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CHALLENGES TO SUSTAINABLE AFFORDABLE HOUSING USING FRUGAL INNOVATION

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Across the globe, and especially in the developed world, housing remains one of the crucial challenges of growth due to the immense difference between housing supply and demand. Broadly speaking, the housing crisis is primarily a matter of demand for housing, outstripping supply and/or the price of housing above the average worker's income. The global COVID 19 pandemic has shown how important it is to reduce the global housing crisis by ensuring sustainable, affordable, and healthy housing for all. However, in terms, of financial and limited natural resources, one idea currently gaining traction is frugal innovation. The aim of this research is to establish the challenges to sustainable affordable housing using frugal innovation. Frugal innovation is simple, a low-cost innovation (LCI) developed to serve customers at the bottom of the pyramid (BOP) of the unserved mass market. A comprehensive literature review was conducted using a deductive approach. The structured survey questionnaire was used as an instrument for collecting data, using a non-probability purposive sampling technique, and the data was analysed using descriptive statistics. The seven (7) most significant challenges to sustainable affordable housing using frugal innovation in Ghana are; difficulty in significantly lowering costs while retaining functions, perceived low benefit or profit return on investment, lack of research and design, lack of demand, ineffective local partners, difficulty establishing key functional elements, and low confidentiality. This research will build an immense contribution to improving the access for all adequate, safe and affordable housing and basic services and upgrade the slums of the sustainable development goal target of the 2030. Future research should focus on how to use frugal innovation to effectively establish the core functional elements of a sustainable, affordable housing system, and how to apply frugal innovation to other construction sectors, especially in developing countries.

Keywords: affordable housing, frugal innovation, sustainability

INTRODUCTION

Frugal innovation (FI) simply refers to efforts to produce products or services that offer customers significant cost savings over existing alternatives in order to meet

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the needs of resource-constrained consumers (Zeschky et al., 2011). FI focuses on re-designing products, services, and business models by lowering complexity throughout the product's complete lifecycle costs, while maintaining high value and affordable solutions for the unserved market of BOP customers in developing nations (Agarwal and Brem, 2012; Bhatti, 2012; Rao, 2013; Zeschky et al., 2011).

Frugal innovation (FI) is rapidly becoming a benchmark for assessing alternative, sustainability (Basu and Sweeny, 2013). The 17 Sustainable Development Goals (SDGs) outline unsolved global issues including poverty alleviation and social exclusion (Arnold, 2018). To solve global sustainability, frugal innovation can be considered a key competency (Basu and Sweeny, 2013). The phenomenon of financial and natural resource limitations calls for imaginative ways to counteract these conditions in times of limited resources. In this regard, one idea currently gaining traction as a relatively new innovation is frugal innovation (Imhof and Mahrr, 2017). The aim of this study is to establish the challenges to sustainable affordable housing (SAH) in Ghana using frugal innovation (FI).

The global COVID 19 pandemic has shown how important it is to reduce the global housing crisis by ensuring sustainable, affordable, and healthy housing for all, according to the Sustainable Development Goals (UN-Habitat, 2020). Sustainable affordable housing (SAH) through frugal innovation will be the way forward from the new COVID-19 protocols of social distance and isolation. Housing shortages in Ghana have crossed 2 million units, this does not however, account for the projected housing needs for isolation and social distancing for CODVID-19 houses, implying that the government will have to build more than 200,000 houses every year for the next decade to close the gap (Minister for Works and Housing, 2019).

The world is gradually becoming more urbanised. More than 50% population in the world lived in cities since 2007, and this number is projected to rise to 60% by 2030 (United Nations, 2019). Cities and metropolitan areas are the driving forces of economic growth, accounting for more than 60% of global GDP. On the other hand, they account for more than 70% of global greenhouse gas emissions and about 60% of resource consumption (United Nations, 2019). Rapid urbanization causes air pollution and unplanned urban sprawl in many slum dwellers, as well as inadequate and overwhelmed infrastructure and services (including waste disposal, water and sanitation systems, roads and transport). COVID-19 will have the most negative effects in poor and densely populated urban areas, especially for the one billion people living in informal settlements and slums around the world, where overcrowding already makes it difficult to take recommended measures, including social distancing and self-isolation measures (UN-Habitat, 2020).

However, most developed countries have failed in the past to pursue a cost-effective innovation strategy, and due to conventional approaches to product and service innovation, the world is experiencing resource shortages, environmental damage, and a number of other negative consequences (Sammut-Bonnici et al., 2015). Several well-known scholars, including Chan et al., (2018), Agyekum et al., (2019), Oke et al., (2019), Ayakwa et al.,(2017), and so on. Despite research into various challenges to sustainable building development, no study has attempted to apply the concept of frugal innovation to the development of sustainable affordable housing, resulting in a significant gap in the literature on the application

of frugal innovation concept to sustainable affordable housing and construction in general. Therefore, to close this gap, it will be imperative to establish the challenges to sustainable affordable housing using frugal innovation, hence the need for this research.

FRUGAL INNOVATION

Frugal innovation is clearly defined as Low-cost innovation (LCIs) produced or manufactured to serve consumers at the bottom of the pyramid (BOP) of the unserved mass market is specifically characterised as frugal innovation. The term "unserved" refers to a category of people that cannot afford a particular product, service, or housing for the cost of the product or service, which may be due to its complexity or sophistication, technical requirements, structural elements, or complex design nature, making it costly (Kahle et al., 2013; Lim and Fujimoto, 2019). Furthermore, frugal innovation aims to optimise use of materials and financial resources across the entire value chain (development, production, delivery, use, and disposal) by using minimal raw materials, reusing existing parts, lightweight structures, and cutting-edge technologies to achieve low costs and a low cost of ownership while simultaneously satisfying customer demands. The production of low-cost mass-market products that are affordable to all social strata, including the less affluent segments, is the economic significance of frugal innovation (Sammut-Bonnici et al., 2015). It's characterised by a scarcity of resources to build low-cost, climate-friendly technologies. Comparatively to conventional product development methods, these resource-constrained product development techniques can result in products that are more sustainable, resulting in lower energy consumption and greater supply chain efficiencies (Sharma and Iyer, 2012; Khan, 2016). Frugal innovation is also consistent with (ecological and social) sustainability because it is more affordable and accessible than conventional technology because it uses fewer resources (raw materials, manufacturing resources, energy, heat, water, waste, financial resources) than traditional technology (Albert, 2019). Frugal innovation is critical to achieving social sustainability; it promotes the SDGs and contributes to the larger goal of sustainable growth (Khan, 2016).

Although they are other concepts similar and sometimes interchangeable with frugal innovation, including grassroots, disruptive, jugaad, Gandhian innovation and reverse innovations, resource-constrained innovation, good-enough innovation etc. (Brem and Wolfram, 2014; Zeschky et al., 2014a; Soni and Krishnan, 2014; Prabhu and Jain, 2015; Hossain et al., 2016). FI is perceived as a better concept that encompasses various different types of innovation under one umbrella (Adari and Ganesh, 2015).

Challenges to SAH using Frugal Innovation (FI)

Frugal innovation is often not concerned with environmental sustainability (Sharma and Iyer, 2012), and it appears that environmental sustainability is more of a byproduct than a primary reason for frugal initiatives (Wohlfart et al., 2016). Weyrauch and Herstatt (2016) point out that frugal innovation need not mean sustainability, and that sustainability is not frugal innovation's primary objective. In their debate, Levanen et al. (2015) point out that conceptually equating frugality and sustainability is problematic. Usage of inefficient raw material processing

practises to address resource-constrained problems poses a danger to the ecological and social climate. Furthermore, in the pursuit of extreme affordability, there is unsustainable low-cost manufacturing and processing, which can result in substantial waste generation. The emphasis on limited resources and affordability can divert attention away from long-term consequences, including technology mingling with non-sustainable components. The rebound effect may influence how frugal innovation is used or consumed. If frugal innovation is produced more affordable, more customers will buy it and use it, resulting in increased demand and probably more environmental damage (increasing material use, energy use, and waste generation). When it comes to end-of-life concerns, cost-cutting innovation will cause environmental problems due to improper disposal. Another danger is that a less expensive, lower-cost innovation could cannibalise a company's existing high-end service, resulting in a drop in sales. Furthermore, if a low-cost innovation falls short of the previous company's performance, the company's image can be damaged (Albert, 2019).

Lack of public awareness, expense, and insufficient knowledge are some major barriers to sustainable affordable housing using frugal innovation (Oke et al., 2019). In addition, one of the major challenges to the effective adoption of sustainable construction methods was identified as insufficient financial incentives, including high taxes and low profit margins. This contrasts with the results of Djakoto et al. (2014), who found that a lack of demand was the most significant obstacle to achieving long-term affordable housing through frugal innovation. (Ayakwa et al., 2017). Previous research has shown that both emerging and developed countries face difficulties achieving Sustainable affordable housing through frugal innovation. The five critical barriers to sustainable housing in the United States, according to Ahn et al. (2013), are high cost efficiency, long payback times, a proclivity to continue existing practises, restricted subcontractors' expertise and skills, and higher prices of sustainable goods and materials. In a similar report, the most critical barriers to sustainable affordable housing using frugal innovation in the US were identified as resistance to reform, higher costs of sustainability, insufficient information and understanding, insufficient expertise, and insufficient government incentives (Chan et al., 2016). High costs of equipment and materials, insufficient interest and communication firms, insufficient research, insufficient interest among clients and market demand, a lengthy pre-construction phase, and uncertainty with sustainable materials and equipment were also major challenges in Singapore (Hwang et al., 2012; Hwang et al., 2013). Moreover, higher prices, insufficient government incentives, insufficient funding schemes including bank loans, the unavailability of suppliers, and insufficient local institutes and facilities for R&D were identified as the five major challenges to sustainable affordable housing in technology and innovation in Ghana (Chan et al. ,2018). Likewise, the eight main barriers to the implementation of green certification of buildings in Ghana are lack of information on existing sustainable housing, lack of incentives, conservatism of Ghanaians, lack of active government participation, insufficient human resources, lack of awareness of gains, costs and financing, and lack of legal support (Agyekum et al., 2019).

In addition, Love et al.,(2011) described one of the key impediments to sustainable development as a lack of government incentives (green building). According to Obeng-Odoom and Amedzro (2011), the high inflation rate in building materials

and other development factors is a major obstacle to the economic sustainability of affordable housing. High interest rates and "tight credit conditions" are also obstacles (Boamah, 2010). According to Trudeau (2018) and Nguyen et al.,(2013), one of the main obstacles to its implementation is "group resistance to affordable housing programs." Similarly, Sturzaker (2011) said that there is strong opposition in the United Kingdom to social housing. As well, income inequality between households is an obstacle to social cohesion. For example, a "poor culture of mortgages" (Sidawi and Meeran, 2011) and "high mortgage defaults" (Boamah, 2010) do not encourage financial institutions to participate in housing supply. Furthermore, Ruparathna and Hewage's,(2015) report, obstacles include the lack of consideration of sustainability standards in the evaluation of bids, the lack of traditional procurement processes, the lack of awareness of local conditions and the lack of clear legislative provisions covering sustainable procurement in Canada. According to Shafii et al.,(2006), barriers to sustainable buildings in Malaysia include a lack of awareness of sustainable buildings, a lack of training and training, higher costs of sustainable building options, procurement problems, regulatory barriers, a lack of professional skills / designers, incentives for local material production and a lack of case studies / examples. The biggest obstacle to the delivery of sustainable buildings is a lack of awareness, information and understanding (Jusoh, 2015). According to a study conducted in Malaysia, one of the biggest obstacles to the construction of green buildings in the country is the lack of public knowledge. People's knowledge of the definition of green housing should be improved first, then business knowledge, and finally industry knowledge (Lop et al., 2012; Lim et al., 2018). Although the most significant barriers to GBT adoption in developing countries, including Ghana, differ from those in developed countries such as the United States, Canada, and Australia, higher GBT costs remain a major challenge among all, according to a comparative study (Chan et al., 2018).

METHODOLOGY

For this research, a comprehensive literature review was conducted using a deductive approach to develop current literature on the challenges of sustainable affordable housing using frugal innovation as a reference (Syed-Jamaludin et al.,2018). The structured survey questionnaire was used as an instrument for collecting one-time cross-sectional quantitative primary data for the analysis. The data was collected using a non-probability purposive sampling technique (Owusu-Manu et al.,2018;Oke et al., 2019;Debrah et al., 2020). The questionnaires were designed with Google Survey Form and distributed to only stakeholders within the housing and construction industry with the knowledge, experience, accessible and willing to provide the needed information for the study. They were contacted for the data collection using online (via email and Whatsapp) to allow for easy and quick responses. However, measures were put in place to prevent multiple responses via email verification by ensuring that each response was verified once with only one email of respondents. Although this approach had its limitation, especially when a respondent with multiple emails decides to use it to respond multiple times it was very uncommon. 103 questionnaires were returned answered out of 200 distributed to stakeholders in Ghana's building and housing market, primarily architects, quantity surveyors, consultants, engineers, academicians, both public and private sectors, contractors, and others. The data from the Google form

survey was extracted to Excel and then exported to SPSS to obtain the data compliant with any type of research format provided by SPSS. The data was analysed using descriptive statistics to extract percentages and frequencies; mean and standard deviation were used to analyse the difficulties. This was based, on previous research, of a similar nature (Otali and Ujene,2020).

DATA ANALYSIS

Data analysis on background of stakeholders

Respondents' background information was provided in frequencies and percentages. First, the data on gender, age and professional background are grouped in Table 1.0, as they all fall into a single set of responses from which the respondents were asked to choose, while the professional background as well as the type of company / organisation / institution is represented in Figure 1.0 and Figure 2.0. All but 103 of the 200 questionnaires distributed were returned with answers. Most of the respondents (94.2%) were males, with only 5.8% being females. The most common age group for respondents was 20-29 years, which accounted for 50.5% of all responses, followed by 30-39 years, which accounted for 35.9%, and 40-49 years, which accounted for 12.6 percent of all responses. The results indicate 34 respondents out of 103 total respondents have the highest educational qualification, accounting for 33% of the total responses. Post-graduates, master's, and doctoral degrees were the highest credentials, with 19 respondents accounting for 18.4 percent of all responses. Bachelor's degrees are the lowest qualification (BSc.). However, the highest qualification was Higher National Diploma (HND), with 48 respondents representing 46.6 percent, while Technician (CTC I/II/II/Advance) and other qualifications each had one respondent. The findings also showed respondents' years of working experience were mainly 1-5 years, with 54 responses representing 52.4% of the total, 6-10 years, with 25 respondents representing 24.3 percent, and 11-15 years, with 23.3 percent of the total responses.

Respondents' professional backgrounds, as shown in Figure 1.0, were primarily stakeholders in the housing and construction sector, including architects, quantity surveyors, engineers (all categories), lecturers, teachers, and others in the housing industry. Most of the respondents were Building Technology, construction management, and housing related students, both those who had completed tertiary education and those who were in their final year at the universities in Ghana, accounting for 44.6 percent of the total responses. Quantity surveyors came in second with 24 respondents accounting for 23.8 percent of the total responses, and engineers (all ages) came in third. The types of business, organisation, or institution, of respondents were conversely considered significantly for the study in figure 2.0. The results from the study revealed that most of the respondents were from academic/research institutions, with 36 respondents accounting 35.6 percent of the general responses, followed by contracting firms 24 respondents, accounting for 23.8 percent of the general responses, and other forms of construction and housing related sectors with 18, accounting for 17.8 percent of the total respondents. Also, consulting firms with 16 respondents representing 15.8 percent and so on as can be seen in figure 2.0.

Table 1: Background of respondents

Gender	Frequency	Percent
Male	97	94.2
Female	6	5.8
Total	103	100.0
Age		
20-29 years	52	50.5
30-39 years	37	35.9
40-49 years	13	12.6
50-59 years	1	1.0
Total	103	100.0
Highest Educational Qualification		
Post-Graduate/Master/PhD	34	33.0
Bachelor degree (Bsc)	19	18.4
Higher National Diploma (HND)	48	46.6
Technician (CTC I/II/III)/Advance	1	1.0
Others	1	1.0
Total	103	100.0
Years of working experience		
1-5	54	52.4
6-10	25	24.3
11-15 and above	24	23.3
Total	103	100.0

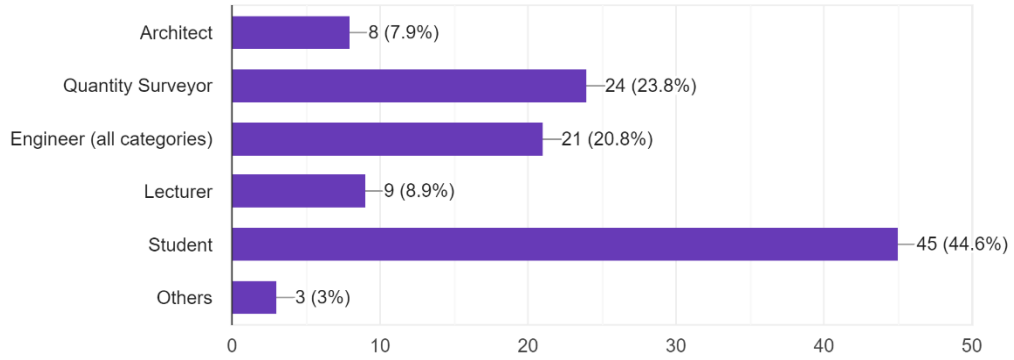


Figure 1.0 Professional Background

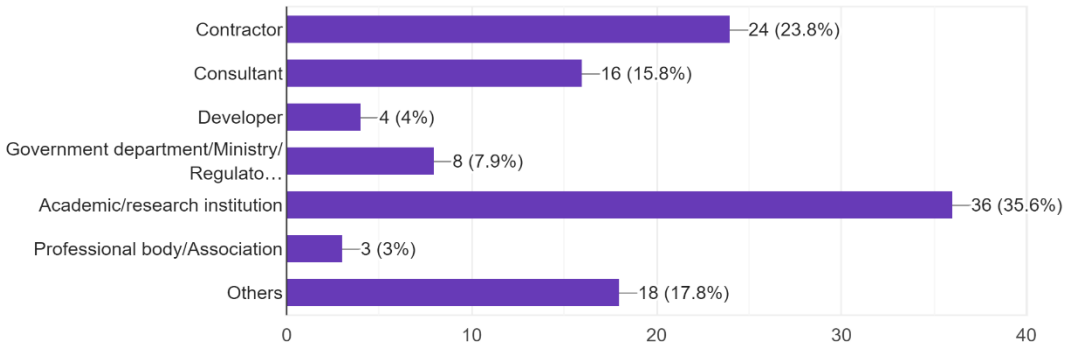


Figure 2.0 Type of company/organisation/Institution

Data analysis on challenges to SAH using FI

The data on the challenges to sustainable affordable housing using frugal innovation concept was extracted into mean and standard deviation score values for all the variables. In table 2.0, respondents were asked to rank on whether, variables were; 1=Very Significant, 2=Significant, 3=Not sure, 4=Insignificant, and 5=Very insignificant, in accordance with previous research.

Table 2.0 Challenges to SAH using FI

Descriptive Statistics	N	Minimum	Maximum	Mean	Std. Deviation	Rank
Difficulty reducing cost substantially while maintaining functions	103	1.00	5.00	2.3398	1.03425	1st
Perceived slow/low profit return on investment	103	1.00	5.00	2.2913	.93548	2nd
Lack of research and design	103	1.00	5.00	2.2913	1.00617	3rd
Lack of demand	103	1.00	5.00	2.2718	1.04969	4th
Unreliable local partners	103	1.00	5.00	2.2621	.94932	5th
Difficulty in establishing core functional elements	103	1.00	5.00	2.2621	1.03811	6th
Low confidentiality	103	1.00	5.00	2.2427	.98485	7th
Perceived higher cost	102	1.00	5.00	2.2255	1.00402	8th
Lack of standard measurements/scaling	103	1.00	5.00	2.2233	.99933	9th
High tax system	103	1.00	5.00	2.2136	.90370	10th
Risk associated with Investing/implementation of new practices	103	1.00	5.00	2.1845	.82542	11th
Concern on brand image/high quality	103	1.00	5.00	2.1650	.88669	12th
Lack of clear benefits of concept	103	1.00	5.00	2.1650	.97112	13th
Lack of funding_	103	1.00	5.00	2.1359	.99063	14th
Lack of reliable information on cost savings associated with frugal	103	1.00	5.00	2.1165	1.03186	15th
Lack of existing houses or examples for people to appreciate concept	103	1.00	5.00	2.1068	1.03765	16th
Lack of skill/expertise/professional know-how	103	1.00	5.00	2.1068	1.14543	17th
Lack of government commitment	103	1.00	5.00	2.0971	.96522	18th
Lack of methods to support the adoption	103	1.00	5.00	2.0971	.97533	19th
Resistance to changes in the current practices	103	1.00	5.00	2.0971	.97533	20th
Lack of training opportunities systems	103	1.00	5.00	2.0971	1.04332	21st
Lack of legislation enforcement and monitoring	103	1.00	5.00	2.0971	1.04332	22nd
Lack of measurement tool to showcase benefits	103	1.00	5.00	2.0971	1.02436	23rd
Compliance to conventional standards building codes/regulations	103	1.00	5.00	2.0874	1.07655	24th
Lack of cooperation among stakeholders	103	1.00	5.00	2.0777	.91490	25th
Perceived increase in cost and time	103	1.00	5.00	2.0583	.97845	26th
Resistance/unwillingness to change from current practices	103	1.00	5.00	2.0583	.87251	27th
Lack of publicity strategy approach to promote concept	103	1.00	5.00	2.0583	.96837	28th
Lack of creativity to simplify and find alternatives approach	103	1.00	5.00	2.0291	.94409	29th
Lack of public awareness of the benefits	103	1.00	5.00	2.0291	.90159	30th
Risk associated with investing in new concepts	103	1.00	5.00	2.0291	.84548	31st
Lack of adaptation to local innovation	103	1.00	5.00	2.0000	1.07558	32nd
Insufficient resource availability scarcity of inputs	103	1.00	5.00	1.9806	.94952	33rd
Lack of national policy direction	103	1.00	5.00	1.9806	.99981	34th
Lack of local documentation/standards	103	1.00	5.00	1.9612	.89577	35th
Institutional weakness	103	1.00	4.00	1.9515	.98398	36th
Lack of awareness education	103	1.00	5.00	1.9515	.96384	37th
Lack of government incentives and support_	103	1.00	5.00	1.9515	.87871	38th
Price sensitive clients	103	1.00	4.00	1.9223	.73684	39th
Contract conditions/specification	103	1.00	4.00	1.8252	.79739	40th
Lack of government commitments/support incentives for innovation	103	1.00	5.00	1.8058	1.03903	41st

When comparing variables using mean score, the variable with the highest mean score value is ranked higher than the variable with the lowest mean score value (Chan et al., 2018). Where two or more variables have the same mean value, however, the one with the lowest standard deviation (SD) rank is ranked higher (Owusu-Manu et al.,2019; Kissi et al.2020 and Debrah et al., 2020).

Table 2.0 shows that the biggest challenge to sustainable, affordable housing with frugal innovation was seen as the difficulty of substantially reducing costs while maintaining functions, with the highest mean score of 2.34 among all variables. Second to it was perceived slow/low profit return on investment, which has the same mean score of 2.29 with lack of research and design since it had a lower SD= .94. Lack of research and design was rated as the third most significant challenge to sustainable affordable housing using frugal innovation, whereas lack of demand was ranked as the fourth most significant challenge with a mean of 2.27. Unreliable local partners were ranked as the fifth most important challenge for sustainable affordable housing using frugal innovations, with an average of 2.262 and SD of 1.049; difficulty in identifying core functional elements was ranked sixth, with an average of 2.262 and SD of 1.038; and low confidentiality was ranked seventh, with an average of 2.2427, followed by perceived higher cost, lack of standard measurements/scaling, and high tax respectively as challenges.

One-sample T-test

Once again, this is a one-sample situation. The data was subjected to a test analysis to determine whether the mean score data produced on the challenges of sustainable housing in terms of affordable housing through frugal innovation was statistically relevant. The one-sample T-test is a statistical method for determining the relative significance of variables by examining the mean difference between the sample and the known value of the population mean (Ross and Willson, 2017; Owusu-Manu et al., 2018; Kassi et al., 2020; Debrah et al., 2020). If variables had a p-value (significance of the test) of P 0.05 at 95% confidence interval of the difference, they were considered important, while variables with a p-value >0.05 were considered insignificant. If the null hypothesis is valid, the p-value is simply the probability that random variables will take on values farther from the mean (Debrah et al., 2020). Table 3.0 shows that all 42 variables have a sig. 000 value less than the p-value (p0.05). Thus, the study found that all the challenges of sustainable affordable housing using frugal innovation presented for the study were statistically significant.

Table 3.0

One-Sample Test

	Test Value = 0					
	t	df	*p -value*	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Lack of awareness/education	20.548	102	.000	1.95146	1.7631	2.1398
Risk associated with Investing/implementation of new practices	26.859	102	.000	2.18447	2.0231	2.3458
High tax system	24.859	102	.000	2.21359	2.0370	2.3902
Lack of national policy direction_	20.105	102	.000	1.98058	1.7852	2.1760
Lack of local documentation/standards	22.220	102	.000	1.96117	1.7861	2.1362
Institutional/weakness	20.128	102	.000	1.95146	1.7591	2.1438
Insufficient resource availability scarcity of inputs	21.169	102	.000	1.98058	1.7950	2.1662
Price sensitive clients_	26.477	102	.000	1.92233	1.7783	2.0663

Concern on brand image high quality	24.781	102	.000	2.16505	1.9918	2.3383
Lack of adaptation to local innovation	18.872	102	.000	2.00000	1.7898	2.2102
Perceived slow low profit return on investment	24.858	102	.000	2.29126	2.1084	2.4741
Unreliable local partners_	24.184	102	.000	2.26214	2.0766	2.4477
Low confidentiality	23.111	102	.000	2.24272	2.0502	2.4352
Lack of clear benefits of concept__	22.626	102	.000	2.16505	1.9753	2.3548
Lack of existing houses or examples for people to appreciate concept	20.606	102	.000	2.10680	1.9040	2.3096
Lack of government commitments/support incentives for innovation	17.639	102	.000	1.80583	1.6028	2.0089
Lack of skill expertise/professional know-how	18.667	102	.000	2.10680	1.8829	2.3307
Lack of publicity strategy/approach to promote concept	21.571	102	.000	2.05825	1.8690	2.2475
Lack of demand_	21.965	102	.000	2.27184	2.0667	2.4770
Lack of legislation enforcement and monitoring	20.399	102	.000	2.09709	1.8932	2.3010
Lack of government incentives and support	22.539	102	.000	1.95146	1.7797	2.1232
Lack of public awareness of the benefits_	22.841	102	.000	2.02913	1.8529	2.2053
Resistance/unwillingness to change from current practices	23.941	102	.000	2.05825	1.8877	2.2288
Lack of training opportunities systems	20.399	102	.000	2.09709	1.8932	2.3010
Perceived increase in cost and time	21.349	102	.000	2.05825	1.8670	2.2495
Lack of measurement tool to showcase benefits_	20.777	102	.000	2.09709	1.8969	2.2973
Lack of cooperation among stakeholders_	23.047	102	.000	2.07767	1.8989	2.2565
Risk associated with investing in new concepts_	24.357	102	.000	2.02913	1.8639	2.1944
Lack of local documentation/standards	22.220	102	.000	1.96117	1.7861	2.1362
Perceived higher cost_	22.386	101	.000	2.22549	2.0283	2.4227
Lack of research and design_	23.111	102	.000	2.29126	2.0946	2.4879
Resistance to changes in the current practices_	21.821	102	.000	2.09709	1.9065	2.2877
Lack of reliable information on cost savings associated with frugal innovation	20.817	102	.000	2.11650	1.9148	2.3182
Lack of methods to support the adoption	21.821	102	.000	2.09709	1.9065	2.2877
Lack of government commitment_	22.050	102	.000	2.09709	1.9084	2.2857
Lack of funding_	21.882	102	.000	2.13592	1.9423	2.3295
Difficulty reducing cost substantially while maintaining function	22.960	102	.000	2.33981	2.1377	2.5419
Difficulty in establishing core functional elements	22.115	102	.000	2.26214	2.0592	2.4650
Lack of standard measurements scaling	22.579	102	.000	2.22330	2.0280	2.4186
Lack of creativity to simplify and find alternatives approach	21.813	102	.000	2.02913	1.8446	2.2136
Compliance to conventional standards building regulations	19.678	102	.000	2.08738	1.8770	2.2978
Contract conditions/pacification	23.231	102	.000	1.82524	1.6694	1.9811

Reliability test

Furthermore, using Cronbach's Alpha coefficient (α), a reliability test was performed on the data to determine the accuracy of the study's findings when repeated independently on the same test sample at a different period. It determines the reliability of the questionnaire by measuring the internal accuracy of a list of items in the questionnaire (Chan et al., 2018). If the Cronbach Alpha Test yields a co-efficient of 0.700 or higher, the scale is considered accurate (Muijs, 2010; Hair et al. 2010). The table 4.0 below shows that the study has a Cronbach's alpha of 0.960, indicating it is accurate for further research.

Table 4.0: Reliability statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.960	.960	42

DISCUSSION

Background of stakeholders

The study's findings showed almost all stakeholders in the housing sector are male-dominated, as shown by the fact that 94.2% of the respondents were males. Most of the respondents were young people aged 20 to 29 years (50.5%) and 30-39 years (35.9%), implying that about 86.4 percent of the stakeholders in the housing sector for this study were young people. Higher National Diploma (HND) was the most common educational qualification among respondents, accounting for 46.6 percent, followed by post-graduates, masters and Ph.D. at 33 percent, and Bachelor degree (BSc.) at 18.4 percent. Quantity surveyors, building and construction related engineers within government departments, academicians, and architects in Ghana were the main housing stakeholders in this research.

Challenges to SAH using FI

For this research, the major challenges to sustainable affordable housing using frugal innovation were identified as follows: difficulty in reducing costs significantly while maintaining functions (mean=2.34), Slow/low benefit return on investment (Mean=2.29, SD=0.94), lack of research and design (mean =2.29, SD = 1.006), lack of demand (mean = 2.27), unreliable local partners (mean=2.262,SD=.949), difficulty defining the key functional elements (mean=2.262,SD=1.038), and low confidentiality (mean= 2.2427).

The complexity or ability to implement something new or innovating differently while simultaneously minimising cost or resources is the real challenge for frugal innovation, according to Pisoni's,(2018) report. Weyrauch and Herstatt,(2016), whereas, offer a major solution to this problem by focusing on only the main functional elements of the product, which results in a lower price or slightly lower prices of product or service as opposed to traditional goods and services. For this report, the lack of research and design was revealed as the third most significant obstacle to sustainable affordable housing using frugal innovation. This is in line with Chan et al., (2018), Hwang and Tan, (2012), and Hwang and Ng, (2013) studies, which identified a shortage of local institutes and facilities for R&D as one of the major challenges to affordable housing sustainability. Low profit returns on investment are a major obstacle, owing to the fact that most housing developers are profit-driven. This proof backs up due to the high initial cost associated with sustainable housing growth, Syed-Jamaludin et al., (2018) believe developers are more interested in profit and careless about sustainability issues. Again, one of the major challenges to sustainable affordable housing using frugal innovation is a lack of client demand. This is significant because demand is often perceived to be the driver of production, from the basic economics principle that the lower the price, the higher the demand, so profit can be maximised by increasing production to meet demand, thereby making lack of demand, a significant challenge. This is consistent with previous research, like Djakoto et al.,(2014) report, which found that

lack of demand is one of the most significant barriers to sustainable housing. It also supports Hwang and Tan's (2012), Hwang and Ng's (2013) findings that lack of consumer demand, and interest among clients is a major barrier to sustainable affordable housing using frugal innovation. However, the most significant obstacle to sustainable building development, according to the literature reviewed for this report, is high costs and a lack of knowledge (Hwang and Tan, 2012; Hwang and Ng,2013;Ahn et al.,2013; Chan et al., 2016;Chan et al., 2018, Agyekum et al., 2019). Although this study contradicts this, it nevertheless describes them as barriers to sustainability of affordable housing through frugal innovation, but not as the biggest challenges to sustainable affordable housing using frugal innovation.

CONCLUSION

The aim of this study was to establish the challenges to sustainable affordable housing through frugal innovation. Quantitative data was obtained from stakeholders in Ghana's building and housing sectors using survey questionnaires. The seven (7) most significant challenges to sustainable affordable housing using frugal innovation in Ghana are: the difficulty in significantly reducing costs while retaining functions, perceived low benefit or profit return on investment, lack of research and design, lack of demand, ineffective local partners, difficulty in establishing key functional elements, and low confidentiality. This research finding presents a significant contribution to the theoretical and practical knowledge on the application of frugal innovation concept to the development and construction of affordable housing in general; as well as help stakeholders especially the government, academic institutions and housing solutions practitioners to improve their policy direction in housing development in Ghana. This study offers guidelines to UN-SDGs and UN-Habitat policymakers on how to use frugal innovation in the drive to make cities inclusive, secure, resilient, and prosperous by 2030, as part of their sustainable cities agenda. The research will make a significant contribution to the theoretical knowledge gap in sustainable affordable housing, which is currently lacking in literature, and would lead to knowledge in applying the frugal innovation concept to sustainable affordable housing development, commonly used in the manufacturing and service sectors. Housing professionals and developers in their housing developments can learn from this finding to plan to how to overcome the challenges to sustainable affordable housing using frugal innovation concept. This study will also serve as a blueprint for potential studies in the field of affordable housing that is both sustainable and frugal. Future research should focus on how to use frugal innovation to effectively establish the core functional elements of a sustainable, affordable housing system, and how to apply frugal innovation to other construction sectors, especially in developing countries. Finally, future research should focus on developing a framework for sustainable affordable housing using frugal innovation.

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