ABSTRACT
Sustainable building construction process in the urban Tanzania has been a problem for the low-income households for years. The current priority and trend to desire for the application of innovative materials without a professional analysis contributes to this major setback. On the other hand, technically uninformed people are indirectly being incorporated to building designs and approaches, which are not sustainable and in the long run they become economically not viable. Parallel to this, experts on housing issues are not taking a strong consideration to this trend. Construction industry professionals dealing with housing production use design solutions and building materials which are not appropriate for local use leading to unsustainable development. In view of this, there is a need to consider revising different factors related to sustainable building, including materials, standards and guidelines.

Keywords: Appropriate Design, Building Materials, Environment, Sustainable Building, Urban Tanzania.

1. INTRODUCTION

1.1 Tanzania, a Developing Country

Many developing countries in Sub Saharan Africa including Tanzania, are facing serious problems which are related to provision of affordable housing (Nguluma, 2003). Efforts to address this issue have been included in various national development agendas for years. However,
achievements seem to be comparatively low against expectations, which are normally included in the formulated objectives. This might be attributed by a number of factors, among them, lack of priorities and harmonisation of different activities related to building design and building materials optimisation. At the same time, a traditional trend has been to adopt the western developed world approaches in housing issues by local professionals, even in conditions where it could have been better to adopt local approaches.

Another contributing factor to this situation is the rapid urbanisation which is facing developing countries including Tanzania. The rapid urbanisation is mainly based on the rural-urban migration. Under normal circumstances, people migrate to large cities and towns in search of reliable employment, social services and even other facilities which may provide a large room for comfortability and security, which are somehow difficult to achieve in rural areas.

The estimated population growth rate for Tanzania was at 2.8% in 1995, and the population of Tanzania was approximated to be 34 million people in 2000. This is verified by the national census held in 2002, which recorded a population of 34 million people (Online www.tanzania.gov.tz). It is clearly stated in the National Environment Policy (NEP, 1997) that demographic factors and trends are directly linked with development and environmental issues. Therefore, a rapid growing population implies an increase in absolute terms. This in turn affects the use of land, water, energy and other natural resources. The accompanying rapid increase in the number and size of urban centres pose dramatic additional demands in the capacity of providing serviced land, shelter, infrastructure and employment.

In consideration with the above facts, Tanzania has to, and needs to get out of this complex situation by prioritizing timely actions which are monitored and controlled on regular basis.

1.2 Agendas on Sustainable Building for Developing Countries

As pointed out in the Agenda 21 for Tanzania in “Social Aspects of Sustainable Development in the United Republic of Tanzania”, the highest priorities in sustainable provision of services were on water supply and sanitation, whereas human settlements sector was still hampered by high investment, operational and maintenance costs.

More than a decade has passed since the 1992 Earth Summit in Rio de Janeiro. The summit addressed the issues of human developments and environment. The Agenda 21 report, highlights a number of issues to be dealt with in the next century. The issues are mainly related to the promotion of sustainable human settlement development. Among the programme areas, one was intended to focus on how to provide adequate shelter for all.

As a basis for action, it was agreed that access to safe and healthy shelter is essential to a person’s physical, psychological and socio-
economic well-being, and should be a fundamental part of national and international action. The estimate was that approximately 1 billion people do not have access to safe and healthy shelter, and that if appropriate action was not taken, the number will increase at the end of the century and beyond (Agenda 21, 1992). Suggestions from the report insist that, all countries especially the developing ones, should appropriately, formulate and implement programmes that address the specific problems of the concerned populations in their respective countries.

The “CIB Agenda 21 for Sustainable Construction in Developing countries (CIB Agenda 21, 2002)”, in response and support of the UN Agenda 21 report, discusses in detail a number of issues which relate to the situation in most developing countries. The report, in very critical statements mentions that “the developing world has very little time left to decide the future of its settlements. It can choose to blindly follow the model laid down by the developed nations, or it can choose to opt a more sustainable model of development”. In a positive direction, it means to seriously address issues such as adequate housing, rapid urbanisation and lack of infrastructure. The report further suggests that the developing countries still, have the opportunity to avoid the problems currently experienced in the developed countries. These countries can chose to base all their future development programs on the principles of sustainability.

The main purpose of this paper is to discuss the use of building materials and design challenges involved towards sustainable building construction in developing countries like Tanzania.

2. METHODOLOGY

Information used in this paper is drawn from literature review collected from various sources. Information from a study conducted by authors on building challenges in the City of Dar es salaam is also used. This study involved interview with key stakeholders including architects, planners and artisans in the local building construction industry. Besides, discussions were also carried out with those involved in production of building materials and users at various sites in the city. A total number of 50 interviews were carried out.

In addition observations were made focusing on newly constructed buildings in various areas of the Dar es Salaam and Mbeya City; Iringa and Morogoro Towns where there is an increase use of modern materials. Observations were carried out with regard to building form, treatment of facades and type of building materials.

3. SUSTAINABLE BUILDING AND ENVIRONMENTAL ISSUES

3.1 Past and Present Experience
A series of Agenda 21 based documents including UNEP (UN Environmental Programme), Tanzania NEP (National Environmental Policy) and CIB Agenda 21 for Sustainable Construction indicate that, sustainable development means achieving a quality of life that can be maintained for many generations because it is socially desirable, economically viable and environmentally sustainable. Development is sustainable if it takes place within nature's tolerance limits, both in the short and in the longer-term perspective.

Environmental issues are definitely fundamental, and need to be considered and integrated in the sustainable building programs and actions. Development is certainly associated with building and construction, and the built environment. Natural resources are consumed by modification of land, the manufacture of materials and systems, the construction process, energy requirements and waste products that result from operation, occupation and renewal. Building projects continue to be a major contributor to both economic growth and environmental degradation, as such, is directly concerned with sustainable development. Based on these facts, the concept of sustainable development has stimulated the search for building and construction solutions that do not result in clash between living standards and environmental protection.

We live in an environment age where, valuable resources are further depleted and limits to growth are approached. The lives of Tanzanians, just like the people from the rest of the world, are intimately connected to the environment. Therefore, the survival and that of their future generations depends on the harmonious relationship with the natural elements. Indeed, they have no choice but strive to manage the environment and its natural resources in ways that enhance the potential for growth and opportunity for sustainable development of present and future generations. Every individual must realize and accept that environmental problems are real, and not someone else's problem.

3.1 Optimization of Building Materials for Sustainable Building Construction

In a simple explanation, optimization of building materials can be defined as the process meant to achieve the best use of available materials, in order to make their use as useful and effective as possible. In such a process, several factors are included to get the best optimized values. Such factors must include the following items:

- availability of the material in discussion
- production costs
- local climatic conditions
- environment impact
- durability properties
- predicted service life based on LCA (Life Cycle Assessment) models
• materials transportation (whether locally or imported), and
• the related environmental impact.

To optimise building materials in the building and construction industry is of significant value if we need to achieve sustainable building, especially in the developing countries of Sub Saharan Africa, and Tanzania in particular.

The earth’s crust resources are usually defined as being ‘renewable’ or ‘no-renewable’. Renewable sources are those that can be harvested in regular intervals, for example timber. These resources are renewable provided right conditions for production exist. Non-renewable resources are those that cannot be renewed through harvesting, e.g. iron ore. However, research reports indicate that most of these resources will be exhausted in the near future (Berge, 2000).

Another established fact is that, the building industry is the largest consumer of raw materials in the world today. Thus, a major guiding principle for the future should be a drastic reduction in the use of raw materials. Another important consideration is to reduce the loss of resources during production, the construction process and throughout the life time of the completed building. The re-use of materials after demolition should be taken into account. Recycling processes models should be developed and encouraged at all levels. Figure 070-1 represents a good explanation on how the cycle of materials can be included in sustainable building design process.

3.2 The Choice of Materials for Sustainable Building Construction in Tanzania

![Figure 070-1 The cycle of materials.](image-url)
Major building materials used in Tanzania today are still of classical types. Materials such as cement, cement blocks, concrete and reinforced concrete, timber, GI sheets and recently roofing tiles dominate the building industry. This is the case in most urban cities and towns including Dar es Salaam, Mbeya, Morogoro and Iringa (BE FT Report, 2006).

Majority of people continue to adopt new trends in selecting building materials, probably from the western developed countries, where applied building materials reflects a symbol of wealth. The traditional way of thinking and the wish to use locally available building materials is rarely practised.

In Dar es Salaam city, concrete blocks continue to dominate as a basic material in residential and commercial building. In Morogoro and Iringa municipals, both use of concrete blocks and soil burnt bricks is common. The case is similar in Mbeya city. However, Iringa and Mbeya there is an additional desire of local people to use timber products in residential buildings. This decision is probably based on the fact that timber products are produced in large quantities in these regions.

However, on the other hand, sand-cement floors finishes are also common in these cold highlands regions. The temperatures are low especially in the May-July months and cement floors tend to be cold especially in the nights. One would have expected that local people could have opted for an alternative combination of materials. But this is exactly what can be reflected as a struggle to own houses using modern industrial materials for the sake of prestige.

The traditional way of using building materials in combination which looks natural and beautiful, and yet environmentally friendly, is no longer a top option. This is even happening amid professionals who have vast experiences in the building and construction industry.

Clay building bricks, red soil burnt bricks, natural roofing materials are nowadays regarded as inferior, even though they are functional and contain aesthetical values. Such traditional African huts from Sub Saharan Africa are nowadays very rare to find in large scale, and if found, then are only in remote districts or tourist attractions centres (Figure 070-2).

Figure 070-2 Traditional African Huts.
Woolley (2004) summarizes the various benefits that can be achieved if one applies the so called natural building as related to building materials as shown in Table 070-1.

The author further argues that, work on environmental assessment tools largely fail to take a global perspective on resource consumption and thus continue to use expensive materials at a high rate. To avoid such a problem, an alternative is the development of the so called 'Natural building' which tries to use materials and building methods which have a lower impact and use renewable energies.

In this approach, few changes must be proposed in terms of better energy efficiency, construction management, less wastage and the inclusion of new appropriate technologies. The conclusion is that mass materials like cement and concrete cause significant pollution, use a lot of energy and non-renewable resources. Although many professionals may assume that using green materials or technology will be much expensive, however, the aim of the natural building alternative is for such materials to be economical, of high standard and with good life cycle performance.

Table 070-1 Comparison of possible benefit of conventional and natural materials.

<table>
<thead>
<tr>
<th>S. No</th>
<th>Conventional building</th>
<th>Natural building</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Uses non-renewable resources and materials</td>
<td>Uses renewable materials, which can be grown and provide cash to the local people, e.g. farmers</td>
</tr>
<tr>
<td>2</td>
<td>Uses a lot of energy in extraction - high embodied energy</td>
<td>Uses materials which need little energy to extract</td>
</tr>
<tr>
<td>3</td>
<td>Extraction is often damaging and causes social problems</td>
<td>Materials are extracted and processed locally</td>
</tr>
<tr>
<td>4</td>
<td>Significant energy and chemicals are used to create energy efficient solutions</td>
<td>Generally, little energy is used</td>
</tr>
<tr>
<td>5</td>
<td>External air pollution caused by manufacturing processes</td>
<td>Virtually no external pollution</td>
</tr>
<tr>
<td>6</td>
<td>Internal pollution due to the use of toxic additives like solvents</td>
<td>Natural materials rarely cause health problems if handled properly and not treated with toxic fire retardants, etc.</td>
</tr>
<tr>
<td>7</td>
<td>Waste in manufacturing and installation is a normal part of process</td>
<td>Little waste if care is taken</td>
</tr>
<tr>
<td>8</td>
<td>Damage to eco-systems at end of life disposal</td>
<td>End of life can be recycled or returned to the earth and decompose</td>
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3.3 Towards Appropriate Designs for the Building Construction Industry in Tanzania

Appropriate building design is not really a new concept for building designers/ professionals around the world. However, putting it into practice in actual daily industrial activities seems to be unrealistic; and a contradiction to the objectives of sustainable development and the building industry at large. This observation is applicable to the current situation in Tanzania.

Appropriate design is considered as an important component in order to achieve a financial balance return, social contribution, energy efficient and minimal environmental impact objectives. There are various ways in which built facilities can reduce their dependence on environmental resources. Examples of such strategies may include appropriate material selection and radical designs that embody both passive and active solutions to create more comfortable spaces at reduced cost and energy input (Langston and Ding, 2001). Environmentally-compatible design which is sometimes referred to as 'green design', apply designs that exhibit reduced dependence on energy for maintaining comfortable internal environments. The results are anticipated to meet the requirements of high productivity levels and increased satisfaction by the occupants.

In analysing the challenges facing urban development in Dar es Salaam city, Nguluma and Lyakwipa (2006) were concerned with the negative effects associated with designs, construction activities and unregulated development of buildings in both formal and informal settlements.

Figure 070-3. A concrete blocks fenced house in Dar es Salaam.
For the case of Dar es Salaam, cement is regarded as a basic building material, however, architects and designers need to formulate designs which can reduce the use of cement. Regarding the social aspects of design, the need for security, privacy and territorially is among the key consideration in the design process. Due to this reason, massive concrete blocks or metal fences are erected to justify security measures in most residential areas in Dar es Salaam.

Architecture has to respond ecological demands; and designs that take into account the local conditions, culture and identity, emphasize on environmental design and energy efficiency.

In a related study, Nguluma (2003) highlighted that families construct fences around their houses to improve security. Some walls are as high as three metres, and in most cases constructed of massive concrete blocks. Such walls are constructed using a lot of materials, which are not healthy and socially interactive. Figure 070-3 represents a house which is totally fenced using concrete blocks in Hanna Nassif, in Dar es Salaam, as documented by Nguluma (2003).

In regard to building design and materials, Nguluma (2003) comments that, people's admiration of concrete blocks as good 'modern' materials could be interpreted as a mere ignorance on the performance of building materials. This is simply because not much effort is done to educate and convince people the positive aspects of traditional building materials.

In agreement with the arguments related to sustainable building design in Tanzania, it is important to consider and regularly update building standards to meet local needs. The popular British standards that are commonly used in the building industry in Tanzania need to be updated for local use. Tanzanian standards (TBS), whether developed or modified from the International standards, need to be realistic. They should include basic factors such as climatic conditions. For example, the 230 mm thick concrete blocks wall used commonly used in wall construction design is not compatible to local climatic conditions of areas like Dar es Salaam. This is because thermal conductivity (k) of concrete is comparatively high, i.e. 1.44 W/mK. The resulting effect is high indoor temperatures in most households in the region in longer periods of the year. Other materials, e.g. earth brick is having a k value of 0.14 W/mK and cement-sand mixture is 0.53 W/mK which are considerably low.

Thomas (2002) discusses various aspects and alternative approaches which can successfully be applied in dealing with various problems in architecture and the urban environment. He pinpoints that, sustainability in construction relates not only to the extraction and production of raw materials, but also consideration in efficiency in terms of the design execution of the structure. Such approaches can be very useful if carefully studied and adopted in the building and construction industry in Tanzania.
4. CONCLUSIONS

This paper has discussed problems and challenges concerning sustainable building design in urban Tanzania, in a direction supporting the concept of construction for development. It shows that sustainable construction should be considered as an important component in creating a sustainable development to the country. One important consideration is to integrate building design and building materials from the design process stage. This can easily be implemented by using optimization models. The paper further reveals that:

- The design approaches and materials used in the building process in urban Tanzania do not really comply with the principles of sustainable construction.
- Building professionals are reluctant to use their entire knowledge in a realistic approach.
- There is a lack of proper coordination between the various professionals involved in the building industry.
- Building standards are not realistic, i.e. they are not affordable and compatible with the local needs.
- The majority of the people lack knowledge on the various performance properties of building materials and rational designs.
- Environmental impact consideration in most cases is neglected during the design process.

As best explained in the CIB Agenda for Sustainable Construction; sustainable construction means that the principles of sustainable development are applied to the construction cycle from the extraction and beneficiation of raw materials, through planning, design and construction of buildings and infrastructure, until their final deconstruction and management of the resultant waste.

The Agenda concludes that, creating a sustainable built environment in the developing world requires a different approach from that used in the developed world. This is not normally understood and in most cases excluded in discussion.

As such, a country like Tanzania needs to take these remarks strongly for action. It must be noted that, in order to achieve sustainable development, the society, the environment and economy should be linked together with the application of appropriate technology.

5. REFERENCES
