# Delivering Sustainable Low-income Housing in Uganda, Challenges and Opportunities

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***Abstract:*** While the developed world is adapting to the consequences of climate changes, global warming will negatively affect the quality of life and economic growth in developing countries. The low-income populations from low and medium Human Development Index (HDI) countries would suffer even more from climate changes because of their vulnerable living conditions and the lack of appropriate and adequate infrastructure. Particular attention should therefore be paid to the low-income housing conditions not only to address the environmental concerns but also to improve the living standards and health and wellbeing of low-income populations. This paper reviews the Ugandan housing conditions in order to identify the opportunities and challenges for delivering sustainable energy efficient low-income housing in Uganda. Urbanisation; slums; housing costs, types and sizes; construction methods and materials and renewable energy sources are some of the areas which have been reviewed and discussed in detail. The findings reveal some critical areas such as informal settlement, overcrowding and access to housing facilities as well as embodied energy of construction methods and materials which require immediate attention.

***Keywords:*** Sustainable Housing, Low-income, Tropical, East Africa, Uganda.

## Introduction

Uganda is located in East Africa, neighboured by South Sudan, Kenya, Tanzania, Rwanda and Democratic Republic of Congo. Despite a rather stable economy and an inflation rate of 6.6% in 2014 [1] (4.9% according to [2], Uganda suffers from high poverty rates. In 2013, Uganda was ranked 164 out of 187 countries in Human Development Index (HDI). Around 38% of Uganda's population lives below the international poverty line of $1.25 a day [3,4].

Uganda has an area of 241,038 $Km^2$ and an average altitude of 1000-1500m above the sea level [5,6,7]. It has a tropical climate with temperatures ranging between 16 °C and 30 °C [8] with the hottest period between December and February [7]. There are two rainy seasons between April-May & October-November and two dry seasons between December-February & June- August, respectively; although climate change has considerably affected this [5,9]. The annual rainfall in different parts of the country varies between 750-2100mm [8]. Northern and Eastern parts of the country may experience high temperatures above 30 °C while South Western parts may experience temperatures below 16 °C. It is estimated that the temperatures in East African countries may rise between 3-4 °C during the next 70 years due to global warming [10].

Developing countries in tropical and subtropical areas will be hit the worst by the climate changes [11]. The low level of awareness of environmental concerns makes the situation even more critical in these countries. Moreover, although improving gradually, environmental policies are neglected by the governments as the higher priority is usually given to economic growth [12,13]. The low-income populations from low and medium HDI countries, such as Uganda, would suffer more from global warming because of their vulnerable living conditions and the lack of appropriate and adequate infrastructure (Bartlett, 2008 as quoted in [14]).

Unlike the rich countries who have the resources to invest and respond to such changes, adaptation in developing countries and particularly in the poorest ones is left to the individuals as a matter of "self-help". The current strategy in many developing countries is "climate-proofing" of the existing resources and infrastructure in response to the increasing risks [11]. This situation will considerably affect the living standards and health and wellbeing of low-income people the majority of whom live in substandard slums and informal settlements. Particular attention should therefore be paid to the low-income housing conditions not only to address the environmental concerns but also to improve the living standards and health and wellbeing of low-income people to increase their resilience to long-term environmental risks and disasters caused by the global warming.

To this end, this study intends to evaluate the current Ugandan housing conditions in order to identify the barriers and opportunities for delivering sustainable low-income housing in Uganda.

**Research Methodology**

Relevant documents published by individual researchers, Ugandan Government, UN-Habitat and other research organisations are reviewed. Site visits and surveys are also carried out to collect primary data and photographic evidence to support the discussions. The outcomes of the literature review along with the surveys are used to identify the critical factors which affect the Ugandan housing conditions. The challenges and opportunities for providing sustainable, energy efficient low-income housing in Uganda are discussed and short-, mid- and long-term plans and policies are recommended as the conclusion of this study.

**Population Growth, Urbanisation and Slums**

Africa is experiencing the highest rate of urban growth in the world. All African countries, except East African ones, have an urban population of 40% or more. The majority of population in African cities live in slums and informal settlements [15]. It is estimated that by 2050, around 56% of the African population live in the urban areas [16]. Table 1 shows the actual and estimated rural and urban populations in during 1990-2050.

Table 1. Urban and rural populations and rates of annual changes [16].

| Population (1000s) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Urban | | | Rural | | | Proportion Urban (%) | | | Average annual rate of change (%) |
| **Area/Country** | 1990 | 2014 | 2050 | 1990 | 2014 | 2050 | 1990 | 2014 | 2050 | 2010-2015 |
| **World** | 2,285,031 | 3,880,128 | 6,338,611 | 3,035,786 | 3,363,656 | 3,212,333 | 43 | 54 | 66 | 0.9 |
| **Africa** | 196,923 | 455,345 | 1,338,566 | 433,064 | 682,885 | 1,054,609 | 31 | 40 | 56 | 1.1 |
| **East Africa** | 35,564 | 96,610 | 378,763 | 162,822 | 287,296 | 490,458 | 18 | 25 | 44 | 1.7 |
| **Uganda** | 1942 | 6124 | 33367 | 15,593 | 32,721 | 70,711 | 11 | 16 | 32 | 2.1 |

Uganda can be considered as an agricultural country since, despite a high growth rate in urban population (5.6% p.a.), only around 14-15% of the population live in the urban areas [5]. In 2009/10, the number of households in Uganda was 6.2 million showing an increase of one million since 2005/06. During the same period, urban households grew by 1.4% from 17.4% to around 18.8% [17]. According to the National Census in 2002, Uganda's population was 24.2 million [8]. With a growth rate of 3.2%, the country's population is estimated to be around 38 million in 2015 and 68.4 million by 2035, 30% of which would live in urban areas [5,18]. By 2050, Uganda is estimated to be one of the most urbanised African countries [2].

**Housing Conditions**

The share of the construction industry in Uganda has increased from 4.1% in 1988 to 12% in 2008 [19] and 14.6% [20] of GDP in 2012. Since 1988 the housing sector has been growing with an average rate of 6.3%. This is while in 2005/6 less than 1% of the labour force were employed by the construction industry. The private sector is the major housing provider in Uganda and the government therefore only needs to develop and implement appropriate housing regulations and standards to improve the housing conditions [19].

In 2010, Uganda's housing stock was around 5.28 million dwellings with an estimated shortage of 612,000 residential units [19]. The projected housing deficit in 2012 varied between 560,000 and 1.6 million 28% of which was in urban areas. The annual housing demand has been estimated to be around 233,000 units. The housing deficit is likely to increase to eight million by 2020 if the current supply remained the same [2].

***Housing types***

Making up around 58% of the total housing stock, detached houses are the most common housing type in Uganda (Table 2). Huts and tenements (locally called Muzigo/Mizigo) take the next places with 21.5% and 18.4% respectively. Although the share of huts has almost remained the same since 2005, the share of tenements has increased by more than 3%. This is while in urban areas, the share of tenements has increased sharply from

around 49% to 58% (9% since 2005 and 11% since 2002) compared to only 1.1% increase in rural areas. Moreover, according to the national surveys in 2002, around 27% of households lived in "room/rooms" dwelling units. The share of "room/rooms" dwelling type was considerably higher in urban areas (62%) compared to rural areas (21%) [8].

Table 2. Types of dwelling and tenure in Uganda (2005-2010) [17,19].

| **Indicator** | **Year 2005/06** | | | **Year 2009/10** | | |
|---|---|---|---|---|---|---|
| | Urban | Rural | Uganda | Urban | Rural | Uganda |
| **Dwelling Types** | | | | | | |
| Detached house | 36.8 | 65.6 | 60.5 | 30.2 | 64.4 | 57.9 |
| Huts | 8.9 | 24.8 | 22 | 6.2 | 25.1 | 21.5 |
| Tenements/ Muzigo | 48.9 | 8.1 | 15.2 | 58 | 9.2 | 18.4 |
| Others | 5.4 | 1.6 | 2.2 | 5.7 | 1.4 | 2.2 |
| **Tenancy Types** | | | | | | |
| Owned | 78.4 | | | 76 | | |
| Rental | 15.3 | | | 17.9 | | |
| Other | 6.3 | | | 6.1 | | |

Many people in African cities live in rental properties. In 2009/10, around 18% of Ugandan families lived in rental properties. The situation is more critical in urban areas. In 2007, for example, 57% of the urban population were renting their homes [21]. This figure was around 70% for households living in Kampala [17]. The major reason for the very high rate of renting is the high housing costs [19] which make houses unaffordable for the families living in Kampala. Increasing prices have forced many people out of the housing market resulting in more demand for rental properties.

***Household size and number of rooms***

Overcrowding is one of the major challenges in Uganda. Overcrowding increases the risk of contracting infectious and transmissible diseases. The National Housing Survey 2005/06 indicated that more than 50% of Ugandan households lived in single roomed houses [19]. Also, according to Uganda Bureau of Statistics, in 2011, around 46% of Ugandan households used only one room for sleeping. Overcrowding has been more serious in urban areas as 62.3% of urban families sleep in one room compared with 42% for the rural areas [6].
Figure 1 shows the average number of bedrooms and sleeping occupants in each room in different parts of the country in 2005/06 and 2009/10. Table 3 also shows the average household size over a period of eight years in different regions of Uganda [17]. In 2002 there were 5 million Ugandan families 14% of which lived in urban areas [8]. The average household size for urban families was 4.2 compared to 4.9 for rural areas [8] representing an average of 4.6 for the whole country. This is while according to [17], average rural and urban household size in 2002 were in order 5.3 and 4.1. In 2011, this figure decreased to 3.8 and 5.1 for urban and rural areas respectively [6].

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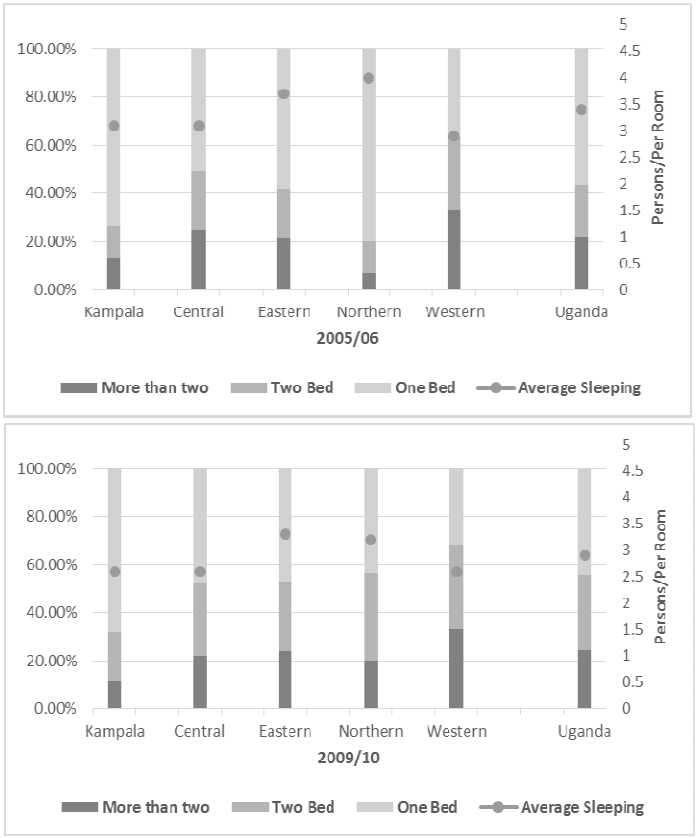


Figure 1. The average number of bedrooms and sleeping occupants in each room (2005-2010); Source of table: [17].

Table 3. Average household size in different regions of Uganda (2002-2010) [17].

| | **2002/03** | **2005/06** | **2009/10** |
|---|---|---|---|
| **Rural** | 5.3 | 5.3 | 5.2 |
| **Urban** | 4.1 | 4.6 | 3.9 |
| | | | |
| **Central** | 4.8 | 4.8 | 4.1 |
| **Eastern** | 5.5 | 5.6 | 5.6 |
| **Northern** | 5.1 | 5.2 | 5.2 |
| **Western** | 5.2 | 5.3 | 5.1 |
| | | | |
| **Uganda** | 5.1 | 5.2 | 5 |

### *Access to energy*

Wood fuel and paraffin are respectively the main fuel sources for cooking and lighting in Uganda. Access to alternative energy sources such as electricity is very limited. In 2011, for instance, only 14.6% [6] (12% according to [22]) of Ugandan households had access to electricity. This figure was only 5.3% in rural areas compared to 55.4% in urban areas (Figure 2). In 2013, the rate of National Grid Electrification was 14.9%, showing an increase of 4.9% since 2010 [22]. The situation is even more critical when considering the common cooking fuels since around 95% [6] of Ugandan households use wood related fuels, such as firewood or charcoal, for cooking purposes. This figure improved by only 2% over year 2002 figures when around 97% of household reported their main cooking fuels as firewood or charcoal [8].

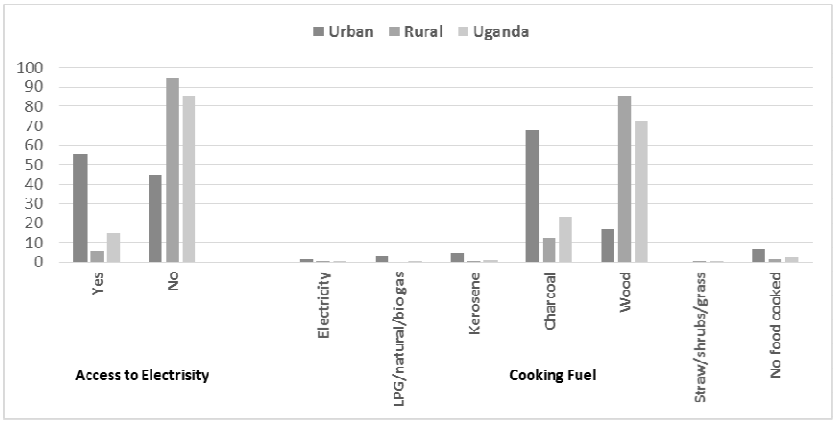


Figure 2. Access to electricity and cooking fuels (%); Source of table: [6].

Figure 3 also summarises the sources of lighting in different parts of the country. "Tadooba", which is a local paraffin candle, is the most common (66%) source of lighting in Uganda. It is followed by lantern (14%) and electricity (12%) as the second and third most common lighting source. In Kampala, 48% of people use electricity for lighting [17].

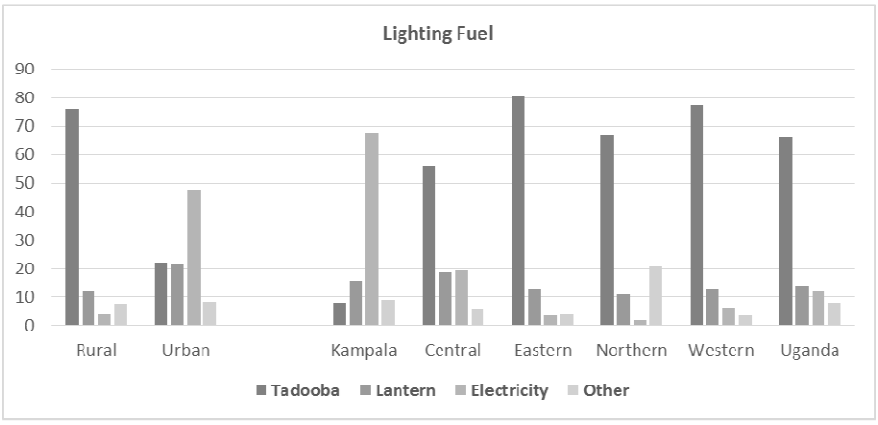


Figure 3. Types of lighting fuels in different regions of Uganda (%); Source of table: [17].

**Construction Methods and Materials**

Iron sheets (62%) followed by thatched roof (37%) are the most common roofing systems/materials in Uganda (Figure 4). In 2010, around 57% of all dwellings (84% urban and 51% rural) had brick walls and 39% (12% urban and 46% rural) were made with mud and poles. Figure 5 and Figure 6 summarise the main walling and flooring methods/materials between 2002 and 2010. The only noticeable change during this period has been the 6.4% and 3% increase in brick walls and cement flooring, respectively [17,19].

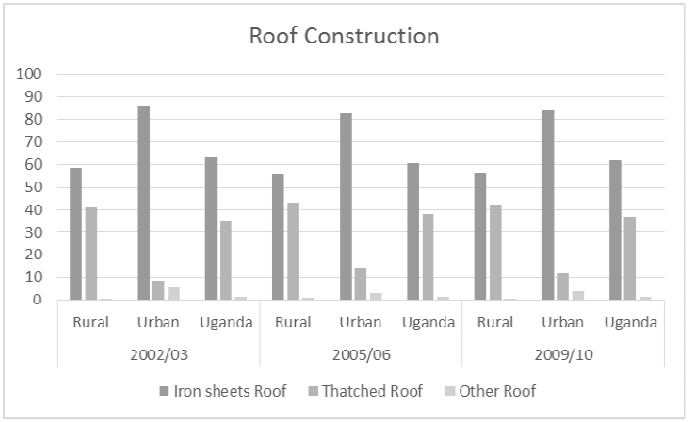


Figure 4. Roof construction methods/materials during 2002-2010 (%); Source of tables: [17,19].

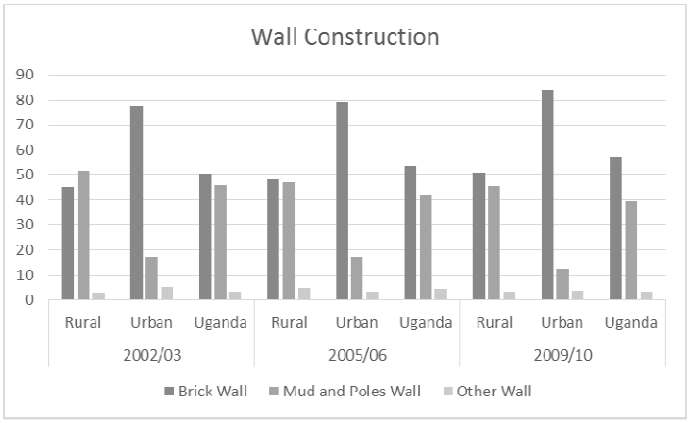


Figure 5. Wall construction methods/materials during 2002-2010 (%); Source of tables: [17,19].

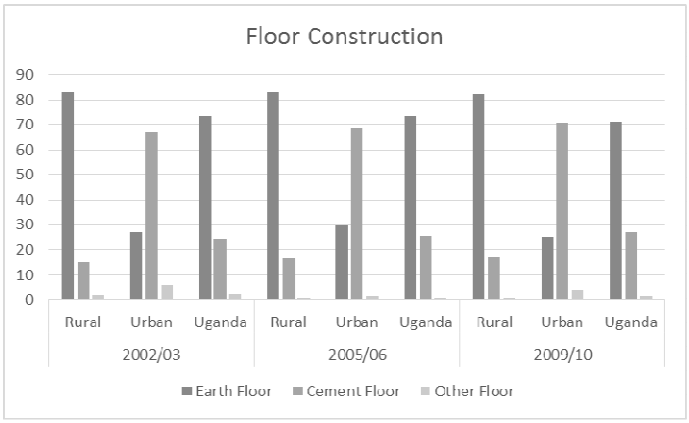


Figure 6. Floor construction methods/materials during 2002-2010 (%); Source of tables: [17,19].

***Walling methods/materials and environmental considerations***

Following are the most common walling techniques used in many developing countries including Uganda [23,24,25,26,27]:

1. Adobe (also known as mud bricks or sun-dried earth block);
2. Cob;
3. Rammed earth;
4. Wattle and daub (also known as Mud and Poles);
5. Burned bricks;
6. Stabilised earth blocks; and
7. Concrete.

Table 4 summarises the advantages and disadvantages of common construction methods and materials in Uganda. Adobe is an affordable and environmentally friendly material making it very suitable for low-income housing; however, its aesthetics/appearance, low resistance and high maintenance requirements (due to vulnerability to rain/water) are the major issues associate with Adobe. Plastering the external surfaces would, to some extent, resolve the aforementioned issues. The major social challenge for using this material is to change the people's mentality as Adobe is commonly considered as the "material of the poor"[25]. Cob (Figure 7) construction is also a common construction method/material in Uganda. Cob is similar to adobe but is uncompressed without framework. Cob is a mixture of clay, sand and straw and is used to make walls and roofs [24].

Rammed earth walls are more stable compared to adobe and Cob walls. Rammed earth walls are made from 100-150mm moist earth, tipped into a formwork and compressed by ramming [26]. The framework is then removed compacted/moulded clay is then left to dry [24]. Wattle and daub (Mud and Poles) is very common for low cost housing in Uganda. Wattle and daub consists of a wooden grid filled with earth. It stands for around

40% of all constructed houses in Uganda [17,19]; however, compared to adobe, wattle and daub is less environmental friendly as it increases deforestation due to the application of local wood in its structure.

Figure 7. Cob construction (left) and adobe (right) construction. Source: The authors.

Burned bricks (Figure 8) are also a common and readily available material in both urban and rural areas of Uganda. Living in houses built with burned brick represents higher social status compared to adobe and wattle and daub. Burned brick is environmentally harmful due to (often excessive) soil extraction (Figure 9) which may directly or indirectly affect agriculture and health of local communities. Due to the need for firewood, it also heavily damages the forests and causes air pollution as well as affects the available fuel sources [24].

Figure 8. Burned Bricks are very common in both rural and urban areas. Source: The authors.

The excessive use of mortar (up to 30mm; Figure 10) during construction due to the uneven sizes of burned bricks is the other major issue in Uganda. Moreover, plastering the walls is necessary due to aesthetics reasons [24]. Such issues significantly increase the overall cost of this method of construction making it inappropriate for low-cost housing.

Figure 9. Extensive soil extraction has negative environmental impacts. Source: The authors.

Compressed Stabilised Earth Blocks (CSEB) are also widely used in the construction projects. CSEB is relatively strong and environmental friendly due to the moderate use of cement and energy involved in

production processes. However, consistent production control is required to assure the quality of the final product [10]. Compressed Earth Blocks (CEBs) and CSEBs are similar to Adobe blocks however CEBs and CSEBs are more uniform in sizes and shapes [24].

Figure 10. Excessive use of mortar due to uneven sizes/shapes of bricks. Source: The authors.

Concrete is also a common construction material which is more common in urban areas of the country. The use of cement has been increasing during the last decade [28]. Although concrete is strong and durable, it is rather expensive and is considered as a less environmental friendly material due to high energy consumptions and $CO_2$ emissions during the production of cement. Yet, in view of unprofessional, energy intensive production methods of burned bricks, concrete may be considered as a more sustainable material. Concrete is also regarded as a stylish material and living in concrete homes represents a high social status; however, its weak thermal performance/properties [29] may raise concerns over occupants' thermal comfort living in such houses. Moreover, relatively high costs of concrete makes it less appropriate for low-income housing.

Table 4. Advantages and disadvantages of prevailing construction methods/materials in Uganda [10,24,25,27,29,30]

| Construction Method/ Material | Durability | Resistance | Economy | Environmental Impacts |
|---|---|---|---|---|
| **Adobe** | Long life if plastered and maintained well | Weak to medium | Very affordable. Final cost varies depending on the plaster used. | Environmentally friendly considering there is little waste or energy involved making it |
| **Wattle and daub** | Require high maintenance | Weak | Low cost, considering raw materials are readily available | Causes deforestation due to the use of wood for the structure |
| **Burned Bricks** | Relatively durable | Relatively Strong | Reasonable unit cost; however overall it is expensive due to the amount of cement required for mortar and plaster | Environmentally harmful due to the deforestation/firing and excessive clay excavation |
| **Compressed Earth Stabilised Blocks** | Relatively durable (consistent quality control is required) | Relatively Strong | Respectively, 20% cheaper, same costs and 15% more expensive than a fired bricks wall with equivalent, lower or poor quality | Relatively sustainable due to moderate use of cement and energy involved in productions |

| | | | | |
|---|---|---|---|---|
| **Concrete** | Durable | Strong but weak thermal performance | Expensive | Not environmentally friendly as massive energy is needed to produce cement. |

***Embodied energy***

Operational energy (except for cooking and hot water) is not currently a major issues in African low-income housing. Embodied energy, in contrast, is the key factor in evaluating the sustainability of construction projects, methods and materials [29]. Many of the prevailing materials and methods of construction in Uganda are environmentally harmful. This is because of the very inefficient and energy intensive production and manufacturing processes.

Considering the required energy for processing and manufacturing the common construction materials, adobe, rammed earth and unfired clay bricks are the most environmental friendly materials with minimal embodied energy and $CO_2$ emissions. According to Oti et al., unfired pressed clay with no binder has an embodied energy and $CO_2$ emission of around 525.3 MJ/t and 25 $kgCO_2/t$, respectively. These figures for the unfired clay brick with binders are between 657.1-667.1 MJ/t energy usage and 40.9-42.9 $kgCO_2/t$ emissions. The embodied energy and emissions of common PC-stabilised bricks with binder of around 12%, are in order 1025.6 MJ/t and 125.1 $kgCO_2/t$ [31].

Thomas & Cruickshank calculated the embodied energy of common construction materials in Uganda [32]. They argue that the material costs and embodied energy are not proportional in Uganda as, for example, country fired bricks are relatively cheap while they are the most environmentally damaging construction material/method. Country bricks are followed by kiln-fired bricks and hollow concrete blocks as the second and third environmentally damaging methods of construction. Hashemi et al. also evaluated the embodied energy of different construction methods and materials in Ugandan low-income housing [29]. The findings of their research confirm that fired bricks are the most energy intensive construction material in Uganda. They argue that the embodied energy of fired bricks is up to 5.7 times higher than generic fired clay bricks in developed countries. The results of their research reveal that hollow concrete blocks are the most environmentally friendly walling method/material followed by cement stabilised soil blocks, artisan burned bricks/blocks and small-scale manufacturers' bricks. Table 5 summarises the embodied energy of common walling methods and materials in Uganda.

Table 5. Embodied energy of common walling methods [29].

| Walling Methods/Materials | Embodied Energy (MJ) for $1m^2$ of walling |
|---|---|
| 200mm Hollow Concrete Blocks Wall, 20mm 1:4 cement mortar | 127 |
| 140mm Cement Stabilised Soil Blocks Wall, 20mm 1:4 cement mortar | 176 |
| 215mm Generic Brick Wall, 10mm 1:4 cement mortar | 791 |
| 220mm Artisan Brick Wall, 20mm 1:4 cement mortar cement mortar | 1067 |
| 220mm Small-scale Manufacturer's Brick Wall, 20mm 1:4 cement mortar | 3542 |

**Discussions**

According to Uganda's National Development Plan 2010/11-2014/15 the main issues related to housing sector performance are as follows [19]:

- Old, fragile and unharmonised governmental laws and policies;
- Limited access to and expensive financing (e.g. high interest rates on mortgages);
- Skill shortages in areas such as architecture and structural engineering; and
- Expensive construction materials (e.g. a 50kg bag of cement is $15 in Uganda compared to $4 in the Middle East).

The low quality materials with massive embodied energy, slums, low housing supply, poor indoor air quality, and limited access to basic facilities should be added to the above issues. The high population and urban growth rates also contribute to the abovementioned issues. Land and housing demands have also been greatly affected by the high population and urban growth rates [5]. Such conditions have led to increasing slums and informal settlements in many African countries including Uganda. In some African countries, slums and informal settlements make up more than 50% of the whole city's population [33]. For instance, over 60% of Uganda's capital city, Kampala, live in slums [20].

One of the major reasons for high rate of slum formation is access to urban land by low-income people which put low-income population under pressure to build, buy or rent low quality, small/high-density dwellings in informal settlement zones [33]. Compared to developing countries' slums, such settlements are in a much worse conditions and do not fit for the purpose by any standards [34]. The residents of such slums usually have very limited access to basic utility services and face risky environmental and health conditions [15]. The other reason for such rapid development of slums and informal settlements is the lack of structure to control the quality of housing by enforcing appropriate standards and guidelines [20]. Implementing land and housing regulations, policies and standards would help to address some issues such as housing quality, slums and informal settlements. Yet, as an "underdeveloped" country, Uganda does not have enough resources to effectively deal with such conditions. Previous attempts to improve the conditions have failed due to the lack of appropriate and sustained research which considers the local needs and circumstances [34]. Moreover, although the draft National Housing Policy gives particular attention to low-income housing aiming to improve slums and enforce minimum housing standards, considering the allocated budget, housing is not one of the Ugandan government's priorities. Nevertheless, the government's intention is to increase the private sector housing from less than 10,000 to 250,000 units by 2025 aiming to reduce the housing deficit by 50% [2].

Housing affordability is another major issue in Uganda. House prices may vary between 9000 and 719,000 USD. This is while the daily income of more than 50% of population in Kampala is about 1.33 USD. The available mortgages are well above the affordability level for 99% of the population [35]. High costs of land, infrastructure and construction materials are also major contributors to housing costs. The land and infrastructure stand for around 20% and 15-25% of the housing costs respectively. The cost of infrastructure is usually added to the housing units built by the private developers [2,21]; although, according to the Local Government Act (1997), local authorities are responsible for providing urban services [21]. This is while the affordable housing delivered by the government costs up to 3.5 times less than the private sector housing [2]. Due to housing costs, which are clearly outside the financial strength of a great portion of Ugandan families, there has been considerable growth in the urban rental market from 28% in 2002 to around 70% in 2007 [35]. The Ugandan government should therefore take responsibility for providing affordable housing and basic infrastructure in order to reduce housing costs. Low-interest, long-term mortgages should also be provided to make houses more affordable particularly for low-income populations.

Overcrowding and poor indoor air quality due to the limited space and cooking indoors (using firewood or charcoal) should be added to the abovementioned issues in Uganda. Figure 11 shows the common places of cooking for urban and rural households. Around 22% of urban and 9% of rural households cook indoors while 23% of rural and 48% of urban families cook outdoors. Around 60% of Ugandan families cooked indoors in a separate building [6,8]. This situation could considerably affect the health of the occupants living in these properties particularly women and children who are in direct contact with generated fumes and smoke from the wood (Figure 12). In this respect, implementing minimum housing design and quality standards particularly in terms of ventilation would help to improve the current conditions.

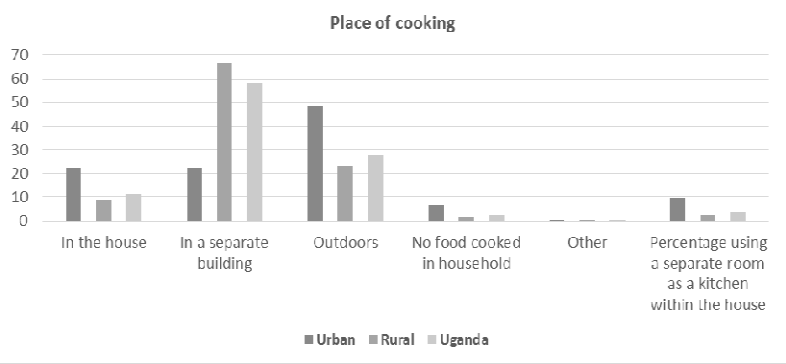


Figure 11. Place of cooking (%); Source of table: [6].

Effective and efficient use of renewable energies is one of the key opportunities which can address many of the current issues in Uganda. The potential sources of renewable energy in Uganda are [36,37]:

- Solar energy: With an average solar insolation of 5-6 kWh/m$^2$/day and 8 hours of sunshine per day, solar energy is a clean and reliable source of energy particularly for off-grid rural areas. 200 MW of solar electricity capacity is potentially available in Uganda;
- Wind: Although not as viable as solar energy, wind is also a potential source of clean energy for rural areas. Wind speed of more than 6m/s is experienced in areas such as lake shores and hills which is enough to operate wind turbines;
- Biomass and geothermal energy are other potential sources of green energy. Geothermal can potentially provide 450 MW of energy;
- Hydropower: Currently only less than 10% of the potential hydropower energy is exploited. Hydropower can potentially provide 3000 MW of energy in Uganda.

Despite such massive potentials, in 2011, less than 15% of Ugandan households had access to electricity. This figure was only around 5% for the rural areas [6]. According to the Ministry of Energy and Mineral Development, the Ugandan Government aims to increase the share of renewable energy from 4% to 61% by 2017 [36]; and increase the rural access to electricity to 22% by 2022 [38]. It is not clear as to how much these objectives have been achieved. Increased access to renewable energies would not only have environmental benefits, such as reduced deforestation and excessive $CO_2$ emissions caused by wood related fuels, but also improves the indoor air quality and health and wellbeing of Ugandan families by reducing their exposure to harmful fumes and smoke from firewood.

Figure 12. Poor indoor air quality due to cooking indoors affects the halth and wellbeing of the occupants.
Source: The authors

Environmental impacts and embodied energy of prevailing construction methods and materials are also of major concerns in Uganda. Improving manufacturing/production processes could significantly reduce the embodied energy of the abovementioned materials [29]. Yet, although mechanisation improves the production processes, mechanisation may not be economical in Uganda due to the low production scales. The availability of spare parts and maintenance services are the other important issues [27]. For this and many other reasons, traditional, locally available materials and methods of construction are more appropriate in Uganda. The efforts should therefore be towards improving the processes and quality of prevailing construction methods and materials in Uganda.

## Conclusions

This paper studied the current housing conditions in Uganda in order to identify the limitations, barriers and opportunities for providing sustainable low-income housing in Uganda. Housing affordability; informal settlements and slums; unacceptable living conditions and standards in terms of overcrowding and access to basic amenities; and low quality, environmentally harmful construction methods and materials were identified as the major issues which should be addressed in Uganda. Based on the findings of this paper, the following short-, mid- and long-term plans and policies are recommended in order to improve the current housing conditions in Uganda.

### *Immediate and short-term plans/policies*

a) Improving the conditions of existing slums and informal settlements seems to be the most urgent issues which requires immediate attention. Affordable and easy to maintain facilities and infrastructure should

be provided by the local authorities to improve the health and wellbeing of the low-income populations.

b) Overcrowding is also a major issue which should be addressed to improve the living standards and reduce the risk of contracting infectious and transmissible diseases. Considering many Ugandan families live in rental properties, especially in urban areas, enforcing minimum building and occupancy standards for rental properties would help to address this issue. Providing design guidelines and standards, associated with education and training on the effects of occupancy conditions and behaviours on indoor air quality (IAQ), would also help to reduce the risks of poor IAQ in buildings improving the health and welling of the occupants particularly women and children who spend more time indoors.

c) The current wasteful production methods of construction materials have negatively affected the local environment in both urban and rural areas contributing to issues such as deforestation, desertification, excessive and extensive soil extractions as well as health issues. It is therefore necessary to improve the current production/manufacturing methods of construction materials to mitigate the environmental impacts of the construction industry. In this respect, particular attention should be paid to production processes of fired bricks which are over four times more energy intensive than generic brick walls per square meter.

***Mid-term plans/policies***

a) The absence of appropriate urban land policies seems to be a major reason for rapid growth of slums and informal settlements. Managing and providing urban lands for low-income housing would help to address these issues.

b) The very high housing costs, which are outside the financial strength of low-income people, also contribute to issues such as slum growth and very high rate of rental properties in urban areas. Providing long-term, affordable and accessible mortgages for low-income people would make houses more affordable and help to address these issue.

c) Building regulations and standards should also be developed and implemented by the government and local authorities to control and improve the housing quality.

d) Simultaneously, use of environmentally friendly, locally available materials should be encouraged to reduce the costs as well as the environmental impacts of construction methods and materials. Raising public awareness on environmental issues would help to improve the current conditions. Moreover, builders and artisan producers should be educated/trained in order to improve both production and construction methods and processes. In this respect providing samples/examples, national exhibitions, competitions, awards and incentives would encourage the construction industry to review and improve its current practices.

***Long-term plans/policies***

a) Access to alternative sources of energy such as electricity should be increased. This is particularly important in rural areas where access to electricity is only around 5% of the households. In this respect, taking advantage of renewable energy sources such as solar and wind energy in rural areas is recommended. Access to alternative energy sources would also help to reduce the rate of deforestation by reducing fuelwood consumption for cooking. This would in turn reduce the risk of poor indoor air quality and improve the health and wellbeing of low-income populations.

b) New construction methods and materials should be developed and encouraged. This may be considered along with construction technology transfer to improve the current conditions in Uganda. The statistical data discussed in this paper reveal that the share of alternative and new construction methods/materials in Uganda is negligible. The current trend is, in fact, more towards replacing high maintenance materials such as adobe with more durable, but less sustainable energy intensive, materials such as fired bricks. This trend should be associate with gradual replacement of current environmentally damaging construction methods and materials with more innovative and sustainable ones which are adapted to the current conditions and requirements of the country.

It should be noted that reducing embodied energy is the key factor in reducing the $CO_2$ emissions and environmental impacts of Ugandan low-income housing sector. Nevertheless, rising living standards may transform the operational energy from negligible to a major issue in the near future. Similar trends have been experienced in other developing countries such as India and China where space cooling has become a major issue. Therefore, passive design strategies should also be promoted to address thermal comfort and indoor air quality as well as operational energy in both domestic and non-domestic buildings. The above factors need to be collectively addressed to achieve a truly sustainable housing industry in Uganda.

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