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Evaluation of Symmetries and Asymmetries on Barriers to Sustainable Housing in Developing Countries

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Abstract

For effective policy development and implementation for sustainable housing, the perspectives of professionals (i.e., suppliers of housing facilities and services) and households (i.e., consumers thereof) must be assessed concurrently. However, with sparse studies examining both the supply and demand-sides of sustainable housing development simultaneously, policymakers are plagued with unbalanced information. Consequently, eclectic and specific policies cannot be formulated for implementation. This study presents a concurrent evaluation of sustainability challenges from both perspectives towards identifying symmetries and asymmetries on sustainable housing barriers. Four categorizations of barriers were developed from extant literature, viz: 'economic', 'social', 'environmental' and 'institutional' barriers. Primary data was gathered using a structured questionnaire that was distributed via a non-probability purposive sampling technique to both professionals working in formal/regulated institutions of the Ghanaian housing market and household occupants. A test of significant difference on underlying barriers was conducted using Mann-Whitney *U* test. The fuzzy synthetic evaluation (FSE) technique was also employed for dealing with subjectivity in responses attributed to differences in respondents' aim, motivation and experience for an objective evaluation of a multivariate factor (i.e., category of barriers). The study's findings revealed significant differences among some underlying barriers rated by the two respondent groups. Likewise, there were significant differences supported at $p < 0.05$ at a Z-value of -2.24 and $p < 0.05$ at a Z-value of -1.48 on the social and environmental categories of barriers, respectively. Practically, results on the test of significant difference are indicative of barriers that require all-inclusive and specific policies. Moreover, the FSE indices provide allocative purpose by directing resources from policymakers towards more critical barriers for sustainable housing.

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Keywords: Sustainable housing; economic sustainability; social sustainability; environmental sustainability; institutional sustainability barriers; circular economy

1. Introduction

Sustainable housing entails a holistic attainment of economic, social, environmental and institutional sustainability goals (Ogunsanya et al., 2019; Debrah et al., 2020). For economic sustainability, housing facilities ought to be price/rental affordable to the targeted households (Nazir et al., 2020), and daily commuting cost of the households should be affordable (i.e., < 15% of households' income). Furthermore, the utility bills (i.e., electricity bills and water bills) should be at most 10% of the income of household (Chan and Adabre, 2019). Integrating the rental cost and commuting cost, contemporary studies have stipulated an affordability index of 45% of household's income (Isalou et al., 2014; Acolin & Green, 2017). Regards social sustainability, it involves development sustainability (i.e., households' satisfaction on quality of housing facility, aesthetic view, functionality and neighbourhood satisfaction, creation of social capital and equity). It also entails 'bridge sustainability' (i.e., changes in behaviour to achieve bio-physical environmental goals) and 'maintenance sustainability' (i.e., preservation of social-cultural patterns and practices in a changing social and economic milieu) (Vallance et al., 2011; Karji et al., 2019). Environmental sustainability requires that both economic and social sustainability goals are achieved without posing threats to the environment. This mostly includes optimum utilization of natural resources (i.e., land) by strategically positioning housing facilities to mitigate greenhouse gas emissions caused by household commuting activities. Additionally, it includes effective operation and maintenance (O&M) of housing facilities through efficient utilization of energy while curbing increasing emissions (Balasbaneh et al., 2018; Cruz et al., 2019). In achieving the three main pillars of sustainability, the fourth dimension 'institutional sustainability' is exigent and includes four main hierarchical tiers, viz: legislation and regulation; governance and contracts; agents' and firms and beliefs and values; with each tier shaping those below (Crabtree and Hes, 2009 cited in Williamson, 2000).

Globally, every nation seeks to ensure the attainment of all the four sustainability aspects as depicted in the framework of the 2030 United Nations (UN) Sustainable Development Goals (SDGs) (Owusu-Manu et al., 2020); where specifically, the economic, social and environmental sustainability goals are specified in target 11.1 of the UN SDGs in housing. Besides, a transparent, effective and accountable governance for institutional sustainability is enunciated in targets 16.5 and 16.6. Although the sustainable development goals are intended to ensure that all goals are prioritized equally (Coscieme et al., 2021), the impact of challenges on different stakeholders and countries has often contradicted the original design of the SDGs (Zhou et al., 2021). Consequently, the challenges impeding the different SDGs have been prioritised differently among different stakeholders. While a section of extant literature on the views of professionals (including developers) identified some challenges to attaining the SDGs (Owusu-Ansah et al., 2018; Adabre et al., 2020), findings from the views of households have revealed a different set of challenges (Schmidt and Zakayo, 2018; Ebekozien et al., 2019). Without adequately and simultaneously evaluating the sustainability challenges from both perspectives, policymakers are often plagued with unbalanced information (Prendeville et al., 2018; Sauermann et al., 2020). Indeed, Mulliner and Algrnas (2018, p. 154) 'stressed that there are limited studies examining both demand and supply-sides of the housing market simultaneously'. Consequently, generally implemented strategies and development programmes, which are solely based on the views of professionals, have often been vitiated and vice-versa (Sauermann et al., 2020). Typical cases of policies failures are evinced in Ganiyu et al. (2017) and Mulliner & Algrnas (2018). Considering the problem of unbalanced information among policymakers and its effects among most developing countries in general (Mulliner and Algrnas, 2018) and in sub-Saharan African countries (Grant et al., 2019), this study focuses on the Ghanaian housing market as a case study.

Housing supplies in the Ghanaian housing market emanate from both self-builders and regulated institutions, namely, parastatal institutions (i.e., Public Works Department (PWD), Ministry of Water Resources, Works and Housing); privatised institutions (i.e., State Housing Cooperation (SHC), Tema Development Cooperation (TDC), Social Security and National Insurance Trust (SSNIT)) and members of the Ghana Real Estate Developers Association (GREDA) (Ehwi et al., 2020). The state's direct participation in housing supply is on a low scale. Therefore, supranational institutions such as the United Nations and the World Bank provide donor funded housing projects to improve housing supply by the state. Ownership of housing facilities is mostly through self-built with relatively low purchases from the regulated institutions of the housing market. Nonetheless, households mainly rely on professionals of regulated institutions (including consultancy firms) for housing-related services (i.e., housing designs, cost estimations and analysis). Thus, in the housing market, professionals are either supplying housing facilities or services or both while households are the consumers thereof.

The government provides an enabling environment to the housing market for ensuring sustainable housing development. Besides infrastructural development, the government has been embarking on tax incentives; establishing financing schemes for providing loans and offering incentives for retrofitting housing facilities to sustainability standards (Adabre and Chan, 2021). Yet, there are prevailing challenges which impede sustainable housing development, especially in Ghanaian cities. These challenges include: economic (i.e., inadequate incentives, high cost of sustainability measures/technologies); social (i.e., income inequality, social exclusion and segregation, high default rate concerning loan repayment, high inertia on adopting sustainability measures); environmental (i.e., inadequate design for disassembly of building elements and components for reuse, lack of interest and knowledge on using recyclables for new housing) and institutional challenges which are either mostly attributed to bureaucracy or inadequate/lack of legislation (i.e., delays in obtaining building permit; inadequate financing institutions for housing loans / mortgage and lack of regulatory support on guidelines for sustainable housing) (Djokoto et al., 2014; Mensah et al., 2016; Trianni et al., 2017; Nnaji & Karakhan, 2020; Adabre et al., 2021a). These challenges plague professionals (including developers) and households differently and unequally which affect all-inclusive policy implementation for the economic-social-environmental-institutional sustainability in housing development (Crabtree and Hes, 2009). Against this backdrop, this study aims to evaluate the perspectives of professionals and household occupants on a set of barriers to sustainable housing.

This study is both topical and pressing given the compelling need for sustainable housing for partly realizing the UN SDGs by 2030. Essentially, practitioners, developers, households, government and supranational institutions could be informed on general and specific barriers that hinder SDGs in housing. Thus, the findings are prerequisite for appropriate resource allocation among different stakeholders for sustainable housing.

2. Sustainable Development in Housing: A Literature Review

Sustainable development in housing is a dynamic process that combines the four sustainability goals (viz: economic, social, environmental and institutional goals) (Shen et al., 2011). Although the principle of sustainable housing development entails all round development of the four sustainability goals, studies suggest that some polices do not always yield the holistic UN SDGs in housing (Awadh, 2017; Adabre and Chan, 2020). This is an inevitable problem, because the barriers to the attainment of the various sustainability goals are not objectively prioritized for an efficient and effective resource allocation among various stakeholders towards achieving the goals. The barriers that militate against stakeholders' sustainability attainment require different attention and effort for effective policy implementation.

Extant literature has identified various barriers (categorized into manageable groups) that could affect sustainable housing development. Owusu-Ansah et al. (2019) examined the factors that hinder sustainable housing development from the views of developers, making a clear distinction between the economic (market) and institutional barriers. While maintaining these two categorizations, Adabre et al. (2020) broadened the groupings of barriers to include social and environmental forces. The groupings were based on the impacts/effects of underlying barriers on the four sustainability pillars. Akin to the study by Owusu-Ansah et al. (2019), Adabre et al. (2020) employed descriptive statistical analysis for ranking the underlying barriers in each category but failed to prioritize the four main categories of barriers – thus, assigning the same weight to each category. Yet, there is a dominant advocacy for environmental sustainability as the basis for sustainable development (Velenturf & Purnell, 2021; Zhou et al., 2021). This is evinced in the green building rating systems (GBRSs) of most developed/industrialized countries in which most measures are geared towards controlling environmental sustainability problems/barriers. Prominent GBRSs such as Building Research Establishment Environmental Assessment Method (BREEAM) of the United Kingdom and Leadership in Energy and Environmental Design (LEED) of the United States (Martek et al., 2019; Ofori-Boadu et al., 2020) are mostly focused on alleviating environmental sustainability problems while policies for ebbing the tripartite economic-social-institutional sustainability problems are inadequate (Shan and Hwang, 2018; Lazar & Chithra, 2020). On that regard, Awadh (2017 – p. 25) contended that "(GBRSs) are environmental-oriented tools and should not be confused with sustainability assessments systems." Arguably, the prioritization of environmental sustainability goals in the GBRSs of most developed economies could be attributed to the dominant environmental challenges and the geographical context of such economies. Furthermore, the worldwide attention on environmental sustainability is due to a shift in perspective towards environmental protection because of constantly changing climatic conditions (Daniel, 2005; Salmenperä et al., 2021; van Ellen et al., 2021). For example, Zhou et al. (2021) found that due to a decline in air quality and reduction in green space, the public in Liaoning paid the most attention to the environmental system.

Despite the global advocacy for environmental sustainability which underpins sustainable development, studies (Daniel, 2005; Marans, 2015) have asserted that many lower incomes ‘resource-based’ economies could be reticent about the clarion call for sustainable development through environmental sustainability. Arguably, the challenges of environmental sustainability attainment could be attributed to economic barriers as revealed in such studies. For instance, economic barriers such as high inflation rates, high interest rates, high cost of serviced land, high cost of sustainable building materials/technologies and tight credit conditions have been identified as formidable barriers to sustainable housing development (Daniel, 1992; Darko et al., 2018; Adabre et al., 2021a). Consequently, these barriers could lead to environmental problems such as urban congestion, squalor, slums, residential waste and air pollution. Thus, economic barriers are prioritized in such studies as more important than barriers to environmental sustainability. Using Australia as an example of a natural resource-based economy, Daniel (1992, p.258) concluded that the global goal of sustainable development is untenable “in view of a number of problems linked to economic structure and internal economic and political relations that are facing many natural resource-based economies.”

Yet, among the four categories of barriers, other studies have identified social sustainability challenges as the most critical barriers to the SDGs in housing. A review study by Vallance et al. (2011, p.344) inferred that “it is only when people’s basic needs are met that they can begin to actively address biophysical environmental concerns, and this view is well-represented in the social sustainability of housing literature.” Therefore, social sustainability challenges such as income inequality (i.e., poverty, income segregation and inequity) and social exclusion and segregation among households have been identified as the most critical barriers to attaining the SDGs in housing. Some of these barriers have also been found to influence environmental problems concerning inefficient utilization of natural resources (i.e., peripheralization of housing facilities) (ibid). Citing Crabtree and Hes (2005) for example, Vallance et al. (2011) stated that poverty acts as a barrier to the uptake of green technologies (e.g., solar panels). Therefore, Vallance et al. (2011) deduced that social sustainability barriers influence barriers in the remaining tripartite aspects of sustainable development. Although most of the barriers in Vallance et al. (2011) pertain to households, Schmidt and Zakayo (2018) and Ebekozien et al. (2019) identified other barriers (i.e., high mortgage default rates and negative culture towards mortgage) that could affect both households and suppliers. Nonetheless, from a different perspective of households, it seems the barriers to social sustainability are the most prioritized challenges to sustainable housing.

Other studies proffer that the implementation of sustainable housing strategies is hindered by institutional barriers. For example, Crabtree and Hes (2009) found that low uptake of sustainable technologies for housing is related to institutional problems. Institutional challenges could be related to the: beliefs and values of policymakers; legislation and regulation (i.e., weak enforcement of planning control on property development, delays in government approval process or regulatory proceedings); governance and contracts (i.e., such as policy instability); and agents and firms (i.e., inadequate mortgage/financing institutions, low-capacity of utility service providers on infrastructure development) (Adabre et al., 2021c). Similarly, Owusu-Ansah et al. (2019) validated the hypothesis that between institutional barriers and market barriers, the former are the main reasons for housing deficit among developers regards meeting the SDGs in housing in a sub-Saharan African country. North (1990) and Owusu-Ansah et al. (2019) further posit that effective institutional development has significant influence on economic development.

The review of extant literature reveals that there is no consensus on ranking of the four main barrier categories. This is because the barriers to sustainable housing development could be context-dependent and, therefore, reflect the different challenges in various countries. Additionally, the perspectives of different stakeholders (i.e., developers/professionals and households) concerning the barriers could be different as evinced in extant literature (see Owusu-Ansah et al., 2019 on developers and Ebekozien et al., 2019 on households). Moreover, a plethora of analyses deployed could yield different outcomes. Descriptive quantitative assessments (cf. Owusu-Ansah et al., 2019; Adabre et al., 2021a) and discursive qualitative assessments (cf. Daniel, 1992; Daniel, 2005; Crabtree and Hes, 2009; Vallance et al., 2011) employed in the literature reveal a tantalising glimpse of the barriers. On such assessments, Lin and Wu (2008) cautioned against inadvertently capturing subjectivity in results. The literature reviewed, conducted for this present study, notes scant research that provides concurrent assessment of barriers (refer to Table 1) from the perspectives of professionals and households. Besides, there is a dearth of research that provides an objective and quantitative evaluation of barriers impact on the SDGs in housing. These knowledge gaps provide the premise upon which to conduct statistical difference as well as prioritize the barriers to sustainable housing.

Table 1: Barriers to Sustainable Housing (Adapted from Adabre et al., 2020)

Categories of Barriers	Codes	Underlying Barriers	References
Economic sustainability barriers			
	ESB1	Lack of public funding to support adoption of sustainable housing strategies / technologies	Trianni et al. (2017); Darko et al. (2018); Adabre and Chan (2021)
	ESB2	Inadequate access to credit and capital by developers and households	Grodach (2011); Ebekozien et al. (2019)
	ESB3	High cost of capital (i.e., interest rates on loans)	Mensah et al. (2020); Owusu-Ansah et al. (2019)
	ESB4	High inflation rates (including exchange rate)	Daniel (1992); Adabre et al. (2020)
	ESB5	High cost of serviced land in cities / towns	Owusu-Ansah et al. (2019); Akrofi et al. (2019)
	ESB6	High cost of building/construction materials and technologies	Darko et al. (2018); Adabre et al. (2021a)
	ESB7	High cost of land registration and acquisition of building permit	Owusu-Ansah et al. (2019); Adabre et al. (2021a)
	ESB8	Inadequate incentives for sustainable housing development	Trianni et al. (2017); Darko et al. (2018)
	ESB9	Extra cost and time for sustainable housing	Djokoto et al. (2014); Darko et al. (2018); Khan et al. (2020); Adabre and Chan (2021)
Social sustainability barriers	SSB1	Inadequate public facilities and difficult access to them (i.e., inadequate infrastructural development)	Owusu-Ansah et al. (2019); Fatourehchi & Zarghami (2020)
	SSB2	Inadequate participation in housing design and information sharing among stakeholders on sustainable strategies (wide communication gap)	Atanda (2019); Stender & Walter (2019); Fatourehchi & Zarghami (2020); Sauermann et al. (2020)
	SSB3	Income inequality (weak income growth among most households)	Roca-Puig (2019); Fatourehchi & Zarghami (2020)
	SSB4	Social exclusion and segregation	Wang et al. (2020); Niembro et al. (2021)
	SSB5	Negative culture towards mortgage / loans for housing	Vallance et al. (2011); Ebekozien et al. (2019)
	SSB6	High default rates concerning loan repayments	Schmidt and Zakayo (2018); Ebekozien et al. (2019)
	SSB7	Inadequate expertise for sustainable housing	Häkkinen & Belloni (2011); Adabre et al. (2020)
	SSB8	Lack of awareness creation and training on sustainable technologies for housing	Häkkinen & Belloni (2011); Opoku et al. (2019)
	SSB9	Fear and risk in the adoption of new technology (high inertia to conventional building)	Trianni et al. (2017); Hoffman & Henn (2008); Häkkinen & Belloni (2011); Oluleye et al. (2021)
	SSB10	Inadequate adaptability in housing design to meet changing lifestyle of households	Adinyira & Anokye (2013); Stender & Walter (2019); van Ellen et al. (2021)
Environmental sustainability barriers	NSB1	Scarcity on land availability within cities / town	Cobbinah and Amoako (2012); Akaateba (2019)
	NSB2	Inadequate brownfield development for sustainable housing (i.e., peripheralization)	Cobbinah and Amoako (2012); Ahmad et al. (2019)
	NSB3	Lack of high-density use of land (i.e. low-rise housing development)	Cobbinah and Amoako (2012); Agyefi-Mensah et al. (2015)
	NSB4	Lack of sustainable building codes and standards	Opoku et al. (2019); Mensah et al. (2020)
	NSB5	Lack of certification for sustainable buildings	Ranta et al. (2018); Opoku et al. (2019)
	NSB6	Inadequate design for disassembly of building elements and components for reuse or alteration	Charef & Emmitt (2021); Salmenperä et al. (2021); van Ellen et al. (2021)

	NSB7	Lack of knowledge and interest on reusing materials or components (i.e., recyclables) for new housing	Ranta et al. (2018); Bilal et al. (2020); Charef & Emmitt (2021)
	NSB8	Lack of sustainable waste management in housing design and construction	Allam & Jones (2018); Tsai et al. (2020); Salmenperä et al. (2021)
Institutional sustainability barriers	ISB1	Delays in government's approval process	Trianni et al. (2017); Owusu-Ansah et al. (2019)
	ISB2	Weak enforcement of planning control on property development	Akrofi et al. (2019); Adabre et al. (2021a)
	ISB3	Low capacity of service providers (regards electricity and water suppliers)	Ameyaw and Chan (2015); Osei-Kyei and Chan (2017)
	ISB4	Lack of sustainability requirements in building permit approval	Mahpour (2018); Oluleye et al. (2021)
	ISB5	Over concentration on active government-based planning schemes / policies to the neglect of previous policies (i.e., policies instabilities)	Twumasi-Ampofo et al. (2014); Adabre et al. (2020); Tsai et al. (2020); Sadri et al.(2022)
	ISB6	Lack of clearly defined policies and goals for sustainable housing (i.e., regulating faster land depletion)	Mensah et al. (2020); Trianni et al. (2017); Khan et al. (2020); Qi et al. (2020); Adabre et al. (2021a)
	ISB7	Lack of regulatory support on guidelines for sustainable housing (i.e., public education & training platforms)	Mensah et al. (2020); Atanda (2019); Khan et al. (2020); Oluleye et al. (2021); Patra et al. (2021)
	ISB8	Inadequate financing institutions for housing loans / mortgage	Owusu-Ansah et al. (2019); Baidoo & Akoto (2019)

3.1 Research Methodology

3.2 Research Method

For this empirical research, primary data was collected through a structured questionnaire survey. Respondents of the survey are in the formal/regulated institutions of the Ghanaian housing market and experts of consultancy firms (herein collectively referred to as professionals) and house owners or household occupants (herein referred to as households). Prior to its administration, the questionnaire was piloted by soliciting views of two practitioners, two researchers and two households, who are knowledgeable of the Ghanaian housing market. Feedback from the pilot survey was used to improve and finalise the data collection instrument. The final questionnaire consisted of three sections. Section one contained questions that solicited information on the respondents' demographic profile. Section two contained closed-ended questions on critical success criteria or indicators for sustainable housing, which respondents were requested to rate using a 5-point Likert scales of 1=not important; 2=less important; 3=neutral; 4=important; and 5=very important. In Section three, respondents were invited to rate the criticalities of the barrier to sustainable housing using a similar 5-point Likert scales; where 1=not critical; 2=less critical; 3=neutral; 4=critical; and 5=very critical. A summary of the research process is shown in Figure 1.

Attributed to lack of a sampling frame, purposive sampling and social referral networks (i.e., snowballing) were employed to accrue sample composition. The questionnaire was administered to members of GREDA through email (sourced from organisational brochures/marketing literature) and via face-to-face contacts. Besides, the questionnaires were administered to other professionals from the parastatal and privatized institutions (such as PWD, TDC, SSNIT, SHC, Architectural Engineering and Service Limited (AESL) and Building and Road Research Institute (BRRI)). Out of 141 questionnaires administered, 61 valid responses were retrieved which constitute a response rate of 43.3%. Concerning administering the questionnaire to households, this was mainly achieved through purposive sampling of houseowners of recently built or purchased facilities (i.e., < 5 years). Forty-five questionnaires were administered to household occupants of which 21 were retrieved (i.e., a response rate of 46.7%). The adequacy of the sample (i.e., 82 respondents of professionals and households) was assessed based on the central limit theorem which states that a sample size of 30 is deemed suitable for statistical analysis (Ott & Longnecker, 2015; Darko et al., 2018).

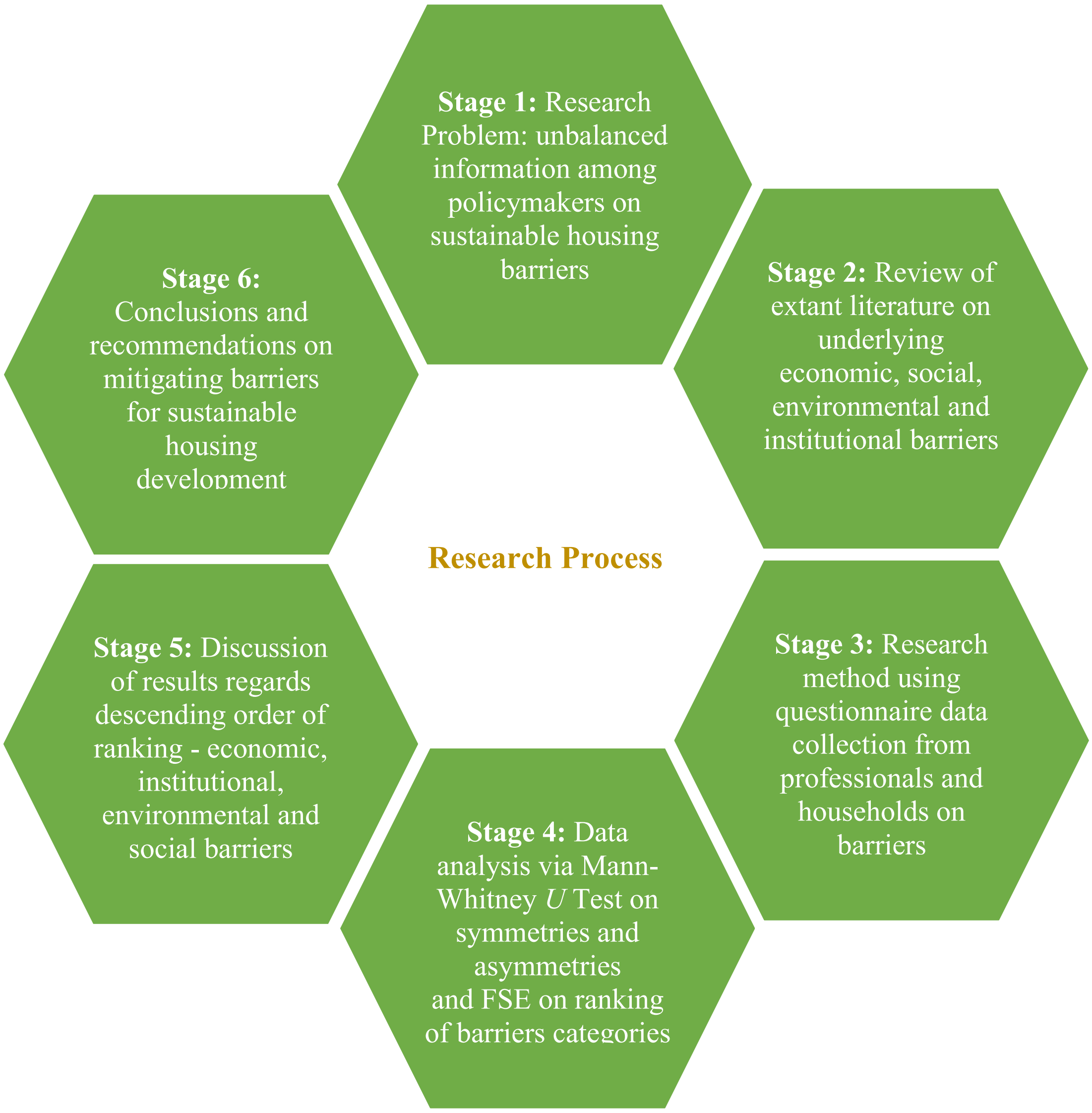

Figure 1: Research Process for the Study

3.3 Data Analysis

Data analysis was conducted using the statistical package for social science (SPSS) version 20. SPSS was used to estimate descriptive statistics such as mean score, standard deviation, Cronbach's alpha and Mann-Whitney *U* test. For data reliability, a Cronbach's alpha of 0.70 is the required threshold (Adabre and Chan, 2019). Aside their essence for ranking the underlying barriers, the mean scores were also deployed for conducting the Mann-Whitney *U* test and for prioritizing the barrier categories through the fuzzy synthetic evaluation (FSE) technique.

The Mann-Whitney *U* test is a non-parametric test that is used to compare differences between two independent groups when the dependent variable is either ordinal or continuous, but not normally distributed (Laerd Statistics, 2015, p.1; Osei-Kyei et al., 2019). In this study, it was employed for statistical comparison of means of the two independent groups (i.e., professionals and households) on the set of sustainable housing barriers. Due to the relatively small sample size, parametric test could not be deployed. However, the Mann-Whitney *U* test is suitable for low sample size (i.e., ≥ 20) and was therefore, conducted at significance level of 0.05 for testing the null hypothesis; where the null hypothesis assumes that there is no significant difference(s) on means of the sustainable housing barriers between the two respondent groups (i.e., professionals and households).

The FSE analysis was employed for an objective quantification of the barrier categories. Since multi-stakeholder professionals are mostly involved in the construction of sustainable housing, their perceptions on the various barriers are generally subjective and biased (Lin and Wu, 2008). This problem of subjectivity is exacerbated because a linguistic rating scale (1=not critical, 2=less critical, 3=neutral, 4= critical, 5=very critical) was used to enable respondents assess the criticalities of the barriers (Ameyaw and Chan, 2015). However, the FSE technique is suitable for handling such subjectivities and biases in responses on multivariate barriers (Zadeh, 1965). Through the FSE technique, the linguistic rating scale (5-point Likert scale) is converted into fuzzy numbers to determine the magnitude of impact (FSE index) of the barrier categories on sustainable housing development. The systematic procedures (Nwaogu & Chan, 2020 and Adabre and Chan, 2020) for using the FSE to assess the barriers are as follows:

I. A set of fundamental barrier factors is developed i.e., B = {b_1, b_2, b_3 … b_n}; where n represents the number of barriers within a particular grouping or category;

II. Labels for the set of grade alternatives are established as L = {L_1, L_2, L_3 … L_n}. For this study, the 5-point Likert scale is used. Therefore, L_1 = not critical, L_2 = less critical, L_3 = neutral, L_4 = critical, L_5 = very critical.

III. The weighting (W) of each barrier is estimated from the survey results using eqn. (I).

$$W_B = \frac{M_i}{\sum_{B=1}^{K} M_i}, \; 0 < W_B < 1, \text{ and } \sum_{B=1}^{k} W_B = 1 \qquad \text{eqn. (I)}$$

Where W_i = weighting; M_i = mean score of a particular barrier factor; $\sum W_i$ = summation of mean ratings of the barriers within a particular grouping. The weightings of the barrier groupings are calculated in like manner to the underlying barrier.

IV. A fuzzy evaluation matrix for each set of barriers is established. This matrix is expressed as $R_i = (r_{ij})_{m \times n}$, r_{ij} is the degree to which alternative L_j satisfies the barrier category B_j

V. The FSE results of the barrier categories are determined through the weighting vector and the fuzzy evaluation matrix as expressed in eqn. (II):

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

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

VI. The FSE evaluation matrix is normalized to develop an objective level of criticality (OLC) of the barrier categories by using eqn. (III):

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

4. Results of Data Analysis

4.1 Demographic Profile of Respondents

An analysis of respondents' demographic profile revealed that 41.0% (frequency (*f*) = *25*) of the respondents are public sector employees followed by 34.4% (*f = 21*) in academic/research institutions and 24.6% (*f = 15*) as private real estate developers or contractors. On profession of respondents, 47.5% (*f = 29*) are quantity surveyors, 18.0% (*f = 11*) are construction managers, 11.5% (*f = 7*) are architects, 6.6% (*f = 4*) are engineers, 6.6% (*f = 4*) are planners and 9.8% (*f = 6*) are researchers. Regarding number of housing projects handled in the Ghanaian housing market, 57.4% of the respondents have handled more than two housing projects. Regards working experience, 63.9% of the respondents have over five years of work experience. Requested demographic data of the 21 household occupants include age and size of household. Concerning age, 42.9% (*f = 9*) are 40-49 years, 23.8% (*f = 5*) are 30-39 years, 19.0% (*f = 4*) are below 30 years and 14.3 (*f = 3*) are 50-59 years. Regards size of households, 42.9% (*f = 9*) are at least 6 persons in a household, 42.9% (*f = 9*) are 4-5 persons in a household and 14.3% ($f = 3$) are 2-3 persons in a household. The respondents' profile suggests that both professionals and households are abreast of contemporary developments in the Ghanaian housing market and could provide insightful data to evaluate symmetries and asymmetries on sustainable housing barriers on one hand and to objectively assess the impact of barriers on sustainable housing.

4.2 Results of Mean Score Ranking and Mann-Whitney *U* Test

Rankings of the barriers are based on their mean scores and standard deviations (refer to Table 2). For two barriers with the same estimated mean scores, the one with the lower standard deviation is ranked higher. The mean scores range from 3.556 to 4.583 and 3.333 to 4.846 for professionals and households, respectively. The results suggest that some barriers were rated higher by the households (i.e., housing owners) than the ratings by the professionals. On the other hand, regarding the lower values, some of the barriers were rated higher by the professional than the ratings by the households. The low standard deviations (i.e., < 1.00) estimated for both groups of respondents for most barriers confirmed that there is high consistency among the respondents' regards ratings of the barriers. Moreover, an overall Cronbach's alpha of 0.882 was estimated for the barriers, which is greater than the recommended threshold (i.e., 0.70) for data reliability and internal consistency. This implies that the data are adequately reliable and internally consistent for subsequent analyses.

Results on test of significant difference between professionals and households on the barriers are shown in the last column of Table 2. The Mann-Whitney *U* test revealed that two economic barriers have significant p-values < 0.05 (i.e., one barrier with p-value < 0.05 and the other with p < 0.01). On *'social sustainability barriers'*, four barriers have significant test values < 0.05 (two barriers of p < 0.05 and the other two barriers of p < 0.01). Regards *'environmental sustainability barriers'*, two barriers have significant test values (one barrier of p < 0.05 and the other of p < 0.01). Concerning *'institutional sustainability barriers'*, two barriers have significant test values (p < 0.05 and the other p < 0.01) (refer to Table 2). The results imply that some barriers have different impacts on the two groups of respondents. This reinforces the assertion that it is essential to ensure a holistic assessment of the barriers to sustainable housing development from the different perspectives to avoid the problem of unbalanced information and its effects on policy formulation.

Among all the barriers, *'high cost of capital (i.e., interest rates on loans)'* was the highest rated barrier by the two groups of respondents. There was no significant difference between the two independent groups (p = 0.45, Z= -0.763). However, households rated *'high cost of building/construction materials and technologies'* higher with a significant difference supported at a p-value < 0.05. Besides, *'inadequate incentives for sustainable housing development'* was rated higher by professionals with significant difference of p-value < 0.05. On 'social sustainability barriers', professionals rated *'negative culture towards mortgage / loans for housing'* and *'high default rates concerning loan repayments'* higher at significant difference of p < 0.05. Furthermore, professionals rated *'lack of awareness creation and training on sustainable strategies / technologies'* and *'fear and risk in sustainable technologies adoption'* higher at significant difference of p < 0.05. Regards *'environmental sustainability barriers'*, professionals rated *'lack of sustainable building codes and regulations'* and *'lack of sustainable waste management in building design and construction'* higher. The mean comparison of these barriers between professionals and households have significant differences supported at p-values < 0.05 and < 0.01, respectively. On 'institutional sustainability barriers', most of the barriers were equally rated high (i.e., > 3.5). However, '*lack of regulatory support on guidelines for sustainable housing (i.e., public education and training* *platforms)'* and *'inadequate financing institutions for housing loans / mortgage'* were rated higher by households and professionals at significant difference of $p < 0.01$ and $p < 0.05$, respectively.

Table 2: Results of Descriptive Statistics and Mann-Whitney *U* Test of Underlying Barriers

Code	Categories and Underlying Barriers	Professionals			Households (House Owners)			Mann-Whitney *U* test		
		Mean	Standard Deviation	Ranks	Mean	Standard Deviation	Ranks	U statistics	Z	Sig.
	Economic Sustainability Barriers									
ESB1	Lack of public funding to support adoption of sustainable housing strategies / technologies	4.407	0.714	6	4.381	0.921	8	554.500	-0.165	0.869
ESB2	Inadequate access to credit and capital by developers and households	4.404	0.681	7	4.385	0.961	6	423.500	-1.856	0.064
ESB3	High cost of capital (i.e., interest rates on loans)	4.583	0.563	1	4.846	0.358	1	508.000	-0.763	0.446
ESB4	High inflation rates (including exchange rate)	4.389	0.712	8	4.714	0.463	3	430.500	-1.833	0.067
ESB5	High cost of serviced land in cities / towns	4.467	0.726	4	4.539	0.519	5	457.000	-1.215	0.224
ESB6	High cost of building/construction materials and technologies	4.444	0.572	5	4.833	0.389	2	338.000	-2.851	0.004**
ESB7	High cost of land registration and acquisition of building permit	4.148	0.627	18	4.333	0.730	10	474.500	-1.213	0.225
ESB8	Inadequate incentives for sustainable housing development	4.222	0.883	16	3.810	0.750	21	395.500	-2.162	0.031*
ESB9	Extra cost and time for sustainable housing	3.925	0.829	28	4.191	0.750	11	456.000	-1.338	0.181
	Social Sustainability Barriers									
SSB1	Inadequate public facilities and difficult access to them (i.e., inadequate infrastructural development)	4.000	0.801	23	3.524	1.078	31	430.500	-1.701	0.089
SSB2	Inadequate participation in housing design and information sharing among stakeholders on sustainable strategies (wide communication gap)	4.333	0.817	10	4.000	1.000	15	436.000	-1.806	0.071
SSB3	Income inequality (weak income growth among most households)	3.982	0.789	26	4.095	0.768	12	532.500	-0.445	0.656
SSB4	Social exclusion and segregation	4.085	0.908	19	3.923	1.115	16	483.500	-1.037	0.300
SSB5	Negative culture towards mortgage / loans for housing	3.852	0.856	31	3.143	1.062	35	350.000	-2.702	0.007**
SSB6	High default rates concerning loan repayments	3.907	0.917	29	3.429	0.978	32	405.000	-2.030	0.042*
SSB7	Inadequate expertise for sustainable housing	3.567	1.047	35	3.400	0.821	33	491.000	-0.824	0.410
SSB8	Lack of awareness creation and training on sustainable strategies / technologies for housing	4.333	0.817	10	3.857	0.727	17	182.500	-5.231	0.000**
SSB9	Fear and risk in the adoption of new technology (high inertia to conventional building)	4.167	0.757	17	3.857	0.727	17	380.500	-2.455	0.014*
SSB10	Inadequate adaptability in housing design to meet changing lifestyle of households	4.000	0.894	24	3.762	0.995	22	478.000	-1.229	0.219

	Environmental Sustainability Barriers									
NSB1	Scarcity on land availability within cities / town	4.037	0.889	20	3.667	1.278	29	495.500	-0.895	0.371
NSB2	Inadequate brownfield development for sustainable housing (i.e., peripheralization)	3.630	0.808	33	3.714	0.845	24	518.500	-0.604	0.546
NSB3	Lack of high-density use of land (i.e., low-rise housing development)	3.556	0.883	34	3.600	0.995	30	535.000	-0.399	0.690
NSB4	Lack of sustainable building codes and standards	4.333	0.817	10	3.667	1.197	28	372.500	-2.565	0.010**
NSB5	Lack of certification for sustainable building	4.000	0.632	21	3.714	1.102	26	502.500	-0.900	0.368
NSB6	Inadequate design for disassembly of building elements and components for reuse or alteration	3.833	0.983	32	3.333	0.796	34	463.000	-1.305	0.192
NSB7	Lack of knowledge and interest on reusing materials or components (i.e., recyclables) for new housing	4.000	0.632	21	3.714	0.956	25	477.500	-1.531	0.126
NSB8	Lack of sustainable waste management in housing design and construction	4.500	0.548	2	4.375	0.516	9	201.000	-4.966	0.000**
	Institutional Sustainability Barriers									
ISB1	Delays in government's approval process	3.944	0.878	27	3.714	1.007	27	480.000	-1.098	0.272
ISB2	Weak enforcement of planning control on property development	4.226	0.800	15	4.095	0.889	13	515.500	-0.536	0.592
ISB3	Low capacity of service providers (regards electricity and water suppliers)	4.300	0.483	14	4.381	0.498	7	465.500	-1.360	0.174
ISB4	Lack of sustainability requirements in building permit approval	4.000	0.894	24	3.857	1.062	19	545.000	-0.183	0.854
ISB5	Over concentration on active government-based planning schemes / policies to the neglect of previous policies	4.333	0.680	9	4.000	0.894	14	454.000	-1.454	0.146
ISB6	Lack of clearly defined policies and goals for sustainable housing (i.e., regulating faster land depletion)	3.907	0.996	30	3.762	1.091	23	525.000	-0.519	0.604
ISB7	Lack of regulatory support on guidelines for sustainable housing (i.e., public education & training platforms)	4.500	0.548	2	4.625	0.518	4	204.000	-5.010	0.000**
ISB8	Inadequate financing institutions for housing loans / mortgage	4.319	0.726	13	3.846	1.281	20	388.500	-2.287	0.022*

Note: Test of statistical significance: $**p < 0.01$; $*p < 0.05$

4.3 Results of FSE Technique

Prior to using the FSE technique for evaluating the barriers, two levels were established, namely, the first level (level one) and second level (level two). The first level entails the four main categories of barriers: economic, social, environmental and institutional sustainability barriers. These categories are represented as B_{ESB}, B_{SSB}, B_{NSB} and B_{ISB} respectively. The individual barriers under the categories constitute the second level (Osei-Kyei and Chan, 2017; Adabre and Chan, 2020; Gurmu et al., 2021). Equations for both the categories and their underlying barriers can be expressed as follows:

$B_{ESB} = \{B_{ESB1}, B_{ESB2}, B_{ESB3}, B_{ESB4}, B_{ESB5}, B_{ESB6}, B_{ESB7}, B_{ESB8}, B_{ESB9}\}$

$B_{SSB} = \{B_{SSB1}, B_{SSB2}, B_{SSB3}, B_{SSB4}, B_{SSB5}, B_{SSB6}, B_{SSB7}, B_{SSB8}, B_{SSB9}, B_{SSB10}\}$

$B_{NSB} = \{B_{NSB1}, B_{NSB2}, B_{NSB3}, B_{NSB4}, B_{NSB5}, B_{NSB6}, B_{NSB7}, B_{NSB8}\}$

$B_{ISB} = \{B_{ISB1}, B_{ISB2}, B_{ISB3}, B_{ISB4}, B_{ISB5}, B_{ISB6}, B_{ISB7}, B_{ISB8}\}$

The underlying barriers at the second level serve as input variables for the first level in the FSE analysis. For example, B_{ESB1}, which represents *'lack of public funding to support adoption of sustainable housing strategies / technologies'*, is an input variable for the category *'economic sustainability barriers'* which is represented as B_{ESB}.

4.3.1 Determining the Weighting of Input Variables

Weightings of the underlying barriers represent their relative mean scores within each category of barriers, which are estimated using eqn. (I). Recall eqn. (I):

$$W_B = \frac{M_B}{\sum_{B=1}^{k} M_B}, \; 0 < W_B < 1, \text{ and } \sum_{B=1}^{k} W_B = 1 \qquad \text{eqn. (I)}$$

Where W_B represents the calculated weighting of an underlying barrier in its category. W_B is obtained by dividing the mean score, represented as M_B, of a barrier by the sum of all the means scores within that category. For example, using the barrier category – *economic sustainability barriers* – the weighting of the underlying barrier *'lack of public funding to support adoption of sustainable housing strategies / technologies'* is calculated as follows:

$$W_B = \frac{4.407}{4.407+4.404+4.583+4.389+4.467+4.444+4.148+4.222+3.925} = \frac{4.407}{38.989} = 0.113$$

Similarly, weightings of the barrier categories are calculated by dividing their mean score (obtained by summing the mean scores of all the underlying barriers in a category) by the summation of the mean scores of all the barrier categories. For example, the weighting of the *'economic sustainability barriers'* is determined as

$$W_c = \frac{38.989}{38.989+40.226+31.889+33.529} = \frac{38.989}{144.633} = 0.270$$

Thus, the weightings of both the underlying and groupings of the other barriers are calculated using the same approach (refer to Table 3).

Table 3: Weighting of Underlying Barriers and their Categories

Categories & Underlying Barriers	Codes	Professionals				Households (House Owners)			
		Mean	Weightings of Barriers (W_B)	Total Mean of each Category (M_c)	Weightings of each Category (W_C)	Mean	Weightings of Barriers (W_B)	Total Mean of each Category (M_c)	Weightings of each Category (W_C)
Economic Sustainability Barriers									
	ESB1	4.407	0.113			4.381	0.123		
	ESB2	4.404	0.113			4.385	0.123		
	ESB3	4.583	0.118			4.846	0.136		
	ESB4	4.389	0.113			4.714	0.132		
	ESB5	4.467	0.115			4.539	0.127		
	ESB6	4.444	0.114			4.833	0.135		
	ESB7	4.148	0.106			4.333	0.121		
	ESB8	4.222	0.108			3.810	0.107		
	ESB9	3.925	0.101	38.989	0.270	4.191	0.117	35.699	0.265
Social Sustainability Barriers									
	SSB1	4.000	0.099			3.524	0.095		
	SSB2	4.333	0.108			4.000	0.108		
	SSB3	3.982	0.099			4.095	0.111		
	SSB4	4.085	0.102			3.923	0.106		
	SSB5	3.852	0.096			3.143	0.085		
	SSB6	3.907	0.097			3.429	0.093		
	SSB7	3.567	0.089			3.400	0.092		
	SSB8	4.333	0.108			3.857	0.104		
	SSB9	4.167	0.104			3.857	0.104		
	SSB10	4.000	0.099	40.226	0.278	3.762	0.102	36.990	0.275
Environmental Sustainability Barriers									
	NSB1	4.037	0.127			3.667	0.123		
	NSB2	3.630	0.114			3.714	0.125		
	NSB3	3.556	0.112			3.600	0.121		
	NSB4	4.333	0.136			3.667	0.123		
	NSB5	4.000	0.125			3.714	0.125		
	NSB6	3.833	0.120			3.333	0.112		
	NSB7	4.000	0.125			3.714	0.125		
	NSB8	4.500	0.141	31.889	0.220	4.375	0.147	29.784	0.221

Institutional Sustainability Barriers									
	ISB1	3.944	0.118			3.714	0.115		
	ISB2	4.226	0.126			4.095	0.127		
	ISB3	4.300	0.128			4.381	0.136		
	ISB4	4.000	0.119			3.857	0.119		
	ISB5	4.333	0.129			4.000	0.124		
	ISB6	3.907	0.117			3.762	0.117		
	ISB7	4.500	0.134			4.625	0.143		
	ISB8	4.319	0.129	33.529	0.232	3.846	0.119	32.280	0.240
Total mean and total weighting values				144.633	1.000			134.753	1.001

4.3.2 Determining Membership Functions of Underlying Barriers

Membership functions (which range between 0 and 1) refer to the degree of an element's membership in a fuzzy set. The membership functions are first obtained for level 2 before obtaining the membership functions for level 1. Membership functions of level 2 are derived from the respondents' ratings of the underlying barriers in the questionnaire survey. Since a five-point Likert scale (i.e., R_1=not critical, R_2=less critical, R_3=neutral, R_4=critical, R_5=very critical) was deployed in the questionnaire survey, each membership function has five elements. Using the barrier factor *'lack of public funding to support adoption of sustainable housing strategies / technologies'*, for example, none (0%) rated it as 'not critical', 2% of the respondents rated it as 'less critical', 7% were neutral on rating its criticality, 39% of the respondents rated it as critical while 52% as 'very critical'. Given that $B_{1\mathrm{ESB1}}$ is the percentage of responses per each rating on the barrier, then the membership function ($MF_{1\mathrm{ESB1}}$) of *'lack of public funding to support adoption of sustainable housing strategies / technologies'* could be expressed in the following equations:

$$MF_{1\mathrm{ESB1}} = \frac{B_{1\mathrm{ESB1}}}{R_1} + \frac{B_{2\mathrm{ESB1}}}{R_2} + \frac{B_{3\mathrm{ESB1}}}{R_3} + \frac{B_{4\mathrm{ESB1}}}{R_4} + \frac{B_{5\mathrm{ESB1}}}{R_5}$$

$$MF_{1\mathrm{ESB1}} = \frac{B_{1\mathrm{ESB1}}}{\text{not critical}} + \frac{B_{2\mathrm{ESB1}}}{\text{less critical}} + \frac{B_{3\mathrm{ESB1}}}{\text{neutral}} + \frac{B_{4\mathrm{ESB1}}}{\text{critical}} + \frac{B_{5\mathrm{ESB1}}}{\text{very critical}}$$

$$MF_{1\mathrm{ESB1}} = \frac{0.00}{R_1} + \frac{0.02}{R_2} + \frac{0.07}{R_3} + \frac{0.39}{R_4} + \frac{0.52}{R_5}$$

Since the "+" denotes a notation and not an addition in the fuzzy synthetic evaluation analysis (Ameyaw and Chan, 2015), the membership function can also be expressed in the following form:

$$MF_{1\mathrm{ESB1}} = (0.00, 0.02, 0.07, 0.39, 0.52)$$

Similarly, the membership functions of the other barriers are obtained as shown in Table 4.

4.3.3 Determining Membership Functions of the Categories of Barriers

After obtaining the membership functions of the underlying barriers, the membership functions of the barrier categories could be determined using eqn. II.

$$D_B = W_B \circ M_B \qquad \text{eqn. (II)}$$

Where W_B = weightings of a barrier within a category; and M_B is the fuzzy evaluation matrix. Using the barrier category *'economic sustainability barriers'*, for example, its fuzzy evaluation matrix M_B can be expressed as follows:

$$M_B = \begin{bmatrix} MF_{1\mathrm{ESB1}} \\ MF_{1\mathrm{ESB2}} \\ MF_{1\mathrm{ESB3}} \\ MF_{1\mathrm{ESB4}} \\ MF_{1\mathrm{ESB5}} \\ MF_{1\mathrm{ESB6}} \\ MF_{1\mathrm{ESB7}} \\ MF_{1\mathrm{ESB8}} \\ MF_{1\mathrm{ESB9}} \end{bmatrix} = \begin{bmatrix} B_{1\mathrm{ESB1}} & B_{2\mathrm{ESB1}} & B_{3\mathrm{ESB1}} & B_{4\mathrm{ESB1}} & B_{5\mathrm{ESB1}} \\ B_{1\mathrm{ESB2}} & B_{2\mathrm{ESB2}} & B_{3\mathrm{ESB2}} & B_{4\mathrm{ESB2}} & B_{5\mathrm{ESB2}} \\ B_{1\mathrm{ESB3}} & B_{2\mathrm{ESB3}} & B_{3\mathrm{ESB3}} & B_{4\mathrm{ESB3}} & B_{5\mathrm{ESB3}} \\ B_{1\mathrm{ESB4}} & B_{2\mathrm{ESB4}} & B_{3\mathrm{ESB4}} & B_{4\mathrm{ESB4}} & B_{5\mathrm{ESB4}} \\ B_{1\mathrm{ESB5}} & B_{2\mathrm{ESB5}} & B_{3\mathrm{ESB5}} & B_{4\mathrm{ESB5}} & B_{5\mathrm{ESB5}} \\ B_{1\mathrm{ESB6}} & B_{2\mathrm{ESB6}} & B_{3\mathrm{ESB6}} & B_{4\mathrm{ESB6}} & B_{5\mathrm{ESB6}} \\ B_{1\mathrm{ESB7}} & B_{2\mathrm{ESB7}} & B_{3\mathrm{ESB7}} & B_{4\mathrm{ESB7}} & B_{5\mathrm{ESB7}} \\ B_{1\mathrm{ESB8}} & B_{2\mathrm{ESB8}} & B_{3\mathrm{ESB8}} & B_{4\mathrm{ESB8}} & B_{5\mathrm{ESB8}} \\ B_{1\mathrm{ESB9}} & B_{2\mathrm{ESB9}} & B_{3\mathrm{ESB9}} & B_{4\mathrm{ESB9}} & B_{5\mathrm{ESB9}} \end{bmatrix}$$

From the matrix, $B_{1\mathrm{ESB1}}$ is an element of the fuzzy evaluation matrix which is the weighting element of an underlying barrier. The fuzzy evaluation matrix is then obtained as a product of the weighting function set of the barriers and fuzzy matrix, which is computed as follows:

$$
D_B = (W_{B1}, W_{B2}, \ldots, W_{in}) \times \begin{bmatrix} B_{1ESB1} & B_{2ESB1} & B_{3ESB1} & B_{4ESB1} & B_{5ESB1} \\ B_{1ESB2} & B_{2ESB2} & B_{3ESB2} & B_{4ESB2} & B_{5ESB2} \\ B_{1ESB3} & B_{2ESB3} & B_{3ESB3} & B_{4ESB3} & B_{5ESB3} \\ B_{1ESB4} & B_{2ESB4} & B_{3ESB4} & B_{4ESB4} & B_{5ESB4} \\ B_{1ESB5} & B_{2ESB5} & B_{3ESB5} & B_{4ESB5} & B_{5ESB5} \\ B_{1ESB6} & B_{2ESB6} & B_{3ESB6} & B_{4ESB6} & B_{5ESB6} \\ B_{1ESB7} & B_{2ESB7} & B_{3ESB7} & B_{4ESB7} & B_{5ESB7} \\ B_{1ESB8} & B_{2ESB8} & B_{3ESB8} & B_{4ESB8} & B_{5ESB8} \\ B_{1ESB9} & B_{2ESB9} & B_{3ESB9} & B_{4ESB9} & B_{5ESB9} \end{bmatrix}
$$

Using this matrix format, the membership functions of all the barrier categories are computed as shown in Table 4.

4.3.4 Determining Criticalities of the Barrier Categories

4.3.4.1 Criticalities of Barriers from the Perspectives of Professionals

After estimating the membership functions at level 1, the criticality of each category of barriers is determined using eqn. (III). For instance, the objective level of criticality of the ‘economic sustainability barriers’ (OLC_{ESB}) is calculated as follows: Recall eqn. (III)

$OLC_{ESB} = D_{ESB} \times R_n = (D_{ESB1}, D_{ESB2}, D_{ESB3}, D_{ESB4}, D_{ESB5}) \times (R_1, R_2, R_3, R_4, R_5)$ eqn. (III)
Where $D_{ESB} = (D_{ESB1}, D_{ESB2}, D_{ESB3}, D_{ESB4}, D_{ESB5})$ is the fuzzy evaluation matrix or MF for level 1 and $R_n = (1, 2, 3, 4, 5)$ is the grade alternative. Thus, the OLC_{ESB} of the ‘economic sustainability barriers’ is calculated as follows:
OLC_{ESB} = (0.002, 0.013, 0.089, 0.408, 0.489) x (1, 2, 3, 4, 5) = 4.371

Using similar approach, the criticalities of the other three barrier categories are computed as follows:
OLC_{SSB} = (0.002, 0.052, 0.186, 0.442, 0.322) x (1, 2, 3, 4, 5) = 4.040
OLC_{NSB} = (0.000, 0.033, 0.144, 0.557, 0.271) x (1, 2, 3, 4, 5) = 4.082
OLC_{ISB} = (0.002, 0.032, 0.103, 0.491, 0.374) x (1, 2, 3, 4, 5) = 4.209

4.3.4.2 Criticalities of Barriers from the Perspectives of Households

The criticalities of the barrier categories from the perspectives of the households were evaluated similarly as follows:

OLC_{ESB} = (0.030, 0.053, 0.070, 0.388, 0.581) x (1, 2, 3, 4, 5) = 4.801
OLC_{SSB} = (0.024, 0.117, 0.260, 0.361, 0.241) x (1, 2, 3, 4, 5) = 3.682
OLC_{NSB} = (0.012, 0.129, 0.203, 0.426, 0.237) x (1, 2, 3, 4, 5) = 3.768
OLC_{ISB} = (0.012, 0.081, 0.148, 0.398, 0.366) x (1, 2, 3, 4, 5) = 4.039

The FSE values and the Mann-Whitney *U* test on significant differences of the barrier categories are provided in Table 5.

Table 4: Membership Function of Underlying Barriers and their Categories

Categories & Underlying Barriers	Codes	Professionals				Households (House Owners)			
		(W_B)	MF for Level 2	MF for Level 1	(W_C)	(W_B)	MF for Level 2	MF for Level 1	(W_C)
Economic Sustainability Barriers									
	ESB1	0.113	0.00,0.02,0.07,0.39,0.52	0.00,0.01,0.09,0.41,0.49	0.270	0.123	0.05,0.00,0.00,0.43,0.52	0.03,0.05,0.07,0.39,0.58	0.265
	ESB2	0.113	0.00,0.00,0.09,0.37,0.54			0.123	0.19,0.05,0.05,0.33,0.38		
	ESB3	0.118	0.00,0.00,0.00,0.25,0.75			0.136	0.00,0.19,0.00,0.10,0.71		
	ESB4	0.113	0.00,0.02,0.07,0.41,0.50			0.132	0.00,0.00,0.00,0.29,0.71		
	ESB5	0.115	0.00,0.02,0.08,0.33,0.58			0.127	0.00,0.00,0.00,0.62,0.38		
	ESB6	0.114	0.00,0.00,0.04,0.48,0.48			0.135	0.00,0.00,0.00,0.15,0.85		
	ESB7	0.106	0.00,0.00,0.13,0.59,0.28			0.121	0.00,0.00,0.14,0.38,0.48		
	ESB8	0.108	0.02,0.00,0.19,0.33,0.46			0.107	0.00,0.14,0.38,0.29,0.19		
	ESB9	0.101	0.00,0.08,0.15,0.55,0.23			0.117	0.00,0.05,0.05,0.57,0.33		
Social Sustainability Barriers									
	SSB1	0.099	0.00,0.02,0.26,0.43,0.30	0.00,0.05,0.19,0.44,0.32	0.278	0.095	0.00,0.24,0.19,0.38,0.19	0.02,0.12,0.25,0.36,0.24	0.275
	SSB2	0.108	0.00,0.00,0.17,0.33,0.50			0.108	0.00,0.10,0.19,0.33,0.38		
	SSB3	0.099	0.00,0.06,0.15,0.56,0.24			0.111	0.00,0.00,0.24,0.43,0.33		
	SSB4	0.102	0.00,0.04,0.22,0.35,0.39			0.106	0.19,0.10,0.10,0.24,0.38		
	SSB5	0.096	0.00,0.07,0.22,0.48,0.22			0.085	0.05,0.24,0.33,0.29,0.10		
	SSB6	0.097	0.00,0.11,0.13,0.50,0.26			0.093	0.00,0.19,0.33,0.33,0.14		
	SSB7	0.089	0.02,0.17,0.23,0.40,0.19			0.092	0.00,0.15,0.35,0.45,0.05		
	SSB8	0.108	0.00,0.00,0.17,0.33,0.50			0.104	0.00,0.05,0.19,0.62,0.14		
	SSB9	0.104	0.00,0.00,0.17,0.50,0.33			0.104	0.00,0.05,0.38,0.24,0.33		
	SSB10	0.099	0.00,0.08,0.15,0.55,0.23			0.102	0.00,0.10,0.33,0.29,0.29		
Environmental Sustainability Barriers									
	NSB1	0.127	0.00,0.00,0.29,0.43,0.29	0.00,0.03,0.14,0.56,0.27	0.220	0.123	0.00,0.29,0.14,0.19,0.38	0.01,0.13,0.20,0.43,0.24	0.221
	NSB2	0.114	0.00,0.00,0.00,0.86,0.14			0.125	0.00,0.10,0.24,0.52,0.14		
	NSB3	0.112	0.00,0.11,0.37,0.37,0.15			0.121	0.05,0.05,0.30,0.50,0.15		
	NSB4	0.136	0.00,0.00,0.17,0.33,0.50			0.123	0.00,0.24,0.19,0.24,0.33		
	NSB5	0.125	0.00,0.00,0.17,0.67,0.17			0.125	0.00,0.19,0.19,0.33,0.28		

	NSB6	0.120	0.00,0.17,0.00,0.67,0.17			0.112	0.00,0.14,0.43,0.38,0.05		
	NSB7	0.125	0.00,0.00,0.17,0.67,0.17			0.125	0.05,0.05,0.19,0.57,0.14		
	NSB8	0.141	0.00,0.00,0.00,0.50,0.50			0.147	0.00,0.00,0.00,0.63,0.38		
Institutional Sustainability Barriers									
	ISB1	0.118	0.02,0.06,0.13,0.56,0.24	0.00,0.03,0.10,0.49,0.37	0.232	0.115	0.00,0.10,0.38,0.24,0.29	0.01,0.08,0.15,0.40,0.37	0.240
	ISB2	0.126	0.00,0.04,0.11,0.43,0.42			0.127	0.00,0.10,0.05,0.52,0.33		
	ISB3	0.128	0.00,0.00,0.00,0.70,0.30			0.136	0.00,0.00,0.00,0.62,0.38		
	ISB4	0.119	0.00,0.00,0.33,0.33,0.33			0.119	0.05,0.05,0.19,0.43,0.29		
	ISB5	0.129	0.00,0.00,0.09,0.48,0.43			0.124	0.00,0.05,0.24,0.38,0.33		
	ISB6	0.117	0.00,0.13,0.15,0.41,0.32			0.117	0.00,0.14,0.29,0.24,0.33		
	ISB7	0.134	0.00,0.00,0.00,0.50,0.50			0.143	0.00,0.00,0.00,0.38,0.63		
	ISB8	0.129	0.00,0.04,0.04,0.50,0.43			0.119	0.05,0.24,0.10,0.33,0.29		

Table 5: FSE values and Mann-Whitney *U* test on significant differences

Categories of Barriers	Professionals		Households (House Owners)		Man-Whitney *U* test		
	FSE Weight	Rank	FSE Weight	Rank	*U* Statistics	Z	Sig.
Impact of economic sustainability barriers on sustainable development in housing	4.371	1	4.801	1	35.000	-0.486	0.627
Impact of social sustainability barriers on sustainable development in housing	4.040	4	3.682	4	20.000	-2.237	0.023*
Impact of environmental sustainability barriers on sustainable development in housing	4.082	3	3.768	3	18.000	-1.477	0.044*
Impact of institutional sustainability barriers on sustainable development in housing	4.209	2	4.039	2	20.500	-1.209	0.227

Note: Test of statistical significance: $**p < 0.01$; $*p < 0.05$

5. Discussion of Results (Symmetries and Asymmetries on Barriers)

5.1 Economic Sustainability Barriers

5.1.1 Symmetries / Similarities on Economic Sustainability Barriers

The 'economic sustainability barriers' category has the highest impact of 4.371 and 4.801 from both perspectives of professionals and households, respectively (refer to Table 5). There is no significant difference on the mean comparison between the two respondents (i.e., a p-value of 0.627 and a Z-value of -0.486) regarding the economic barriers category. Thus, economic challenges equally affect professionals and households. Within the economic challenges, some barriers were highly ranked with no significant difference on their mean comparison. These underlying barriers together with their respective rankings (in brackets) from the views of professionals and households include: *'lack of public funding to support adoption of sustainable housing strategies/technologies'* (ranked 6th and 8th by professionals and households); *'high cost of capital / interest rates'* (ranked 1st by both professionals and households); *'high cost of serviced land in cities and towns'* (ranked 4th and 5th); *'high cost of land registration and acquisition of building permit'* (ranked 18th and 10th); *'high inflation rates*' (ranked 8th and 3rd) and *'inadequate access to credit and capital by developers and homeowners'* (ranked 7th and 6th) (refer to Table 2). Since these barriers have no significant difference on their mean comparisons, it implies that the barriers similarly buffet professionals and households on sustainable housing development. This is not surprising because the said underlying barriers are external factors of which the professionals and households have no control over.

Similarly, Trianni et al. (2017) observed that the economic barriers have the most emphasized impact on sustainable development. On underlying economic barriers, Owusu-Ansah et al. (2019) identified some of these barriers as market-based constraints that affect housing supply by developers in Ghana. Ghana has one of the highest interest rates in the world, after Malawi (Owusu-Ansah et al., 2019). The *'high interest rates'* and *'high inflation rates'* are influenced by high prime/monetary rates (quoted at 23.60 and 23.83 in 2015 and 2017 respectively). These macroeconomic factors affect the cost of housing supply and make housing prices unaffordable for most middle- and low-income earners. Furthermore, *'tight credit conditions'* (i.e., cumbersome loan provision on request for collateral by financial institutions); high cost of land attributed to speculations and high cost incurred on land acquisitions, registration and permit approval have hindered housing supply by some developers. Most small-scale developers and households do not have the required assets as collateral to access banking facilities. In sub-Saharan Africa in general, Cobbing and Hiller (2019) asserted that access to banking facilities and banking systems is labyrinthine and onerous. Besides, the high cost of land and its related costs restrict housing supply from emerging developers. Consequently, these barriers affect housing accessibility and affordability among households.

5.1.2 Asymmetries / Disparities on Economic Sustainability Barriers

'High cost of building / construction materials and technologies' is ranked 5th and 2nd by professionals and households, respectively. There was a significant difference on the mean comparison which is supported at a p-value of 0.004 and Z-value of -2.851. Although ranked high in both cases, its relative low rating by professionals (i.e., 4.444) compared to households (i.e. 4.833) could be attributed to the benefits of wholesale purchases by the professionals such as developers. However, households such as self-builders do not enjoy such benefits due to purchases of construction materials in small (often incomplete) batches from retailers. Typical of this is cement which is among the most expensive construction materials in Ghana. The highly inflationary price of cement could be attributed to importation taxes on its raw materials. Another reason for the significance difference could be component re-use among developers.

Developers benefit from economy of scales due to re-use of building materials such as formwork materials, tools and technologies for construction. However, among self-builders, housing construction is mostly one-off which does not encourage re-use of construction materials/technologies. Therefore, wholesale purchases by households could be adopted to reduce the cost impact of construction materials and technologies on sustainable housing. This could be achieved through establishing online platforms like Uber for partnership among households within communities for wholesale purchase of materials such as cement. Such partnership or stakeholder networks could also be a recipe for promoting circular economy (CE) strategies such as sharing of unused building resources or resale of unused construction materials, tools and technologies among households at discounted price. Besides, the partnership could facilitate CE centres for repair and remanufacture of construction resources as well as enabling a functional market for recyclables. Moreover, online platform networks between buyers and suppliers of resources could lead to dematerialization (Yevu et al., 2022; Mhatre et al., 2021; Hosseini et al., 2015). Thus, a virtual environment could be created for purchase of materials, which could save buyers the cost and time associated with traditional window shopping. Promotion of product-service-systems for materials that are used one-off to facilitate construction (i.e., formwork and scaffolding) could be a key strategy for materials cost reduction. In such systems, business stakeholders sell services to consumers while ownership of the product or material resides with the producer. Considering the high rating of the barrier 'high cost of construction materials and technologies' (i.e., > 4.000) by both households and professionals, strategies for material efficiency such as design for remanufacture and design for longer use and design for longer-life of construction materials could be essential design principles by designers and material producers (Allwood et al., 2011).

'Inadequate incentives for sustainable housing development' is ranked 16th and 21st by professionals and households, respectively. There is a significant difference on the mean comparison which is supported at a p-value of 0.031 and a Z-value of -2.162. Although 'inadequate incentives for sustainable housing development' is ranked high (i.e., > 3.5) in both cases, its mean score of 4.222 by the professionals is higher than the mean score by the households i.e., 3.810. The finding implies that the barrier has more impact on professionals than on households. 'Inadequate incentives for sustainable housing development' is one of the reasons for inadequate housing supplies from developers. Besides, it contributes to price or rental unaffordability of housing facilities supplied by developers in most Ghanaian cities (Eduful & Hooper, 2019).

5.2 Institutional Sustainability Barriers

5.2.1 Symmetries on Institutional Sustainability Barriers

With FSE weights of 4.209 and 4.039, the 'institutional sustainability barriers' category was ranked second by both the professionals and households. There was no significant difference on the mean comparison of the institutional barrier category between the two respondents considering an estimated p-value of 0.227 and a Z-value of -1.209. Thus, institutional challenges equally affect both professionals and households. This is unsurprising since the institutional challenges are external impacts on professionals and households, which are mostly caused by bureaucracy and inadequate legislation (Trianni et al., 2017). Therefore, most institutional barriers were highly ranked albeit with no significant differences on their mean comparisons. Some of these underlying barriers with their respective rankings by the professionals and households in bracket include: 'delays in government's approval process' (ranked 27th and 27th), 'weak enforcement of planning control on property development' (ranked 15th and 13th), 'low capacity of service providers regards electricity and water suppliers' (ranked 14th and 7th), 'lack of sustainability requirement in permit approval' (ranked 24th and 19th), 'over concentration on active government-based planning schemes' (ranked 9th and 14th) and 'lack of clearly defined policies and goals for sustainable housing' (ranked 30th and 23rd).

The high mean scores of institutional barriers suggest a pressing need for enhancing institutional strategies. For instance, legislation and regulations require improvement concerning enforcement of planning control on property development and expedited government regulations/approval on housing development. In Ghana, chieftaincy institutions mostly allocate land while the planning institutions determine and manage development on it (Siiba et al., 2018). However, the chieftaincy institutions assume the planning institution's role due to bureaucracy in government's approvals on planning and other regulatory requirements on development (Siiba et al., 2018). Besides, *'bureaucracy in government's approvals'* has inflationary impact on prices of construction materials. Therefore, most households, for instance, rely on chiefs/landowners for expedited development approvals, which exacerbates unplanned development and land litigations due to multiple sales (Akaateba, 2019). This leads to unregulated land allocation and development which lower land use for sustainable housing. Moreover, policy instability due to changes in government has often culminated in delays in government approval process of public housing project. This leads to delayed payments of contractors and abandonment of uncompleted housing projects.

5.2.2 Asymmetries on Institutional Sustainability Barriers

'Lack of regulatory support on guidelines for sustainable housing (i.e., public education and training platform)' was ranked 2nd and 4th by professionals and households. There was a significant difference between their mean comparison which is supported at a p-value of 0.000 and a Z-value of -5.010. With a mean score of 4.625, the barrier was ranked higher by the households which implies a more pressing need for education and training on guidelines for sustainable housing among households. Televised programs on educating the public about sustainable technologies and strategies and the benefits of such technologies will ensure an informed public. Besides, training centres on promotion of experimental approaches for sustainable housing (i.e., sustainability centre, living lab) and support in the form of technical assistance for sustainable strategies could promote awareness creation among households (Trianni et al., 2017).

'Inadequate financing institutions for housing loans / mortgage' is ranked 13th and 20th by the professionals and households with mean scores of 4.319 and 3.846, respectively. The mean comparison showed significant difference which is supported at a p-value of 0.022 (i.e., < 0.05) and a Z-value of -2.287. The significant difference suggests that 'inadequate financing institutions for housing loans' has higher impact (i.e., 4.319) on professionals such as developers than on households (i.e., 3.846). Besides, its relatively low ranking among household is not surprising in the Ghanaian context since most households would rather prefer to build piecemeal with their own capital to building with loans from financing institutions.

5.3 Environmental Sustainability Barriers

5.3.1 Symmetries on Environmental Sustainability Barriers

The 'environmental sustainability barriers' category is ranked third by professionals and households with estimated FSE scores of 4.082 and 3.768, respectively (refer to Table 5). Concerning the mean comparison, there is a significant difference between the two groups of respondents, supported at a p-value of 0.044 (i.e., < 0.05) and a Z-value of -1.477. Thus, environmental challenges are more prevalent among the professionals. Notwithstanding the overall significant difference on the environmental challenges, some of the individual barriers were not significantly different concerning their mean comparison between the two groups of respondents. Some of these barriers together with their rankings (in brackets) by the professionals and households include: 'scarcity on land availability within cities / towns' (ranked 20th and 29th); 'inadequate brownfield development for sustainable housing i.e. peripheralization' (ranked 33rd and 24th); 'lack of high density use of land i.e., low-rise housing (ranked 34th and 30th); 'lack of certification and accreditation for sustainable building' (ranked 21st and 26th); 'inadequate design for disassembly of building elements and components for reuse or alteration' (32nd and 34th) and 'lack of knowledge and interest on reusing materials or components i.e., recyclables for new housing (21st and 25th). Barriers within environmental sustainability could influence one another (Adabre et al., 2021a). For instance, *'low-rise housing development'*, especially within cities/towns, could contribute to faster land consumption. This situation could influence *'inadequate access to land'* which could lead to *'siting and construction of new housing facilities in peripheral of cities/towns'*. Aside faster depletion of land, these barriers contribute to increasing emissions from vehicular movement due to long commuting distance from cities/towns to the peripheral (*ibid*). Moreover, low-rise development leads to congestion within cities and towns which has ripple effects on visual intrusion.

5.3.2 Asymmetries on Environmental Sustainability Barriers

'Lack of sustainable waste management in housing design and construction' is ranked 2nd and 9th by the professionals and households respectively with mean scores of 4.500 and 4.375. There is a significant difference between the two groups of respondents on the mean comparison of the environmental barriers category which suggests that this barrier is more dominant among professionals. Accordingly, professionals of the construction and design team could explore ways to reuse and recycle waste. Such strategies must be considered at the designing and construction stages. For instance, in most construction projects in Ghana, construction of septic tanks entails huge excavations which are mostly carried out when projects are near completion. Consequently, only a little portion of the excavated material is used for backfilling while the remaining is mostly left on sites as waste. Therefore, if the subsoil is suitable, such excavations could be carried out at the early stages of the projects so that the excavated materials could be used for backfilling and hardcore filling. Besides, wastage resulting from mortar and broken blocks could be reused or recycled for subsequent uses. CE strategies that ensure design for material recovery, design for minimum waste generation, design for material or elements reuse and design for waste recovery are essential for minimizing wastage in the Ghanaian construction industry in general.

With mean scores of 4.333 and 3.667, the barrier 'lack of sustainable building codes and standards' is ranked 10th and 28th by professionals and households, respectively. There is a significant difference on the mean comparison, which is supported at a p-value of 0.010 (i.e., < 0.05) and a Z-value of -2.565. Globally, most developed countries have established building codes and standards for ensuring environmental sustainability. However, 'inadequate codes and standards for sustainable buildings' is a worldwide problem. Therefore, in Ghana, for example, buildings codes that promote sustainable housing strategies could be established and implemented by the various governmental institutions. On sustainability standards for instance, CE indicators such as modularity, recyclability, design for remanufacture and reusability of construction materials should be included as requirements of building designs (Allwood et al., 2011; Jin et al., 2021).

5.4 Social Sustainability Barriers

5.4.1 Symmetries on Social Sustainability Barriers

'Social sustainability barrier' category is ranked forth by both professionals and households with estimated mean scores of 4.040 and 3.682, respectively. There is a significant difference between the two respondent groups on its mean comparison supported at a p-value of 0.023 (i.e., < 0.05) and Z-value of -2.237 (refer to Table 5). However, mean comparisons of some social sustainability barriers did not show significant differences which imply similarities on the views of respondents concerning impacts of such barriers. Notable among them include: 'inadequate public facilities and difficult access to facilities'; 'inadequate participation in housing design and information sharing among stakeholders on sustainable strategies'; 'income inequality' and 'inadequate adaptability in housing design to meet changing lifestyle of households'. These barriers are rated high (i.e., > 3.500) by both professionals and households. Therefore, they form the key barriers which plague both suppliers and consumers of the Ghanaian housing market. On the high rating of *'inadequate participation in housing design and information sharing among stakeholders'*, Atanda (2019, p. 247) attributed this to 'a reluctance mindset towards social programs - seminar and conference' on awareness creation and a lack of interest to adopt sustainability strategies. Nonetheless, promoting regenerative design strategies such as co-creation and co-production (i.e., participatory design), co-evolution and adaptability will ensure social sustainability attainment. On co-creation and co-production, these strategies promote engagement of the design and construction team with the households or consumers for adequate information sharing.

The need for housing adaptability is more exigent in responding to environmental changes, to user needs and to the economy. Designs that ensure multiple use of building elements, flexibility (i.e., demountable partition walls in self-contained accommodation) and energy efficiency (i.e., incorporating daylight into a building) are relevant in these times of energy and economic crises in Ghana and in other developing countries. Design for building flexibility is key to housing adaptability. Adaptability dimensions such as adjustable, movable and convertible building elements are essential for designing flexible housing facilities (Van Ellen et al., 2021). Indeed, such adaptability dimensions will ensure reuse of building elements and prevent demolition and waste attributed to alteration works and refurbishment, which could promote CE in residential facilities. Ensuring the adoption of at least one adaptability strategy (i.e., respond to environment, users or economy) could have ripple effects on the other adaptability strategies. For instance, reduction in energy consumption will also result in economic gains to households.

5.4.2 Asymmetries on Social Sustainability Barriers

Underlying social sustainability barriers which have significant differences regards their mean comparison between professionals and households include: 'negative culture towards mortgage / loans for housing'; 'high default rates concerning loan repayments'; 'lack of awareness creation and training on sustainable strategies / technologies' and 'fear and risk in the adoption of new technologies (i.e., high inertia to conventional buildings)'. The relative low ratings by households regarding 'high default rates on loan repayments' and 'negative culture towards mortgage / loans for housing' suggest a relatively low level of interest among households on banking facilities for housing in the Ghanaian context. Most households have a negative aversion to bank loans/mortgages due to high interest rates, tight credit condition and fear of default. Similarly, Byabato (2005) cited in Schmidt and Zakayo (2018), found that 80% of interviewed households stated that they would not consider a bank loan premised upon title deed(s) as collateral because of the fear of losing their property. Schmidt and Zakayo (*ibid*) state that ambivalence and mistrust of the macroeconomic conditions and financial institutions are amongst prominent reasons for the negative attitude towards bank loans/mortgages. Adequate measures for economic sustainability could have significant influence on controlling these social sustainability barriers. For instance, measures on reducing interest rates, inflation rates and improved access to credit could alleviate *'high mortgage default rates by clients'* and *'negative culture towards mortgage/credit from financing institutions'* among professionals and households. Effective policies on low-interest rates and other incentives (i.e., land supply) for private developers could motivate developers to ensure inclusionary housing for middle- and low-income earners, which could control income inequality and social exclusion and segregation. This could serve as an effective policy for reducing the segregation effects of gated communities. Besides, long-term and low-interest loans and subsidies that are linked to effective retrofitting of existing housing facilities among property owners could enhance social sustainability attainment in housing development. In addition to improved loan access, other incentives such as tax-rebates, tax credit and subsidies could be deployed to promote sustainable housing (Adabre et al., 2021b).

'Lack of awareness creation' and 'fear and risk in the adoption of new technology' are rated higher (i.e., mean scores of 4.333 and 4.167, respectively) by professionals (Table 5) which indicate that these barriers have higher impact among the professionals. Thus, strategies for knowledge dissemination on sustainable technologies should target the professionals. Continuous awareness creation among professional concerning sustainable technologies and strategies will have trickle-down effect on households' awareness. Households rely on professionals' knowledge for decision making on housing design and construction. Therefore, once the professionals are informed, they could suggest appropriate technologies to the households during design briefing, conceptual design and construction. Awareness creation backed by economic incentives could ensure adoption of sustainable technologies in housing.

5.5 Implications and Policy Recommendation for Sustainable Housing

The four categories of barriers that plague sustainable housing development are rated high (i.e., > 3.500). Economic barriers are the most critical, followed by institutional, environmental and social sustainability barriers. The study's findings concur with findings of Daniel (1992) that sustainable development could be untenable because of barriers that are related to the economic structure and internal economic relation. *High inflation rate*; *high interest rate*; *tight credit conditions*; *inadequate public funding and high cost of building materials/technologies* are barriers that affect the Ghanaian economic structure, internal economic relations and the Ghanaian housing market. These barriers affect local developers, self-builders and foreign developers. Nonetheless, the findings contradict the work of Owusu-Ansah et al. (2019) which ranked institutional barriers higher than the underlying economic barriers. Thus, while Owusu-Ansah et al. (*ibid*) considered the mean scores of underlying barriers for ranking the economic and institutional categories, this study extends on that former work to include the summation of the mean scores of underlying barriers using the FSE technique. The sum being greater than the parts for determining the impact of barrier categories upon sustainable housing (Squires & Hutchison, 2021). Notably, although the institutional barriers could have causal influence on other barriers (Owusu-Ansah et al., 2019; Adabre et al., 2021a), this does not imply that the institutional barriers ought to have the highest effect or impact on sustainable housing development; albeit they could originate other more impactful barriers. That is evidenced in this present study since the economic barriers have the highest impact on sustainable housing although study by Adabre et al. (2021a) showed that economic barriers are caused by institutional barriers.

To achieve the UN SDGs in housing, respondents believe that the barriers which require the most attention are economic-related. Therefore, a fundamental requirement is to develop and ensure continued stable macroeconomic policies such as appropriate reduction in inflation rate, low-interest rates, long-term loan amortization, appropriate reduction of treasury bill rates and fixed deposits rates. These policies are essential for reducing cost-burden of sustainable housing on developers and households. Besides, stable macroeconomic policies offer an enabling environment for attracting foreign investors for public-private partnership / joint venture on housing supply (Osei-Kyei and Chan, 2017; Tetteh et al., 2021).

Furthermore, through stringent measures on fixed deposit rates and treasury bills rates, the government could prevent future microfinance crisis as witnessed in the past five years (i.e., 2015 to 2020) (Boateng et al., 2016). These short-term investments partly contributed to the collapse of micro-finance institutions such as DKM, Diamond Winners, GN Bank and Gold Coast Securities (Boateng et al., 2016). Most micro-finance institutions capped their interest/fixed deposit rates against the then high treasury bills rate to attract deposits. The micro-finance institutions in turn lent at high interest rates (i.e., > 25) to contractors including developers. Due to the exorbitant rate (i.e., > 25% interest rate per annum) and the short-term amortization, most developers could not defray the loans and therefore, the banks and micro-finance could not pay the amounts of depositors. Another effect of high interest rates of these short-term investments is that most small-scale developers who could have supplied small-scale rental facilities preferred to deposit their money with micro-finance institutions because the interest rates were higher than returns from rental housing supply and the risk-free investments (i.e., fixed deposits and treasury bills). Therefore, stringent measures on treasury bills and fixed deposits could discourage such portfolio investments and rather promote real investment including rental and owner facilities supply. This could also prevent the future collapse of microfinance institutions.

Effective institutional policies are essential in the Ghanaian housing market considering the high estimated impact of institutional barriers. Land litigations, prolonged procedure in land acquisition, land registration and acquisition of building permit have delayed housing supply among developers. Additionally, they have contributed to unauthorised development among self-builders (Owusu-Ansah et al., 2019). Therefore, institutional policies on expedited regulatory procedure for property development (at the planning agencies and authorities) could incentivise and improve housing supply. Besides, such policies will improve adequate planning control on land development for sustainable use of land for achieving the SDGs in housing. Planning agencies and authorities at the district, municipal and metropolitan level could implement these policies effectively if they are adequately supplied with financial and human resources. Additionally, improved capacity of service providers (i.e., GWCL, GNFS and Electricity Company of Ghana) could encourage high-rise housing in cities (Agyemang et al., 2018).

Moreover, policies should be implemented to ensure alleviation of most environmental problems. Such measures are more related to agents and firms. For instance, to control fast depletion of land, peripheralization and increasing emissions due to long commuting distance, adequate urban containment policies should be enacted. Policies that encourage appropriate densification through compact city development and urban regeneration are essential for controlling loss of biodiversity (Abo-El-Wafa et al., 2018). Such policies will promote appropriate urban developments with coordinated infrastructure supply and ensure reduced commuting cost/distance. Zoning regulations on urban expansion and suburbanization should be established for controlling leapfrogging of low-density housing. These regulations could be effective if supported by incentives to encourage high-rise development. Essentially, urban sprawl in cities such as Accra and Kumasi should be regulated to restrict the rate at which the natural environment is converted into the built environment to engender sustainable harmonisation and reduce the impact of anthropogenic activities (Arku, 2009).

To promote environmental sustainability via circular economy, standardization of building components and elements is essential for reuse and sharing of resources in the Ghanaian housing market. Standardization will ensure that designs of housing facilities are aligned for possible reuse of building components or elements in other housing facilities. This could mitigate construction and demolition (C&D) waste. Enforcing standardizations of building designs could require the efforts of policymakers responsible for building permit approval. Design for standardization of building elements and components should be one of the criteria for granting permit (Guerra & Leite, 2021). Furthermore, online network platforms that function like Uber and Airbnb could be established among professionals and households in the Ghanaian housing market. Such platforms would promote sharing and purchases of resources among stakeholders for reuse. This will ensure optimum resource utilization by preventing wastage and low utilization attributed to one-off housing projects among households.

On controlling the social sustainability barriers in housing, a key area that requires reconsideration in the Ghanaian housing market is the traditional housing (otherwise known as 'compound housing'). Compound housing offers affordable facilities for most middle and low-income earners, and it provides relatively high level of residential density (Eduful & Hooper, 2019). Thus, effective policies towards developers and parastatal institutions on promoting high-rise compound housing within urban areas could address housing challenges of middle and low-income earners. Furthermore, the state could provide developers with incentives (such as land supply and interest-free loans) to ensure inclusionary housing facilities for middle- and low-income earners in major urban areas. Cumulatively, these measures will reduce income inequality, social exclusion and segregation. Since developers could be averse to loans, other incentives such as tax exemptions and subsidies could be deployed to motivate such low-cost traditional compound housing (Eduful & Hooper, 2019).

6. Conclusions

This study presented an assessment on impact of four main categories of barriers on sustainable housing development from the perspective of professionals (suppliers) and households (consumers). The identification and categorization of the barriers were based on the four main pillars of sustainable development, namely, 'economic'; 'social'; 'environmental' and 'institutional sustainability'. Primary data on the underlying barriers were garnered through a questionnaire survey of professionals of regulated/formal institutions of the Ghanaian housing market and households (homeowners).

Data analysis was conducted using Man-Whitney *U* test to identify symmetries and asymmetries on barriers to sustainable housing. Additionally, FSE technique was used to objectively assess the impact of the barrier categories on sustainable housing. The results revealed similarities and disparities on the underlying and groups of barriers from the views of professionals and households. Mean comparison of key barriers which did not have significant differences from the perspectives of professionals and households include: 'high cost of capital (i.e., interest rates on loans)'; 'high cost of serviced land in cities / towns'; 'lack of public funding to support adoption of sustainable housing strategies / technologies'; 'low capacity of service providers (regards electricity and water supply)' and 'high cost of land registration and acquisition of building permit'. However, barriers that showed significant differences include:

‘high cost of building / construction materials and technologies’; ‘negative culture towards mortgage / loans for housing’; ‘lack of awareness creation and training on sustainable strategies / technologies for housing’; ‘lack of sustainable waste management in housing design and construction’ and ‘lack of regulatory support on guidelines for sustainable housing’. Additionally, FSE results on the barrier categories revealed that economic barriers have the highest impact followed by institutional, environmental and social sustainability barriers. Significant differences between the views of professionals and households were observed on environmental and social sustainability barriers. Thus, the economic and institutional barriers categories are general barriers while social and environmental sustainability barriers are specific barriers that have different impacts on professionals and households regards implementation of sustainable housing.

The findings imply that the main challenges to achieving the SDGs in housing are economic related barriers although they could be influenced by institutional barriers. Therefore, for sustainable housing from the perspective of professionals and households in Ghana, improvement on access to credit, low-interest rate loans and strategic measures for reducing inflation rate are relevant. Enhanced macroeconomic conditions in addition to effective and adequate institutional strategies on planning control, financial institutions for housing loans, adequately resourced utility providers and online platforms for stakeholders collaboration could mitigate the economic and institutional challenges. Besides, such policies could alleviate the environmental and social sustainability barriers in the Ghanaian housing market in towns and cities. Furthermore, material efficiency for assuaging the cost of construction resources could be achieved through circular economy principles viz: sharing and reuse of resources. These principles could be implemented by establishing online platform for stakeholder networks especially among households for second-hand market of resources. Moreover, institutional agents such as the planning and building permit departments could include standardization of building designs as a requirement for granting building permit. ‘Use of standard sizes’ in housing design and construction will ensure resource sharing and material reuse among stakeholders. Despite the theoretical and practical contributions of this work, the study findings have some limitations. Future study could explore the possible causations among the underlying barriers.

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