Sustainability in traditional African architecture: a springboard for sustainable urban cities

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ABSTRACT: It is a generally held view that, in tropical countries, traditional houses are more sympathetic to the prevailing climate and provide comfortable interiors. A typical traditional building of earth, maintains a high level of internal thermal comfort, regardless of prevailing solar radiation outside. Global temperatures are expected to rise in the next decade in the tropics due to increased levels of green house gases (GHGs) from global warming activities. It may become necessary to promote the construction of such earth structures - especially as singlestorey dwellings. The potentials that lie in mud bricks, stone and straw bale may also need to be combined with modern technology so as to produce a new generation of homes that require no mechanical air-conditioning during hot days and nights. This paper addresses how to technologically improve the building craft on the African continent, through the use of traditional materials. The paper studied the benefit of using bio-degradable, natural and native materials in housing delivery in three selected countries in Sub-Saharan Africa namely: Nigeria, Kenya and South-Africa. The paper discusses the relevance of local inputs to affordable housing with an overview into tropical architecture: - and it's evolution from ecological tropical architecture to neo-traditional tropical architecture to modern tropical architecture. Traditional architecture entails architecture that appears to be traditional because it bears certain formal resemblances to traditional vernacular architecture and it is often constructed out of similar local construction material such as tropical hardwood, and mud. It posits that the successful fusion of traditional materials and modern technology will sustain a decent lifestyle, liveable neighbourhoods, - in a balanced urban city. It will also encourage good building practice through the art of "green building".

Conference Theme: Sustainability and Urbanism

Key words: bio-degradable materials, green-house-gases, sustainable architecture, technological hybrid system, tropical architecture.

INTRODUCTION

In November of 2011 the United Nations Climate Change Conference tagged COP17 – 17th Conference of Parties held in Durban, South Africa. Among the burning issues discoursed was the implementation of the Kyoto Protocol, Bali Action Plan and the Cancun Agreements. The Kyoto Protocol was negotiated in 1997 and ratified in 2005. Article three (3) item one (1) states:

The Parties included in Annex I shall, individually or jointly, ensure that their aggregate anthropogenic carbon dioxide equivalent emissions of the greenhouse gases listed in Annex A do not exceed their assigned amounts, calculated pursuant to their quantified emission limitation and reduction commitments inscribed in Annex B and in accordance with the provisions of this Article, with a view to reducing their overall emissions of such gases by at least 5 per cent below 1990 levels in the commitment period 2008 to 2012 (UN, 1998).

In summary, developed countries, known as "Annex 1 countries", are bound legally to targets for cutting greenhouse gas emissions. In total, these cuts seek a minimum 5% reduction in the 1990 level of all Annex 1 emissions before the end of a first commitment period in 2012. Greenhouse gases are solely responsible for climate change and its associated effects in the world today. The built environment makes substantial contributions to the degradation of our environment. "Buildings including construction, operations and deconstruction impacts, use approximately: 15% of the world's fresh water resources; 40% of the world's energy; producing about 23-40% of the world's greenhouse gas emissions" (Gunnell 2009). With the world's population rising geometrically and Africa making significant contributions is billed to provide housing and other amenities for its teeming population.

Looking into history particularly on the African continent; Egypt, Nigeria, Kenya, Mali etc, we hear and sometimes carry out studies on the New Gourna Village by Hassan Fathi, the Ancient Kano and Zaria cities by the indigenous craftsmen, the Great Mosque of Djenné directed by Ismaila Traoré, and a few other examples. These

buildings have lasted for over sixty (60) at the least and have proved themselves to be outstanding works of architecture that have not only stood the test of time but, are cheap, comfortable with little or no carbon footprint. Having such immense potential, traditional African architecture particularly building with adobe bricks is worth looking into. This paper focuses on the gains of using local materials and possible integration of technology into housing delivery on the African continent with particular reference to the Nigerian, Kenyan and South African landscapes.

THE CONCEPT OF SUSTAINABILITY

A vivid example of the concept of sustainability around us is nature; it is based on the closed-loop nutrient cycles, in which there is no waste. By the system of birth, life and death, each organism supports the next. It is on this premise that sustainable architecture/green building/sustainable construction/green construction all referring to the same thing is based. Some definition of the term includes; "refers not to individual buildings but to the whole process and life-cycle of building from design, site selection, sourcing materials, construction, operation and eventually decommissioning" (Gunnell 2009). "Sustainable construction is a holistic process aiming to restore and maintain harmony between the natural and the built environments, and create settlements that affirm human dignity and encourage economic equity" (Du Plessis et al 2002).

Green buildings emit fewer greenhouse gases, consume less energy, use less water, and offer occupants healthier environments than do typical buildings. Green buildings use salvaged, recycled or low carbon materials; they support rainwater harvesting, bicycle commuting, solar heating, natural ventilation, and/or many other environmentally friendly practices (UN-HABitAt, 2010).

Sustainable architecture in a broad perspective consists of buildings designed, built, renovated, operated, or reused in an energy efficient and economic manner. Sustainable building can also be viewed as "the combination of building design and construction that examines all aspects of the building process that will effect and be affected by the environment" (Poveda 2009). "The goal of sustainable design is to find architectural solutions that guarantee the well-being and coexistence of these three constituent groups – inorganic elements, living organisms and humans" (Kim, Rigdon 1998).From the above definitions it is obvious to see that the aim and purpose of sustainable architecture is to construct greener and better functioning buildings that acts in response to the resources consumed and emission/pollution produced, during a building's lifecycle with a view to reducing its impact on the natural environment (Serlin 2002).



Figure 1: Levels of interface between the building and the environment.

Source: (Poveda 2009)

AFRICAN ARCHITECTURE

The architecture of Africa has been seen and labeled internationally and even by its own as being primitive. This 'primitive' classification comes partially from the building materials and their relatively low technological uses when compared to present day western (architectural) construction techniques which result in skyscrapers. The definition of architecture as the art and science of building has over the years seen a lot of reforms to include useability, acceptability and comfortability. That African architecture does not have documented scientific approach to its design and construction does not mean that it fails to satisfy these conditions, because, for a building system proven to satisfy thermal comfort, aesthetics and sustainability and being a major part of the daily life of its occupants cannot be anything short of architecture. The focus of this section is not making an argument for African architecture but to examine its nature and features.

African traditional architecture is essentially sustainable and had evolved culturally to suit the people. Usually, earth, timber, straw, stone/rock and thatch were constructed together with the simplest of tools and methods to

build simple, livable dwellings. Although globalization has relegated them as being 'primitive', present interpretations of sustainability has given them a new status as likely technologies for the contemporary world. Along with the others that have been re-devised, earth has of late gained acknowledgement as a suitable technology for contemporary buildings. Africa as a tropical continent between the Atlantic (west) and Indian (east) oceans has an over 5000 year's old recorded history that shows buildings and monuments made of numerous natural materials available in abundance in its geographical landscape. Its indigenous architectural practice had been shaped by ideologies of sustainability though this was done in ignorance. Developed from naturally existing materials and cyclical possibilities of their regeneration, they impacted on the judicious use of earth's resources in the construction of its villages and hamlets, the cities and urban centers as well as the temples, tombs, monuments and religious edifices. In reality, the act of choosing a site, utilisation and re-use of materials and sites in that respect have all been formed by the culture of uncomplicatedness and frugality, respecting nature and understanding that the earth must be cared for and gently because it is both delicate and expendable (Dayaratne, 2000).

Predictably, earth/mud/adobe has been one of its most important and chief building material combined with timber (mostly from palm trunks) and palm/coconut/grass thatch and straw bales as roofing; all materials abundantly available in the settlements. Stones were used when available and fitting to build with, particularly the public and religious buildings that demanded lasting durability. In entirety, Africa's traditional architecture made certain that its use of the resources neither diminished their availability, nor adversely affected the ecological balance upon which it relied on as an agrarian society.

AFRICAN ARCHITECTURAL ANTHROPOLOGY

The three well-defined materials that are prominent in the building traditions of Africans are; stone, straw and earth which have been independently and jointly used and skillfully applied. In actual sense, in the history of its architecture, diverse areas to great extent have used materials peculiar to them based on their availability and the developed technology of its artisans. Remarkably, irrespective of the materials used, their technologies have been advanced, developed and grasped with such ingenuity, substantiated by the remains of ancient cities and other archeological sources. The very few structures that have lived through centuries of human indwelling, present lack of maintenance and abandonment clearly explains that, if they had been appropriately used and maintained, they would have served for few more centuries; a major quality in sustainable building practice indeed. As earlier mentioned, of all the materials developed, stone, straw and raw earth stand out.

Stone Architecture

The basic form of the use of stones/rocks for dwellings had begun with the habitation of the naturally occurring caves about which walls and roofs in mud or thatch, brick and straw were erected converting them to liveable places. As an ethical standard, when natural rock caves, rocks or boulders were converted to dwellings, little modifications were made to the rock itself but other constructions finished up the enclosure that existed. Besides, the surrounding environment were developed using similar thoughts to stone which were methodically placed and arranged to fashion out the finery of the natural landscape. The existence to of such favourable conditions within the physical environment obviously, enhanced its exploitation. As a result of its natural endowment stones/rocks/boulders have been exploited in its natural and man-made formation to define spirituality, reverence and seclusion (Dayaratne 2011).

Certainly, Africa's constructed stone architecture has historically produced some distinct works. The crafts men of Rock buildings in Africa are highly skilled in the art of stone construction with distinctive understanding on the types of rocks, their material constituent, refining; involving extraction from earth, cutting and reshaping them to fit together into architecturally stable forms. The attainment of this feat in skill is evident in the pyramids of Egypt the only surviving wonder of the ancient world.



Source: www.portpromotions.com



Figure 2: Pyramids of Egypt Figure 3: Ruins of the Sultanate of Adal in Zeila, Somalia. Source: (Somalian architecture - Wikipedia 2012)

Definitely, the progression in stone construction has been so widespread that there existed an era of civilization centered on stone/rocks constructions: refined and crafted stone. Chiefly, in Somalia and other parts of the continent, countless number of ruins of buildings that have been made of stone exists, standing as proof to the skills of the African builders who had used stones and rocks as natural resources of the earth considerately, meaningfully, creatively and with a sense of purpose.

Straw/Thatch Architecture

Various natives of Africa took to straw/thatch as a construction material in a comparable way choosing to great extent the appropriate materials for the most suitable use. In contrast to stone which is not easily renewed, straw/thatch is a byproduct of grown plants hence, a cultivated material. Even though, large quantities of this material could be sourced form the immediate surrounding and the wild, the villagers cultivated much of the straw as cereals in their farms which in turn provided them a building material.

Although, large numbers of stone ruins remain, indicative of a predominant stone use, straw has in most case being used with adobe bricks or masonry walls or singularly. Even today nomad tribes within this region still use this form of construction. Straw construction uses matted or baled straw from wheat, oats, barley, rye, rice and others as walls or covered by earthen or lime stucco. Straw bale are traditionally a waste product; it is the dry plant material or stalk left in the field after a plant has matured, been harvested for seed, and is no longer alive. Two fundamental styles of straw bale construction have and it's being used: wooden post and beam construction with straw bale infill, and structural straw bale construction.



Figure 4: Typical African Straw hut Source: www.members.virtualtourist.com

Adobe Architecture

Although stone architecture of historic periods have left remains for display, very little of adobe/earth/mud brick architecture have lasted, apart form some of the monuments, temples and mosques. Nevertheless, the enduring cultural practice of the rural people indicates that adobe surely has been one of the most common and abundantly obtainable materials that influenced and sustained the rural villages as a part of the environment which connected it to the cyclic and delicate eco-system responsibly and carefully, while using its resources and occupying the areas responsively created. Local earth technologies of Africa have spanned form the employment of raw-earth, to refined earth brick.

Generally employed was wattle-and-daub earth technology; a method in some cases which uses solid wooden post frame which is first made then filled with adobe balls to create a wall. Most often, the African builders construct the walls of their building layer by layer using the mud bricks and a slurry mixture of earth as the mortar (Osasona 2008, Dmochowski 1990). Once the wall dries up and binds into a monolithic structure, a dense mud plastic plaster strengthen with various additives depending on the people's culture (cow dung, goat dung, beaten straw, animal hair, animal skin fat) was spread on by hands to smoothen the facade. This method had been used in building even the granary storage houses (Dmochowski 1990, Fathy 1973). The materials having being gotten from the environment, and the work force having been made available by the community, certainly made it a highly sustainable practice, that utilised small amount of energy and did not generate any greenhouse gas or harmful waste. As soon as it is plastered and properly covered with overhanging roofs, these earth buildings were structurally firm, environmentally sound and could exist for years as long as the day to day maintenance was

adhered to. Africa's socio-cultural practices had ceremonies and events integrated in them that guaranteed their renewal and maintenance thus ensuring the continuity of those sustainable building practices.



Figure 5: Typical African Mud Houses

Source: www.world-traveler.eu

FUSION OF TRADITIONAL AFRICAN ARCHITECTURE WITH TECHNOLOGY

To gain knowledge on how traditional building materials have been re-devised in the today's architectural customs, two different scopes need to be considered. First, there are those ethnic communities that continue to employ these age-old traditional building practices together with modern techniques that have reached the rural settlement. This practice has been reinvented majorly because of its economic benefits. Secondly, there are contemporary architects and clients that individually or collectively promote and use these materials in innovative ways motivated either by ideology or by individual interest.

Societal perspective

The introduction of modern technologies such as the concrete blocks and slabs during the industrial periods had relegated traditional components and methods to the background and it became the goal of those in the *wattle-and-daub* houses to remake them with the new trend material; concrete blocks, in spite of the obvious truth that they did not present the same kind of thermal comfort. The native dwellers thus replaced their comfortable, low-cost and sustainable houses with the modern opposite which were the current fashion and expressed advancement, modernity and a show of affluence and status in the social hierarchy. Recently, amidst these unsustainable practices earth construction has received greater attention as a building material that can be very affordable and still deliver the same modern needs (Dayaratne 2011).

This solution does not seek to drastically alter the community building practices in its use of adobe/earth except for the introduction of compressed earth blocks (CEBs) and the retraining of artisans. Although with slow acceptability the material is gaining acceptance by the community. Currently, many researches are underway as to maximizing all the benefits offered by indigenous traditional architecture nevertheless, urban earth buildings are becoming a common place where recreational park structures, shops and eating houses are being built in earth.

Sustainable urban cities

The gradual return to traditional technologies within the conventional architectural practices in Africa has emerged as a result of the world call for proactive steps in managing the earth's resources. It still behooves on architects of the continent to explore all the options available to be creative. Consequently, many need to return to local materials and technologies like the late Hassan Fathy who being innovative re-invented a number of traditional technologies to cater to the modern housing requirements.

In many instances, the re-invention is not so much in the material itself, but the methods in which the material and its products are utilized for creating architectural splendor in structures. Really, these innovations are important in that collectively, they have evolved a methodology to architecture that is supported on the vernacular and traditions of the African building custom. It is necessary for African architects to stick to this approach and adopt the attitude and expertise on how to use materials and technologies of the past and re-create them for the contemporary world in a sustainable manner.

COMPRESSED EARTH BLOCKS (CEBs): THE RECREATION OF EARTH BUILDING METHODS

Lately, the ushering of CEBs has caught the interest of many architects searching for sustainable building technologies, and have committed themselves to the task of building with earth as a modern material. A few fascinating projects have come in place from urban houses to tourist hotels. Nonetheless, the technology that has become widespread in the new system of re-invented buildings is the Compressed Earth Blocks that makes unbaked earth blocks.





Figure 6: Compressed Earth Block construction project Figure 7: Roofing a CEB project Source: Whyte 2011

Source: Whyte 2011

Compressed earth blocks are a creative, re-engineering of the adobe brick promoted by the likes of Advanced Earthen Construction Technologies (AECT), Koji Tsutsui Architects and Associates and other similar bodies. Unlike the native adobe block, which is a mixture of soil, water and distinct cultural additives moulded to desired shape with the hand, the compressed earth block is supplemented in very small amounts (in most cases less than 10%) with either cement or lime component in its blending process. The blend is not worked to achieve a plastic state, but simply blended until the cement/lime and soil are thoroughly mixed. Afterwards, the mixture either machine pressed or placed in a mould and compacted with a high level of pressure applied through a handoperated machine. After aeration, the CEBs gain a high compressive strength appropriate generally for three floors constructions but higher potentials can also be attained for up to five floors constructions (Maini, 1999).

Combing it with other contemporary technologies have ensured that earth buildings do not necessarily require dome vaulting and other forms of this nature, which are associated with earth constructed buildings (Fathy, 1969). These blocks; CEBs can be left un-plastered or covered with plaster or can be coated with watered earth (muddy plastic mixture), sometimes added with natural colouring. Its facades in comparison to the contemporary urban houses offer a feeling of a cooler interior in fact, the inside temperature is lower than many cement block houses.

SAMPLES OF RE-INVENTED TRADITIONAL AFRICAN TECHNOLOGIES



Tholego Ecovillage Rustenburg, South Africa.

The Tholego ecovillage demonstrates how a holistic approach to sustainable buildings on community level can be applied. It was established in order to address the challenges of sustainable development in rural areas. The community applied sustainable designs during the construction of its dwellings which are characterised by the use of local materials and local knowledge. Some of the buildings include traditional 2000 year old Tswana designsusing earth and thatch as well as buildings constructed from large earth-filled bags with fired brick domed roofs. The houses are built from locally available and recycled materials to form foundations, walls, floors and roofs. The Tihlego ecovillage can provide an example of how other African communities can also benefit from sustainable building designs (Tessema et al, 2009).

Figure 8: Building at ecovillage

Source: Tessema et al 2009



Tebogo Home Soweto, South Africa.

Constructed for physically handicapped children, Tebogo home is also a response to sustainable architecture through re-invented traditional practice. The construction materials used incorporated mainly locally available resources and local construction methods. First, wooden frames were constructed to form the walls of the buildings. Grass mats, straw bale and earth blocks were used to fill the inside of the walls which were further reinforced with concrete. It displays a good example of how to use sustainable building methods in an urban surrounding relying mainly on inexpensive and locally available materials. It shows that thanks to local materials as well as an innovative building design no outside energy is needed to provide a pleasant indoor climate (Tessema et al, 2009).

Figure 9: Tebogo Home Source: Tessema et al 2009

House Brodie Project Town, South Africa.



Developed by Eco Design with a single storey concept the project demonstrates how natural local materials can be used in housing construction. House Brodie is a low energy consumption structure with straw bale walls and well insulated roof. The small footprint makes the house easy to heat and cool. The advantages extend to aspects like the fact that straw bales are a renewable resource that reduces environmental impact. Straw bale as a raw material increases energy efficiency, providing thermal comfort and minimising energy costs. It also has the capacity to absorb noise, increase the acoustic quality of space (Tessema et al, 2009).

Figure 10: Brodie House Source: Tessema et al 2009

CONCLUSION

These experimental housing projects using straw, stone and earth among many others substantially shows that, stone, straw bale and particularly earth can easily be employed as urban modern materials to build at least two storey residential buildings. It also demonstrates that straw bale/earth as a material produces cooler interiors. Meanwhile these dwellings were made using wall on wall support system, the structural ability of straw bales and compressed earth blocks to take the loads of an upper floor has been reestablished. Great minds like Hassan Fathy have made attempts to reintroduce earth technology, but it is important that new buildings try to avoid using vaults as these appeals most to the great public. Larger spans can be gained by applying the hybrid system of using other materials for constructing the roofs and floor slabs. Besides, while earth as a material may be utilised, the contemporary concept of space such as open planning and spatial fluidity, visible inclusion of courtyards through large openings, indoor bathrooms and so on, are basic essentials that should be included in the design because today's clients look at houses as stylish and spacious, with innovative settings.

In terms of construction, it is significant to state that the use of earth when compared with burnt bricks or the popular cement blocks; consumes less energy to make and consumes far less cement in instances where applied for both the brick and the mortar. On the other hand, this method of construction should not eliminate concrete or any other materials where necessary. The mission is in fact to harness and properly integrate various technologies, both traditional and modern. These test constructions also showed that it is easy to transfer the technology to the craftsmen and make them become creative in its use. On the other hand, it is advised that the wages for earth construction artisans be made competitive to draw them to build with earth instead of cement blocks or burnt bricks. This is important because, artisans have a great influence in determining the materials to build with and they can either encourage or deter prospective builders from admitting earth, straw bale and its various technological expressions.

It is expected that these experiments scattered in various parts of Africa, would lead to earth, straw bale and stone as materials to be accepted overall and mainly to scrap its offensive/derogative image as a material for the poor. The building methods being exercised yields savings in both the material and labour since in most cases no plastering is required. Furthermore, these projects being carried out can pass for magnificence and comfort, consequently promoting the complete change in the impression of earth as an inferior material to one of dominance. Most certainly, the design and construction of these projects have proved that it is thinkable to reorient the public opinion of earth, straw bale and stone as building materials at the same time emphasising that architecturally prestigious dwellings can be achieved using a combination of low-cost technologies. This paper has discussed the manner in which the indigenous architecture of Africa can use a number of local natural building materials in ideal technologies to construct dwellings that are basically sustainable, responsive to Nature, gentle on and to the environment and with great potentials in advancing and encouraging local skills and craftsmanship. It is expected that these projects would spark an architectural revolution that is culturally well-suited to the attitudes and aspirations of the people (Oliver, 1985). Modernization and societal advancement somehow had downgraded these practices in favouring the machine intensive, unsustainable building practices (Khalil, 1999), which are now being slowly re-evaluated.

With increasing problems of poverty, dwindling resources and unfavourable economic atmosphere architects should be encouraged to return to the local traditional materials and technologies and through creativity and innovation come up with ways of true building. Today, raising consciousness on sustainability and the increasing cost of unsustainable building practices as well as climate change in developing countries encourages the revisit of many of these as possible technologies for the today dwelling units. As traditional technologies are being reinvented, chief among them, the earth technology is becoming one of the most experimented technologies of housing construction (Dayaratne, 2011).

Amongst the major impediments in the campaign for earth, straw bale and stone buildings is in their property value as economic commodities. Even though the clients may be persuaded to build with such technologies, there is likelihood that these houses may be priced lower by estate valuers given their relative newness and complexity in marketing. There is no certainty in this because none of these re-invented houses have entered the housing markets on mass production level.

This paper reiterates the prospects of re-inventing technologies such as stone, earth and straw bale construction which are gentle and responsive to the environment, granted that they had not been fully described and analysed in sustainability terms and made evident in that manner. Straw, earth and stone as materials have had long history and regardless of its acceptance in the past (Agrawal, 1981; Damulji, 1993; Denyer, 1978; Gardy, 1973; Jain, 1992) efforts to promote (Fathy, 1969; Graeme, 2002; Houbent, and Guillaud, 1985) it still continues to be unfamiliar as a appropriate modern material, nevertheless sustainability has given it a renewed momentum and stimulus. As a result of this new drive and re-conceptions, it is reasonable to assume that the future of the straw and earth industry will create more advanced ways of building (Norton, 1986; Khalil, 1999) that will be sustainable and lighter in demands on the earth's resources and on the environment.

Architecture has somewhat over time neglected the principle of sustainability in residential building; there is therefore the need to return to the archetype of seeing buildings as organisms where several purposeful activity takes place in which exist a synergy between man made and the natural environment. This synergy and dynamics between the two systems makes available favourable conditions for new idea/method to provide answers to environmental challenges. Today's building practise should embrace the holistic approach to deal with natural assets shortages and the abuse of the planet's resource ability.

The built environment should be considered as an arm of natural systems, not just artificial elements that provide spaces for human activities, but as habitats and houses where human living takes place. Sustainability is a vague term that mixes economic, social and environmental aspects and needs to be clarified when used for a specific context. Like the ancient dwellings of Egypt, the ancient Zaria mosque and Emir's palace that have disappeared as a result of biological degradation, materials produced for housing should mimic this quality such that after a buildings useful life its components can reintegrated into the natural environment without constituting itself as a toxic waste to the environment

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