	Relationships	Std. Beta	Std. Error	|t-value|^	Decision	f^2	q^2	95% CILL	95%CIUL
H1	Cost-Related Barriers -> Incentive-Related Barriers	0.500	0.125	3.673**	Supported	–	–	0.297	0.681
H2	Incentive-Related Barriers -> Retrofitting-Related Barriers	0.651	0.122	5.316**	Supported	0.675	0.210	0.420	0.818
H3	Cost-Related Barriers -> Retrofitting-Related Barriers	0.118	0.165	0.637	Not supported	0.034	0.001	-0.150	0.366
H4	Cost-Related Barriers -> Sustainable Housing	0.273	0.186	1.507	Not supported	0.086	0.014	-0.058	0.557
H5	Incentive-Related Barriers -> Sustainable Housing	-0.574	0.161	3.443**	Supported	0.192	0.053	-0.830	-0.327
H6	Retrofitting-Related Barriers -> Sustainable Housing	0.824	0.155	5.087**	Supported	0.430	0.184	0.563	1.062

**p < 0.01, *p < 0.05

R^2 (Sustainable affordable housing = 0.433)

Effect Size (f^2) are according to Cohen (1988), f^2 values: 0.35 (large), 0.15 (medium), and 0.02 (small)

Predictive Relevance (q^2) of predictor independent construct as according to Henseler et al (2009), q^2 values: 0.35 (large), 0.15 (medium), and 0.02 (small).

9.1.10 DISCUSSION OF RESULTS ON MEASUREMENT MODEL

9.1.10.1 Sustainable Housing Construct

From the results of the measurement model, sustainable housing was reflectively and significantly measured by seven indicators, namely, energy efficient housing (CSC10); rental cost of housing facility (CSC16); commuting cost of household (CSC17); technology transfer (CSC19); safety performance (CSC04); end-user's satisfaction (CSC05) and stakeholders' satisfaction (CSC06). These indicators are critical for defining the scope of sustainable housing in the Ghanaian construction industry.

For sustainable housing from the perspective of Ghana, there should be an efficient supply of energy. However, the current energy supply situation in Ghana is unreliable, which is exacerbated by increasing residential electricity demand. Gyamfi et al. (2018) stated that seven appliances and one lighting technology consisting of refrigerator, air conditioner, television, freezer, fan, electric iron, washing machine and CFL constituted about 93% of residential electricity consumption in 2015. It is projected that electricity consumption by these appliances could be reduced by 24-51% in 2050 through energy efficient technologies. Therefore, the adoption of energy efficient or sustainable technologies that are environmentally friendly would ensure sustainable housing development in Ghana.

Furthermore, between 'rental cost of housing' (an indicator of preference for renting) and 'price of housing facility' (an indicator of preference for homeownership), only the latter was significantly loaded as an indicator for sustainable housing. However, the higher ranking of 'price of housing' over 'rental cost of housing' in the descriptive statistics (shown in Table 9.1) could be an indication that there is high preference for homeownership over renting in the case of Ghana. This was also confirmed in prior study by Chan & Adabre (2019) among developing countries. Generally, economic development among developing countries mostly leads to increasing preference for homeownership over renting. This is not only attributed to reasons for shelter but also for investment. Besides, housing facilities serve as assets for hedging against the rapid escalation of general inflation rate and high advance rent charges. These could possibly be the reasons 'price of housing facility' (indicator of ownership) was rated higher than 'rental cost of housing facilities' (an indicator of renting) in the descriptive statistics.

Consequently, successive governments in Ghana have often built and sold out housing facilities to the general public in order to improve access to housing facilities among the citizenry. Though this practice is good to meet the desire for home ownership among the citizenry, it may not be a laudable policy for sustainable housing development as indicated in the measurement model of the sustainable housing construct. Hence, for sustainable housing from the Ghanaian perspective of the public sector, ensuring affordability of 'rental cost of housing facilities' is more sustainable than ensuring affordability of 'price of housing facilities'. The availability of public rental facilities in major cities in Ghana (i.e. Accra) will ensure access to housing facilities among the 40.9% of all urban households that depend on rental facilities.

Furthermore, technology transfer or innovation was significantly loaded as a CSC for sustainable housing. Prior studies identified technology transfer as one key indicator for public housing in Ghana (Adinyira et al., 2012). Technology transfer entails the use of new technologies that are cost effective to improve energy and housing supply. Improved technologies on the use of alternative materials for construction could advance sustainable housing development in Ghana. Currently, the Ghanaian construction industry relies so much on cement and its products for the construction of most housing facilities. Yet, aside being expensive, cement contributes to the emission of greenhouse gases. Approximately a ton of

CO_2 is emitted into the environment for each ton of cement produced. Besides, concrete production is one of the construction processes that emit the highest amount of CO_2 (Djokoto et al., 2014). Through innovative measures, environmental-friendly materials such as burnt bricks and hydraform bricks could be used together with cement for constructing housing facilities. This will reduce the number of bags of cement used for constructing housing facilities. Consequently, the rent of such housing facilities could be affordable to low-income household, and this could have ripple effects on the market equilibrium rent of housing facilities charged by developers. Besides, the amount of CO_2 emission could be mitigated since the amount of cement used for constructing housing facilities will be reduced.

Moreover, for sustainable housing, end-user's satisfaction and stakeholders' satisfaction are key CSC. Ensuring security provision is important for end-user's satisfaction. In addition, housing design features (i.e. separate bedrooms for parents and children), availability of public facilities (i.e. kindergarten and other basic level education facilities) and social design features (i.e. leisure facilities) within the neighbourhood are critical for households' satisfaction and stakeholders' satisfaction (Chan and Adabre, 2019).

Though the measurement model for the sustainable housing constructs revealed the CSC for sustainable housing, the attainment of these CSC is often hindered by key barriers. Besides, some of the strategies that are stated within the various indicators may not be attainable because of barriers to sustainable housing. These barriers that pertain to the Ghanaian housing market are discussed in subsequent sections.

9.1.10.2 'Cost-Related Barriers' Construct

'Cost-related barriers' were significantly measured by four-indicator items, namely, 'delays in government approval process' (CRB1); 'high upfront cost of building materials and technologies' (CRB2); 'high cost of serviced land' (CRB3) and 'high inflation rate' (CRB4). From the structural equation model (shown in Fig. 9.3), the construct for 'cost-related barriers' was not significant related to the constructs for 'sustainable housing' and 'retrofit-related barriers'. However, there was a significant relationship between 'cost-related barriers' and 'incentive related barriers'. Thus, although it has been stated that 'cost-related barriers' are critical barriers to sustainable development (Yang & Yang, 2015; Chan et al., 2016), surprisingly, 'cost-related barriers' do not have a direct significant impact on 'sustainable housing' from the Ghanaian perspective. Similarly, a study conducted by Darko et al. (2018) revealed that 'cost and risk-related barriers' did not have significant impact on green building adoption from the Ghanaian perspective. In Darko et al. (2018), 'incentive-related barriers' were significant as found in this study. Since 'cost-related barriers' rather have a direct significant influence on 'incentive-related barriers' (as shown in Table 9.7 & Fig.9.3), this implies that the 'cost-related barriers' are as a result of inadequate incentives in the Ghanaian housing sector. Similarly, Kaygusuz (2012) asserted that 'cost-related barriers' are secondary to other barriers such as lack of financing, education or proper incentives among most developing countries.

Accordingly, 'cost-related barriers' affect 'incentive-related barriers' which could then significantly influence one or more of the sustainable housing indicators. For example, 'delays in permit approval or government approval process' was significantly loaded as a 'cost-related barrier'. Delays in the Ghanaian construction industry is evinced in prior study. Gough & Yankson (2000) found that only 40% of land acquirers / developers were able to register their plots of land. Further analysis showed that among the 40%, some were able to register their plots of land in 12 months while some did so in five years. Bureaucracy in land registration delays sources of funding since most banks will usually require permit approval as one of the requirements for granting loans. Besides, 'delays in permit approval' increases the cost of capital / interest payment on borrowed funds since it interrupts development on land. Consequently, this increases the cost of housing construction, making such construction economically unsustainable. This does not incentivize or motivate developers to provide affordable housing since developers or landlords may increase the price / rent to expedite payment on borrowed capital used for constructing the housing facilities (Owusu-Ansah et al., 2019).

Concerning construction materials, cement is the main building material in most construction projects in Ghana. Within the past years, price of cement has increased exorbitantly. This has partly contributed to the high cost of housing construction and high rental charges among developers. Even if such houses were built in the past when costs of building materials were low, the current high cost of building materials and sustainable technologies could increase the sinking fund that private landlords have to deposit for the construction of similar facility after its lifespan or for maintenance of the facility. High sinking fund requirement for such purposes implies higher rental charges as evinced in the current Ghanaian rental housing market (Arku et al., 2012).

9.1.10.3 'Incentive-Related Barriers' Construct

'Incentive-related barriers' were significantly measured by 'inadequate incentive for private investors' (IRB1); 'inadequate access to secured land' (IRB2); 'income inequality' (CRB7) and 'lack of planning control on land development' (IRB3). From the structural equation model (as shown in Fig.9.3), the construct for 'incentive-related barriers' had direct significant impact on the construct for 'sustainable housing'. It also has direct significant impact on 'retrofitting-related barriers'. These relationships mean that 'incentive related barriers' could directly influence sustainable housing and indirectly by instigating 'retrofit-related barriers'.

A major incentive-related barrier to sustainable development is split incentive (Alam et al., 2019). In most tender documents for construction projects, tenderers are requested to provide tender security, advance payment security, tax payment certificates and other documents as prequalification requirements. However, project sustainability measures or policies are often not requested. Therefore, though the tenderers may have the required expertise for sustainable housing they may be reluctant to integrate sustainable technologies / measures into such developments. This is because if such technologies are integrated into housing projects, the beneficiaries of such technologies are the potential residents or households while the contractor may incur higher cost for sustainable development. The cost may not be reimbursed if borne out of contractual agreement. Besides, contractors are not incentivized (i.e. no certificate of recognition for sustainable development) to provide them a competitive advantage in subsequent tendering for public projects.

Another incentive-related barrier to sustainable housing is 'inadequate access to secured land'. This is attributable to the customary land tenure system in Ghana, which often results in litigations over land with ripple effects of delays in court proceedings. Inadequate plot lay-outs, time-consuming boundary disputes and conflicts are some of the problems associated with customary land tenure system in Ghanaian construction industry (Gough & Yankson, 2000). Moreover, the customary land tenure is bedevilled with problems of multiple land sales and boundary disputes due to the state of land transaction, inefficient data storage and unscrupulous land sales (Crook, 2004). For instance, land disputes pending in Ghanaian courts due to family disputes are 52.7% while 17.7% are boundary disputes and 12.8% are disputes due to unauthorized sale of land by chief or stranger and 4.9% are unauthorized sale by a family member (Crook, 2004).

Furthermore, income inequality is a major barrier to sustainable housing development in most urban centres in Ghana. Sulemana et al. (2019) found a positive correlation between income inequality and corruption. Similarly, Owusu et al. (2019) revealed that most procurement activities in Ghana are susceptible to corrupt practices. Thus, public housing facilities which could be economically sustainable in perpetuity through renting of such facilities are mostly bought by public officials or party members for investment purpose. This practice often leads to increasing income inequality between low-income earners and high-income earners in most developing countries. Moreover, income inequality could be exacerbated by weak enforcement of planning control on land development (Agyemang & Morrison, 2018). According to David Ricardo, as more and more land is brought into production, landowners capture a share of the total value accruing to land, which leads to general decline in economic growth (Obeng-Odoom, 2010). Explaining this further in the context of cities, Stilwell (2011) stated that increasing urbanization leads to widespread use of land for roads and housing. Consequently, the value of land appreciates which is captured by landowners. Therefore, there is an incentive for high-income earners (the rich) to merely buy and hold land till it accumulates values resulting from road and other infrastructure development provided by the government or public. Without planning control on land (i.e. time-limited holding on vacant land and taxes that capture values on land attributed to public infrastructure supply), speculations could increase prices of land and, consequently, the prices/rent of housing facilities. Thus, such facilities could be unaffordable to low- and middle-income earners. This could lead to high income disparity, income segregation and slum development in cities.

Based on the significant direct impact of ‘incentive-related barriers’ on sustainable housing, the provision of adequate incentive schemes to various stakeholders could motivate sustainable housing development. For instance, in addition to the usual required documents (i.e. bid security, VAT & SSNIT Clearance Certificate), tenderers of public housing project should also be assessed based on their sustainability attainment strategies on the project. Thus, evaluation of tenderers on sustainability strategies/performance should be conducted and the outcome of their sustainability strategies should form part of the prequalification and selection criteria for a contractor (Sourani & Sohail, 2011). This approach could be a remedy for the problem of split-incentive. Besides, financial incentives such as interest free loans and non-financial incentives such as expedited permit approval could be offered to contractors / developers. This could reduce the cost of capital on borrowed funds incurred by contractors due to delays in land registration. In return for expedited permitting or low-interest loans, contractors may be required to integrate some sustainable strategies or technologies into the housing facility.

Moreover, since 'incentive-related barriers' indirectly affect sustainable housing through 'retrofit-related barriers', policies on incentives could be developed to enhance retrofitting activities. An innovative financing incentive such as revolving fund could be established to incentivize sustainable housing development among developers and energy efficient retrofit among households. Though upfront investment for the revolving fund could be high, it is suitable for developing countries with frequently constrained public fund and financial austerity. This scheme could be cost-neutral in the long term (Gouldson et al., 2015). With revolving fund, initial deposits could be provided by the government and other financial institutions. Then, the fund can be provided as low-interest loans to low-income and middle-income households for energy efficient retrofitting. For instance, since the adoption of solar panels is at an incipient stage in Ghana, the fund could enable households to purchase tin film solar photovoltaic (PV) polymer for alternative source of energy for lighting and other minor domestic uses. Consequently, the savings in energy cost, attributed to the PV panels, after accounting for rebound effects and performance gaps, could be used for the amortisation of the loan for subsequent funding of retrofitting activities. Arguably, most Ghanaian could be averse to loans that are linked to housing facilities. Therefore, to encourage households' participation and to reduce rebound effects on energy savings, a percentage of the savings could be given as 'cash-back' to households who participate in the scheme.

9.1.10.4 'Retrofitting-related barriers' Construct

The items/indicators that significantly measured 'retrofit-related barriers' include: 'low-level or inadequate maintenance operation/retrofitting of existing housing facilities' (RRB1); 'inadequate policies or sustainability assessment tools for retrofitting' (RRB2); 'lack of routine maintenance/poor maintenance culture of public housing facilities' (RRB3) and 'policy instability/abandoned public housing facilities or projects by successive governments' (RRB4). From the structural model (shown in Fig. 9.3), 'retrofit-related barriers' have a direct significant impact on 'sustainable housing'.

Retrofit is the replacement of element or components of a building. In a broader perspective, the U.S. Green Building Council (USGBC) defined retrofit as "any kind of upgrade of an existing building that is wholly or partially occupied to improve energy and environmental performance, reduce water use and improve comfort and quality of the space in terms of natural light, air quality and noise – all done in a way that it is financially beneficial to the owner." 'Inadequate retrofitting or low-maintenance operation' is one of the critical barriers to sustainable housing in Ghana and other developing countries. Gyamfi et al. (2018) reported that through the replacement of 6 million incandescent lamps with compact fluorescent light (CFL), a saving of 200-240MW was achieved. However, without broadening this retrofitting or maintenance operation to other appliances, these savings are often lost as a result of rebound effects. Similar to the case of Ethiopia, a significant energy saving was achieved through CFL bulb distribution program. Yet, about 20% of the initial energy savings was loss to rebound effects within 18 months after the execution of the programs (Costolanski et al., 2013). Rebound effects are typical in a growing economy. As noted by Gyamfi et al. (2015), "rapid economic development in Ghana results in increased per capital income." As such, changes in households' behaviour such as demands for other electrical appliances (if the appliances are not energy efficient), could annul the energy savings from other energy efficient appliances. Thus, though the 2007 CFL bulb distribution and supply of energy efficient refrigerators in Ghana are laudable policies, there should be an extensive retrofitting regarding freezer, television, electric iron, washing machine and air-conditioners or electric fan to avoid rebound effects on the energy savings from using CFL and energy efficient refrigerators.

Furthermore, 'inadequate policies/standards and tools' are key barriers to retrofitting aged housing facilities to sustainability standards. Information dissemination policies on energy saving techniques and energy efficient appliances to guide household in energy consumption and purchasing decisions are inadequate. Besides, directive-based policies or mandatory-based policies on retrofitting of existing public housing facilities are lacking. Moreover, evaluation-based policies for assessing retrofitting operation on existing housing facilities and for new housing projects are inadequate in Ghana. Finally, sustainable construction and retrofitting of housing facilities are hindered by the absence of tailored sustainable policies for housing facilities. For instance, Green building rating systems such as leadership in energy and environmental performance (LEED), Global Sustainability Assessment System (GSAS) and Green Star do not provide complete assessment criteria for sustainable development (Awadh, 2017 and Hamid et al., 2014). According to Awardh (2017), these rating systems are environmental-oriented tools and are not sufficient to assess the social sustainability and economic sustainability development in housing facilities. Yet, these tools are often adopted for assessing sustainability of projects including housing facilities. Accordingly, the provision of sustainable housing policies (i.e. sustainable housing codes and rating systems) in Ghana will not only be relevant for retrofitting existing public housing facilities to sustainable standards but also for the construction of sustainable housing facilities.

Moreover, 'lack of routine maintenance/poor maintenance culture of public housing facilities' and 'policy instability/abandoned public housing facilities or projects by succeeding governments' are critical barriers (Twumasi-Ampofo et al., 2014) that could affect upgrading of unsustainable housing facilities to energy efficient facilities. These two barriers could be caused by insufficient time and financial resources to address sustainability issues. Sourani & Sohail (2011) argued that in a situation where funding is available within a limited period, public clients may not have enough time to address sustainability issues in retrofitting of aged housing facilities. Besides, due to short tenure of office coupled with limited resources and financial constraints, governments and politicians mostly favor their own interest of starting new projects while initiated projected by previous governments or aged unsustainable housing facilities are neglected.

Therefore, mandatory policies on passive designs of housing facilities such as cross ventilation could ensure energy efficient housing. By improving the ventilation design of housing facilities, households could reduce the use of fans and air conditioners and consequently reduce residential energy consumption. Furthermore, households are often ill-informed on energy efficiency of appliance when making purchasing-decision. As a result, most households may purchase appliance based on its initial cost. However, information on energy and lifecycle cost performance of appliances could enable households to make an informed decision. Policies on '*caveat emptor* - let the buyer be aware' of energy efficiency and lifecycle cost of an appliance could avert purchasing decision made solely on the initial cost of appliance. This could be achieved by enforcing the placement of labels on appliance to inform households on its energy performance and its long-term cost performance.

9.2 DATA ANALYSIS AND RESULTS - A SUSTAINABLE HOUSING MODEL FOR SUSTAINABLE CITIES: THE GHANAIAN PERSPECTIVE

9.2.1 CONCEPTUAL FRAMEWORK

Based on the analysis of the data from the international survey on critical success factors (CSFs) (as shown in Chapter 7), four main categories of CSFs were developed, namely, 'developers' enabling CSFs'; 'households' enabling CSFs'; 'mixed land use CSFs' and 'land use planning CSFs'. These groupings were further confirmed as appropriate in the case of Ghana through the confirmatory factor analysis in the PLS-SEM. Table 9.8 shows the categories of CSFs with their respective underlying factors while Fig. 9.4 shows how the various categories of CSFs could influence the critical success criteria (CSC) of sustainable housing.

Table 9. 8: Critical Success Criteria (CSC) and Success Factors of Sustainable Housing (Adopted from Chan & Adabre, 2019; Adabre & Chan, 2019)

Constructs	Code	Observable variables
Sustainable Housing (Measured by CSC)	CSC1	Timely completion of project
	CSC2	Construction cost performance of housing facility
	CSC3	Quality performance of project
	CSC4	Safety performance
	CSC5	End user's satisfaction with the housing facility
	CSC6	Project team satisfaction with the housing facility
	CSC7	Environmental performance of housing facility (Eco-friendly)
	CSC8	Reduced life cycle cost of housing facility
	CSC9	Maintainability of housing facility
	CSC10	Energy efficiency of housing facility
	CSC11	Reduced occurrence of disputes and litigation
	CSC12	Reduced public sector expenditure on managing housing facility
	CSC13	Functionality of housing facility
	CSC14	Technical specification of housing
	CSC15	Aesthetic view of completed house
	CSC16	Price affordability of housing facilities
	CSC17	Rent affordability of housing facilities
	CSC18	Reduced commuting cost/distance from the location of housing to public facilities
	CSC19	Technology transfer/innovation
	CSC20	Take up rate of housing facility (marketability of housing facility)
Success Factors		
Developers' Enabling Success Factors (DESF)	DESF1	Mandatory inclusion of affordable unit in developer's projects
	DESF2	Access to low interest housing loans to developers
	DESF3	Incentives for developers to include sustainable low-cost housing
	DESF4	Improved supply of low cost developed land by government
	DESF5	Energy efficient installations and designs
	DESF6	Water efficient design and installations
	DESF7	Use of environmentally friendly materials for construction
	DESF8	Effective private sector participation
	DESF9	Stable macro-economic system
	DESF10	Stable political system
Household Enabling Success Factors (HESF)	HESF1	Monitoring housing conditions/performance for retrofitting

	HESF2	Government provision of subsidies to households
	HESF3	Adequate maintenance of existing houses
	HESF4	Adequate infrastructure supply by government
	HESF5	Adaptable housing design
	HESF6	Transparency in allocation of housing facilities
	HESF7	Compliance with quality targets
Mixed-Use Development Success Factors (MDSF)	MDSF1	Adequate accessibility to social amenities
	MDSF2	Good location for housing projects
	MDSF3	Mixed development of housing and commercial buildings
	MDSF4	High rise housing developments within cities and town
Land Use Planning Success Factors (LPSF)	LPSF1	Linking commercial development approval to funding for housing
	LPSF2	Increase tax to discourage long holding periods of vacant land
	LPSF3	Siting low-cost housing within cities/towns
	LPSF4	Political will and commitment to low-cost housing by land-use strategy
	LPSF5	Taxation on property or capital gains for housing facilities
	LPSF6	Sufficient staffing of public housing/planning agencies

9.2.2 THEORETICAL MODEL

The aforementioned studies in the literature review (as shown in Chapter 4) provide the fundamentals for developing a theoretical model between the critical success criteria and success factors. A theoretical model/framework is a network of constructs that provides a thorough understanding of how the potential success factors could influence the critical success criteria for sustainable housing.

Collectively, five constructs constitute the theoretical model of sustainable housing (as shown in Fig. 9.4). The fact that there is the need for sustainable housing in Ghana and that sustainable housing is a construct that could be inferred from other observable variables (listed in Table 9.8) form the ontological basis of the theoretical model. The epistemological assumption is rooted on the unresolved problem of identifying the success factors among the four other constructs that could lead to the required observable variables/goals in the 'sustainable housing constructs' for ensuring sustainable cities. Based on the epistemological assumptions, four hypotheses were developed. The arrow line (as shown in Fig. 9.4) represents the direction of the hypothesized impact of a construct on another construct. The derived hypotheses include:

Hypothesis 1: 'Developers' enabling success factors' have a positive influence on sustainable housing.

Hypothesis 2: 'Household enabling success factors' have a positive influence on sustainable housing.

Hypothesis 3: 'Mixed-use development success factors' have a positive influence on sustainable housing.

Hypothesis 4: 'Land-use planning success factors' have a positive influence on sustainable housing.

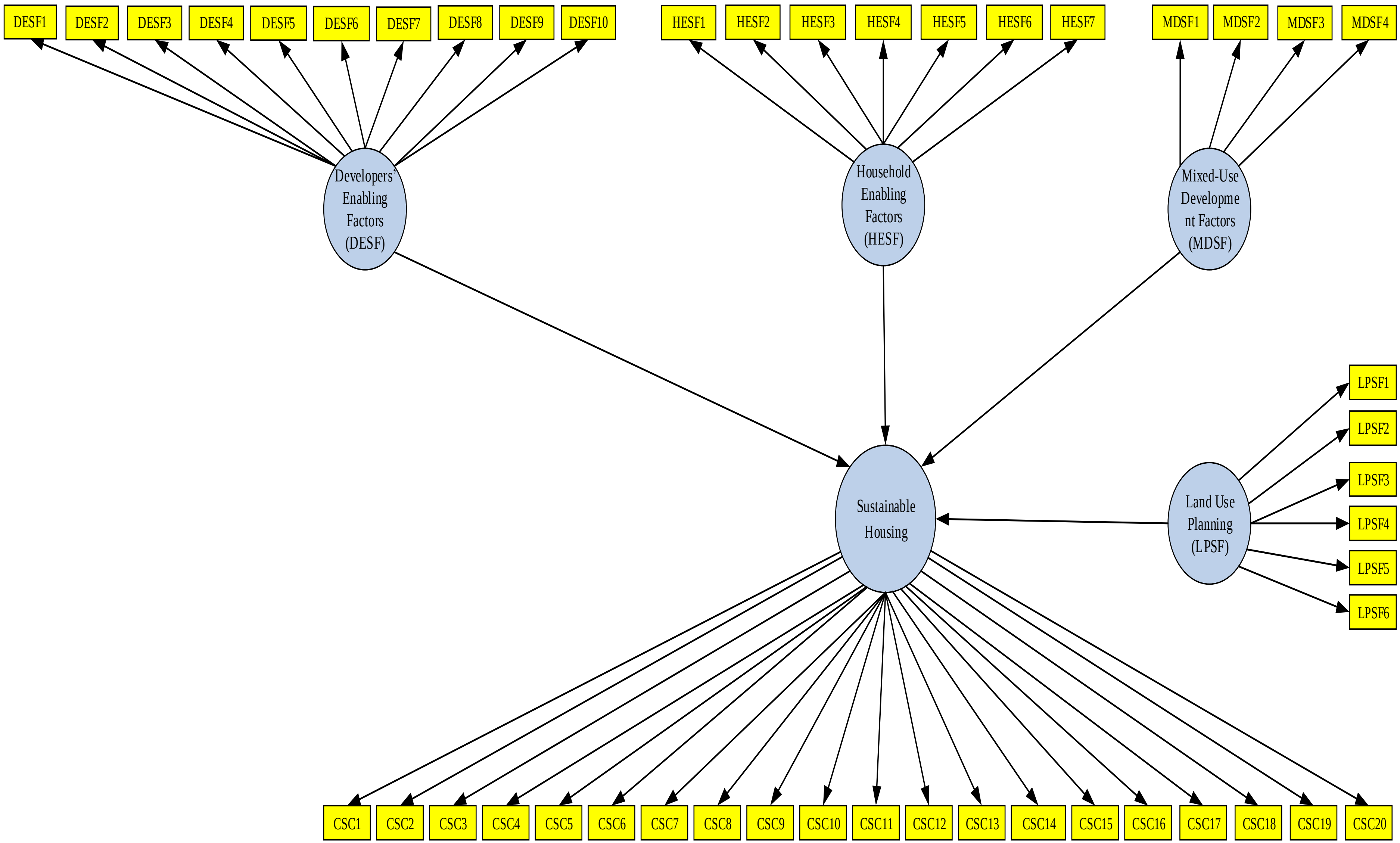


Fig. 9. 4: Theoretical Model of the Influence of Success Factors on critical Success Criteria of Sustainable Housing

9.2.3 DESCRIPTIVE & RELIABILITY ANALYSIS

From the results of the mean score ranking (shown in Table 9.9), respondents considered all the 20 critical success criteria of sustainable housing as important since they were rated above the scale category of *less important* (< 2) on the 5-point Likert scale. Apart from '*reduce disputes and litigation'*, all the other variables have relatively low standard deviations (< 1), which depicts a relatively high consistency in the rating of the variables by the varied respondents. Moreover, the overall Cronbach's alpha (0.878) for the 20 critical success criteria is satisfactory (Vaske et al., 2017).

Regarding the observable variables of the success factors, the mean scores vary from 4.511 (for political will and commitment to low-cost housing by land-use strategy) to 3.149 (for increase tax to discourage long holding period of vacant land). Other observable variables such as 'access to low interest housing loans for developers'; 'improved supply of low cost developed land by government'; 'use of environmentally friendly materials for construction'; 'stable political system' and 'adequate accessibility to social amenities' were among the top six success factors. In terms of reliability, the relatively low values (< 1) of the standard deviations of most observable variables suggest a relatively high consistency level among the different respondents who ranked the variables. Besides, the overall Cronbach's alpha (0.897) for the 28 observable variables of the success factors is above the recommended 0.70, which shows a satisfactory internal consistency of the success factors scale (Vaske et al., 2017).

Table 9. 9: Descriptive Statistics of Constructs and Observable Variables for Sustainable Housing

Construct	Code	Observable Variables	Mean Score	Standard Deviation	Rank	Corrected Item-total correlation	Cronbach's Alpha if Item Deleted	Overall Cronbach's Alpha
Sustainable Housing (Measured by CSC)								
CSC	CSC1	Timely completion of project	4.340	0.815	3	0.378	0.875	0.878
	CSC2	Construction cost performance	4.468	0.584	1	0.231	0.878	
	CSC3	Quality performance	4.343	0.644	2	0.496	0.872	
	CSC4	Safety performance (crime prevention)	4.085	0.803	10	0.654	0.867	
	CSC5	End user's satisfaction	4.319	0.980	4	0.646	0.866	
	CSC6	Stakeholders' satisfaction	3.957	0.833	12	0.385	0.875	
	CSC7	Environmental-friendly (Eco-friendly)	4.085	0.803	10	0.380	0.875	
	CSC8	Reduced lifecycle cost	3.933	0.918	14	0.502	0.872	
	CSC9	Maintainability of housing facility	4.283	0.851	6	0.566	0.869	
	CSC10	Energy efficient housing	3.915	0.880	16	0.547	0.870	
	CSC11	Reduced disputes and litigation	3.660	1.027	19	0.469	0.873	
	CSC12	Reduced public expenditure on housing management	3.851	0.932	17	0.377	0.876	
	CSC13	Technical specification	4.128	0.824	9	0.563	0.870	
	CSC14	Aesthetic view of housing facility	3.913	0.717	15	0.363	0.876	
	CSC15	Price affordability of housing facility	4.298	0.749	5	0.393	0.875	
	CSC16	Rent affordability of housing facility	4.196	0.824	7	0.472	0.872	
	CSC17	Commuting cost of household to facility	3.787	0.999	18	0.582	0.869	
	CSC18	Functionality of housing facility	4.174	0.789	8	0.567	0.870	
	CSC19	Technology transfer / innovation	3.468	0.856	20	0.621	0.868	
	CSC20	Take up rate of housing facility	3.936	0.818	13	0.264	0.879	
Success Factors for Sustainable Housing								
DESF	DESF1	Mandatory inclusion of affordable unit in developer's projects	3.915	0.952	22	0.526	0.894	0.897
	DESF2	Access to low interest housing loans to developers	4.404	0.712	2	0.366	0.897	
	DESF3	Incentives for developers to include sustainable low-cost housing	4.277	0.743	9	0.517	0.895	
	DESF4	Improved supply of low cost developed land by government	4.383	0.739	3	0.369	0.897	
	DESF5	Energy efficient installations and designs	4.085	0.855	17	0.396	0.897	
	DESF6	Water efficient design and installations	4.277	0.579	8	0.475	0.896	
	DESF7	Use of environmentally friendly materials for construction	4.370	0.671	4	0.529	0.895	
	DESF8	Effective private sector participation	4.064	0.845	18	0.382	0.897	

	DESF9	Stable macro-economic system	4.174	0.601	12	0.325	0.898
	DESF10	Stable political system	4.319	0.783	7	0.270	0.899
HESF	HESF1	Monitoring housing conditions/performance for retrofitting	4.149	0.834	14	0.680	0.891
	HESF2	Government provision of subsidies to households	3.979	1.073	21	0.412	0.897
	HESF3	Adequate maintenance of existing houses	4.149	0.780	13	0.431	0.896
	HESF4	Adequate infrastructure supply by government	4.192	0.770	10	0.509	0.895
	HESF5	Adaptable housing design	4.044	0.833	19	0.581	0.893
	HESF6	Transparency in allocation of houses	4.000	0.860	20	0.461	0.896
	HESF7	Compliance with quality targets	4.128	0.711	15	0.488	0.895
MDSF	MDSF1	Adequate accessibility to social amenities	4.340	0.668	5	0.404	0.897
	MDSF2	Good location of public housing projects / facilities	4.192	0.825	11	0.480	0.895
	MDSF3	Mixed development of housing and commercial buildings	3.809	0.770	23	0.463	0.896
	MDSF4	High rise housing developments within cities and town	4.085	0.803	16	0.500	0.895
LPSF	LPSF1	Linking commercial development approval to funding for housing	3.723	0.902	24	0.514	0.895
	LPSF2	Increase tax to discourage long holding periods of vacant land	3.149	1.063	27	0.361	0.898
	LPSF3	Siting low-cost housing within cities/towns	4.362	0.705	6	0.379	0.897
	LPSF4	Political will and commitment to low-cost housing	4.511	0.621	1	0.322	0.898
	LPSF5	Taxation on property or capital gains for housing facilities	3.362	1.112	26	0.387	0.898
	LPSF6	Sufficient staffing of public housing/planning agencies	3.575	0.773	25	0.527	0.898

9.2.4 RESULTS OF PLS-SEM – MEASUREMENT MODEL ESTIMATION

The reliability of the survey data was evaluated by analysing the data using smart-PLS version 3.2.7. During the analysis, observable variables with loading below 0.50 were deleted, after which the analysis was reiterated until reliable and valid measurement models were obtained. The factor loadings of all the observable variables and the AVEs of the constructs were above the recommended 0.50 for internal consistency (shown in Table 9.10). The AVE measures the amount of variance extracted by a construct from it observable variables relative to the amount caused by measurement errors. Besides, since the composite reliability and the Cronbach's alpha of all the constructs are above 0.70 (shown in Table 9.10), it can be concluded that all constructs show a satisfactory level of convergent validity (Nunnally, 1978).

Table 9. 10: Results of Measurement Model

Constructs	Observable Variable	Factor Loadings[a]	AVE[b]	CR[c]	CA[d]
Critical Success Criteria (CSC)	CSC10	0.746	0.504	0.875	0.850
	CSC17	0.537	–	–	–
	CSC16	0.689	–	–	–
	CSC19	0.724	–	–	–
	CSC4	0.682	–	–	–
	CSC5	0.811	–	–	–
	CSC8	0.749	–	–	–
Developers' Enabling Factors (DESF)	DESF5	0.707	0.536	0.819	0.762
	DESF6	0.751	–	–	–
	DESF7	0.867	–	–	–
	DESF8	0.574	–	–	–
Household’ Enabling Factors (HESF)	HESF1	0.853	0.643	0.843	0.744
	HESF2	0.727	–	–	–
	HESF5	0.820	–	–	–
Mixed-use Development Factors (MDSF)	LPSF1	0.736	0.558	0.834	0.744
	MDSF1	0.836	–	–	–
	MDSF2	0.732	–	–	–
	MDSF3	0.673	–	–	–
Land-Use Planning Factors (LPSF)	LPSF2	0.868	0.712	0.881	0.805
	LPSF5	0.855	–	–	–
	LPSF6	0.806	–	–	–

Observable variables removed: observable variables or items are below 0.5 factor loading: CSC1, CSC2, CSC3, CSC7, CSC6, CSC9, CSC11, CSC12, CSC13, CSC14, CSC15, CSC18, CSC20, DESF1, DESF2, DESF3, DESF4, DESF9, DESF10, HESF3, HESF4, HESF6, HESF7, HESF8, MDSF4, LPSF3, LPSF4

a. All item loadings 0.5 shows indicator Reliability
b. All Average Variance Extracted (AVE) > 0.5 suggests Convergent Reliability
c. All Composite reliability (CR) > 0.7 implies internal consistency
d. All Cronbach’s alpha (CA) > 0.7 indicates Reliability

9.2.5 MEASUREMENT MODEL ASSESSMENT - DISCRIMINANT VALIDITY

9.2.5.1 Fornell and Lacker Criterion

From the results in Table 9.11, the highest correlation for a construct is the correlation between a construct and itself. These correlation values, indicated diagonally in Table 9.11, are the square root of the AVE of the latent variable and indicate the highest in any column or row. Besides, no correlation between any two constructs exceeded the square roots of their AVEs, which justifies the discriminant validity of the constructs (Chin, 1998).

Table 9. 11: Discriminant Validity (Fornell and Larcker Criterion)

Constructs	CSC	DESF	HESF	MDSF	LPSF
CSC	**0.710**	–	–	–	–
DESF	0.621	**0.732**	–	–	–
HESF	0.462	0.477	**0.802**	–	–
MDSF	0.674	0.521	0.681	**0.747**	–
LPSF	0.211	0.289	0.223	0.199	**0.844**

*The diagonal are the square root of the AVE of the Constructs and items and are the highest in any column or row; CSC=Critical Success Criteria; DESF=Developer-Enabling Success Factors, HESF=Household Enabling Success Factors; MDSF=Mixed Land-Use Development Success Factors and LPSF=Land use Planning Success Factors

9.2.5.2 Cross Loading of Items / Attributes

The discriminant validity can also be estimated using the cross-loading values of the observable variables. As shown in Table 9.12, observable variables had the highest factor loading on the constructs they were theoretically identified to measure as compared to their loadings in other constructs, indicating that discriminant validity by the cross loading was satisfactory.

Table 9. 12: Cross Loading of Observable Variables / Item

Variable	DESF	HESF	LPSF	MDSF	CSC
CSC10	0.561	0.477	0.083	0.565	**0.746**
CSC17	0.270	0.171	-0.111	0.343	**0.537**
CSC16	0.331	0.283	0.201	0.437	**0.689**
CSC19	0.531	0.394	0.270	0.515	**0.724**
CSC4	0.374	0.116	0.133	0.295	**0.682**
CSC5	0.476	0.423	0.096	0.522	**0.811**
CSC8	0.449	0.304	0.291	0.573	**0.749**
DESF5	**0.707**	0.401	0.154	0.414	0.418
DESF6	**0.751**	0.401	0.340	0.344	0.417
DESF7	**0.867**	0.376	0.237	0.489	0.604
DESF8	**0.574**	0.207	0.098	0.231	0.323
HESF1	0.472	**0.853**	0.110	0.595	0.386
HESF2	0.177	**0.727**	0.135	0.477	0.292
HESF5	0.451	**0.820**	0.277	0.559	0.417
MDSF1	0.317	0.466	0.079	**0.836**	0.534
MDSF2	0.47	0.483	0.099	**0.732**	0.561
MDSF3	0.331	0.512	0.208	**0.673**	0.392
LPSF1	0.426	0.587	0.234	**0.736**	0.500
LPSF2	0.202	0.176	**0.868**	0.122	0.193
LPSF5	0.181	0.189	**0.855**	0.174	0.150
LPSF6	0.337	0.199	**0.806**	0.211	0.186

Bold value indicates that each observable variable had the highest loading on its respective construct; CSC=Critical Success Criteria; DESF=Developer-Enabling Success Factors, HESF=Household Enabling Success Factors; MDSF=Mixed Land Use Development Success Factors and LPSF=Land use Planning Success Factors

9.2.6 STRUCTURAL MODEL ESTIMATION

The structural model results are shown in Fig. 9.5. The path coefficients are indicated on the lines linking the constructs. The higher the path coefficient between constructs, the higher the influence of the independent construct on the dependent construct. Path coefficients that range from 0.1 to 0.3 show weak influence from the independent construct on the dependent construct, coefficients between 0.3 and 0.5 indicate moderate influence whereas coefficients between 0.5 to 1.0 suggest high influence (Murari, 2015). Therefore, the results show that ‘developers’ enabling factors’ have a moderate influence (0.380) on ‘sustainable housing’. The ‘Mixed land use development factors’ have a high influence (0.530) on ‘sustainable housing’.

However, the path linking 'household enabling factors' and 'sustainable housing' revealed a weak influence (0.084). Likewise, the path between 'land use planning factors' and 'sustainable housing' indicates weak influence (0.040).

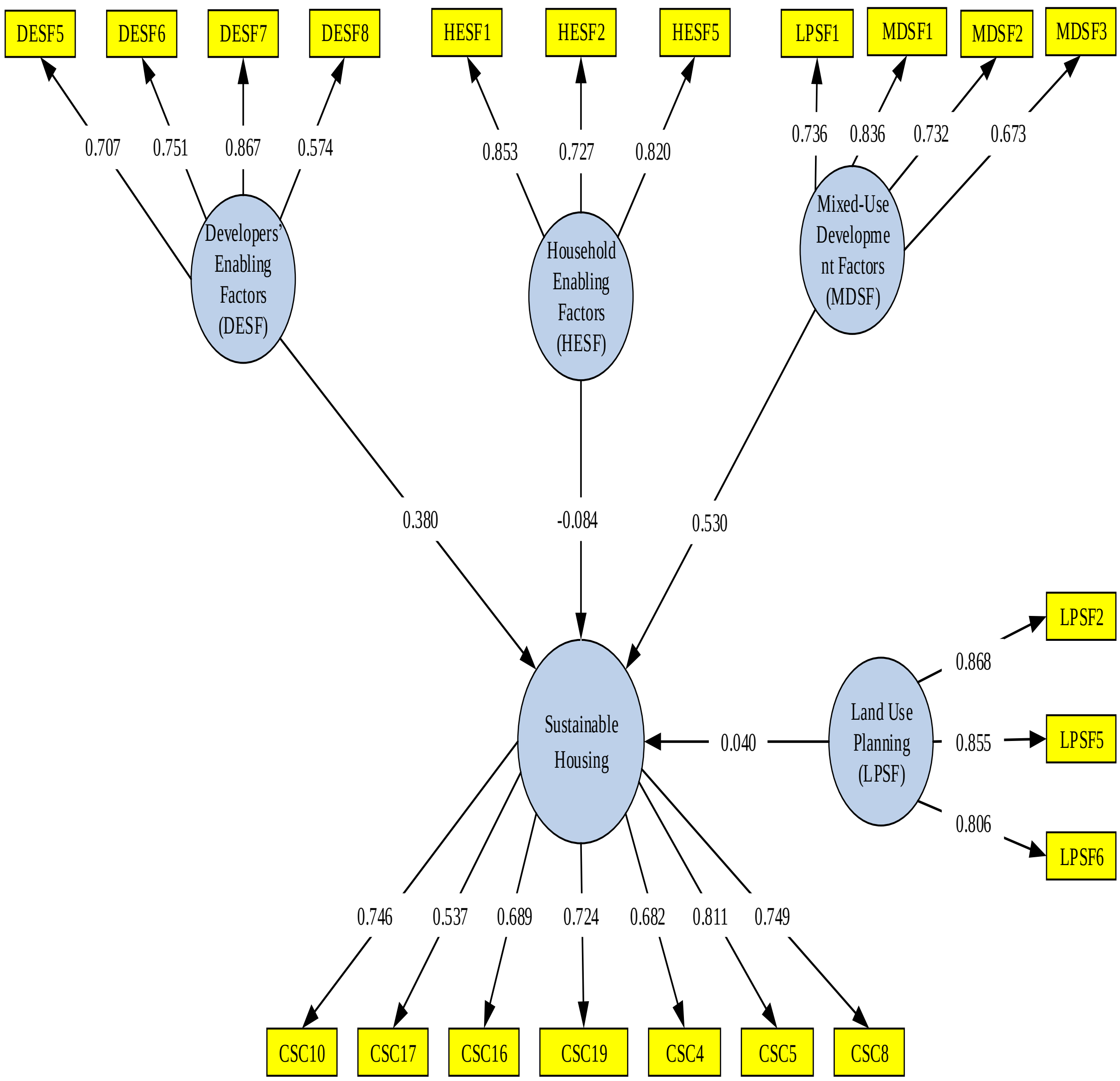


Fig. 9. 5: Structural Equation Model of Success Factors and Success Criteria

9.2.7 STRUCTURAL MODEL ASSESSMENT

The following tests were conducted to evaluate the structural model: multicollinearity test, model fitness test, assessment of coefficient of determination (R^2), test of significance of the structural model and assessing the effect size (f^2). The inner variance inflation factor (VIF) values were used to assess multicollinearity of the structural equation model. If the calculated VIF values are all below 5, then there is no multicollinearity. All the VIF values were below 5, which indicates that multicollinearity was not a problem with the structural model.

Goodness-of-Fit (GOF) of the model (as shown in Table 9.13) was analysed to corroborate that the model adequately explains the data. As shown in Table 9.13, some of the relevant parameters for estimating model fitness include standardized root mean square residual (SRMR), chi-square and the non-normed fit index (NFI). "The SRMR is an index of the average of the standardized residuals between the observed and the hypothesized covariance matrices". Lower SRMR values (≤ 0.08) imply good model fit. Furthermore, the NFI is mostly preferred to the Chi-square in predicting the goodness of fit. The closer the NFI to 1, the better the fit. Since the NFI was relatively high (above 0.50), the structural model has a good fitness (Lohmoller, 1989).

Table 9. 13: Test of Model Fitness

	Saturated Model	Estimated Model
SRMR	0.073	0.073
d_ULS	1.991	1.991
d_G	1.246	1.246
Chi-Square	244.166	244.166
NFI	0.562	0.562

9.2.7.1 Assessing the Coefficient of Determination (R^2) of the Structural Model

The coefficient of determination is a measure of the total effect size and variance explained in the sustainable housing construct (endogenous construct) by the success factor constructs. It measures the overall predictive accuracy of the structural model. The coefficient of determination obtained for this study is 0.558. This implies that the four constructs of the success factors adequately explain 55.8% of the variance in the sustainable housing construct. Thus, 55.8% of the change in the sustainable housing construct can be attributed to these four constructs. According to Hair et al. (2014), the R^2 value of 0.558 for this study is considered satisfactory.

9.2.7.2 Assessing the Significance and Relevance of the Structural Model

Prior to evaluating the significance and relevance of the structural model, the normality of the data was checked through the Mardia's Multivariate skewness and kurtosis. The skewness value and the kurtosis value were 5.722 and 35.212, respectively. These values were then compared to the cut offs i.e. Mardia multivariate skewness ±1 and kurtosis ±20. Since the computed skewness value and kurtosis value are higher than the cut offs, it shows that the data are not normally distributed. Therefore, bootstrapping could be used to assess the significance of the structural model. Bootstrapping analysis was conducted to examine the direct effects of all the hypothesized relationships. Results of the bootstrapping together with the t-values are shown in Fig. 9.6 and Table 9.14. Generally, if t-values are above 1.96 for a 2-tailed test, then the hypothesis is supported at 0.05 ($t_{0.05} > 1.96$). Similarly, if t-values are above 2.58 for a 2-tailed test, then the hypothesis is supported at 0.01 ($t_{0.01} > 2.58$) (Peng & Lai, 2012; Hair et al., 2016). From Fig. 9.6, the path linking 'developers' enabling success factors' to 'sustainable housing' construct had a t-value (2.640) greater than 2.58. This implies a significant path. Therefore, *hypothesis 1* was supported. Similarly, *hypothesis 4* was supported since its t-value (3.478) is above 2.58. However, with t-values of 0.609 and 0.117, respectively, *hypotheses 2* and *3* were not supported.

9.2.7.3 Assessing the Effect Size of the Structural Model (f^2)

The structural model was also assessed by calculating the effect sizes of the various constructs. Effect size (f^2) measures how strongly one independent construct contributes to explaining a certain dependent construct in terms of R^2. The effect size was evaluated by investigating the changes in R^2 to find out if there is a substantive impact on the sustainable housing construct from any of the success factor constructs. The effect size was calculated using eqn.9.3:

$f^2 = (R^2_{included} - R^2_{excluded}) / (1 - R^2_{included})$ ……………………………………………....…eqn. (9.3)

where $R^2_{included}$ and $R^2_{excluded}$ are the R^2 values of the dependent construct when a selected independent construct is included or excluded from the model. The change in the R^2 values is computed by estimating PLS path model twice: once with the independent construct included (generating $R^2_{included}$) and then with the independent construct excluded (generating $R^2_{excluded}$). At the structural level, the effect size of a construct is small if $0.02 \leq f^2 < 0.15$; medium, if $0.15 \leq f^2 < 0.35$ and large, if $f^2 \geq 0.35$ (Cohen, 2013). Table 9.14 shows the results of the effect size. From Table 9.14, 'developers' enabling factors' have moderate effect size (0.210) on 'sustainable housing'. Similarly, 'mixed-development success factors' have moderate effect size (0.290) on sustainable housing. However, 'household-enabling success factors' and 'land use planning success factors' have small effect sizes (0.007 and 0.002, respectively) on 'sustainable housing'.

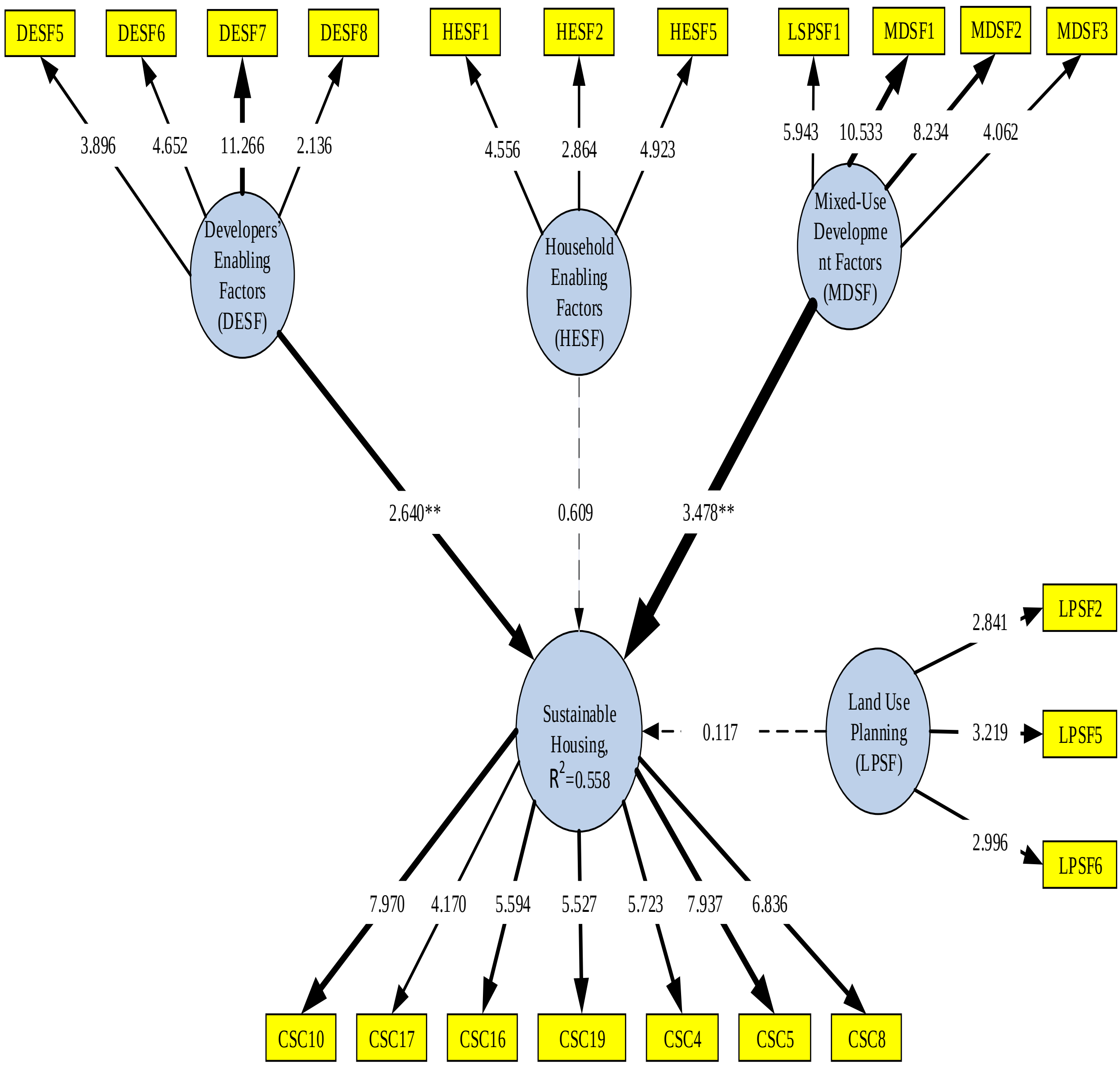


Fig. 9. 6: Structural Model of Influence of Success Factors on Critical Success Criteria of Sustainable Housing

Table 9. 14: Direct Relationships for Hypothesis Testing

Hypothesis	Relationship	Std. Beta	Std. Error	| t- value|^	Decision	f^2	95% CILL	95% CIUL
H1	DESF -> CSC	0.380	0.144	2.64**	Supported	0.210	0.159	0.650
H2	HESF -> CSC	-0.084	0.138	0.609	Not supported	0.007	-0.296	0.158
H3	MDSF -> CSC	0.530	0.152	3.478**	Supported	0.290	0.227	0.716
H4	LPSF -> CSC	0.040	0.126	0.117	Not supported	0.002	-0.167	0.242

**p < 0.01, *p < 0.05

R^2 (Sustainable housing = 0.558)

Effect size impact are according to Cohen (1988), f^2 values: 0.35 (large), 0.15 (medium), and 0.02 (small)

9.2.8 IMPORTANCE-PERFORMANCE ANALYSIS (IPMA)

It is useful to prioritise the constructs to identify those that are critical for the attention of policy-makers and practitioners. The critical constructs or factors could be identified by using the 'importance-performance analysis (IPMA)' (Ringle & Sarstedt, 2016). IPMA provides a broader view of the results of PLS-SEM by also taking the performance of each construct into account. Consequently, the constructs are prioritised based on two dimensions i.e., both importance and performance. Results of the IPMA are shown in Fig. 9.7 and Table 9.15. The x-axis represents the importance of the success factors constructs for explaining the sustainable housing construct while the y-axis depicts the performance of the success factors in terms of their average rescaled scores (Ringle & Sarstedt, 2016).

IPMA results shows those constructs with high importance (high total effect) but also have a relatively low performance (low score on sustainable housing). Generally, it is preferable to mainly focus on the constructs that show high importance but at the same time have relatively low performance regarding their explanation of the latent construct 'sustainable housing'. Therefore, by focusing on the lower right section of the IPMA results, it can be seen that 'mixed-use development success factors' have a high importance for sustainable housing development but at the same time shows a relatively low performance. Similarly, 'developers enabling success factors' shows a high importance and performance for 'sustainable housing' development. However, 'household enabling success factors' have relatively low importance but a relatively high performance on sustainable housing. On 'land use planning success factors', both its importance-performance values were the lowest in comparison with the other four constructs.

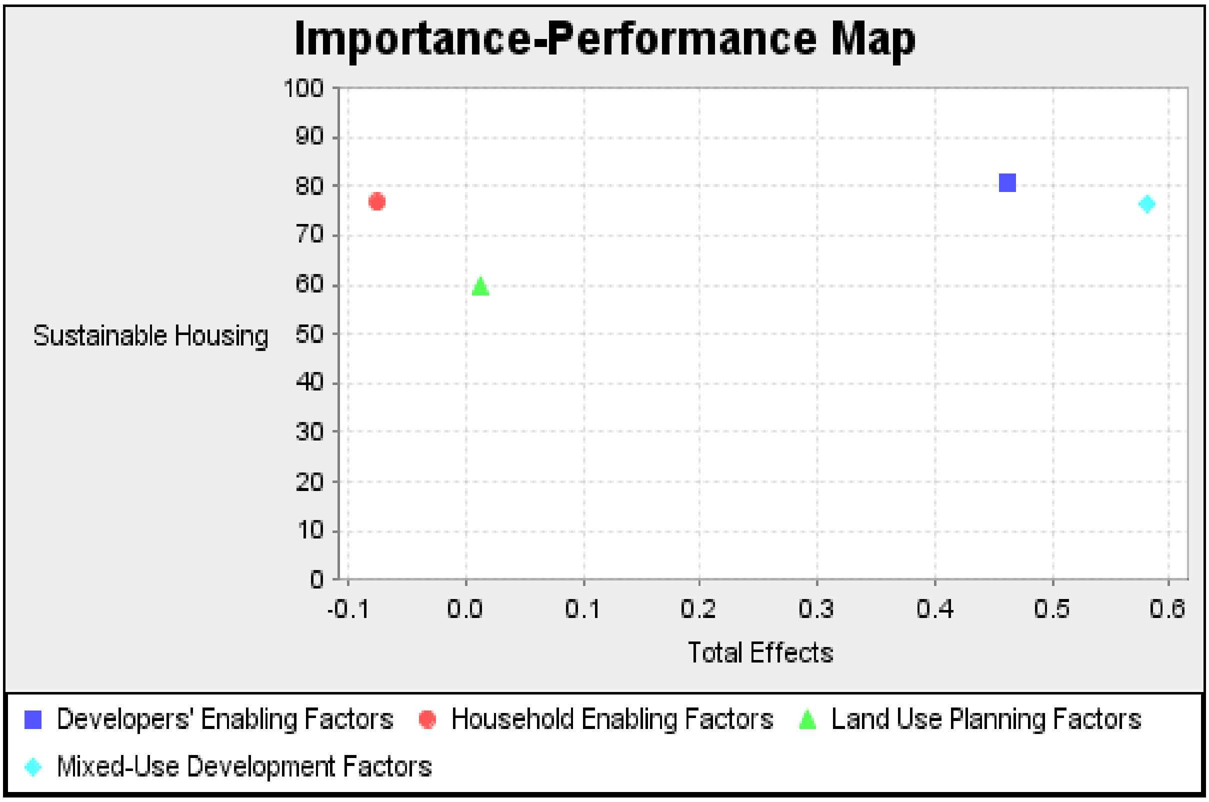


Fig. 9. 7: Results of Importance-Performance Map of Success Factors and Sustainable Housing

Table 9. 15: Importance-Performance Effect

Constructs	**Importance (Total effect)**	**Sustainable Housing / Performances (Index Values)**
Developers' Enabling Factors	0.462	81.000
Household Enabling Factors	-0.076	76.720
Land Use Planning Factors	0.012	59.998
Mixed-Use Development Factors	0.582	76.489

9.2.9 DISCUSSIONS OF MEASUREMENT AND STRUCTURAL MODEL RESULTS

From the measurement model, seven observable variables were significantly and reflectively loaded onto the 'sustainable housing' construct. These observable variables/goals together with their loadings in bracket include: CSC5-end user's satisfaction (0.811); CSC8- reduced lifecycle cost' (0.749); CSC10-energy efficient housing (0.746); CSC19-technology transfer (0.724); CSC16– rental affordability of housing facility (0.689); CSC4-safety performance or crime prevention (0.682) and CSC17- reduced commuting cost/distance from the location of housing to public facilities (0.537) (shown in Fig. 9.5 & Fig. 9.6). Therefore, sustainable housing could be achieved if policymakers focus much attention on achieving these seven goals. Subsequent sections include discussions on the categories of policies or success factors and how they could influence the goals.

9.2.9.1 Developers' enabling factors

This construct has a t-value of 2.640 and four main variables, namely, 'DESF7-use of environmentally friendly materials for construction (0.867)'; 'DESF6 – water efficient design and installation' (0.751); 'DESF5 –energy efficient installations and designs (0.707); 'DESF8 – effective private sector participation' (0.574) (shown in Fig. 9.6). This category of success factor or policy has a significant impact on sustainable housing (shown in Table 9.14). Besides, from the performance-importance map (shown in Fig. 9.7), it has the highest performance/index value (81.00) and a higher importance / total effect (0.462) on sustainable housing.

Effective private sector participation in housing supply is essential for sustainable cities in Accra and beyond. Developers or property owners could participate effectively through the provision of affordable rental facilities. Over three-quarters of the urban population in Ghana rely on rental accommodation (Asante et al., 2018). However, most rental facilities in urban centers are unaffordable with minimum rent advance to income ratios estimated at 209% and 132% for Kumasi and Tamale, respectively while the ratio for Accra could be speculated to be the highest. This is often attributed to high rent advances demanded by private developers or property owners (Arku et al., 2012). On this, Asante et al. (2018, p. 1235) averred that 'the lax in the enforcement of the rent control law has been the bane of Ghana's rental market'. Therefore, policymakers could ensure effective private sector participation in affordable rental facilities through legislation and incentive-backed policies. On legislation, it is essential to ensure enforcement of the Rent Act, 1963 which stipulates that landlords shall not demand more than six months of advance rent (Asante et al., 2018; Arku et al., 2012). Regarding incentive-backed policies, subsidies for refurbishment could be provided to property owners as a strategy for motivating compliance with the Rent Act. Besides, in public-private partnership housing projects, the government could focus more on providing rental facilities than owners-occupy facilities. Moreover, privatization through sales of existing public housing facilities could be minimized. This will ensure adequate availability of public rental facilities, which could be affordable in perpetuity.

Enhancing water efficient design and installation among developers or property owners is also essential for sustainable housing in the Accra-city region and beyond. From 1998 to 2013, there has been a declined in pipe-borne water supply by 29% (Cobbinah et al., 2020). Though access to water is relatively high in certain areas in the Accra metro such as Tema metro and the Ashaiman municipal, alternatively water supply from rainwater harvesting could reduce the overall demand of pipe-borne water for non-potable uses. Rainwater could be deployed in non-potable uses such as flushing of toilets, construction purposes, watering of gardening and washing of cars. Besides, installation of rainwater harvesting technology in cities will ensure effective management of surface water which could mitigate the common occurrence of flooding in Accra. The media through television and radio broadcasts could be an essential driver for promoting uptake of this technology. Such programmes could be focused on awareness creation on the socioeconomic benefits of rainwater harvesting technology. Furthermore, financial incentives such as subsidies on cost of rainwater harvesting technology, low-flow toilet, faucets aerators and showerheads could be utilized to enhance high take-up rate of these technologies among developers.

Moreover, with photovoltaic solar panels, radiation from the sun could be suitable for augmenting electricity generation in Ghana. The climate of the country is tropical which could be favorable for solar power generation. Currently, Ghana's electricity sector has been saddled with problems of inadequate electricity supply to the citizenry. Gyamfi et al. (2018) attributed this problem to fuel supply constraints and uncertainty in the rainfall patterns and water inflow into the hydroelectric plant. However, solar energy generation does not require fuel input and could lead to shorter payback time on investment if deployed in the Ghanaian settings. Photovoltaics is an environmentally and economically feasible alternative for electricity generation (Pinto et al., 2016). The adoption of solar panels among developers could lessen grid dependency; provide social benefits such as job creation. Implementation of solar technology requires robust policies for collaboration between the public sector and private sector. Subsidies and public demonstrations could serve as incentives to motivate the up-scaling of solar technology among developers. Awareness creation, nation-wide training of artisans including workers of VRA and ECG on installation of solar technology and how to store the power generated and the establishment of information centers are essential for promoting accessibility of expertise on solar technology. Furthermore, subsidies on cost of solar technology, availability of soft loans and tax incentives are key strategies for ensuring affordability and uptake of solar technology among members of GREDA.

9.2.9.2 Mixed-use development factors

Mixed-use development factors have a high t-value of 3.478 with four variables reflectively loaded as 'MDSF1 – adequate accessibility to social amenities (0.836)'; 'LPSF1-linking commercial development approval to funding for housing (0.736)'; 'good location of housing facility (0.732)'; 'mixed development of housing and commercial facilities (0.673)' (shown in Table 9.14 and Fig. 9.6). Besides, from the IPMA results (shown in Fig. 9.7 and Table 9.15), 'mixed-use development factors' have the highest importance/total effect (0.582) and a relatively high performance/index value (76.489) on sustainable housing.

It is worth noting that one of the variables 'high rise housing development within cities & town' was not significantly loaded under the 'mixed-use development factors'. This is not surprising since high-rise residential facilities have low social acceptability in the case of Ghana (Agyefi-Mensah et al., 2018). Institutional challenges concerning evacuation service provided by Ghana National Fire Service (GNFS) to households beyond sixth floor and low pressure for water supply services by the Ghana Water Company Limited (GWCL) above two storeys have been identified as some of the reasons for the low acceptability of high-rise housing facilities (Agyemang et al., 2018). As such, high rise facilities attract relatively low rents. However, in Hong Kong and other cities in Asia, rooms on upper floors have higher rental values than rooms on lower floors. Cooler air temperature attributed to high indoor air velocity could be the main reason for high rental values in the case of Hong Kong. In Ghana, rooms on the lower floors are preferred by households as a precautionary measure against falls among children. Besides, preparation of certain local dishes such as *fufu* and *konkonte* requires pounding which could cause vibration if such dishes are prepared on upper floors. Therefore, to encourage uptake of high-rise public and private apartments, improvement in the service capacities of institutions and adequate safety measures to prevent falls among children are key. Besides, through an expansion joint, part of high-rise buildings could be separated from the main structure to prevent vibration from preparation of certain local dishes.

Although public housing facilities could be price or rental affordable, they may not be truly affordable if household incur high transportation cost/time in accessing other facilities. Thus, housing location matters for sustainable cities. Optimally sitting new public housing facilities within existing infrastructure could reduce the cost of providing supplementary infrastructure or services for potential households. This could also be an antidote to urban sprawl. Thus, it promotes environmental sustainability through brown field development. Supplementary facilities such as shops, offices, multi-purpose parks, healthcare facilities and kindergartens are key for mixed land used development. This form of development improves accessibility through reduced commuting time and cost of households, reduces traffic congestion, lowers greenhouse gas emissions and abates inefficient energy consumption associated with excessive vehicular transportation (Song & Knaap, 2004).

'Linking commercial development approval to funding for housing' could be an innovative strategy to promote affordable housing and commercial development in cities. Without this strategy, housing in cities could be unsustainable for most low and middle-income earners. Commercial development brings with it the effects of price or rental unaffordability of housing facilities (Alawadi et al., 2018). Therefore, real estate developers in cities could be charged an impact mitigation fee. This strategy, if implemented, could be a source of revenue to the Ghana government. It could enable the government to augment infrastructure supply to enhance residential development among self-builders.

9.2.9.3 Household-enabling factors

The 'household-enabling factors' were loaded by three observable variables, namely, 'HESF1-monitoring housing conditions/performance for retrofitting (0.853)'; 'HESF2-government provision of subsidies to households (0.727) and 'HESF5-adaptable design of housing facility (0.820)' (as shown in Fig. 9.5 & Fig. 9.6).

Housing supply in Ghana is dominated by self-help housing. As such, various policies have been developed to enhance self-built housing and the upgrading of housing facilities. For instance, municipal and district assemblies in the Accra-Tema City-Region (ATCR) have established subsidies system for toilets and bio-digesters in pre-existing housing facilities. Moreover, utility bills of households are often subsidized to reduce the cost burden. Notwithstanding these policies, household-enabling construct does not have a significant impact on sustainable housing (shown in Table 9.15). This finding is in agreement with the assertion of Davis (2006) and Di Muzio (2008) that 'small-scale project-based approach to self-help upgrading has failed to make a significant impact on the housing crisis in the cities of the Global South' (cited in Gillespie, 2018). The insignificant impact of the 'household-enabling factors' could be attributed to challenges faced by self-built households in the Ghanaian housing market. Delays in land registration process, inadequate availability of mortgage packages, colossal cost of land and building materials have negatively affected most low-income earners. Consequently, it is estimated that low-and middle-income earners could spend 5-15 years to complete simple facility for their families, and most of such facilities are low-quality and unsafe. Besides, proliferation of slum is common in Accra since most low-income households resort to informal housing supply. These facilities are often erected on waterways, which leads to flooding. Furthermore, urban sprawl in the Accra-city region could lead to loss of peri-urban land, increased commuting time or cost due to increased traffic and increased vehicular emission. Moreover, lack of regulation on the drilling of wells for ground water is a major problem in both Accra-Tema City Region (ATCR) and Kumasi Metropolis. There are no regulations on who is allowed to drill and where to drill. Some households are taking advantage of the water crisis in these areas and are selling the water to other households that cannot afford to drill. The problem is that households are competing for the same resource – ground water – for domestic and commercial uses. These challenges negatively affect social sustainability, economic sustainability and environmental sustainability and could be the reasons for the insignificant impact of household-enabling factors on sustainable housing (Cobbinah & Amoako, 2012).

Furthermore, the importance (total effect) of 'household enabling construct' on sustainable housing is negative (-0.076) as shown in Table 9.15. This implies that some policies on 'household enabling factors' could be counterproductive to sustainable housing. For instance, the allocation of utility subsidies among households could be counter-productive to sustainable housing. All residential households in Ghana are offered utilities subsidies for the first 50kwh electricity consumed. However, utility subsidies have been identified as one of the reasons for the revenue shortfall in ECG. At the end of 2015, the Government of Ghana owed Electricity Company of Ghana an amount of GHS 950 million in subsidies and non-payment of bills by state institutions including ministries. Shortfall in revenue is rarely covered through timely monetary transfer (Eberhard & Shkaratan, 2012). This makes it difficult for utility companies to recover cost of electricity production (Kumi, 2017). Besides, the frequencies of maintenance operations and investment activities for expansion and improvement in quality of service are often cut back. These lead to inefficiency of major equipment in electricity distribution due to obsolescence of equipment. "About 21.7% of gross electricity generation over the last decade has been loss annually in transmission distribution as a result of inefficiency of equipment" (Kumi, 2017, p. 18). Additionally, subsidies could encourage higher electricity consumption among households since they may purchase additional electrical appliances without paying much attention to the energy efficiency of appliances because of the subsidies they enjoy. Thus, subsidies could have a rebound effect that negatively affects sustainable housing development (Kaygusuz, 2012). Therefore, utility subsidies could be reallocated to only energy poor households. Besides, the subsidies could be channelled to reducing cost of energy efficient technologies such as solar panel, which could incentivize the adoption of this technology among self-builders.

Albeit its insignificant impact and negative total effect, household enabling construct has the second highest performance/index value (76.720) on sustainable housing (shown in Table 9.15). This implies that through significant improvement and scale up of household-enabling policies, sustainable development could be achieved. Two aspects that need to be scaled-up are self-help housing cooperative and public housing supply. In both supply forms, it is essential that co-production and co-design should be conducted for the views of potential households to be incorporated into the design of housing facilities. This will ensure adaptable design of housing facilities to meet the spatial demand of households. Besides, permit approval for self-builders should "encourage proscriptive than prescriptive housing standards, as well as new housing designs that take account of the likely expansion of housing on the site over decades" (Awanyo et al., 2016, p. 36). Adaptable housing design will ensure housing extension for reducing overcrowding. It could also reduce illegal and unsafe building appendages and improve privacy. Ultimately, social sustainability would be achieved. Moreover, drilling of wells for ground water among households, as evinced in both Accra-Tema City-Region and Kumasi, should be regulated to ensure its availability for current and future generations.

9.2.9.4 Land-Use Planning Factors

'Land-use planning factors' have a t-value of 0.117 and it is reflectively loaded with three factors, namely, 'LPSF2-increase tax to discourage long holding periods of vacant land (0.868)', 'LPSF5-taxation on property or capital gains for housing facilities (0.855)'; 'LPSF6-sufficient staffing of public housing/planning agencies (0.806)'. Policies such as 'taxation on property or capital gains for housing development' and 'increase tax to discourage long holding periods of vacant land' could be considered as redistributive policies. Results of the structural model revealed that 'land-use planning factors' do not have a significant impact on sustainable housing (shown in Fig. 9.6 and Table 9.14). This is further buttressed by the results of the importance-performance map analysis (IPMA). From the IPMA results (as shown in Fig. 9.7 and Table 9.15), 'land-use planning factors' have a low total effect (0.012) and the lowest performance/index value (59.998) on sustainable housing.

The insignificant impact and the low IPMA output of 'land use planning factors' on sustainable housing imply that, these policies are unlikely to contribute significantly to sustainable housing in the Ghanaian housing market. Though these policies have proven effective in the case of the United Kingdom for providing affordable housing facilities (Whitehead, 2007), deploying similar strategies for housing supply in the case of Ghana may not yield significant outcome on sustainable housing in Ghana for the following reasons. The main reason is that in major cities such as Accra-Tema City Region, land is allocated by family heads, chiefs and Wulomei (chief priest); in Kumasi, it is by family heads and chiefs and by family heads and skins in northern Ghana. Although these authorities are in charge of land allocation, planning for land used is conducted by the Land and Spatial Planning Authority. As a result, there are always conflicts over land use and haphazard planning of most cities in Ghana. Another reason for the insignificant impact of land-use planning factors is the high level of corruption in the Ghanaian construction industry (Owusu et al., 2019). Similarly, Alesina & Angeletos (2005) cautioned that redistributive policies (taxations) that are intended to correct income inequality (such as equitable supply of housing facilities) could rather lead to high level of corruption and income inequality. Thus, high level of income inequality, corruption and rent-seeking could be self-sustaining in a bigger government.

Therefore, for the possibility of policy transfer from the case of UK to Ghana concerning land-use planning factors, there is the need to first regulate the delivery of land. This could minimize much of the corruption of officials involved in land delivery. Besides, effective anti-corruption measures should be implemented in addition into ensuring adequate staffing of the Land and Spatial Planning Authority for effective compliance with regulations for land delivery.

9.3 DEVELOPING A MODEL FOR SAH

9.3.1 AN INTEGRATED MODEL FOR SUSTAINABLE AFFORDABLE (LOW-COST) HOUSING

The model was developed based on various steps. First, the list of success criteria for assessing sustainable development were established vis-à-vis the housing crisis in the Ghanaian housing market. Next, sets of risk factors and barriers that could influence the success criteria were identified. Then, a list of intervention strategies (critical success factors) was established for mitigating the risk factors and barriers for sustainable housing. Partial least square structural equation modelling was used for establishing the relationship among the success criteria, barriers and success factors (as detailed in previous subsections of Chapter 9). The classifications of the various barriers and success factors were established prior to conducting the PLS-SEM. These classifications are adopted from a factor analysis from a broader survey among international experts (as detailed in Chapters 6, 7 & 8). Fuzzy synthetic evaluation was deployed to evaluate the impact of the risk factors on the success criteria (as detailed in Chapter 10). Finally, an integrated model (shown in Fig. 9.8) is developed based on the findings concerning the success criteria, barriers, risk factors and success factors.

9.3.2 GUIDELINES FOR IMPLEMENTATION OF THE MODEL

To ensure effective implementation of the sustainable housing model, six main systematic steps or implementation guidelines are established. The first step entails problem identification concerning unsustainable development among public housing and self-built housing. Then, a list of success criteria for assessing sustainable housing is developed. The possible risk factors that can negatively influence the attainment of the identified success criteria are established in step 3. The fourth step involves identifying the barriers that could hinder the achievement of the success criteria. In the penultimate step, step five, a set of success factors for mitigating the risk factors and barriers are established. The final step, step 6, involves an evaluation of the success criteria in achieving sustainable housing after intervention with the success factors (as shown in Fig. 9.8).

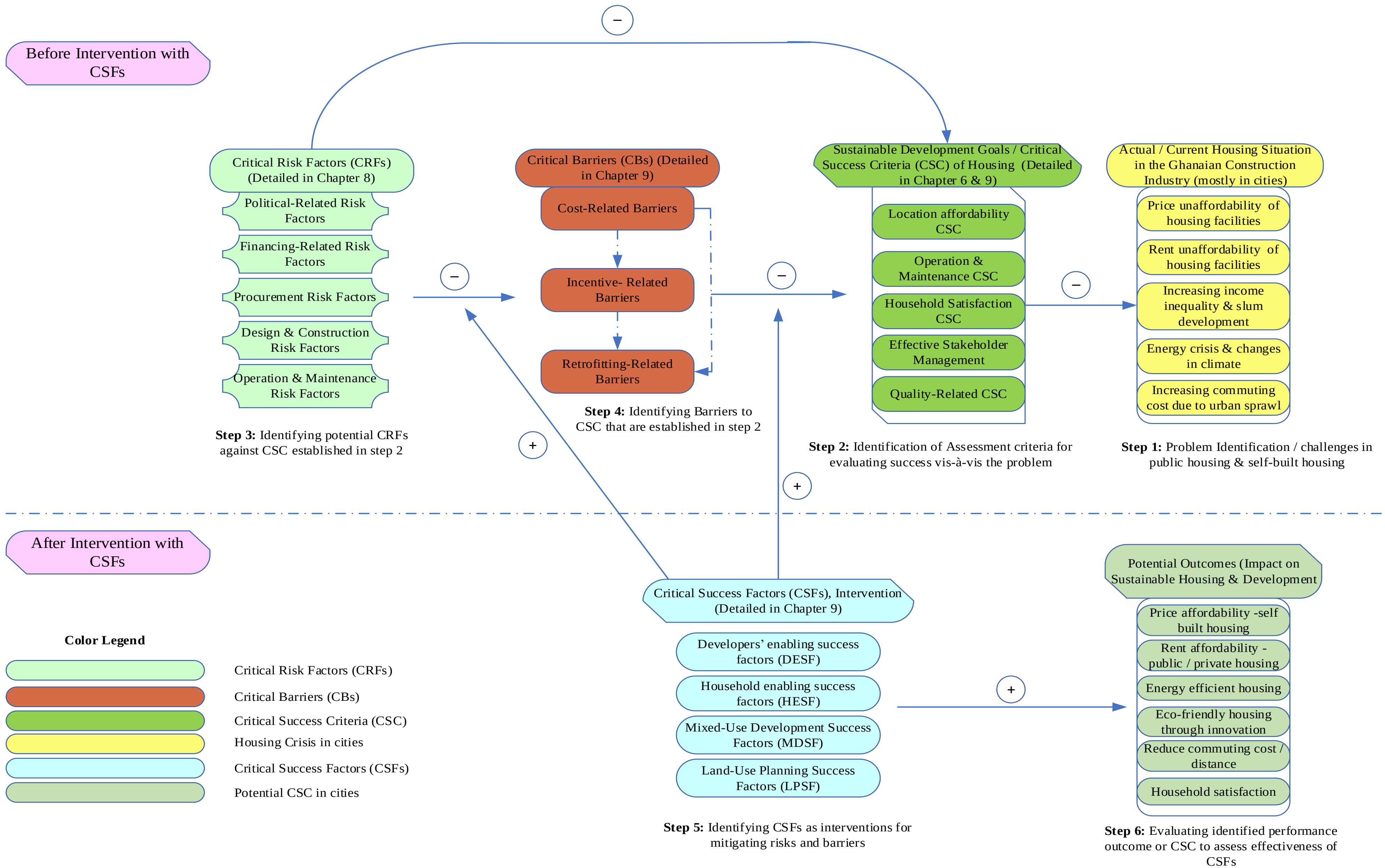


Fig. 9. 8: An Integrated Model of CRFs, CBs, CSFs & CSC for Sustainable Affordable Housing (SAH)

9.3 CHAPTER SUMMARY

This chapter investigated the impact of barriers and success factor on sustainable housing in the Ghanaian housing market. Besides, an integrated model was developed for sustainable affordable housing. The model was developed by integrating findings on critical risk factors, critical barriers, critical success factors and critical success criteria. Valid data were collected from 47 professionals in the Ghanaian housing market and analysed using descriptive statistics (i.e. mean score, standard deviation, 'corrected item-total correlation' and 'Cronbach's Alpha if Item deleted'). Furthermore, partial least square structural equation modelling (PLS-SEM) was employed in developing a model between sustainable housing and three categories of barriers: 'cost-related barriers', 'incentive-related barriers' and 'retrofit-related barriers', on one hand and between sustainable housing and four categories of success factors, on the other hand.

Findings of this chapter revealed some significant relationships among the constructs of the barriers on one hand and between constructs of the barriers and sustainable housing construct on the other hand. Significant relationships were found between 'cost-related barriers' and 'incentive-related barriers'; between 'incentive-related barriers' and 'retrofit-related barriers'. However, there was no significant relationship between 'cost-related barriers' and 'retrofit-related barriers'. Between the constructs of barriers and the sustainable housing construct, a significant relationship exists between 'incentive-related barriers' and sustainable housing; between 'retrofit-related barriers' and sustainable housing. However, the relationship between 'cost-related barriers' and sustainable housing was not significant.

Concerning the modelling between the CSFs and CSC, the findings of the study showed that measurement model of the sustainable housing construct was defined by seven critical success criteria namely, 'rental affordability of housing facility'; 'energy efficiency'; 'end-user's satisfaction';

‘reduced commuting cost’; ‘safety performance’; ‘reduced lifecycle cost’ and ‘technology transfer / innovation’. The ‘developers’ enabling success factors’ was defined by four variables, namely, ‘use of environmentally friendly materials for construction’; ‘water efficient design and installation’; ‘energy efficient designs and installation’ and ‘effective private sector participation’. ‘Mixed-use development success factors’ construct was defined by three indicators: ‘linking commercial development approval to funding for housing’; ‘good location of housing facility’ and ‘mixed development of housing and commercial facilities’. From the structural model, both ‘developers’ enabling factors’ and ‘mixed-use development factors’ have significant impact on sustainable housing. Though ‘household-enabling factors’ had no significant impact, they have high performance/index value on sustainable housing. Moreover, there was no significant impact regarding the ‘land-use planning factors’ which is measured by ‘increase tax rate to discourage long holding periods of vacant land’; ‘taxation on property or capital gains for housing facilities’ and ‘sufficient staffing of public housing/planning agencies’.

In the next chapter, Chapter 10, a validation of the study findings, conclusion of the study and recommendation are presented.

CHAPTER 10 VALIDATION, CONCLUSIONS AND RECOMMENDATION

10.1 INTRODUCTION

Various sections have been expounded in previous Chapters of this study. In Chapter 1, the introduction of the study was presented. This mainly entailed the research problem, aim and research objectives. Extant literature on key areas such as CSC, CRFs, critical barriers and CSFs were reviewed in Chapters 2, 3, & 4, respectively. Then, in Chapter 5, the methodology adopted towards achieving the overall aim and objectives was described. The factors from the literature review provided the basis for developing a questionnaire for data collection from respondents, first from international experts and then from professionals in Ghanaian housing market. Questionnaire survey among international respondents served as a strategy for piloting the questionnaire, for assessing the characteristics of the data and for drawing inferences for possible policy transfer. Subsequently, data were garnered from professionals in the Ghanaian housing market through questionnaire surveys.

Data analysis and findings from the international survey are reported in Chapters 6-7. The analysis of the data and presentation of findings from the Ghanaian perspective are proffered in Chapters 8-9. Using the findings from the Ghanaian perspective, a model for sustainable affordable housing was developed, which is also presented in Chapter 9. The present chapter is a validation study on the proposed sustainable affordable (low-cost) housing model. The chapter also draws a conclusion for the entire study by reviewing the research objectives. Furthermore, the present chapter offers the practical and theoretical significance of the study. Finally, the study’s limitation and recommendation for future research are stated.

10.2 VALIDATION OF SUSTAINABLE AFFORDABLE HOUSING MODEL

Validation is the key final step of a research process (Hu et al., 2016). Essentially, it tests the credibility and acceptability of the research output (Darko, 2018; Osei-Kyei, 2018; Ameyaw, 2014). In conducting a validation study, the important areas of focus include accuracy, reliability, practicality, suitability, objectivity and appropriateness of the research outcome (Yeung, 2007). Within the construction management domain, studies have revealed that there are six main aspects of research outputs that require validation, namely, construct validity, content validity, criterion validity, external validity, internal validity and face validity of the research output.

Validation of this study was conducted through a questionnaire for assessing the external validity, internal validity, construct validity and content validity. External validity concerns the generalizability of the research output (Hu et al., 2016). Thus, in this study, external validity was checked by assessing the broader applicability of the model among the various regions in Ghana. Internal validity assesses causality (Darko, 2018). In this study, internal validity was assessed by evaluating the lucidity and how understandable the sustainable housing model is for practice. 'Construct validity assesses if the study actually measures the various constructs it intended to measure' (Hu et al., 2016). Thus, it evaluates the operationalization and comprehensiveness of the various constructs (such as the CSC, CRFs, barriers and CSFs) in the sustainable housing model (Lucko and Rojas, 2010). Finally, assessing the research output as a reflection of the reality in Ghana was conducted through content validity (Lucko and Rojas, 2010). Content validity of the proposed model was conducted by assessing if the model including its constructs and the stated steps or implementation strategies could improve sustainable housing in Ghana given that it is accurately applied (Darko, 2018; Ameyaw, 2014).

Evaluating the various aspects of validation could be done either qualitatively or quantitatively (Yang et al. 2010). Whereas quantitative approach deploys objective and numerical data for testing hypothesized relationship among variables, qualitative approach employs research methods such as interviews for the collection of non-numeric and opinion-based data. In this study, the qualitative approach for validation is adopted since the various aspects of validations required for this study, namely, external validity, internal validity, construct validity and content validity are all examples of the qualitative approach (Lucko and Rojas, 2010). Comparatively, the qualitative approach provides a simple yet accurate validation approach for corroborating the outcome of this research.

10.3 VALIDATION SURVEY

As in previous studies (i.e. Darko, 2018; Osei-Kyei, 2017), a questionnaire survey was conducted for validating the sustainable affordable housing model. The questionnaire was administered by emailing it to respondents from the Ghanaian housing market. These respondents were selected based on the criterion that they never participated in the questionnaire survey during the data collection for developing the model. This approach to questionnaire administration is convenient for cost and time savings since it expedites communication between the researchers and the respondents. The validation questionnaire (found in appendix C) was modified from previous studies (Darko, 2018; Osei-Kyei, 2018). Though eight respondents from the Ghanaian construction industry were invited for authenticating the research outcome, only four respondents participated in the validation survey. The turn-out of four respondents compares approvingly with previous studies in the Ghanaian construction industry that used five respondents (Darko, 2018) and six respondents (Osei-Kyei, 2018) in their validation studies.

10.3.1 VALIDATION RESULTS

Through a five-point Likert scale (1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree), respondents were asked to indicate their level of agreement on each of the six validation statements (modified from Darko, 2018). The validation results are shown in Table 10.1. All the mean scores for each of the statement are above 3.50, which implies that the four validation aspects, namely, external validity, internal validity, construct validity and content validity for the sustainable housing model are adequate. Regarding the various aspects of the validation, statement 1 and 6 are appropriate for measuring the external validity of the developed model. From Table 10.1, mean score of 4.50 was obtained for statement 1, which implies that the CSC, CRFs, critical barriers and CSFs as established in this study are reasonable within the Ghanaian housing market. Concerning statement 6, mean scores of 4.50 was estimated for the SAH model which revealed the suitability of the SAH model for enhancing sustainable affordable housing in the Ghanaian housing market.

The internal validity of the SAH model was assessed through statement 2 in Table 10.1. The mean scores of 3.75 for the SAH model shows that the model is lucid and could effectively be implemented in the Ghanaian housing market. Construct validity for the SAH was assessed through statements 3 and 4. Both statements 3 and 4 obtained high mean scores of 4.00 and 4.50, respectively. The high mean score for statement 3 implies that the SAH model is appropriate for the Ghanaian housing sector. Besides, on statement 4, the result revealed that the SAH model has high level of inclusiveness.

Content validity of the SAH model was assessed using statement 5. Mean scores of 4.25 was obtained on this statement. As stated in Darko (2018), such high mean score implies that (1) the tendency for the SAH model for ensuring sustainability attainment in affordable housing is high if the SAH model is appropriately deployed by policy makers (such as Ministry of Works, Water Resource and Housing, Public Works Department and GREDA) in the Ghanaian housing market.

Overall, the high mean scores (> 3.50) for the SAH model for the four aspects of the validation imply the results of the research are reliable, credible, inclusive and appropriate for the Ghanaian housing market. Some steps have been taken to ensure the adoption of the SAH model and implementation strategy for sustainable housing. First, some of the results have been made available through publication outlets while some are under review. Part of the results were also made available through conference participation by the researchers. The results could also be made more available in the Ghanaian housing market through workshops, conferences and at the annual general meetings of some of the professional bodies in Ghana (i.e. Ghana Institute of Construction, Ghana Institute of Surveyors, Ghana Institute of Engineers, Ghana Real Estate Developers Association).

Table 10. 1: Validation Results of SAH Model and Implementation Strategy

No	Validation aspects / statements	Responses				Mean
		R1	R2	R3	R4	
1	The SAH CSC, barriers, risk factors and CSFs identified as significant in this study are reasonable and correctly reflect the current situation in Ghana	5	4	4	5	4.50
2	The sustainable affordable housing model is easily understandable and could be used in the Ghanaian construction industry	3	4	4	4	3.75
3	The guidelines or systematic steps as stated in the SAH are appropriate	4	3	5	4	4.00
4	The sustainable housing model is inclusive	5	4	4	5	4.50
5	The appropriate use of the sustainable affordable housing model will definitely help to achieve sustainable housing in the Ghanaian construction industry	4	4	4	5	4.25
6	Overall, the model is suitable for achieving sustainable affordable housing in Ghana	5	4	4	5	4.50

*R1-R4 represent the four respondents who participated in the validation process

10.4 REVIEW OF RESEARCH OBJECTIVES AND CONCLUSION

The ultimate aim of this research is to develop a model for bridging the gap between sustainable housing and affordable (low-cost) housing (SAH) for the Ghanaian housing market.

The global quest for sustainable housing is evinced in the United Nations Sustainable Development goals: Target 11.1 which states that "By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums". This clarion call is more exigent among developing countries in sub-Saharan Africa. As such, Ghana is selected as one of the sub-Saharan African countries for a case study to ensure sustainable development in housing. There are several issues that could arise concerning sustainable development in housing. First, although sustainable housing is the overarching goal, there should be sub-goals for accessing the attainment of this overarching goal. Thus, sustainable housing is a broader term that can only be measured or evaluated by accessing the sub-goals. For instance, sustainable housing could include sub-goals such as price / rental affordability of housing facilities, energy efficiency of housing facility, reduced commuting cost, housing satisfaction, quality of housing facility, stakeholders' / neighborhoods' satisfaction, functionality of housing facility etc. Thus, sustainable housing is a latent construct that can be measured by observable variables/sub-goals. The observables variables, which could be qualitative or quantitative variables, are herein referred to as critical success criteria (CSC). Another issue worth considering is that the CSC could be prioritized differently among various countries due to the specific needs of each country. Therefore, although identifying the CSC for accessing sustainable development is essential, yet more important is the prioritization of the CSC for ensuring efficient and effective resources distribution.

The identification and prioritization of the CSC is one thing while ensuring the attainment of the CSC is another. Ensuring sustainable housing, through the attainment of the CSC, is often influenced by risk factors. That is, the CSC are the project goals which could be affected either positively or negatively by the risk factors. In this study, only the negative impact of risks factors on the CSC is the main focus. This implies that the risks have negative influence on the CSC. Besides, if the risk factors are not adequately managed, they could culminate in barriers or constraints that could lead to project failure or obstruct the initial implementation of the project. The possible barriers or constraints are herein termed as critical barriers (CBs). Therefore, to ensure sustainable housing or achieve the CSC for sustainable housing, the risk factors and barriers or constraints should be controlled or mitigated by interventions. These interventions could be termed as policies or herein referred to as critical success factors (CSFs).

In summary, the CSC, the critical risk factors (CRFs), critical barriers (CBs) and the critical success factors (CSFs) or interventions or policies do not exist in isolation. Rather, they are interdependent or interrelated. The outcome of the CSC depends on the influence of the CRFs, CBs and CSFs. For this reason, a sustainable housing model should entail the CSC for clearly identifying and prioritizing the country's specific sustainable housing needs. Besides, the sustainable development model should reveal the influence of the CRFs and CBs on the CSC for the appropriate interventions. Finally, the intervention for controlling the CRFs and CBs while attaining the CSC should be specified for sustainable housing. Based on this argument, the following objectives were established concerning the research aim: objective one - to identify critical success criteria (CSC) for sustainability attainment in affordable (SAH) and to develop a sustainability assessment model for affordable housing in Ghana; objective two - to identify critical risk factors (CRFs) to Sustainability attainment in affordable housing; objective three - to identify critical barriers (CBs) to Sustainability attainment in affordable housing; objective four - to identify critical success factors (CSFs) for Sustainability attainment in affordable housing; objective five - to develop an integrated model for sustainable affordable housing in the Ghanaian housing market. The research methodology as deployed in this study is detailed in Chapter 5 while the analysis and findings of the study for various objectives are presented in Chapters 8-9. A summary of the findings and conclusion on each of the objectives are presented subsequently.

Objective 1: To identify critical success criteria (CSC) for sustainability attainment in affordable (SAH) and to develop a sustainability assessment model for affordable housing in Ghana.

To identify CSC for SAH, a comprehensive literature review was first conducted. Twenty-one (21) CSC were identified and used to develop a questionnaire. To test the relevance and characteristics of CSC and to further identify CSC that might have been omitted during the literature review, an international survey was conducted. Respondents were asked to rate the CSC and to suggest other CSC for SAH. Comments as well as findings from the international survey were used for enhancing the quality of the questionnaire for data collection from professionals in the Ghanaian housing market. Pattern in the results of the data analysis from Ghana were detected and easily explained by comparing it to the outcome from the international survey. Results (detailed in Chapter 8) revealed that the top five CSC for SAH include ‘quality performance of housing facilities’, ‘end user’s satisfaction’, ‘housing price affordability’, maintainability of housing facility’ and ‘rental affordability of housing facility’. Comparing the results from the international survey and results from survey in Ghana, among developed economies ‘rental affordability’ was ranked higher than ‘price affordability’. However, in the case of Ghana, ‘price affordability of housing facilities’ ranks higher. This shows a higher preference for homeownership than for renting in the case of Ghana.

The CSC as identified in the case of Ghana were used to develop a sustainability assessment model for affordable housing projects or public housing projects. Results of the model revealed that a four-index assessment model could be established, namely, 'housing and transportation (H+T) index', 'household satisfaction index', 'efficient stakeholder-management index' and 'quality-attainment index'. These indices account for 25.3%, 26.3%, 23.6% and 24.9% of sustainability attainment in affordable housing (detailed in Chapter 8). Accordingly, 'household-satisfaction' has the greatest contribution to sustainability attainment in affordable housing. This implies that although price/rental affordability of housing facilities is important, more important is ensuring households' satisfaction in such facilities. This finding could be implicated in the low take-rate of some public and private housing facilities in Ghana. This could be attributed to the speculative nature of these housing facilities. In most cases, the acquisition of land, design of the housing facilities and their construction are carried out without the target household. This creates the problem of unmet households' residential needs which results in a low residential take up rate of some facilities. Therefore, co-production and co-designing of public and private housing facilities with the target household could ensure residential satisfaction and high take-up rate of housing facilities. Furthermore, resources could be allocated to improve accessibility in order to reduce commuting cost or distance among households. This could be achieved when policymakers avoid sitting public housing facilities in the peri-urban areas or peripheral of cities, which lack adequate accessibility. A typical case of peri-urban sited housing project is the Saglemi housing project in the Ningo-Prampram District in the Greater Accra Region. With the hikes in fuel prices in Ghana, even if such facilities are price affordable, increasing commuting cost could annul the price affordability. Therefore, more commendable strategies are compact development and urban containing policies. The assessment model could also serve as a guide to policymakers for post-contract evaluation of housing projects procured through the local government or supranational organizations (e.g. the World Bank or the United Nations). Moreover, the indices could guide policymakers in resource allocation for retrofitting of existing aged housing facilities and for the upgrading of slum communities in most cities in Ghana.

Objective 2: To identify critical risk factors (CRFs) to Sustainability attainment in affordable housing

Thirty potential critical risk factors were identified from a comprehensive literature review. The CRFs were categorized into five underlying themes, namely, 'political-related risk factors', 'financing-related risks factors', 'procurement risk factors', 'design & construction related risk factors' and 'operation & maintenance risk factors'. These risk factors were piloted among Ghanaian experts and subsequently modified and finalized for data collection in the Ghanaian housing market. The data were analyzed using the fuzzy synthetic evaluation (FSE) technique. Results of the FSE (detailed in Chapter 8) revealed that 'financing-related risk factors' have the highest impact on sustainable housing followed by both 'procurement-related risk factors' and 'design & construction risk factors' then 'operation & maintenance risk factors' and lastly, 'political-related risk factors'. Considering the country's energy crisis, there is a need to ensure a more frugal use of the available energy. One of the strategies could be through retrofitting of existing public and private housing facilities and large-scale public facilities to sustainability standards (energy efficiency). For instance, in a guaranteed saving contract, a contractor with expertise on energy saving measures could design and implement an energy performance contract while financing of the contract is provided by a bank. However, the fluctuating interest rates and sometimes high financing cost by banks or financial institutions may render this initiative unfeasible in Ghana. Besides, fluctuating exchange rate could increase the cost of purchasing most of the energy saving technologies for retrofitting activities or for new construction projects since these technologies are mostly imported. Moreover, the challenge of policy instability in the Ghanaian construction industry and risk of default loans may induce a reticent attitude among banks in financing the purchase of technologies such as solar panels to augment the existing electric energy supply crisis among low and middle-income housing facilities. Furthermore, most households in Ghana are averse to loans that are associated with housing facilities. Therefore, aside adopting strategies for providing low-interest loans, the government of Ghana through the Ministry of Water Resources, Works and Housing could focus on tax-rebate and financial subsidies on the cost of solar technologies. This could reduce the impact of financial-related risks in the Ghanaian housing market and augment the purchase of sustainable technologies for sustainable housing.

The effects of 'fluctuating cost of finance' and 'fluctuating inflation rate' could be mitigated through draconian regulations that restrict treasury bill rates and fixed deposit rates to a single figure. The government could achieve this by regulating the use of short-term financing and rather deploy long-term funding such as bonds and stocks. This could partly reduce the rate of inflation in the country. Besides, low interest rates could discourage portfolio investments such as fixed deposits while promoting real investment such as housing supply among developers. Finally, to ensure expedited completion of public housing projects, some contractual clauses need to be reinforced while others ought to be established. For instance, there is the need for the reinforcement of the liquidated and ascertained damages (LAD) clause to encourage timely completion of projects on the part of contractors. However, issuance of payment bonds could prevent delay payment of contractors and its ripple effects of project abandonment and uncompleted housing projects.

Objective 3: To identify critical barriers to sustainability attainment in affordable housing

A comprehensive literature was first conducted and a list of 29 potential critical barriers were identified. Then, a questionnaire survey was conducted among international respondents from both developed and developing countries to identify the relevance, characteristics of the barriers (whether it is suitable for developing reflective or formative constructs) and to identify additional potential critical barriers. Outcome of the survey helped to improve the questionnaire for the main survey in Ghana as well as the analysis of the data. The results of data analysis from the Ghanaian perspective (detailed in Chapter 9) revealed that the top five critical barriers in Ghana include: 'high interest rates', 'high upfront cost of materials and technologies for sustainable housing', 'high cost of serviced land', 'policy instability / abandoned or neglected management of public housing facilities or projects by succeeding governments'. Partial least square structural equation modelling (PLS-SEM) of the responses showed that 'incentive-related barriers' have medium effect size (0.192) on 'sustainable housing' while 'retrofitting-related barriers' have high effect size (0.430) on 'sustainable housing'. Furthermore, 'incentive-related barriers' have a significant impact on 'retrofit-related barriers'. 'Cost-related barriers' only had a significant impact on 'incentive-related barriers'. Accordingly, 'cost-related barriers' are secondary barriers to sustainable housing in the Ghanaian housing market while incentive-related barriers and retrofitting-related barriers are primary. Thus, the results of the interactive assessment of barriers showed that although cost has been identified as barrier to sustainable housing in Ghana, the effects of cost could be attributed to the lack of incentives in Ghana. Therefore, incentive policies such as establishing a revolving fund, availability of low-interest loans and expedited permit approval could improve sustainable housing and incentivize sustainable construction. Developers and contractors should also be encouraged to include sustainable development strategies in housing projects. Developers and contractors should, in turn, be awarded with certificates that show their sustainable development track record. To ensure their relevance, tender requirements of public housing projects should include such certificates. On developers, prioritization of permit approval or regulatory procedure should take into consideration sustainable development strategies proposed by developers. Adopting these approaches to sustainable housing could mitigate the problem of split incentives in the Ghanaian housing market.

It also worth noting that incentive-related barriers have a significant impact on retrofitting-related barriers. Thus, to ensure upgrading of aged, unsustainable housing facilities, incentive-related policies are important. The government of Ghana has taken pragmatic steps in retrofitting of housing facilities through free-of-charge supply of energy efficient bulbs. However, incentives are inadequate to boost such operations to other households' appliance (such as iron, refrigerators, fans etc.). This is urgently needed in the Ghanaian housing market to avoid rebound effects on energy savings which is achieved through the replacement of the incandescent lambs with the energy efficient bulbs.

Objective 4: To identify critical success factors (CSFs) for Sustainability attainment in affordable housing.

A comprehensive review was conducted from which 27 potential CSFs were identified. These were used for a questionnaire survey among international respondents from developed and developing countries for the same reasons as stated in objectives 1 and 2. After further modification of the questionnaire, the main questionnaire administration was conducted among respondents in the Ghanaian construction industry. Forty-seven (47) valid responses were collected and analyzed using descriptive statistics (mean scores and standard deviation) and partial least square structural equation modelling (PLS-SEM). Results of the data analysis (detailed in Chapter 9) concerning the descriptive statistics showed that the top five highly ranked CSFs include: ‘political will and commitment to low-cost housing’, ‘access to low interest housing loans to developers’, ‘improved supply of low cost developed land by government’, ‘use of environmentally friendly materials for construction’ and ‘adequate accessibility to social amenities’. Confirmatory factor analysis showed that success factors for sustainable housing could be grouped into ‘developers’ enabling’; ‘households’ enabling’; ‘mixed-use development’ and ‘land-use planning’. Then, the PLS-SEM revealed that only ‘developers’ enabling’ and ‘mixed-use development’ success factors have significant impact on sustainable housing. However, through the Importance-Performance analysis, ‘household-enabling success factors’ ranked second concerning impact on sustainable housing albeit with a negative total effect on sustainable housing. The negative total effect implies that some of the household enabling success factors could be counter-productive to sustainable development in housing. A typical of this is with regard to utilities subsidies for every household for 50KW of electricity consumed. Instead, more laudable strategies could include reallocating energy subsidies to pro-poor households and redirecting the rest of the subsidies to solar technologies supply. Besides, the surplus subsidies could be used for adequate maintenance and increasing the capacity of the national grid. This will reduce loss of electric energy attributed to obsolescent equipment. Another implication of the negative total effect of the household enabling success factors is that some of the activities of the households could be counterproductive to sustainable housing development. For example, there is over-exploitation of ground water in most cities such as Accra and Kumasi. The problem is that most, without adequate policies to regulate such activity, the sustainability of groundwater for the future generation could be negatively affected.

Regarding 'land-use planning success factors', both its performance and total effect on sustainable housing are the least. This implies that 'land-use planning factors' could be ineffective policies. This assertion could be based on the challenges between owners of land and the Land and Spatial Planning Authorities. In Ghana, 80% of the land is customarily owned by the Chiefs, family heads, skin, stool and Wulomei while the development right on land resides with the planning authorities. In most cases, the land owners do not comply with the planning/development regulations provided by planning authorities. This often leads to residential development on unauthorize places which partly contributes to flooding. Therefore, sustainable housing through 'land-use planning' could be achieved if the delivery of land among family heads, chiefs and Wulomei is regulated. Additionally, the Spatial Planning Authority should be adequately provided with both financial resources and human resources in order to regulate the activities of land owners. Moreover, forging effective communication between the land owners and the authorities will ensure effective land-use policies for sustainable housing in Ghana.

Although mixed-use success factors have a significant impact on sustainable housing, one of its indicators 'development of high-rise housing facilities' within cities and towns was not significantly loaded. This is not surprising in the case of Ghana since there is a low-take up rate of high-rise residential facilities which is partly due to low household satisfaction. Yet, such facilities are essential for compact development, smart and sustainable cities. Therefore, co-production and co-designing of high-rise housing facilities are key to ensuring improved residential satisfaction and high preference for high-rise residential facilities. Additionally, improved capacity of the Ghana Water Company and the Ghana National Fire Service could enhance supply of services to households on subsequent floors (i.e. beyond third floor which is the capacity of most service providers). This could alleviate the aversion of household towards high-rise residential facilities in Ghana.

Between price affordability and rental affordability, the latter was significantly loaded as a criterion for ensuring sustainable housing. Thus, although there is a high preference for owner facilities in Ghana, supply of rental facilities is more important to meet the housing needs of tenants who constitute about 40% in most cities. Government-funded and donor-funded projects should focus more on supply of rental facilities. Besides, privatization of rental facilities to owner facilities should be minimized to ensure housing affordability in the long term.

Objective 5: To develop an integrated model for sustainable affordable housing in the Ghanaian housing market

The SAH model was developed based on the fuzzy synthetic evaluation results on the critical risk factors and the PLS-SEM results on CSC, critical barriers and CSFs. Based on the model, sustainable affordable housing could be achieved through the following guidelines / steps

1. Identification of the CSC for sustainability attainment in affordable housing
2. Development of an assessment model for resource allocation
3. Identification of possible risk factors and critical barriers that could hinder sustainable development in affordable housing
4. Identification of CSFs for mitigating the risk and barriers for a sustainability attainment in affordable housing

The SAH model was further validated by four experts from the Ghanaian housing market. Results from the validation confirmed the credibility, reliability and validity of the SAH model for improving sustainable housing in Ghana.

10.5 VALUE AND SIGNIFICANCE OF THE STUDY

Detailed discussion of the research findings is provided in Chapter 8-9. This section summarizes the findings. The research outputs have practical implication for policymakers and parastatal institutions in Ghana (Ministry of Water Resources, Works and Housing, Public Works Department) and private bodies (Ghana real estate developer's association, GREDA). The findings on the CSC revealed the key indicators for defining SAH in the Ghanaian construction industry. They also point out how resources could be allocated for SAH and for improving self-built housing. This could prevent housing overhang as evinced among some developing countries such as Malaysia, China and a developed country UK. It could also aid members of GREDA to improve sustainability attainment in low-cost housing or affordable housing in the Ghanaian housing market.

Besides, the findings of this study have practical implications for international organization such as the World Bank and the United Nations. These organizations could incorporate the findings and recommendations into their international programs for promoting sustainable affordable housing among most developing countries in sub-Saharan Africa since most of these countries share similar economic and political characteristics with Ghana. Promoting sustainable affordable housing among developing countries would contribute to achieving the Target 11.1 of the UN Sustainable Development Goal 11, which highlights the need for sustainable affordable housing for all by 2030.

Furthermore, the PLS-SEM models of the critical barriers and CSF revealed the CSC for SAH as well as the critical barriers that could hinder the attainment of sustainable development in affordable or public housing. The findings are relevant for policymakers and practitioners in the Ghanaian housing market.

10.6 LIMITATIONS OF THE STUDY

Notwithstanding the relevance of the study findings, there are limitations which are worth stating. First, the sample sizes of the study from the international survey and from the Ghanaian survey are relatively small in both cases. Therefore, the analysis of the data from the international survey is not robust enough to provide global views of respondents from developing and developed economies on the critical success criterial, critical barriers and critical success factors for SAH. Similarly, the available data from the Ghanaian survey are not robust enough to provide a thorough cross-country view.

Additionally, views of households or potential households were not included. The number of stakeholders was restricted to include mostly respondents from the industry. Besides, the perspective of households on the critical success criteria, critical risk factors, critical barriers and critical success factors for the attainment of sustainable housing was not included in this study. Thus, the study only focused on the views of professionals from the formal sector of the Ghanaian housing market while the views from the informal sector (households) were not considered, which could lead to information asymmetry in the housing market. This could lead to housing overhang as evinced in Ghana, Malaysia, China and UK etc. Although one of the constructs for the critical success factors – household enabling factors – is related to households, the constituents of this construct were assessed from views of professionals.

Moreover, the manual computation of the criteria's indices for the sustainability assessment model and the risk impact assessment was laborious. This is attributed to the complex mathematical computations with regard to the fussy synthetic evaluation technique. Therefore, the entire calculation was repeated whenever an error was detected from the onset of the development of the sustainability assessment model and the indices of the risk factors.

Finally, due to the limited size of the data (< 200) and the nature of the data (non-normally distributed), alternative data analysis such as the covariance-based structural equation modelling could not be conducted to confirm the findings from the partial least square structural equation modelling. Such alternative analysis could further corroborate the study's findings.

10.7 RECOMMENDATION FOR FUTURE RESEARCH

For further studies, it is would be interesting to analyze the views of households on the critical success criteria, critical risk factors, critical barriers and critical success factor together with the views of academics and contractors/developers. Future study with much larger responses could employ statistical analysis such as ANOVA to compare and determine any statistical differences among the views of the various affordable housing stakeholders. Such study, from the global perspective and the local perspective (i.e. in the case of Ghana), could improve the generalization and robustness of the study findings. This could enable international policymakers such as the United Nations to achieve the Sustainable Development Goal, target 11.1, in housing facilities both globally and locally. Besides, by including the views of households, this could resolve problems of information asymmetry in housing markets.

Furthermore, due to the laborious manual computation of the criteria's indices and risk impact assessment using the fuzzy synthetic evaluation technique, future study could develop a software to expedite the computation process in determining the various indices. Computer-aided programs could save time in correcting errors and for providing timely updates on indices of criteria and risk factors for sustainable housing. This is essential because of the transient needs of households and the mercurial nature of housing projects due to project risk factors.

Finally, with a larger sample size, future study could use covariance-based structural equation modelling (CB-SEM) to corroborate the findings of this study, or otherwise. This could improve the generalization of the findings.

10.8 CHAPTER SUMMARY

This chapter presented and validated the SAH model and the guidelines for ensuring SAH. The chapter entails elaboration on the conclusion and recommendation of the study. The conclusion regarding the research objectives was presented. This was followed by a description of the significance of the study and recommendation for future study. The following pages contain the appendixes and references for the study.

APPENDIX A

QUESTIONNAIRE FOR GENERAL SURVEY

Questionnaire Survey on Improving Global Supply of Affordable Housing in the Construction Industry.

<u>Letter to Participant</u>

Dear Participant,

Thank you for your participation. Access to affordable housing is a global problem which renders many people homeless and forms the major expenditure of household budget. Therefore, this questionnaire survey aims at soliciting the views of international experts towards improving the global supply of affordable housing in the construction industry. This aim forms part of an ongoing PhD research in the Hong Kong Polytechnic University. Your views and experience are vital for completing this questionnaire which will take approximately nine minutes of your time. Confidentiality of your responses will be strictly ensured. Once again, thank you for your immeasurable contribution and valuable time in making this survey a success. If you have queries, please you are most welcome to contact:

Adabre Michael Atafo
Department of Building and Real Estate, The Hong Kong Polytechnic University
Tel: +8526645 ; **Email**: 1790 @

Section A: Information of Participant

Q1. Please indicate the category you belong to (multiple answers allowed)
☐ Academia/research institute
☐ Consulting firm
☐ Public sector agency / department
☐ Private developer / contractor
☐ Other (s) (please specify): ***Click here to enter text***

Q2. Please indicate your years of industrial and / or research experience in affordable housing supply
☐ 1-5 years
☐ 6-10 years
☐ 11-15 years
☐ 16-20 years
☐ Above 20 years

Q3. Please indicate your professional background
☐ Architect
☐ Project / construction manager
☐ Client
☐ Engineer
☐ Quantity surveyor
☐ Academic/researcher
☐ Other (s) (please specify): ***Click here to enter text***

Q4. Which type of affordable housing supply have you ever been involved in as a practitioner or researcher?
☐ Public housing
☐ Social housing (owned and managed by the state or by non-profit organization or by both, usually with the aim of providing affordable housing)
☐ Cooperative housing (with cooperative housing, you own a part of a corporation that owns the building to provide affordable rent for housing)
☐ Other (s) (please specify): ***Click here to enter text***

Q5. How many affordable housing projects have you been involved in as a practitioner or researcher?
☐ 0
☐ 1-2
☐ 3-4
☐ 5-6
☐ 7 and above

Q6. Please state the country you work in: ***Click here to enter text***

Section B: Critical Success Criteria, Barriers and Success Factors and Barriers for the Supply of Affordable Housing

Q7. **Critical Success Criteria of affordable housing:** In measuring success of affordable housing supply, how would you rate the importance of the following indicators/criteria of success? **1= not important; 2=less important; 3=neutral; 4= important; 5= very important**

No.	Critical Success Criteria of Affordable Housing Supply	Level of Importance
1	Timely completion of project	☐ 1; ☐2; ☐3; ☐4; ☐5
2	Construction cost performance of housing facility	☐ 1; ☐2; ☐3; ☐4; ☐5
3	Quality performance of project	☐ 1; ☐2; ☐3; ☐4; ☐5
4	Safety performance	☐ 1; ☐2; ☐3; ☐4; ☐5
5	End user' satisfaction with the housing facility	☐ 1; ☐2; ☐3; ☐4; ☐5
6	Project team satisfaction with the housing facility	☐ 1; ☐2; ☐3; ☐4; ☐5
7	Environmental performance of housing facility (Eco-friendly)	☐ 1; ☐2; ☐3; ☐4; ☐5
8	Reduced life cycle cost of housing	☐ 1; ☐2; ☐3; ☐4; ☐5
9	Maintainability of housing facility	☐ 1; ☐2; ☐3; ☐4; ☐5
10	Energy efficiency of housing facility	☐ 1; ☐2; ☐3; ☐4; ☐5
11	Reduced occurrence of disputes and litigations among project team	☐ 1; ☐2; ☐3; ☐4; ☐5
12	Reduced public sector expenditure on managing housing facility	☐ 1; ☐2; ☐3; ☐4; ☐5
13	Functionality of housing facility	☐ 1; ☐2; ☐3; ☐4; ☐5
14	Technical specification of housing	☐ 1; ☐2; ☐3; ☐4; ☐5
15	Aesthetically pleasing view of completed house	☐ 1; ☐2; ☐3; ☐4; ☐5
16	House price in relation to income	☐ 1; ☐2; ☐3; ☐4; ☐5
17	Rental cost in relation to income	☐ 1; ☐2; ☐3; ☐4; ☐5
18	Commuting cost from the location of housing to public facilities	☐ 1; ☐2; ☐3; ☐4; ☐5
19	Technology transfer	☐ 1; ☐2; ☐3; ☐4; ☐5
20	Waiting time of applicants before being allocated a housing unit	☐ 1; ☐2; ☐3; ☐4; ☐5
21	Sustainable development	☐ 1; ☐2; ☐3; ☐4; ☐5
22	Take up rate of housing facility (marketability of housing facility)	☐ 1; ☐2; ☐3; ☐4; ☐5
Please indicate and rate other Critical Success Criteria of affordable housing supply (if any)		
23		☐ 1; ☐2; ☐3; ☐4; ☐5

Q8. **Barriers to the supply of affordable housing:** Please, do you agree that the following factors have constrained housing supply? **1= strongly disagree; 2= disagree; 3= neutral; 4= agree; 5= strongly agree.**

No.	Barriers to the Provision of Affordable Housing	Rating
1	Inadequate public funding	☐ 1; ☐2; ☐3; ☐4; ☐5
2	Tight credit conditions	☐ 1; ☐2; ☐3; ☐4; ☐5

No.	**Barriers to the Provision of Affordable Housing**	Rating
3	Inadequate mortgage institutions	☐ 1; ☐2; ☐3; ☐4; ☐5
4	High interest rates	☐ 1; ☐2; ☐3; ☐4; ☐5
5	High cost of serviced land	☐ 1; ☐2; ☐3; ☐4; ☐5
6	High inflation rate	☐ 1; ☐2; ☐3; ☐4; ☐5
7	High cost of building materials	☐ 1; ☐2; ☐3; ☐4; ☐5
8	Income segregation (separation between the rich and the poor)	☐ 1; ☐2; ☐3; ☐4; ☐5
9	High approval cost due to high taxes and fees on developers	☐ 1; ☐2; ☐3; ☐4; ☐5
10	Inadequate infrastructural development	☐ 1; ☐2; ☐3; ☐4; ☐5
11	Zoning restrictions on land for affordable housing projects	☐ 1; ☐2; ☐3; ☐4; ☐5
12	Community opposition to affordable housing projects	☐ 1; ☐2; ☐3; ☐4; ☐5
13	Income inequality (weak income growth of households)	☐ 1; ☐2; ☐3; ☐4; ☐5
14	Negative culture towards mortgage	☐ 1; ☐2; ☐3; ☐4; ☐5
15	High mortgage default rates by clients	☐ 1; ☐2; ☐3; ☐4; ☐5
16	Shortage of skilled labour	☐ 1; ☐2; ☐3; ☐4; ☐5
17	Inadequate incentive for private investors	☐ 1; ☐2; ☐3; ☐4; ☐5
18	Inadequate access to secure land	☐ 1; ☐2; ☐3; ☐4; ☐5
19	Delays in government approval process	☐ 1; ☐2; ☐3; ☐4; ☐5
20	Rent control policies	☐ 1; ☐2; ☐3; ☐4; ☐5
21	Limited productivity improvement / gains in the construction process	☐ 1; ☐2; ☐3; ☐4; ☐5
22	Inadequate affordable housing policy / framework	☐ 1; ☐2; ☐3; ☐4; ☐5
23	Poor maintenance culture of existing housing	☐ 1; ☐2; ☐3; ☐4; ☐5
24	Abandon public housing projects / policies by succeeding government	☐ 1; ☐2; ☐3; ☐4; ☐5
25	Weak enforcement of planning system control on property development	☐ 1; ☐2; ☐3; ☐4; ☐5
26	Inadequate autonomy of local authorities' due to high central government interference	☐ 1; ☐2; ☐3; ☐4; ☐5
Please indicate and rate other Barriers to the Provision of Affordable Housing (if any)		
27		☐ 1; ☐2; ☐3; ☐4; ☐5

Q9. **Success factors for the supply of affordable housing:** Please, rate the importance of the following factors in promoting successful supply of affordable housing. **1= not important; 2=less important; 3= neutral; 4= important; 5= very important**

No.	**Success Factors for Affordable Housing Supply**	Rating
1	Access to low interest housing loan / bank guarantee	☐ 1; ☐2; ☐3; ☐4; ☐5
2	Mixed land development (e.g. blend of housing and commercial buildings)	☐ 1; ☐2; ☐3; ☐4; ☐5
3	Linking commercial development approval to funding for affordable units	☐ 1; ☐2; ☐3; ☐4; ☐5
4	Stable macro-economic system	☐ 1; ☐2; ☐3; ☐4; ☐5
5	Effective private sector participation	☐ 1; ☐2; ☐3; ☐4; ☐5
6	Incentives for developers to include affordable units in their projects	☐ 1; ☐2; ☐3; ☐4; ☐5

No.	Success Factors for Affordable Housing Supply	Rating
7	Governments providing guarantees to developers	☐ 1; ☐2; ☐3; ☐4; ☐5
8	Improved supply of low cost developed land by government	☐ 1; ☐2; ☐3; ☐4; ☐5
9	Political will and commitment to affordable housing	☐ 1; ☐2; ☐3; ☐4; ☐5
10	Stable political system	☐ 1; ☐2; ☐3; ☐4; ☐5
11	Formulation of sound housing policy	☐ 1; ☐2; ☐3; ☐4; ☐5
12	Government's provision of housing subsidies	☐ 1; ☐2; ☐3; ☐4; ☐5
13	Good location for housing project	☐ 1; ☐2; ☐3; ☐4; ☐5
14	Adequate accessibility to social amenities	☐ 1; ☐2; ☐3; ☐4; ☐5
15	Mandatory inclusion of affordable unit policy in developers' projects	☐ 1; ☐2; ☐3; ☐4; ☐5
16	Adaptable housing design and construction	☐ 1; ☐2; ☐3; ☐4; ☐5
17	Transparency in allocation of houses	☐ 1; ☐2; ☐3; ☐4; ☐5
18	Adequate maintenance of existing houses	☐ 1; ☐2; ☐3; ☐4; ☐5
19	Monitoring condition /defects of completed housing	☐ 1; ☐2; ☐3; ☐4; ☐5
20	High density affordable housing development	☐ 1; ☐2; ☐3; ☐4; ☐5
21	Increase tax rate to discourage long holding period of vacant land	☐ 1; ☐2; ☐3; ☐4; ☐5
22	Adequate infrastructure supply by government	☐ 1; ☐2; ☐3; ☐4; ☐5
23	Compliance with quality targets	☐ 1; ☐2; ☐3; ☐4; ☐5
24	Adherence to project schedule	☐ 1; ☐2; ☐3; ☐4; ☐5
25	Compliance with project budget	☐ 1; ☐2; ☐3; ☐4; ☐5
26	Good coordination among project participants	☐ 1; ☐2; ☐3; ☐4; ☐5
27	Sufficient staffing of public housing agencies	☐ 1; ☐2; ☐3; ☐4; ☐5
28	Speculative measures on property sales through taxes	☐ 1; ☐2; ☐3; ☐4; ☐5
29	Taxation on property or capital gains for housing supply	☐ 1; ☐2; ☐3; ☐4; ☐5
30	Time limited planning approval / bonuses on land development	☐ 1; ☐2; ☐3; ☐4; ☐5
Please indicate and rate other Critical Success Criteria for Affordable Housing (if any)		
31		☐ 1; ☐2; ☐3; ☐4; ☐5

Q10. Please provide your email address if you wish to receive a summary of the research findings ***Click here to enter text***

-The End-

Many thanks for your participation

Questionnaire Survey on Improving Sustainability Attainment to Affordable Housing in the Ghanaian Construction Industry: Perspective of Ghanaian Construction Professionals.

<u>Letter to Participant</u>

Dear Participant,

Thank you for your participation. Inadequate access to affordable housing is a global problem which renders many people homeless and forms the major expenditure of household budget. As a result of this affordability crisis, there are worldwide issues on measures of success (herein referred to as criteria / indicators), success factors, barriers and risks with regard to sustainable affordable housing. Though many studies on these issues have been conducted in some specific countries, this survey aims to solicit the views of Ghanaian experts on them.

Given your experience / knowledge on affordable housing or low-cost housing, you are cordially invited to participate in this research to provide a better understanding of the views of Ghanaian experts on these issues. The questionnaire is simple and takes approximately 10 minutes to complete. I would be grateful if you could fill the attached questionnaire (by clicking on the boxes to select your opinion on the issues) and return it to me through this email. I have also attached my identification details.

Your participation is voluntary and anonymous. All responses will be kept confidential and only be used for academic purpose. A summary of the findings will be provided upon request.

This survey is part of a PhD research in the Department of Building and Real Estate, The Hong Kong Polytechnic University, Hong Kong. Your kind consideration is greatly appreciated, and it adds significant value and encouragement to this PhD research.

Adabre Michael Atafo
Department of Building and Real Estate, The Hong Kong Polytechnic University
Tel: +8526645 ; **Email**: 1790 @

Section A: Information of Participant

Q1. Please indicate the category you belong to (multiple answers allowed)
☐ Academia/research institute
☐ Consulting firm
☐ Public sector agency / department
☐ Private developer / contractor
☐ Other (s) (please specify): ***Click here to enter text***

Q2. Please indicate your years of industrial and / or research experience in affordable housing supply
☐ 1-5 years
☐ 6-10 years
☐ 11-15 years
☐ 16-20 years
☐ Above 20 years

Q3. Please indicate your professional background
☐ Architect
☐ Project / construction manager
☐ Client
☐ Engineer
☐ Quantity surveyor
☐ Academic/researcher
☐ Other (s) (please specify): ***Click here to enter text***

Q4. Which type of affordable housing supply have you ever been involved in as a practitioner or researcher?
☐ Public housing
☐ Social housing (owned and managed by the state or by non-profit organization or by both, usually with the aim of providing affordable housing)
☐ Cooperative housing (with cooperative housing, you own a part of a corporation that owns the building to provide affordable rent for housing)
☐ Other (s) (please specify): ***Click here to enter text***

Q5. How many affordable housing projects have you been involved in as a practitioner or researcher?
☐ 0
☐ 1-2
☐ 3-4
☐ 5-6
☐ 7 and above

Q6. Please state the country you work in: ***Click here to enter text***

Section B: Critical Success Criteria, Risk Factors, Barriers and Success Factors for the Supply of Affordable Housing

Q7. **Critical Success Criteria of affordable housing:** In measuring success of affordable housing supply, how would you rate the importance of the following indicators/criteria of success? **1= not important; 2=less important; 3=neutral; 4= important; 5= very important**

No.	Critical Success Criteria of Affordable Housing Supply	Level of Importance
1	Timely completion of project	☐ 1; ☐2; ☐3; ☐4; ☐5
2	Construction cost performance of housing facility	☐ 1; ☐2; ☐3; ☐4; ☐5
3	Quality performance of project	☐ 1; ☐2; ☐3; ☐4; ☐5
4	Safety performance	☐ 1; ☐2; ☐3; ☐4; ☐5
5	End user' satisfaction with the housing facility	☐ 1; ☐2; ☐3; ☐4; ☐5
6	Project team satisfaction with the housing facility	☐ 1; ☐2; ☐3; ☐4; ☐5
7	Environmental performance of housing facility (Eco-friendly)	☐ 1; ☐2; ☐3; ☐4; ☐5
8	Reduced life cycle cost of housing	☐ 1; ☐2; ☐3; ☐4; ☐5
9	Maintainability of housing facility	☐ 1; ☐2; ☐3; ☐4; ☐5
10	Energy efficiency of housing facility	☐ 1; ☐2; ☐3; ☐4; ☐5
11	Reduced occurrence of disputes and litigations among project team	☐ 1; ☐2; ☐3; ☐4; ☐5
12	Reduced public sector expenditure on managing housing facility	☐ 1; ☐2; ☐3; ☐4; ☐5
13	Functionality of housing facility	☐ 1; ☐2; ☐3; ☐4; ☐5
14	Technical specification of housing	☐ 1; ☐2; ☐3; ☐4; ☐5
15	Aesthetically pleasing view of completed house	☐ 1; ☐2; ☐3; ☐4; ☐5
16	House price in relation to income	☐ 1; ☐2; ☐3; ☐4; ☐5
17	Rental cost in relation to income	☐ 1; ☐2; ☐3; ☐4; ☐5
18	Commuting cost from the location of housing to public facilities	☐ 1; ☐2; ☐3; ☐4; ☐5
19	Technology transfer	☐ 1; ☐2; ☐3; ☐4; ☐5
20	Waiting time of applicants before being allocated a housing unit	☐ 1; ☐2; ☐3; ☐4; ☐5
21	Sustainable development	☐ 1; ☐2; ☐3; ☐4; ☐5
22	Take up rate of housing facility (marketability of housing facility)	☐ 1; ☐2; ☐3; ☐4; ☐5
Please indicate and rate other Critical Success Criteria of affordable housing supply (if any)		
23		☐ 1; ☐2; ☐3; ☐4; ☐5

Risk Factors to Affordable Housing Projects. How would you rate the likelihood of occurrence and severity of risk impact of the following risk factors to sustainable affordable housing projects? **1= very low; 2= low; 3= medium; 4= high; 5= very high.**

No.	Risk Factors to Affordable Housing Market	Likelihood of Occurrence	Severity of Risk Impact
	Feasibility Study	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5
1	Political risks (government interventions)	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5
2	Risks associated with land acquisition / compensation	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5
3	Social and public acceptance of housing risks	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5
4	Poor public decision making process	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5
5	Risks due to government leadership	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5
6	Risks due to project permit or approval	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5
	Financing Risks		
1	Fluctuating interest rate	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5
2	Economic risks (inflation, foreign exchange fluctuations)	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5
3	High finance cost	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5
4	Changes in financing strategies / policies	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5
5	Poor financial market	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5
6	Increasing tax rate and fees on developers	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5
7	Delay payments by government / client	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5
8	Litigation over claims payment	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5
	Procurement and Design Risks		
1	Inadequate project design	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5
2	Government bribery and corruption risks	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5
3	Contract risks	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5
4	Inadequate competition for tender of project	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5
5	Too many design changes / variation orders	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5
6	Untested engineering techniques / methods	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5
	Construction Risks		
1	Delays in project execution	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5
2	Construction cost overruns	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5
3	Technical risks	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5
4	Inadequate labour / material availability	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5
5	Too many late variations / change orders	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5
6	Challenges in land acquisition	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5
7	Construction force majeure events	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5
8	Construction accidents and injuries	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5
	Operation Risk		
1	Fluctuating market demand / preferences	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5
2	Operation / maintenance cost overruns on public budget	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5

No.	Risk Factors to Affordable Housing Market	Likelihood of Occurrence	Severity of Risk Impact
3	Congestion on existing amenities / infrastructure due to new households	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5
4	Utilities / infrastructure supply risk	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5
5	Socio-spatial segregation	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5
6	Privatization risk (privatization of public housing stock)	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5
Please indicate and rate other Risk Factors to Affordable Housing Market			
		☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5	☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5

Q8. **Barriers to the supply of affordable housing:** Please, do you agree that the following factors have constrained housing supply? **1= strongly disagree; 2= disagree; 3= neutral; 4= agree; 5= strongly agree.**

No.	Barriers to the Provision of Affordable Housing	Rating
1	Inadequate public funding	☐ 1; ☐2; ☐3; ☐4; ☐5
2	Tight credit conditions	☐ 1; ☐2; ☐3; ☐4; ☐5
3	Inadequate mortgage institutions	☐ 1; ☐2; ☐3; ☐4; ☐5
4	High interest rates	☐ 1; ☐2; ☐3; ☐4; ☐5
5	High cost of serviced land	☐ 1; ☐2; ☐3; ☐4; ☐5
6	High inflation rate	☐ 1; ☐2; ☐3; ☐4; ☐5
7	High cost of building materials	☐ 1; ☐2; ☐3; ☐4; ☐5
8	Income segregation (separation between the rich and the poor)	☐ 1; ☐2; ☐3; ☐4; ☐5
9	High approval cost due to high taxes and fees on developers	☐ 1; ☐2; ☐3; ☐4; ☐5
10	Inadequate infrastructural development	☐ 1; ☐2; ☐3; ☐4; ☐5
11	Zoning restrictions on land for affordable housing projects	☐ 1; ☐2; ☐3; ☐4; ☐5
12	Community opposition to affordable housing projects	☐ 1; ☐2; ☐3; ☐4; ☐5
13	Income inequality (weak income growth of households)	☐ 1; ☐2; ☐3; ☐4; ☐5
14	Negative culture towards mortgage	☐ 1; ☐2; ☐3; ☐4; ☐5
15	High mortgage default rates by clients	☐ 1; ☐2; ☐3; ☐4; ☐5
16	Shortage of skilled labour	☐ 1; ☐2; ☐3; ☐4; ☐5
17	Inadequate incentive for private investors	☐ 1; ☐2; ☐3; ☐4; ☐5
18	Inadequate access to secure land	☐ 1; ☐2; ☐3; ☐4; ☐5
19	Delays in government approval process	☐ 1; ☐2; ☐3; ☐4; ☐5
20	Rent control policies	☐ 1; ☐2; ☐3; ☐4; ☐5
21	Limited productivity improvement / gains in the construction process	☐ 1; ☐2; ☐3; ☐4; ☐5
22	Inadequate affordable housing policy / framework	☐ 1; ☐2; ☐3; ☐4; ☐5
23	Poor maintenance culture of existing housing	☐ 1; ☐2; ☐3; ☐4; ☐5
24	Abandon public housing projects / policies by succeeding government	☐ 1; ☐2; ☐3; ☐4; ☐5
25	Weak enforcement of planning system control on property development	☐ 1; ☐2; ☐3; ☐4; ☐5
26	Inadequate autonomy of local authorities' due to high central government interference	☐ 1; ☐2; ☐3; ☐4; ☐5
Please indicate and rate other Barriers to the Provision of Affordable Housing (if any)		

No.	Barriers to the Provision of Affordable Housing	Rating
27		☐ 1; ☐2; ☐3; ☐4; ☐5

Q9. **Success factors for the supply of affordable housing:** Please, rate the importance of the following factors in promoting successful supply of affordable housing. **1= not important; 2=less important; 3= neutral; 4= important; 5= very important**

No.	Success Factors for Affordable Housing Supply	Rating
1	Access to low interest housing loan / bank guarantee	☐ 1; ☐2; ☐3; ☐4; ☐5
2	Mixed land development (e.g. blend of housing and commercial buildings)	☐ 1; ☐2; ☐3; ☐4; ☐5
3	Linking commercial development approval to funding for affordable units	☐ 1; ☐2; ☐3; ☐4; ☐5
4	Stable macro-economic system	☐ 1; ☐2; ☐3; ☐4; ☐5
5	Effective private sector participation	☐ 1; ☐2; ☐3; ☐4; ☐5
6	Incentives for developers to include affordable units in their projects	☐ 1; ☐2; ☐3; ☐4; ☐5
7	Governments providing guarantees to developers	☐ 1; ☐2; ☐3; ☐4; ☐5
8	Improved supply of low cost developed land by government	☐ 1; ☐2; ☐3; ☐4; ☐5
9	Political will and commitment to affordable housing	☐ 1; ☐2; ☐3; ☐4; ☐5
10	Stable political system	☐ 1; ☐2; ☐3; ☐4; ☐5
11	Formulation of sound housing policy	☐ 1; ☐2; ☐3; ☐4; ☐5
12	Government's provision of housing subsidies	☐ 1; ☐2; ☐3; ☐4; ☐5
13	Good location for housing project	☐ 1; ☐2; ☐3; ☐4; ☐5
14	Adequate accessibility to social amenities	☐ 1; ☐2; ☐3; ☐4; ☐5
15	Mandatory inclusion of affordable unit policy in developers' projects	☐ 1; ☐2; ☐3; ☐4; ☐5
16	Adaptable housing design and construction	☐ 1; ☐2; ☐3; ☐4; ☐5
17	Transparency in allocation of houses	☐ 1; ☐2; ☐3; ☐4; ☐5
18	Adequate maintenance of existing houses	☐ 1; ☐2; ☐3; ☐4; ☐5
19	Monitoring condition /defects of completed housing	☐ 1; ☐2; ☐3; ☐4; ☐5
20	High density affordable housing development	☐ 1; ☐2; ☐3; ☐4; ☐5
21	Increase tax rate to discourage long holding period of vacant land	☐ 1; ☐2; ☐3; ☐4; ☐5
22	Adequate infrastructure supply by government	☐ 1; ☐2; ☐3; ☐4; ☐5
23	Compliance with quality targets	☐ 1; ☐2; ☐3; ☐4; ☐5
24	Adherence to project schedule	☐ 1; ☐2; ☐3; ☐4; ☐5
25	Compliance with project budget	☐ 1; ☐2; ☐3; ☐4; ☐5
26	Good coordination among project participants	☐ 1; ☐2; ☐3; ☐4; ☐5
27	Sufficient staffing of public housing agencies	☐ 1; ☐2; ☐3; ☐4; ☐5
28	Speculative measures on property sales through taxes	☐ 1; ☐2; ☐3; ☐4; ☐5
29	Taxation on property or capital gains for housing supply	☐ 1; ☐2; ☐3; ☐4; ☐5
30	Time limited planning approval / bonuses on land development	☐ 1; ☐2; ☐3; ☐4; ☐5
Please indicate and rate other Critical Success Criteria for Affordable Housing (if any)		
31		☐ 1; ☐2; ☐3; ☐4; ☐5

APPENDIX B

QUESTIONNAIRE FOR VALIDATION

Questionnaire for Validating the Model for Sustainability Attainment in Affordable Housing

Purpose of this survey

This survey aims to solicit responses from experts for validating a developed model for sustainable affordable / low-cost housing. The validation seeks to assess the adequacy of the model on the following aspects of validity: external, internal, construct and content validity.

Background

The validation involves the evaluation of a model for sustainability attainment in affordable / low-cost housing in Ghana. The model is developed as part of a PhD study conducted by the PhD candidate Michael Atafo Adabre under the supervision of Prof. Albert P.C. Chan. Questionnaire survey was conducted among construction professionals in the built environment mostly in Accra and Kumasi. Therefore, the model is intended mainly for urban areas. Through statistical analysis of the data, the model together with the systematic strategies for implementing it was developed (shown in Fig.4). In subsequent pages, the various aspects of the study are presented. First, the list of success criteria (CSC) for assessing sustainable housing is presented (shown in Table 1). Then, sets of risk factors and barriers that could negatively influence the attainment of the CSC are stated. Furthermore, intervention strategies (success factors) are listed for mitigating the risk and barriers towards attaining the CSC for sustainable housing in Ghana. Partial least square structural equation modelling (PLS-SEM) was used for establishing the relationship between the CSC and barriers (shown in Fig. 1) and between the CSC and success factors (shown in Fig. 2 & 3). Fuzzy synthetic evaluation was deployed for evaluating the impact of risk categories and overall risk impact on the CSC (shown in Table 2). Finally, an integrated model (shown in Fig. 4) is developed from the findings on the CSC, risk factors, barriers and success factors.

Instructions

Please, the study findings are first presented followed by a set of statements for validating the model and its implementation strategies / steps. Please, you are required to rate each statement based on your level of agreement on a 5-point Likert scale (1= strongly disagree, 2=disagree, 3=neutral, 4=agree and 5=strongly agree).

Your immense contribution to this validation is greatly appreciated. Please, we would be grateful if you could kindly return the completed questionnaire to Michael Atafo Adabre by email (1790 @) within two weeks from 1st April to 15th April 2020.

Once again, thank you in advance for your kind contribution to this study.

Yours Sincerely,

Michael Atafo Adabre (PhD Candidate)

Prof. Albert P.C. Chan (Head of the Department of Building and Real Estate, PolyU.)

A Brief Description of the Study Findings

Some of the key findings of the study include: 'incentive-related barriers' and 'retrofitting-related barriers' have significant impact on the success criteria for sustainable housing. However, 'cost-related barriers' directly influence 'incentive-related barriers' but do not directly affect the success criteria for 'sustainable housing' (in Fig. 1). Therefore, 'cost-related barriers' are secondary barriers. Regarding the results on the success factors (in Fig. 2, Fig. 3 and Table 2), 'developers' enabling success factors' and 'mixed-use factors' have significant impact on sustainable housing while 'household-enabling success factors' have high performance score on sustainable housing as revealed in the performance-impact analysis

(IPMA) (in Table 2). Furthermore, the insignificant impact of the 'land use planning factors' on sustainable housing imply that though redistributive policies (taxes) have proven as successful policies in the United Kingdom, these policies might not be successful in Ghana considering the relatively high level of corruption in Ghana. Therefore, for the possibly of policy transfer from UK to Ghana, effective anti-corruption measures and adequate staffing of public institutions in charge of land administration are essential. Finally, the risk analysis results showed that 'financing-related risk factors' have a high magnitude of impact on sustainable housing while the overall impact of risk on sustainable housing is moderately high.

For effective implementation of the model, six main systematic steps / strategies or implementation guidelines are offered. Step 1 entails problem identification concerning general housing conditions in most urban areas in Ghana. Step 2 involves identifying a list of CSC for assessing improved housing condition and for promoting sustainable housing. In Step 3 and Step 4, the risk factors and barriers that could affect the attainment of the CSC are empirically investigated, respectively. In the penultimate step, step 5, the intervention strategies or success factors for mitigating the risk factors and barriers were also empirically identified. Finally, step 6 are the CSC when the success factors are implemented (shown in Fig. 4). Please, in the model, it is speculated that unmanaged risks culminate in barriers. Hence, unmanaged risks are precursors of barriers.

Please, Tables 1, 2 & 3 and Figs. 1, 2 & 3 are provided for your perusal while various statements are offered for you to indicate your level of agreement for validating the sustainable housing model and its implementation guidelines (shown in Fig. 4).

Table 1: Constructs and Their Respective Observable Variables

Constructs	Code	Observable variables
Sustainable Development Goals / Success Criteria of Sustainable Housing (Represented as CSC)	CSC1	Timely completion of project
	CSC2	Construction cost performance of housing facility
	CSC3	Quality performance of project
	CSC4	Safety performance
	CSC5	End user's satisfaction with the housing facility
	CSC6	Project team satisfaction with the housing facility
	CSC7	Environmental performance of housing facility (Eco-friendly)
	CSC8	Reduced life cycle cost of housing facility
	CSC9	Maintainability of housing facility
	CSC10	Energy efficiency of housing facility
	CSC11	Reduced occurrence of disputes and litigation
	CSC12	Reduced public sector expenditure on managing housing facility
	CSC13	Functionality of housing facility
	CSC14	Technical specification of housing
	CSC15	Aesthetic view of completed house
	CSC16	House price in relation to income
	CSC17	Rental cost in relation to income
	CSC18	Commuting cost from the location of housing to public facilities
	CSC19	Technology transfer
	CSC20	Take up rate of housing facility (marketability of housing facility)
Critical Risk Factors (CRFs)		
Political-Related Risk	PRF01	Political continuity risks / change in government
	PRF02	Risk associated with land acquisition / land expropriations for housing
	PRF03	Risk associated with opposition to large public-private housing projects
	PRF04	Risk due to policy instability / political opposition to public housing projects
	PRF05	Risk due to delays in project permit approval / delays in obtaining construction permits or issuance of documents
Financing-Related Risk	FRF01	Inflation rate volatility (price fluctuation of materials & labour & sustainable technologies)
	FRF02	Fluctuations in exchange rate
	FRF03	Fluctuating cost of finance (interest rates)
	FRF04	Changes in government financing strategies or project financing
	FRF05	Poor / inadequate financial market
	FRF06	Increasing tax rates and fees on developers
	FRF07	Delays in payments by governments / clients
	FRF08	Litigations over claims payment
Procurement Risks Factors	PRF01	Corruptions in project procurement
	PRF02	Inadequate competition during project tendering
	PRF03	Errors and omissions in tender documents (i.e. inaccurate cost estimation)

Design & Construction Related Risk Factors	DRF01	Construction time overruns
	DRF02	Construction cost overruns
	DRF03	Construction deficiencies / defects
	DRF04	Resource unavailability risks (local skill labour & sustainable technologies and materials)
	DRF05	Design and construction variation orders / alteration and rework due to construction variations
	DRF06	Technical complexity risk associated with project
	DRF07	Force majeure (unforeseen adverse conditions at project site)
	DRF08	Construction accidents and injuries
Operation & Maintenance Risk Factors	ORF01	Fluctuating market demand or preference / low take-up rate of housing facilities
	ORF02	Operation / maintenance cost overruns on public budget
	ORF03	Congestion on existing amenities / infrastructure due to new households
	ORF04	Utilities / infrastructure supply risks
	ORF05	Socio-spatial segregation
	ORF06	Privatisation risk (privatization of public housing stock)
Potential Critical Barriers to Sustainable Housing		
Cost-Related Barriers (CRB)	CRB1	Delays in government approval process
	CRB2	High upfront cost of materials and technologies for sustainable housing both new construction and retrofitting
	CRB3	High cost of serviced land
	CRB4	High inflation rate
	CRB5	High interest rates
	CRB6	High cost of permit approval (high taxes and fees on developers)
	CRB7	Income inequality among households
Incentive-Related Barrier (IRB)	IRB1	Inadequate incentive for private investors
	IRB2	Inadequate access to land among developers
	IRB3	Lack of planning control on land development
	IRB4	Inadequate subsidies / public funding for sustainable technologies
	IRB5	Poor housing location (Inadequate policies on situating housing development in cities / towns)
	IRB6	Inadequate infrastructure development
	IRB7	Inadequate mortgage / financing institutions
	IRB8	Tight credit conditions
Retrofit-Related Barriers (RRB)	RRB1	Low-level or inadequate retrofitting (maintenance operation)
	RRB2	Inadequate policies or sustainability assessment tools (standards or guidelines) for retrofitting housing facilities
	RRB3	Lack of routine maintenance / Poor maintenance culture of public housing facilities
	RRB4	Policy instability / abandoned or neglected management of public housing facilities or projects by succeeding governments
	RRB5	Inadequate local professional skills
Success Factors		

Developers' Enabling Success Factors (DESF)	DESF1	Mandatory inclusion of affordable unit in developer's projects
	DESF2	Access to low interest housing loans to developers
	DESF3	Incentives for developers to include sustainable low-cost housing
	DESF4	Improved supply of low cost developed land by government
	DESF5	Energy efficient installations and designs
	DESF6	Water efficient design and installations
	DESF7	Use of environmentally friendly materials for construction
	DESF8	Effective private sector participation
	DESF9	Stable macro-economic system
	DESF10	Stable political system
Household Enabling Success Factors (HESF)	HESF1	Monitoring housing conditions / performance for retrofitting
	HESF2	Government provision of subsidies to households
	HESF3	Adequate maintenance of existing houses
	HESF4	Adequate infrastructure supply by government
	HESF5	Adaptable housing design
	HESF6	Transparency in allocation of housing facilities
	HESF7	Compliance with quality targets
Mixed-Use Development Success Factors (MDSF)	MDSF1	Adequate accessibility to social amenities
	MDSF2	Good location for housing projects
	MDSF3	Mixed development of housing and commercial buildings
	MDSF4	High density housing developments within cities and town
Land Use Planning Success Factors (LPSF)	LPSF1	Linking commercial development approval to funding for housing
	LPSF2	Increase tax to discourage long holding periods of vacant land
	LPSF3	Siting low-cost housing within cities / towns
	LPSF4	Political will and commitment to low-cost housing
	LPSF5	Taxation on property or capital gains for housing facilities
	LPSF6	Sufficient staffing of public housing / planning agencies

*Please, note that the CSC were grouped into five constructs based on prior study by Chan & Adabre (2019). These grouping are adopted to summarize the CSC for clear representation in the model.

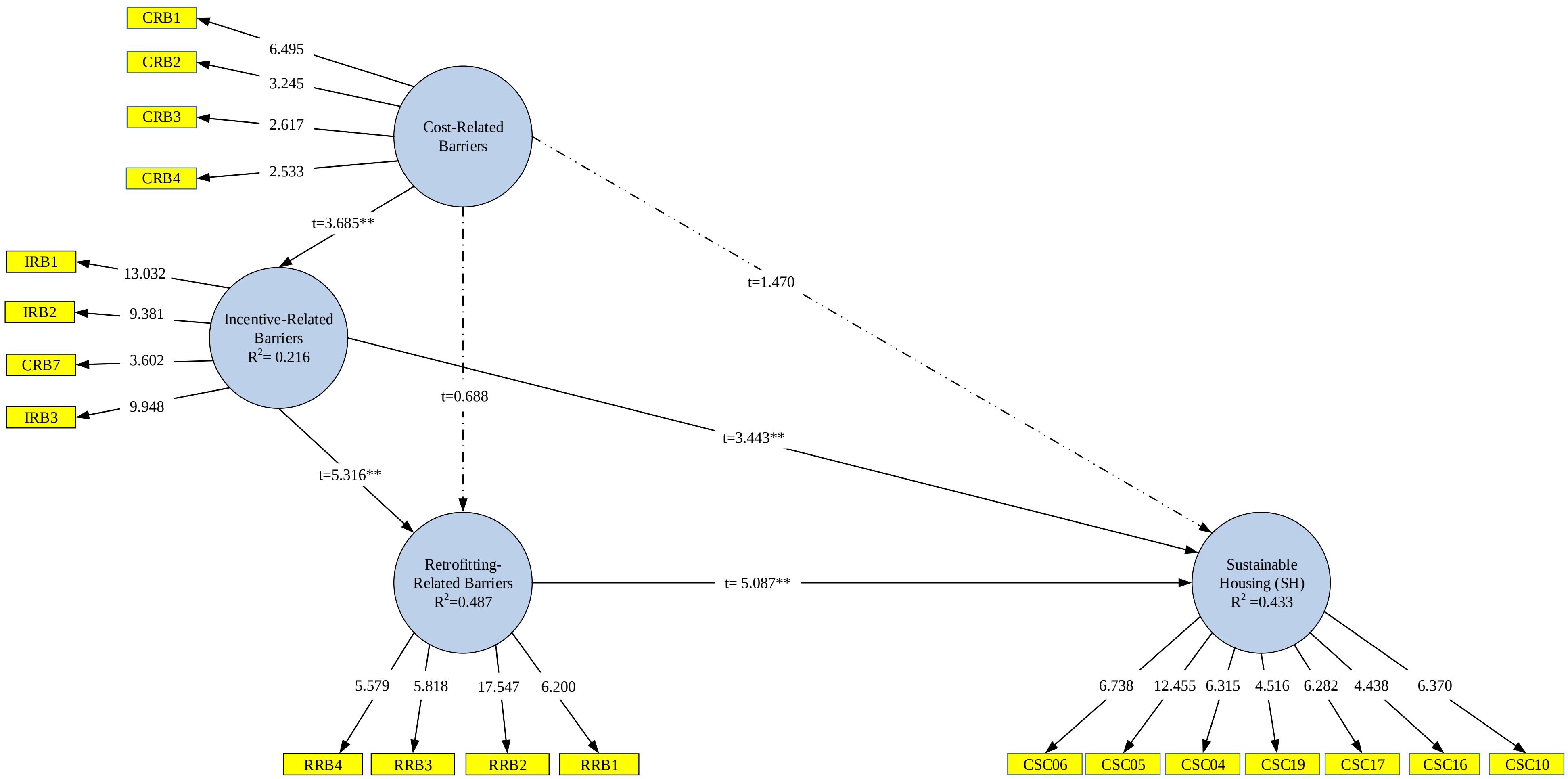
Location affordability CSC include: Reduced public sector expenditure on house management; House price in relation to income; Commuting cost from the location of housing to public facilities; Rental cost in relation to income; Construction cost performance of housing facility

Housing Operation Cost CSC: Energy efficiency of housing facility; Reduced lifecycle cost of housing; Environmental performance of housing facility (Eco-friendly)

Household Satisfaction CSC: Functionality of housing facility; End user's satisfaction with the housing facility; Maintainability of housing facility; Safety performance (crime); Take up rate of housing facility;

Effective stakeholders' Satisfaction CSC: Timely completion of project; Project team satisfaction; Reduced occurrence of disputes and litigation

Quality-Related CSC: Quality performance of project; Aesthetically pleasing view of completed house; Technology transfer; Technical specification of housing.



Note: **p < 0.01, *p < 0.05

-··-··-··-··-··-··-> Indicates an insignificant path; ————> Indicates a significant path

Fig. 1: Structural Model of Impact of Barriers on CSC

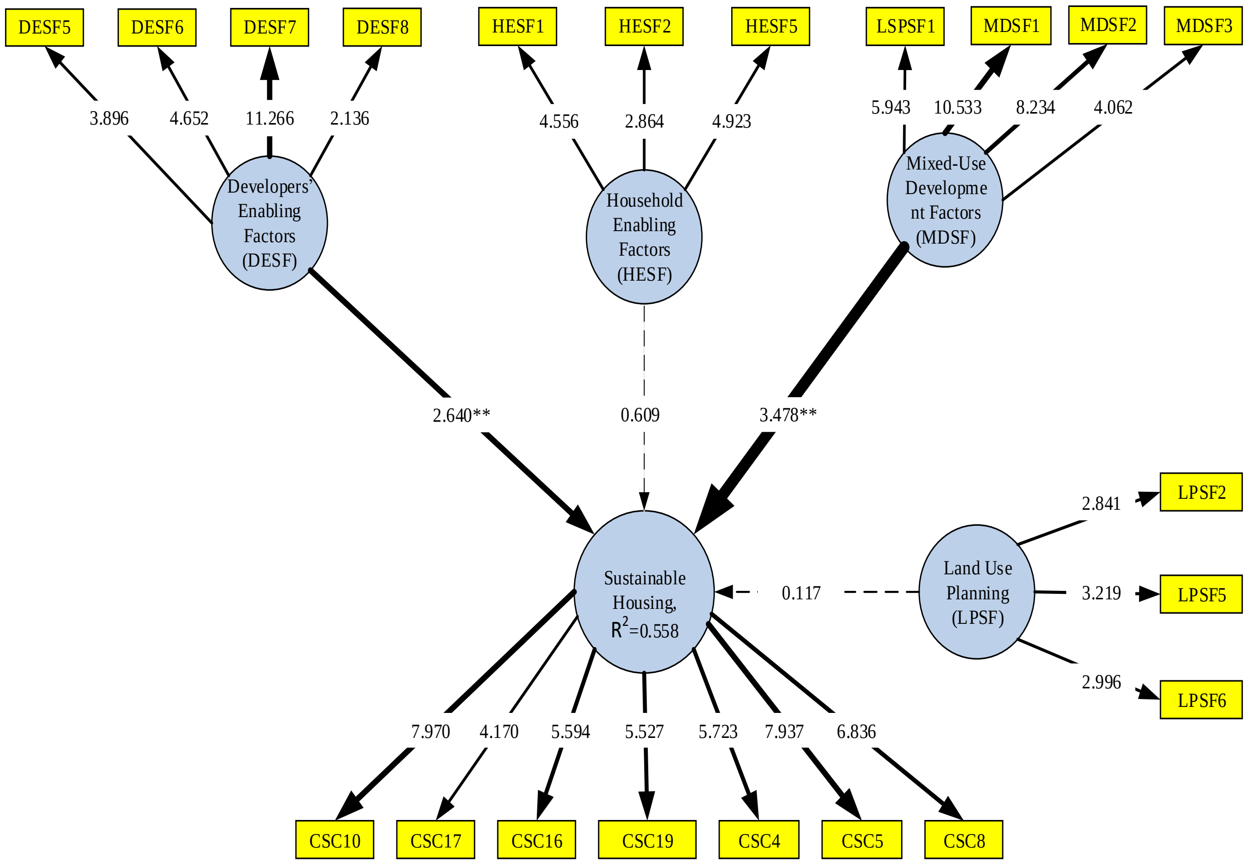


Fig.2: Structural Model on the Influence of Success Factors on CSC

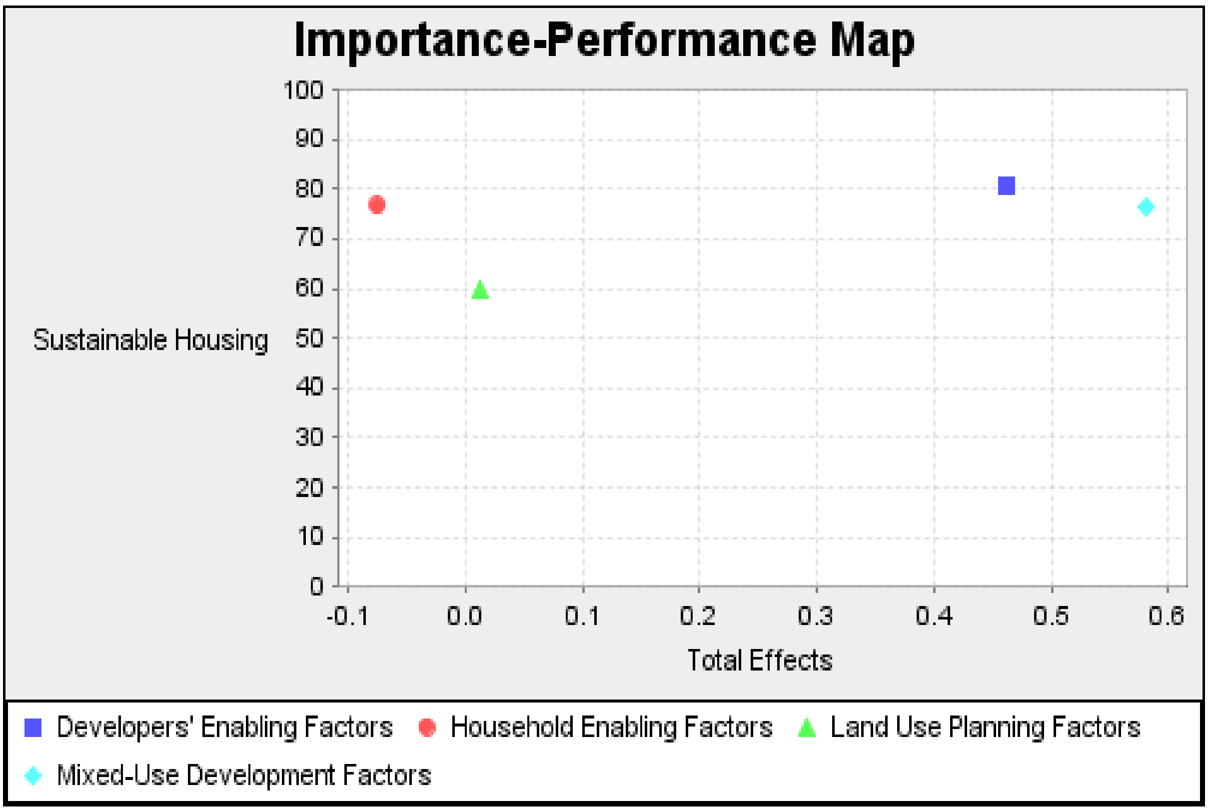


Fig. 3: Results of Importance-Performance Map of Success Factors and Sustainable Housing

Table 2: Importance-Performance Effect

Constructs	Importance (Total effect)	Performances (Index Values)
Developers' Enabling Factors	0.462	81.000
Household Enabling Factors	-0.076	76.720
Land Use Planning Factors	0.012	59.998
Mixed-Use Development Factors	0.582	76.489

Table 3: Interpretation of Various Risk Categories and Overall Risk Level Using the 5-Point Likert Scale

Risk Categories	Likelihood of Occurrence		Severity of Risk		Overall Magnitude of Risk		Ranking
	Index	Linguistic scale	Index	Linguistic scale	Index	Linguistic scale	
Political-Related Risk Factors	2.85	Moderately low	3.00	Moderate	2.92	Moderately low	5
Financing-Related Risks	4.12	High	4.01	High	4.06	High	1
Procurement-Related Risk Factors	3.66	High	3.73	High	3.69	High	2
Design & Construction Risk Factors	3.59	High	3.79	High	3.69	High	2
Operation & Maintenance Risk Factors	3.46	Moderately High	3.45	Moderately High	3.45	Moderately High	4
Overall Risk Level (ORL)	3.35	Moderate	3.63	High	3.49	Moderately High	

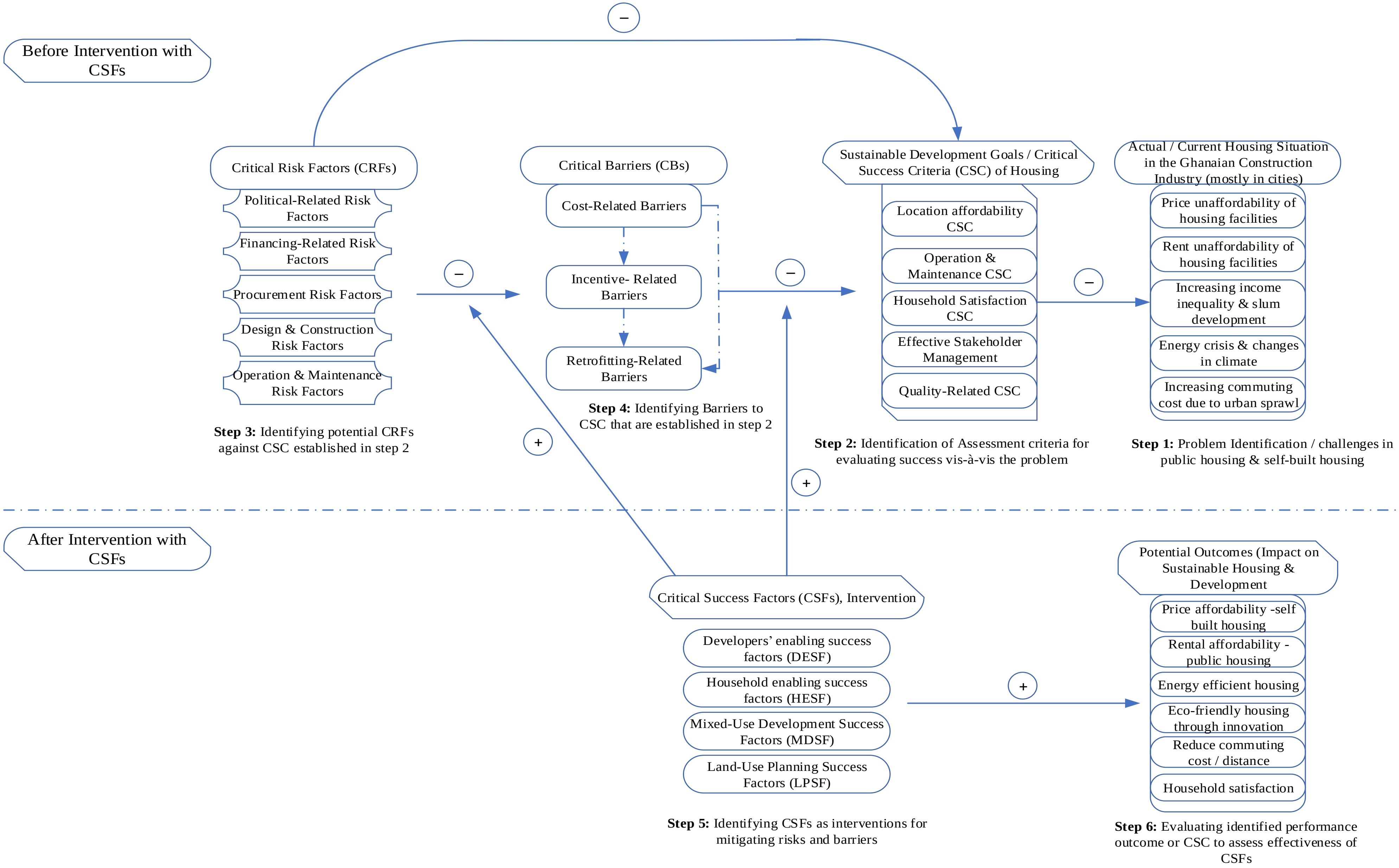


Fig. 4: Integrated Model for Sustainable Housing

Questionnaire for Validating the Model for Sustainable Affordable or Low-Cost Housing in the Ghanaian Construction Industry

Please, to what extent do you agree with the following statement regarding the model for sustainable affordable or low-cost housing in the Ghanaian construction industry. Please, use the following scale: 1=strong disagree; 2=disagree; 3=neutral; 4=agree; 5=strongly agree.

No.	Statement	Agreement Level
Statements for Validating the Guidelines of the		
1	The critical success criteria (CSC), the critical risk factors (CRFs), the critical barriers and success factors identified as relevant in this study are reasonable and rightly reflect the current situation in Ghana	☐ 1; ☐2; ☐3; ☐4; ☐5
2	The sustainable housing model is easily understandable and could be used in the Ghanaian construction industry	☐1; ☐2; ☐3; ☐4; ☐5
3	The guidelines or systematic steps (steps 1 to 6) as stated in the model are appropriate	☐1; ☐2; ☐3; ☐4; ☐5
4	The model together with its steps or guidelines is inclusive / comprehensive	☐1; ☐2; ☐3; ☐4; ☐5
5	The appropriate implementation of the housing model will help to achieve sustainability in low-cost housing in the Ghanaian housing market	☐1; ☐2; ☐3; ☐4; ☐5
6	Overall, the model is suitable for achieving sustainable affordable / low-cost housing in public-private partnership projects or self-built housing projects in Ghana	☐1; ☐2; ☐3; ☐4; ☐5

Please, you could also make comments or suggestions in the box provided below concerning the model for sustainable affordable / low-cost housing as well as comments to improve the model.

General comments:

………………………………………………………………………………………………………

………………………………………………………………………………………………………

Specific comments:

………………………………………………………………………………………………………

………………………………………………………………………………………………………

– End of Survey –

Thank you for your valuable time and participation

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