Research Proceeding on Sustainable Practices in Affordable Housing

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Abstract. Worldwide housing shortages experienced by many developing countries are central to much international debate as the number of people without decent shelter continues to reach unprecedented levels. Housing demands in such countries are usually met by the adoption of conventional approaches that are not always sustainable. Housing affordability and sustainability are therefore crucial to the provision of housing, which sustains its inhabitants economically, socially and environmentally, while ensuring the sustainability of the planet as a whole. Through a scoping study, this paper identifies current construction and design approaches, building features and criteria and policy options favoring the application of sustainability in affordable houses. In the joint implementation of sustainable and affordable housing, a number of practices, such as lean construction methods, building design to improve energy efficiency and reduce costs, and government contributions to planning incentives, subsidies and country-level policies, were found to be effective.

1. Introduction
At present, factors such as rapid economic development, world population explosion, natural disasters and ethnic state conflicts have greatly increased the demand for housing worldwide [1]. According to [2], By 2050, 2.5 billion more people are expected to live in urban areas around the world, with Africa and Asia accounting for 90 percent of that figure. From this perspective, the result has undoubtedly led to a worldwide housing shortage. In 2010, 980m urban families lived in poor conditions, with little living space and no decent housing, according to the literature. Academics estimate that 600 million more people living in urban areas will face the same problem between 2010 and 2030 [2]. With regard to low-income populations in developing countries, the study found that institutions and the informal sector provided 60 to 70 per cent of livable urban housing in Zambia, 70 per cent of housing in Lima, and even 90 per cent of housing supply in Ghana [3].

The provision of adequate housing can meet this growing demand for shelter, which is a basic need. Nonetheless, the supply of appropriate housing does not only cater for immediate needs but also has the potential of making important contributions from social, environmental and economic perspectives in terms of improving the quality of life through aspects like enhancement of employment opportunities, education and training, social cohesion and health conditions [4].

In this regard, the affordability of housing is a persistent issue which not only affects vulnerable households but also has implications for the wider economy and environment [5]. Policy documents in UK define housing affordability as the ‘ratio of lower quartile house prices to lower quartile earnings’ [6].
More specifically, households in the bottom 40 per cent of income distribution are said to be ‘affordable’ if their housing costs (rent or mortgage) are less than 30 per cent of their income [7].

The demand for housing is further crippled by the fact that the responsiveness of the construction sector with regards to sustainable practices has been quite insufficient in underdeveloped or developing countries [8]. It is globally known that the activities adopted by building industry are responsible for a spectrum of environmental problems including but not limited to automobile exhaust emissions, industrial toxic gases and other environmental problems cause air pollution, global warming caused by the increase of greenhouse gas emissions, consumption of non-renewable energy and continuous degradation of the ecological environment [9]. However, there is growing aspiration to make housing construction practices more sustainable and reduce their impact on the environment [10].

Therefore, the ideal solution is to introduce the characteristics of sustainable development into the affordable housing, by reducing the need for urban population to purchase comfort, reduce the greenhouse gas emission caused by heating and cooling and reduce the operating cost of housing [11]. In the same optic, sustainable housing refers to “housing that is designed, built and managed to promote economic development of occupants, environmental stewardship, quality of life and social equity for residents, and to be affordable for all income groups, while still facing the challenges of urbanisation, poverty eradication, lack of access to sustainable energy and economic uncertainty” [8].

Sustainability can be incorporated at various phases including concept, design, and choice of materials, construction approaches and building operations [12]. Many believe that the choice of materials is one of the key factors in improving the provision of sustainable and affordable housing, which accounts for 70% of the total cost of housing construction [13-15]. Moreover, the lack of a systematic approach to sustainability in housing may entail underestimated the cost of energy efficiency measures, overestimation of costs and inadequate policies on energy consumption and greenhouse gas emissions [16].

It can therefore be inferred that sustainability and affordability are essential considerations in the provision of housing to the vulnerable in developing countries as to cater for long-term sustainable development goals and demand of housing. In this regard, this paper utilises an extensive scoping study to identify, highlight and build upon existing criteria and features of sustainable and affordable houses, construction and design concepts favouring housing affordability and sustainability as well as policy options for endorsing sustainability in the housing sector.

2. Construction and Design Approaches to Sustainable and Affordable Housing

In a study designed to provide new methods to sustainable housing development for low-income and middle-income populations in developing countries, various building concepts and their uniqueness in promoting affordable housing sustainability were assessed. Cognitive research methods to collect experts to participate in the construction industry (through the questionnaire survey) the extent of the four concepts (normal construction method, parallel engineering, modular construction and lean construction) factors affecting sustainable housing construction using less material loss, reduce construction cost and time, improve the quality of construction and use of non-renewable materials

Based on the discovery of [8], table 1 presents the ranking of each construction concept by their ability to promote sustainability in affordable housing. It can be inferred that lean construction has the greatest influence on sustainability enhancement of affordable housing through reduced material wastage and construction cost, improved building quality and reduced negative impact on the environment. Furthermore, sustainability in affordable housing is improved with modular construction, which entails reductions in material wastage, construction time and use of non-renewable materials as well as pollution prevention. Concurrent engineering has a positive impact on sustainability in affordable housing by its ability to reduce material wastage, construction time and cost and improve building quality.

Study [1] determined the aspects influencing decision making with respect to the provision of sustainable and affordable housing in developing countries. The research question on the “Major
obstacles and design drivers for affordable and sustainable housing in developing countries” identified these three main design drivers: (1) appropriate design and material selection; (2) Participate, exchange knowledge and use appropriate innovative technologies unique to the developing world; (3) design decision making assistance and assessment tools. The need for immediate shelter being primary compared to prioritising environmental sustainability, issues regarding use and acceptability of alternative materials by people, insufficient training and education in sustainable design and construction, perceived higher cost of sustainable building approaches, lack of access to sufficient information and knowledge on sustainable development and design, improper government planning and policies and the scarcity of professional capabilities amongst others were all regarded as problems hindering the improvement of sustainable and affordable housing in developing countries.

Table 1. Ranking of construction concepts by their ability to enhance sustainability in housing.

| Factors                        | Traditional Construction | Concurrent Engineering | Modular Construction | Lean Construction |
|--------------------------------|--------------------------|-------------------------|----------------------|------------------|
| Minimise materials wastage     | 3                        | 4                       | 2                    | 1                |
| Minimise construction cost     | 4                        | 2                       | 3                    | 1                |
| Reduce construction time       | a                        | 2                       | 1                    | a                |
| Increase in quality            | a                        | 2                       | 3                    | 1                |
| Reduce use of non-renewable materials | a                      | a                      | 1                    | b                |
| Prevent pollution              | a                        | a                      | 1                    |                  |

Note: a Response not available in [8]; b Factor: Minimise negative impact on the environment.

With respect to building material selection, [17] determined that procurement for building materials is related to their green features, which include recycling, energy-saving properties, durability, construction benefits, functionality, friendly construction and indoor environment and appearance.

3. Criteria and Features of Sustainable and Affordable Housing

In a study on the identification of standard system that represents sustainable housing affordability, [5] conducted semi-structured interviews with housing professionals who were asked to rank several criteria based on their importance to sustainable housing affordability. Some of these criteria include relationship between house prices and income, rental costs in relation to incomes, safety, access to employment facilities, quality of housing, energy efficiency of housing and availability of waste management facilities amongst others.

By using the criteria and their individual rankings determined in [5] study, the criteria were grouped under three categories (economic, social and environmental) and the average ranking of each category was calculated in order to identify the importance of each category in defining sustainable housing affordability. As evident in table 2, the economical aspect of sustainable housing affordability is the most important factor followed by the environmental and social aspects.

Similarly, [11] used case studies from housing projects that have already been implemented to evaluate the prospects and future challenges to the mutual inclusion of sustainability and affordability in low-income housing. Initial housing cost, size, functionality, and location (proximity to services, employment and transport) were termed as affordable housing criteria. Sustainable housing features were listed under three categories: (i) social (in terms of safety, security and universal design); (ii) environmental (in terms of water, waste and energy efficiency) and; (iii) economical (in terms of cost-
efficiency, peace of mind and resale value). Table 3 summarises the sustainable features, which have been successfully implemented together with their associated cost implications. It can be seen that cost reductions, in terms of reduced resource and energy requirements, have been achieved through building size, positioning, design, location and features.

### Table 2. Average ranking and importance of economic, social and environmental aspects of sustainable housing affordability.

| Aspect       | Criteria                                                                 | Average Ranking | Importance of Aspect                                                                 |
|--------------|--------------------------------------------------------------------------|-----------------|-------------------------------------------------------------------------------------|
| Economic     | Interest rates and mortgage availability, house prices and rental costs are related to income, rental housing availability and home ownership availability. | 4.4             | It can be inferred that the monetary criteria is the most important aspect to be considered when defining sustainable housing affordability. |
| Social       | Safety and access to employment, transportation, schools, supermarkets, health services, child care, leisure facilities and open public space | 11.6            | Overall, social aspect is claimed to be of least average importance contributing to housing affordability. Nonetheless, access to employment ranked fifth in individual ranking. |
| Environmental| Housing quality, housing energy efficiency and availability of waste management facilities | 8.7             | The environmental aspect of sustainable housing affordability is perceived as the second most important factor. |

### Table 3. Sustainable features of buildings and their cost implications.

| Sustainable features                                      | Cost implications                                                                 |
|-----------------------------------------------------------|-------------------------------------------------------------------------------------|
| Building orientation                                      | Reduced need and cost for heating and cooling                                       |
| Natural ventilation                                       | Reduced need and cost for mechanical cooling                                        |
| Natural lighting                                          | Reduced need and cost for electricity for lighting                                  |
| Shading                                                   | Reduced need and cost for mechanical cooling                                        |
| Low-maintenance materials                                 | Reduced maintenance costs                                                          |
| Solar power                                               | Cost savings on electricity                                                        |
| Rainwater harvesting (with government rebates)            | Reduced need and cost of water (irrigation and toilet flushing)                    |
| Social cohesion (accessibility to services)               | Reduced transportation costs (reduced travelling distances and increased walking and cycling) |
| On-site storm and waste water disposal                    | Reduced infrastructural costs                                                       |
| Limiting building size                                    | Reduced costs in terms of materials and shorter development approval processes.     |
| Relaxation of car park requirements (government planning incentives) | Reduced infrastructural costs                                                    |

### 4. Policy Options for Affordable and Sustainable Houses

Study [18] identified policy options that have been adopted in green building programs by public sector organizations pursuing green building practices in their capital projects. The three categories of options listed below have been considered.

(a) Policy Options in terms of meeting LEED (Leadership in Energy and Environmental Design which is a green building rating system developed by the United States Green Building Council) or
equivalent, approving and encouraging LEED, developing programs to motivate green building activities and creating working groups or commissioning an agency to produce standards and plans.

(b) Program Options in terms of technical support, training, guidance documents, demonstration projects and incentives or subsidies

(c) Evaluation Options in terms of third party certification (LEED or equivalent), consistent reporting mechanism, performance control and reporting and post-occupancy evaluation.

Four scenarios building upon the above-referred options were opted for to create a course of action for green building that could be undertaken by government organizations: 1. Maintain momentum (take no new action and allow current green building activities to continue without intervention); 2. Working with willing agencies (reward current green building practices by means of a policy and through programs that provide tools, rules and motivations to cater for certification costs or commissioning); 3. Coalitions and consensus (setting-up of a council or working group to formulate a vision and plan of action for optimising green building) and; 4. Legislating LEED (legislative process that requires compliance with an external standard). Figure 1 depicts the conclusion reached by [18] study with respect to the fact that the second and third scenarios could be implemented as short-term steps toward an eventual goal of LEED legislation and the combination of these scenarios could enhance green building activity in government buildings.

Study [17] aimed at determining green procurement (GP) behaviour of real estate developers for explaining how various factors generate impact on GP behaviour. Environmental-friendly features of building materials that are related to GP were divided into three groups from a life cycle perspective in terms of production stage, construction stage and operation stage. Factors affecting GP in real estate development such as policy pressure, policy interests, internal organisational pressure, commercial interests, market pressure, marketing interests and supplier-induced interests were determined. The perception and purchasing preferences of mid-level managers (involved in product procurement decisions) were sought through questionnaires. Figure 2 illustrates marketing benefits, market pressure and internal pressure within organisation as having a positive influence on purchasing preference of real estate developers based on the green features of building materials applicable at each life cycle stage.

The research findings which explores these prime GP factors can assist relevant government agencies in the development of workable policies and regulations to facilitate green procurement practice in the built-environment. Furthermore, strategies for successful joint implementation of sustainability and affordability include planning incentives, government subsidies and government regulatory frameworks [11].
5. Findings and Conclusions

Many countries, especially developing ones, are currently facing major challenges in affordable and sustainable housing development. By building upon existing literature, this paper highlighted current practices for achieving affordable and sustainable housing in terms of housing criteria and features, construction and design approaches and policy strategies.

Lean and modular construction methods were found to be effective in enhancing sustainability in affordable housing with their abilities to reduce material wastage, construction costs and negative environmental impacts. Furthermore, the main design drivers in the context of sustainable and affordable housing in developing countries include appropriate material and design selection, use of suitable innovative technology, knowledge transfer and design decision-making assistance and assessment tools. Green features of building materials, which are of interest, comprise recycling, functionality, energy saving, durability and friendly indoor and construction environment.

From economic, social and environmental perspectives, it was determined that the criteria that dictate affordable and sustainable housing relate to house prices based on income levels, access to key services (employment, education, transportation, health and leisure), safety, security, housing quality and water, waste and energy-efficiency with the monetary criteria being the most important factor. Cost reductions can be achieved from the implementation of sustainable features in housing in terms of building design and orientation to optimise natural lighting, ventilation and shading, use of low-maintenance materials, rainwater harvesting, solar power and on-site infrastructure. However, some of these cost reductions would not have been possible without government interventions by means of planning incentives and subsidies.

Concerning policy options, which favour the implementation of sustainable and affordable housing, current literature demonstrates that the creation of councils or working groups with shared interest can lead to the development of regulatory frameworks towards an ultimate goal of legislating a rating system to regulate and encourage sustainable practices in affordable housing.

Because the important driving force for the continuous development of every commodity is consumption, occupants, as the main consumers of housing, should promote sustainable housing demand from the economic, social and environmental perspectives. Only then will it be possible to have affordable and sustainable houses that are both economically and technically feasible and accessible to the wider population, especially to families from the lowest 40 percent of the income distribution range. Adoption of an anti-consumeristic behaviour such as the rejection of housing constructed by conventional and unsustainable practices could eventually motivate policy makers to implement sustainability in affordable housing at a national level.
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