Chapter 14
Reflection on Rhetorics, Appropriate Building Materials, and Domestic Utilities Towards Reduction of Housing Costs in Africa: A Case of Tanzania

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Abstract Africa is facing housing deficit in terms of social infrastructure and number of dwelling units, basically because of overdependence on industrial building materials, technology and commercial energy. Provision of ideal housing includes adequate shelter, safety, sanitation, sewerage, security, privacy and utilities. This chapter gives a reflection on Tanzania's housing national strategies and approaches in solving housing deficiencies. Tanzania is one of the countries in Africa. It is in the eastern part of the continent endowed with vast savannah plains with lakes, rivers, valleys and mountains including Mount Kilimanjaro and Serengeti national parks. Its current population in 2018 is estimated to be 59 million people with a density of 67 people per square kilometre in a tropical climate. The chapter highlights on the use of appropriate building materials such as soil-cement interlocking blocks and sisal concrete roofing tiles and alternative domestic utilities including solar energy and rainwater harvest as an attempt to reduce urban housing cost. The concept of reduce, reuse and recycle of housing resources is emphasized. Reducing is to achieve housing needs by decreasing housing amounts without compromising living standard, reusing is to repeat consuming housing resources instead of throwing, and recycling creates and uses new housing resources from old ones instead of trashing. Architects, engineers, spatial planners and others have a great and important role to play in reducing urban housing cost as the result of critical thinking and innovative professional services deserved to be provided to housing stakeholders especially in the Global South.

Keywords Housing · Building materials · Utilities · Housing costs

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Contextualizing Housing in Tanzania

Housing supply has never met its demand in developing countries especially in Africa. For instance in 2011, it was estimated that there was a demand of 60 million new house units in Africa to accommodate the rapidly growing urban population. This huge demand for housing complicates national efforts of construction and supply of adequate housing to be a fundamental human settlement issue in all African countries (UNCHS 2001). Despite the fact that the term *housing* is popular to many, it appears that there is no general agreed definition. In 1962 Ad Hoc Expert Group convened by the UN Secretary General stated that "Housing is not a 'shelter' or 'household facilities' alone, but comprise a number of facilities, services and utilities which link the individual and his family to the community, and the community to the region in which it grows and progress". In 1970, another Ad-Hoc Group of experts on housing and urban development concluded that in the fulfillment of social needs, housing plays both direct and indirect role, and both roles are decisive. In its direct role, housing serves as a place where individuals become capable of experiencing community and privacy, social well-being and shelter and protection against hostile physical forces and disturbances. It serves social services such as social-cultural education, recreation, intercourse, sports, social welfare and health protecting services, shopping and transportation (UN 1970). In 1975, at the interregional seminar on the social aspects of housing, it was stated that the concept of housing is more than merely a physical shell. Housing encompasses all the ancillary services and social services, which are necessary and essential to human well-being. Therefore, social services create an integral part of the housing concept and should receive equal or greater attention than the housing unit itself (UN 1975). Housing can be described in broad terms as inclusion of houses, flats and other housing typologies, as well as infrastructure services, the whole residential neighborhood and public spaces. Housing is not just about dwellings, but it includes issues in the localized location, social aspects and domestic utilities. Housing should include facilities and services that affect the site on which a house is built such as roads, drainage channels, water, waste disposal and security of tenure. Housing is therefore a composite complex that provides a heterogeneous mix of services including shelter, safety, sanitation, security, privacy, utilities (such as commercial energy and water), total environment and social culture (Mosha 2011).

Tanzania is considered to be a housing window in this research to explore and expose various housing phenomenon and efforts to establish the magnitude of housing potentials and challenges. Tanzania is a country located in East Africa in the region of African Great Lakes. It is bordered by Kenya and Uganda to the north; Rwanda, Burundi and the Democratic Republic of the Congo to the west; and Zambia, Malawi and Mozambique to the south. The country's eastern border is formed by the Indian Ocean. The country's name comes from the union of Tanganyika which is the mainland territory and Zanzibar islands. These two states united in 1964 and formed the United Republic of Tanzania (URT). Tanzania has a total area of 947,300 km^2 of which land area is 885,800 km^2 and water covered area is 61,500 km^2 (DGW 2016).

The population of Tanzania is increasing at a rate of about 2.7% out of which urban population is growing at a rate of 6% annually (Mosha 2017). Hence, the housing issues become more challenging because population increase is not directly proportional to people's income. In the period between 2002 and 2012, the population of Tanzania increased by 30% from 34.4 million to 44.9 million (URT 2016), and it is estimated to be 59 million by the end of 2018. At the continental level, it is estimated that the population of Africa will reach two billion people by 2040, where the level of urbanization is projected to rise from 40% in 2010 to 50% in 2035 and 58% in 2050 (UN-HABITAT 2014).

Dar es Salaam is Tanzania's largest and richest city and a regionally important economic hub. It is the capital of the Dar es Salaam regional administrative province and consists of five local government areas or administrative districts, namely, Kinondoni, Ilala, Temeke, Ubungo and Kigamboni. Dar es Salaam population increase was 5.6% per year from 2002 to 2012. It is the third fastest-growing city in Africa after Bamako in Mali and Lagos in Nigeria. Dar es Salaam is the ninth fastest in the world. According to the population and housing census of 2012, Dar es Salaam accounts for 10% of the total Tanzania Mainland population, whereby it had a population of 4,364,541 people in 2012. Its population in 2017 was estimated to be 5,502,000. Dar es Salaam is close to the equator and warm throughout the year. The city experiences generally tropical climatic conditions of *hot and humid weather* throughout the year. Annual rainfall is approximately 1100 mm, and in a normal year, there are two rainy seasons: *the long rains* in April and May and *the short rains* in October and November. These varying climatical conditions are part of housing issues and challenges in the context of limited resources, poverty and inadequate infrastructural services.

Poverty in Africa is the greatest housing challenge. The World Bank defines poverty by using the bench mark of persons, living cost of less than 1 US$ per day (Mosha 2017), but Tanzania uses the national poverty line to determine poverty. URT (2014) shows that in 2007, percentage of population below the basic needs poverty line in Tanzania was as high as 34.4 (Fig. 14.1). Furthermore, according to the Household Budget Survey (HBS), the national average food poverty percentage was 11.6; rural had 13.5%, and Dar es Salaam had the lowest of the food poverty line of 1% (Fig. 14.2) followed by other urban areas with 8.7% of people who are below food poverty line. This shows that the economic situation of Dar es Salaam is better compared to other urban areas because it is a major economic hub in Tanzania. Today, the world is struggling to ensure that the world population has access to decent housing facilities. Housing as a human basic need should be available to all people. However, the current situation shows that the problem is getting worse as the world population increases especially in the urban areas. In 2010 Africa's population exceeded one billion though majorities were dwelling in rural areas. It is projected that by 2025, half of African population will be urban dwellers (UN-HABITAT 2010). This situation of rapid urbanization as experienced in Dar es Salaam is now acting as a driving force towards worsening housing situation in many developing countries. However, this article does not focus on rural housing context where the majority of African population dwell. Mosha (2017) indicated

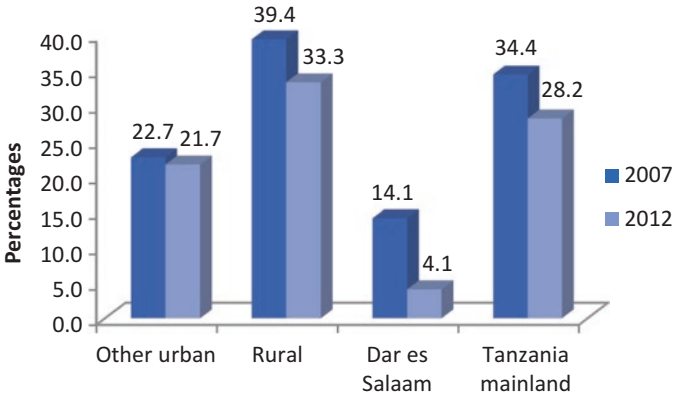

Fig. 14.1 Percentage of population below the basic needs poverty line in Tanzania mainland. (Source: Mosha 2017)

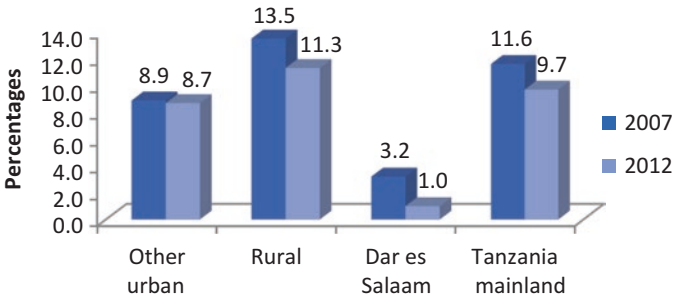

Fig. 14.2 Percentage of population below the food poverty line in Tanzania mainland. (Source: Mosha 2017)

that 79% and 70% of sub-Saharan Africa and Tanzania population, respectively, were rural dwellers in 2017 with average housing condition as shown in Fig. 14.3 and as shown in Table 14.1 expressing use of industrial and/or non-industrial materials in housing. There is a need therefore of critical thinking on possible alternative means and approaches to reduce construction costs to enhance affordable housing concepts.

The current housing deficit in Tanzania is estimated to be more than three million units, and it is growing at a rate of 200,000 units per annum. The problem is more pronounced in urban areas where according to statistics, the urban population has grown from 14.8% in 1980 to 37.5% in 2005. However, there is limited information on how to reduce construction cost of housing as an attempt to provide affordable housing. Lack of knowledge on the effective utilization of both appropriate building materials and utilities has led to unresolved economic burden to residents. This has been a result of overdependence on conventional building materials, technology and commercial energy sources. There is a need to take steps towards provision of

Fig. 14.3 Example of rural housing condition in Tanzania. (Source: 2018 Field Survey in Misungwi Rural Village – Tanzania)

Table 14.1 Household percentages showing usage of industrial and non-industrial building materials in Tanzania

Construction material	Dar es Salaam			Other urban area			Rural area			Tanzania mainland		
	2001	2007	2012	2001	2007	2012	2001	2007	2012	2001	2007	2012
Floors												
Nonmodern	7.6	9.7	3.5	38.8	38	31.6	87.5	84.4	80.1	74.8	68.2	60.6
Modern	92.4	90.4	96.5	61.1	61.9	68.4	12.5	15.6	20	25.2	31.8	39.4
Walls												
Nonmodern	11.5	9.9	2.9	61.7	49.4	32.1	83.3	78.2	66.9	75.3	66.0	51.8
Modern	88.5	89.9	97.1	38.3	50.6	67.8	16.7	21.9	33	24.7	34.1	48.2
Roofs												
Nonmodern	1.8	2.8	0.8	16.3	15.4	9.5	68.7	58	45.2	56.4	44.4	32.3
Modern	98.2	97.1	99.2	83.7	84.6	90.5	31.2	42	54.8	43.6	55.6	70.3

Source: Mosha (2017)

improved housing and related social facilities in both rural and urban areas, especially for low-income groups. Housing professionals are striving to remedy challenges of unplanned urbanization and to undertake necessary urban and rural planning. Particular efforts must be extended to uphold affordable housing concepts in both private and public housing programmes on a self-help basis and through cooperatives, utilizing as much as possible local available building materials, technology and labour.

Different Housing Definitions and Concepts

For the purpose of this study, the term *house* is defined as a structure serving as a dwelling unit for one or more persons, especially for a family. Therefore a *house* as structure for housing has the following basic components: floors, walls, roofs and its surrounding environment. A house is required to act as an entity to keep bad weather from the users of that particular house unit. A house is one of the basic human needs that also act as security and treasured fixed asset as stated in number of human theories of needs.

According to National Housing Building Research Agency (NHBRA), a good house should have the following features: Structurally stable – house stability will depend on the building materials as well as the construction techniques used. If the construction technique used is poor, then, even if the building materials used are strong, the house will have an inferior quality. The house must be durable; capable of protecting inhabitants and their properties from bad weather; able to meet the requirements of all activities which are likely to take place within or outside the building, including cooking, washing, eating and playing; and must meet environmental and human hygiene rules. Human health is very important to all, and hence, a good house should, at all times, be capable to meet health and environmental requirements and capable of meeting privacy and cultural and traditional aspects of inhabitants. These are important because there are some traditional groups in Africa, Tanzania in particular, where parents and their in-laws are restricted to use common washrooms. Likewise for other ethnicities, males and females should not take meals on one table at a time! A good house must be able to meet these cultural values (Mosha 2011). A good house should be attractive in its form. It should have a good visual appealing to both users and passer-by. House possession is a treasured investment and has got its value. A good house should be at the level of investment status which can be saved as collateral and can be sold at a cost worth it and therefore be a source of income.

For the past 53 years after Tanzania's independence, the government of the United Republic of Tanzania has been struggling to ensure that adequate, decent and affordable housing is accessible to all citizens. As an attempt to provide adequate housing facilities which are accessible by the majority of Tanzanians, the government has set out different strategies and action plans to solve the housing deficit in the country. These strategies include formation of the Tanzania Housing Bank (THB), establishment of the National Housing Corporation (NHC), establishment of the Building Research Unit (BRU) now the National Housing and Building Research Agency (NHBRA) and initiated different low-cost housing campaigns to address housing deficit in the country. National Housing Corporation is responsible to provide housing facilities to Tanzanians in a manner that aims at solving the problem of shortage of housing facilities in the country. NHC has the following roles: to construct houses for sale; to facilitate availability of building materials and components; to do business as building contractors, planners or consultants; to rent out and

manage houses or properties built by the corporation and those acquired by the government; and to carry out other activities related to construction of residential houses or other public buildings.

Appropriate Building Materials and Technology in Housing

Use of appropriate building materials has a huge cost implication to any building construction. This aspect is the most crucial in controlling and managing construction cost. The choice of appropriate building material can reduce or increase cost of housing and its services. The choice of building materials can positively affect the affordability of a particular housing unit to a person or group of persons at a certain locality. Appropriate building materials should not be subjected to long distance of transportation. The materials that are specified by designers for walls, roofs, foundations, ceilings and other building elements should be selected wisely so as to establish cost implication on housing delivery. For instance, residential building constructed at Kigamboni housing estate is constructed using appropriate building material of soil-sand interlocking bricks which do not need application of mortar or plaster (Fig. 14.4).

The National Housing and Building Research Agency (NHBRA) is a government housing executive agency, which was launched in 2001 under the Ministry of Lands, Housing and Human Settlements Development. This agency has the following main functions: to conduct research on building materials and technology; to collaborate with central and local government authorities, non governmental organizations (NGOs), community-based organizations (CBOs), development partners

Fig. 14.4 Kigamboni residential house built with soil-cement interlocking bricks. (Source: Moses 2015)

and individuals in the formulation and training of grass-root building construction and production teams/brigades; to promote human resources (i.e. technical, financial and managerial) of all actors involved in housing delivery and human settlements development; to ensure that planning, legislation, building regulations, standards and other controls are in place; and to promote the production and use of appropriate local and affordable building materials. Therefore, the agency is focused on training, research and demonstration on how to build strong residential houses with respect to low cost; to conduct intensive research and to make sure the outcome of research on housing is available on time; to give out education to all; and to create knowledge about quality building materials and technology which are found in a particular context. Figure 14.5 shows NHBRA's appropriate wall material of soil-cement interlocking bricks which are produced by a pressing machine (Fig. 14.6) that can make four different types of bricks without cutting. The machine can produce a full brick, a three-quarter brick, half brick and or quarter brick. Dimension of one full soil-cement interlocking brick is 100 × 150 × 300 mm. Table 14.2 provides comparative dimensions of soil-cement interlocking and non-interlocking cement sand bricks. The second alternative appropriate building material is the sisal concrete roofing tiles (Fig. 14.7) which can be made into two different shapes. Table 14.3 provides dimensions of these tiles. House construction cost is reduced significantly when these two alternative building materials are used. Several non-governmental organizations (NGOs) are assisting development of innovative and appropriate materials and technologies in Africa. The International NGO Practical Action (formerly Intermediate Technology Development Group – ITDG) has greatly assisted in increasing housing affordability through changes in low-cost building materials and technologies (Majale 2005).

Fabrication of sisal concrete roofing tiles is achieved by mixing sand, cement and sisal fibre into a mould of 8 mm thick. A workshop table of appropriate technology (Fig. 14.8) produces vibration by the use of car-cell which can be used up to 7 days at a rate of 10 h a day. When vibration is done, the tile paste mixture is placed on a plastic sheet and transferred into other moulds to get the shape of a desired tile. Drying of tiles is done into two main stages, namely, indoor drying which takes 24 h,

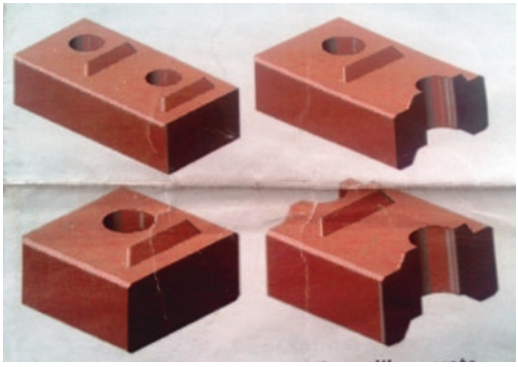

Fig. 14.5 Interlocking bricks. (Source: Field study at NHBRA)

Fig. 14.6 Interlocking bricks pressing machine. (Source: Field study at NHBRA)

Table 14.2 Interlocking and cement sand blocks laboratory data

Item	Soil-cement interlocking brick	Cement sand block
Dimension	100 mm × 150 mm × 300 mm	120 mm × 230 mm × 450 mm
Average weight	6.5 kg	2.4 kg
Expected wall thickness	150 mm	120 mm

Source: Moses (2015)

Fig. 14.7 Example of sisal concrete roofing tiles. (Source: NHBRA Field Survey)

Table 14.3 Quantity and specifications of sisal concrete roofing tiles produced per 50 kg of cement

Tile	Size (mm)	Thickness (mm)	Weight (g)	Number of tiles per 50 kg of cement bag	Surface area to be covered (m^2)	Number of tiles (per m^2)
Type 1	250 × 500	8	3553	95	7.60	13
Type 2	300 × 495	8	2993	75	8.25	10

Source: Moses (2015)

Fig. 14.8 Sisal reinforced tiles workshop. (Source: NHBRA Field Survey)

and it is then deepen into outdoor water pond for 28 days. After that, tiles are ready to be used. There are two types of tiles that can be produced in different sizes, shapes and weights but in the same thickness. When production of tiles is carefully done, 50 kg bag of cement can produce 95 tiles of type 1 which can cover roof surface of 7.60 sqm. However, the same bag of cement can produce 75 tiles of type 2 which can cover 8.25 sqm roof surface as shown in Table 14.3.

Appropriate disappearing beam formwork (Fig. 14.9) is a special beam formwork that upon its application, it becomes part of the structure. It is a precast beam formwork made from sand-cement mixture (1:6), and it is initially prepared in soft timber formwork. This type of beam formwork is used for ring beams of a wall structure (Fig. 14.10). Procedure of making appropriate disappearing beam formwork is as follows: Timber formwork is prepared with exact dimensions as the structural wall and height of the ring beam; mix sand and cement at the ratio of 1:6; sand used must be of good quality as that of plastering. Cast the mixture of cement, sand and water into prepared beam formworks and leave it for 2 days to harden, and remove timber formwork within 3 days. Watering should start on the next day and can be done up to 7 days. Figure 14.11 is a construction model which shows use of

Fig. 14.9 Appropriate disappearing beam formwork. (Source: Moses 2015)

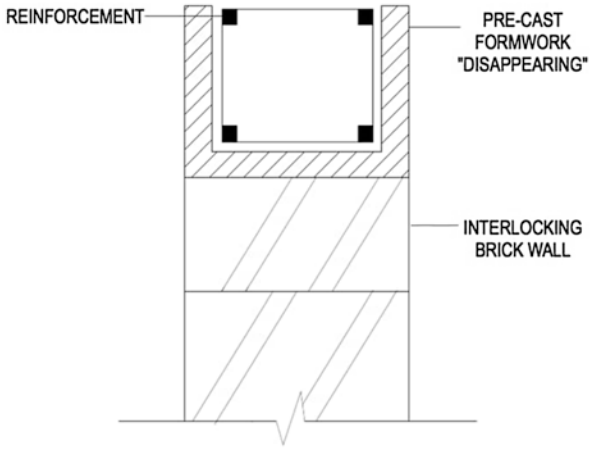

Fig. 14.10 Cross section of a wall to illustrate use of appropriate disappearing beam formwork. (Source: Moses 2015)

soil-cement interlocking brick wall, disappearing beam formwork and sisal concrete roofing tiles on timber truss members. This model provides great knowledge to builders and clients who would wish to use these appropriate building materials and technologies in housing. Construction cost of a structure of soil-cement interlocking brick wall, roofed with sisal concrete roofing tiles, is reduced by 40% from that of a same structure but of sand-cement block wall, roofed with corrugated iron sheets of 30 gauges.

Fig. 14.11 Construction model showing: soil-cement interlocking brick wall, appropriate disappearing beam formwork and sisal concrete roofing tiles on timber truss members. (Source: 2018 Survey at NHBRA)

Low-Cost Housing Concept

UN-HABITAT defines low-cost housing as housing development which can be accessible by the majority of the population in a particular context. Cost of housing is indicated by the total expenses related to building materials, utilities, maintenance and infrastructural services. It is a concept which deals with effective budgeting and building techniques and which helps to reduce housing construction cost by using locally available materials, improved skills and technology without sacrificing the strength, performance and life of the building structure. In sub-Saharan Africa region, housing costs are particularly high due to high prices in building materials, professional fees, transportation and foreign currency exchange rates. About 80% of the population in this region cannot afford construction costs that meet minimum housing standards (Haregewoin 2007). Consequently, UN-HABITAT and few dedicated individual countries devoted their efforts in thinking ways and means of reducing construction cost. Furthermore, UN-HABITAT (2001) indicates that in 1981 the government of Tanzania started a low-cost housing scheme in Dodoma, the new capital of Tanzania, to provide technical and financial support to cooperatives as well as typical house plans, site supervision and construction guidelines. A huge misconception exists that low-cost housing is suitable for only sub-standard works and they are constructed by utilizing cheap building materials of low quality meant to meet poor people's housing demand. Proper management of resources can influence reduction of construction cost of any form of housing to carter for the needs of all income groups. You (2007) assert that there is no universally agreed measure of what constitute "affordable housing" or "low-cost housing" but certainly there are

three common measures to all, namely, house price-to-income ratio, house rent-to-income ratio and the residents income assessment. Chapinduka and Cloete (2007) gives an example of Malawi that only 35% of the urban population is able to access finance from formal sector and less than 16% of households in major urban areas can afford construction of an average house. This signals that majority in Africa cannot afford to have an average decent house as stipulated by the UN-HABITAT standards.

United Nations Habitat estimates that 1.1 billion people live in inadequate housing conditions in urban areas. The right for adequate housing is fundamental human right, enriched in various international human right treaties and instruments and applying equally to all people of the universe, but millions of households across Africa, in particular the poor and women-headed households, lack tenure security (UNCHS 1997). In many cities of developing countries, more than half of the population lives in informal settlements, without security of tenure and in conditions that can be described as life threat. Everyone has the right to own property alone as well as in association with others. Everyone has the right to a standard living, adequate housing, food, clothing, medical care and necessary social services and right to security in the event of unemployment, sickness, disability, widowhood, old age or other lack of livelihood in circumstances beyond his or her control. We recognize that access to safe and healthy housing is essential to person's physical, psychological, social and economic well-being and should be a fundamental part of our urgent actions for more than one billion people without decent living conditions in the world. As part of the strategy of the Tanzania Government to provide low-cost housing, the National Housing Corporation in Tanzania has launched a famous project commonly known as "My life my house" in 2012 with the target of constructing 5000 house units. Few of these residential units are already built. Kigamboni Housing Scheme at Kibada in Dar es Salaam is a good example as shown in Fig. 14.4.

Sustainable Construction Towards Reduction of Housing Cost

Main housing utilities in this discussion are water and electricity supply. Commercial energy sources in developing countries are normally inadequate. See, for instance, condition of poor people struggling for water shown in Fig. 14.15, unreliability of power supply due to undersupply and frequent power shedding in Tanzania and elsewhere with similar situations of poverty (Ozolins 2015). People use water for cooking, washing, flushing toilets, gardening, washing cars and so forth. At night, electricity is needed to light residential houses. The same electricity is used to operate different electronics in bedrooms and lounges. Electricity is also used to run mechanical cooling appliances like ceiling fans and air conditioners. However, human beings are able to perform different domestic activities without the presence of commercial utilities in their places of domicile. Bennetts et al. (2003) express that sustainable construction is how a built structure responds to the effects of

human activities on the environment, sociocultural and economy of a particular context. For the purpose of comparative study, we can see domestic utilities have direct cost implication on housing. Therefore, proper measures should be taken so that the consumption of different utilities in residential buildings is used at a minimum cost in a reductive manner when needed. For instance, use of smart bulbs allows light to be on only when needed. Lighting security lights during night times should be on only when needed. Sustainable construction sometimes referred as "intelligent buildings" and/or "digital building" uses automated power and lighting control systems which bring about energy saving and efficiency (Watson 2011; Sinopoli 2010).

If the cost of housing is to be kept as low as possible, undue reliance cannot be placed on mechanical means of controlling the indoor environment, but housing must be designed to carefully consider the climate and weather to promote human thermal comfort. Climatic factors, namely, winds, temperature, rainfall and humidity, have to be considered. The building design is supposed to address all calamities that are likely to jeopardize minimum housing cost and maximum human comfort. Sustainable construction emphasizes on the effective use of utilities and building materials not only in cost reduction but also environment consideration. Appropriate orientation of a house can reasonably contribute to human thermal comfort of house users. For instance, orienting bedrooms to the eastern side of the house in East Africa is professionally correct than when they are oriented to the western side where the afternoon solar radiations are maximally absorbed in bedrooms and re-emitted during sleeping time. The utilities consumption within the building should be analysed carefully and properly consumed only when needed. This practice reduces the cost of energy on housing significantly. Well-thought utilization of utilities and building materials can lead to minimum wastes during construction and in the course of living. Housing facilities have to be part of the environment so as to minimize the use of mechanical means to perfect indoor thermal condition. This includes the use of passive measures. In this particular discussion, the type and size of window openings may increase or reduce the cost of power consumption in housing. For instance, sliding aluminium windows which allow only half of the window to open may require air conditioners in Dar es Salaam because of the harsh warm and humid weather conditions. A simple thermal performance analysis conducted to compare first floor window in Fig. 14.12 with its openable aluminium window panel shutters showed double performance level to that of sliding aluminium window glass panel of the ground floor which opens only 50%, hence reducing passive thermal cooling by 50% of that of the first floor window. Residents complained of uncomfortable passive thermal cooling and requested the landlord to introduce openable aluminium window shutter panels especially for rooms without two-side exterior windows. When the thermal performance of a window is poor, it necessitates application of mechanical means of cooling, which in turn have a rise in housing cost to achieve the reasonable human thermal comfort inside the house.

Renewable energy sources have constant supply and are reliable, and their cost is less compared to other commercial sources. Water from DAWASCO (Dar es Salaam Water and Sanitation Company) is the most reliable. Electricity main source

Fig. 14.12 Passive thermal cooling through sliding and openable aluminium window shutters. (Source: 2018 Field Survey)

Table 14.4 Water and electricity sources at Boko National Housing Corporation Estate in Dar es Salaam

Source of water	Number of houses	Source of electricity	Number of houses
Bore hole	0	TANESCO	15
DAWASCO	11	Solar power	0
Water vending trucks	0	Generator	0
Water vending points	4	Other sources	0
Rainwater	0		
Total	15	Total	15

Source: Moses (2015)

in Tanzania is TANESCO (Tanzania Electricity Supply Company) which is a sole source of commercial power in Tanzania. DAWASCO users pay between 15,000 and 200,000 Tanzanian shillings (TZS)[1] water bills per month if there is a constant supply. Table 14.4 shows different water and electricity sources in Tanzania. Water vending (Fig. 14.13) is also practised at 200 Tanzanian shillings per 20 l bucket.

The main concern is how we can plan to incorporate renewable sources such as rainwater harvesting in housing design as shown in Fig. 14.14. Among reliable and cost-effective water sources found during field survey is from rain which plays a great role towards cost reduction in housing. However, major challenge associated with rainwater collection is *how to collect* and *how to store*. Rainwater harvesting exercise needs gutter systems to collect and storage tanks for later use. Rainwater is

[1] Exchange rate: 1 US$ = 2226 TZS as of 25 January 2018

Fig. 14.13 Peoples searching for water. (Source: Moses 2015)

Fig. 14.14 Rainwater harvesting. (Source: Moses 2015)

free and pure. Once harvesting infrastructure is set, the harvest can be performed at no extra cost. For example, it was observed during field survey that one resident in Dar es Salaam had an underground tank with a capacity of 25,000 l, while his water consumption per day is 200 l. This means these 25,000 l can last for 125 days which is equivalent to more than 4 months!

Electric and thermal energies are the two components of solar energy systems, which are useful in reducing housing cost. Photovoltaic (PV) panels as shown in Fig. 14.15 are used as roofing materials and produce electricity. Solar thermal systems

in Fig. 14.16 produce heat energy. Installation charges may be expensive but eventually turns to be cheap in the course of use because there is no fuel cost needed, and it has low operational and maintenance cost. Photovoltaic solar panels can be integrated into walls and roofs of residential houses and commercial buildings and reduce consumption of electric load from national power system. Tanzania is within the tropical zone where the sun is in abundance throughout the year. The persisting problem of carbon dioxide emissions can be minimized by the use of solar energy (Mosha 2006).

Fig. 14.15 Use of solar energy in buildings in Mbweni – Dar es Salaam. (Source: 2018 Survey)

Fig. 14.16 Use of solar thermal energy system for heating in Mbweni – Dar es Salaam. (Source: 2018 Field Survey)

Reduce, Reuse and Recycle (3Rs) of Construction Resources Towards Reduction of Housing Cost

Reduce means finding way to decrease or lessen the amount of anything that its absence has no harmful to the performance or attainment of intended objectives. In resource management principles, reduce means using fewer resources in the first place. This is the most effective of the 3Rs. It can be the hardest because it requires letting go of some of the resources we love, but they might be absent and affect nothing. However, we do not need to let go completely or all at once. "Reduce" is a comparative terminology. It says cut back from where you are now, hence "use only when necessary". When resources are not wisely used, they can be termed as being "abused". A resident must choose electronics and appliances that are energy-efficient; control consumption of water at home; waste less energy on lights and equipment; avoid overly packaged goods; use products made from post-consumer recycled materials, especially paper and washroom tissue; turn off lights when you are not using them, this shall save energy; avoid disposable or "use once only" items; and use rechargeable batteries. Reducing will promote conservation efforts and decrease landfill with wastes. Reducing results contribute to less pollution and cleaner environment. It also helps conserve natural resources. Therefore conserving resources, housing dwellers have to reduce unnecessary use of resources.

Reuse means finding way to use things repeatedly instead of throwing them away. We can reduce the purchase of new products by reusing some of them. Before disposing anything, we should consider whether it has life left in it and if it can be used to serve other purposes even after few modifications rather than buying new ones. Reusing methods include repairing damaged items, donating items to less affluent people or finding another way to use them. For example, water used in one activity can be suitable for use in another activity different from the first one. For instance, water used for laundry can be reused to flush toilets. For example, if 50 l of water is used for general cleaning, this same water is reused to flush toilets per day, then the amount of water needed will be 1500 l in a month and 18,000 l in a year. This amount of water is saved if the concept of reusing laundry water is practiced for the purpose of flushing toilets! Figure 14.17 is another example of reusing waste water from soak-away pit in gardening. There is a lot of saving in water bills if water for gardening is tapped from soak-away pits instead of the commercial main water supply source.

Recycling is converting something old to something new. This process involves making new products out of old products. This means potential landfill waste becomes a new product. We can protect the environment by buying products that contain recycling instructions after the first use. Many of the things we use in our everyday life are recycled (Langston et al. 2004). New plastic bottles can be recycled from old ones and can be filled with sand and become construction building material in place of cement sand blocks. Recycling is a process, which uses recovered materials to make new products, and the value of recycling lies primarily in the fact that all products derived from used materials.

Fig. 14.17 Reusing waste water for gardening. (Source: Field Survey 2018)

Conclusion

This article discussed and provided housing rhetoric, appropriate building materials and domestic utilities in the context of Global South in Africa with an in-depth case study of Tanzania. It has been observed that majority of people are poor in Africa; hence poverty is the major housing challenge. In Tanzania, for example, 34.4% of her population are below basic needs poverty line, and they definitely cannot afford adequate housing. Rural communities in Africa are more than 70% of the entire population and certainly cannot afford to buy industrial building materials. Furthermore, 21% of urban population in Tanzania live below basic needs poverty line and cannot afford decent housing units. Even in cities and towns, it is only 48% and 70% of urban population can afford to purchase industrial materials for walls and roofs, respectively. This research promotes use of soil-cement interlocking blocks and sisal concrete reinforced tiles as appropriate building materials for walls and roofs, respectively, to reduce housing cost of dwelling units. Application of renewable energy for lighting and heating as well as upholding principles of "3R", namely "reducing", "reusing" and recycling housing products has significant cost reduction in the construction and utilization of housing resources.

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