Ecological Traditional Architecture Research in Burundi

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Abstract. An in-depth study based on materials and construction techniques used in traditional architecture can make a contribution to the sustainability of modern architecture. In this paper we illustrate the traditional architecture of Burundi. This traditional architecture is known as the Rugo which means a housing complex. This traditional architecture of Burundi is recognized because it is built entirely of plant material and also recognized for its dome shape. In this paper we illustrates 2 case studies about the preservation of this historical legacy of the Rugo, the different stages of its construction and the building materials used. This paper aims to encourage the fusion of ancient and modern building materials and techniques for a better future with modern green buildings and a sustainable architecture.

1. Introduction

In general Buildings are responsible for more than 40 % of global energy consumption and more than 30 % of global greenhouse gas emission [1] this shows that a radical change is essential for sustainable and permanent solutions in this sector.

The United Nation's Inter-governmental Panel on Climate Change states that the Global Warming was caused by greenhouse gases due to human activities. The composition of greenhouse gases is 76% carbon dioxide CO2, 13% methane, 6% nitrogen oxide and 5% fluorocarbons [2].

The world population is growing at a rate of 6.06% according to the UN in its 2015 report. This gives an equivalent of 400,000 million people every 5 years. And the more the population increases, the more housing must be increased. For this, we must always find new innovative ways to meet these needs though we risk having an unbearable world in the future. A world where air pollution would make it almost impossible to breathe in the open air, a world where groundwater would be contaminated with thousands of tons of industrial waste, a world where natural food would be an old memory etc. To avoid this, everyone should commit to make a small contribution for a better world and a healthy environment.

In this article, we discuss the traditional architecture of Burundi so that we can learn the techniques and building materials used in ancient times, especially straw and bamboo to know their applicability to modern times. It concerns 2 case studies of some legacies of the traditional architecture in Burundi.

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2. Case study: the royal enclosure of Gishora

The royal residence of Gishora is located in the town of Giheta 7 km in the province of Gitega in the center of the country. The royal residence of Gishora was established by King Ntare Rugamba in the 19th century after his victory over rebel leader.

The royal enclosure of Gishora consisted of 4 main huts. The first main hut was the king's hut "ingoro", and this hut is in the center of the enclosure. The king's enclosure has a private courtyard reserved only for the king. The second hut was the hut that housed the king's drums, and this hut is near the main entrance of the enclosure. The third hut was the hut of the cooks of the king, this hut is in the back yard of the royal enclosure. And not far from the third hut is the fourth hut and this hut housed the king's witch (shaman) in charge of the ritual cults (Figure 1-2).

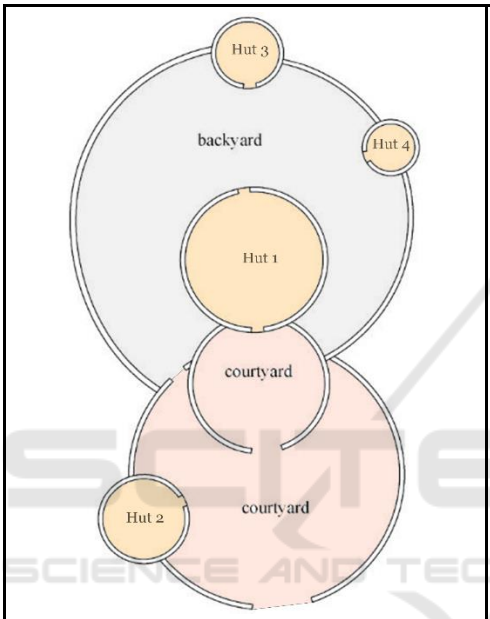

Figure 1. Plan of the royal enclosure.

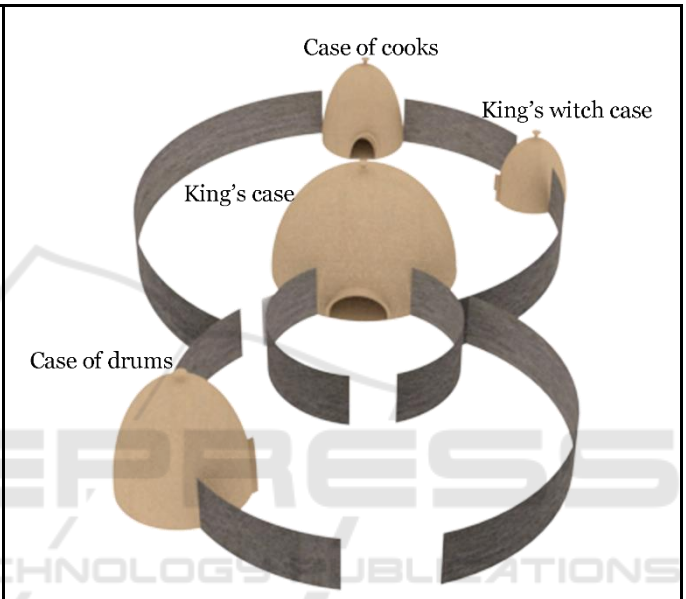

Figure 2. 3d Perspective of the royal enclosure.

This royal enclosure is approximately 45 m long and 24 m wide. And the main courtyard is about 20 m in diameter and these small dimensions of the main courtyard can be explained by the fact that the king's flocks were not gathered in these places. That place was serving as gathering place for meetings. The royal hut, which is the main hut, has an outside diameter of 10 m and 4 m in height. The thatch covering this hut is about 90 cm thick and offers excellent thermal insulation. The thatch was dressed with a sort of dry papyrus mat braided by cords. Unfortunately today this mat that covered the roof is no longer visible because it was damaged and was not been replaced.

Figure 3. Entrance view.

Figure 4. Hut view.

Figure 5. Interior view 1.

The construction of the fence surrounding the dwelling was done through bamboo, branches, stakes and other stems. Tracing of the circumference of the enclosure was done by a rope and piles were planted at a distance of about 2 m between. The fence has an entrance about 1m in diameter and the frame of this entrance is made by bundles of bamboo connected to each other by a thin string. These connected bundles are about 50 cm in diameter each. The interior of the royal hut has a volume of about 60 m³ and this volume is suitable for the occupants because it is not too big which would cause a big drop of the temperature inside during cold period and it is It is not too small which would lead to a feeling of engulfment followed by a lack of air. The interior of the royal hut has been scrupulously executed in every detail with an impressive decorative aspect. Inside the vault has been added a spiral pudding of papyrus reed from the top to the bottom

This spiral pudding was up to 200 m, it was made outside the hut and after that was fixed at the bottom of the ceiling of the vault. This pudding was called “umutente”. The dome is supported by 13 pillars anchored in hooves for a good support. The floor is covered with papyrus mat and the walls are most often made in exploded bamboo (Figure 3-5)..

3. Case study: the hut of the Living Museum of Bujumbura

The Living Museum of Bujumbura is located in the capital Bujumbura and is one of the country's public museums. It is dedicated to the wildlife and art of Burundi

The museum was founded in 1977 and occupies a 3 hectares park on the rue du 13 Octobre in downtown Bujumbura.

The traditional house of Burundi from the point of view of the external aspect is characterized by three main points. The first external aspect is the rounded shape of its architecture. The second external aspect is that the traditional house of Burundi was entirely built by vegetable materials from where also its thatch roof. The third aspect is the small entrance height of about 1 m high and 0.8 m wide to protect against the bad weather (Figure 6-7).

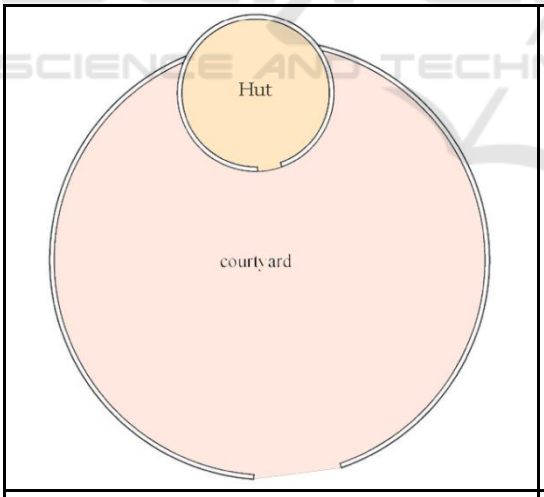

Figure 6. Plan of the enclosure.

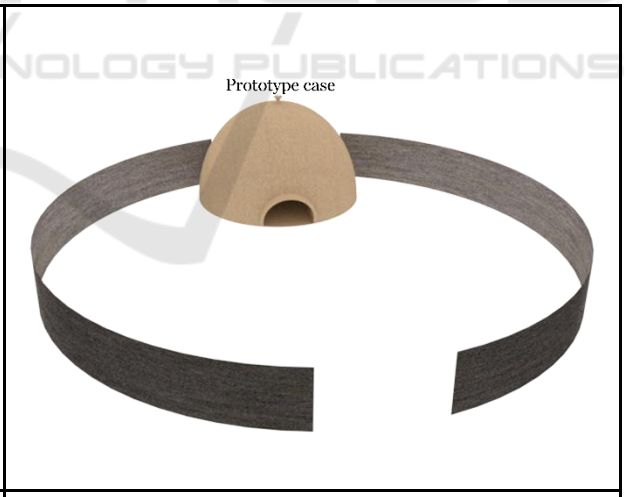

Figure 7. 3d Perspective of the enclosure.

The dome form of the traditional Burundi house has the main function to allow a good flow of rainwater. Moisture is the first menace of the straw covering the dome, it is. To overcome then this problem the builders resulted in an inclined shape. But despite all this a follow-up and replacement of the damaged straw was always necessary due to 2 times a year. The interior of the traditional house consists of a reception room and a living room separated by a light partition made of bamboo, reed or papyrus braided. These partitions do not exceed 1.5 to 2 m high. Just after entering the hut we arrived

at the reception room, it is only after having bypassed the partition that we arrived in the living room. It is in the living room where the heart of the fire was. It was in this living room that food was prepared and the mother was surrounded by her children. The parents' master bedroom “mu buriri” was also separated from the living room by partitions (Figure 8-10).

Figure 8. Entrance view.

Figure 9. Hut view.

Figure 10. Interior view 1.

And the children's bed was not far from the hearth of fire. Inside the living room were shelves made of bamboo or papyrus. The height of these shelves could vary from 50 cm to 1.80m in height. On the shelves of small heights were put, milk pots, baskets, baskets and other basketry. And the high-rise shelves were used to dry grain or firewood but also used to store fragile objects far from the reach of children. The interior walls are braided in exploded bamboo, a technique of know-how passed down from generation to generation

4. Characteristics of the traditional house

4.1. The stages of construction

The ***first operation*** before any construction was first to choose a favorable site for the location of the house. In general Burundians preferred lands that are at mid slope hills. They regarded the tops of the hills as stony and windy, and the bottoms of the valleys were regarded as the domain of ghosts, wild beasts, and cold mists. From where their preference of choice turned to lands situated at half slope. The other advantage of this mid-slope terrain was that in case of rain the cow-manure would flow to the valleys where the cultivated fields were generally located. For the orientation of the entry of the rugo, they took into account the prevailing winds mainly of East and the neighborhood situation. (Figure 11)

After the choice of the site, the ***second operation*** that followed was the collection of all the building materials needed for the rugo. This collection is commonly called "guhumbira". This collection could extend throughout the rainy season because the Burundians felt that it was always favorable to build in the dry season. The collection of building materials was most often done in forests.

During the dry season which is a period of low agricultural activity, the ***third operation*** that followed was the actual construction. The person who was engaged in the construction appealed to the family, friends and neighbors, and with this call he could gather about twenty to thirty person. This call to builders is commonly called "kurarika abubatsi". Being in dry season these people could build in continuity without interruption of rain and to have food from recent harvests.

Figure 11. Favorite site.

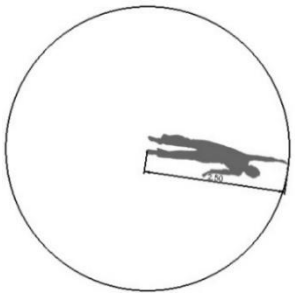

Figure 12. Hut's dimension settings.

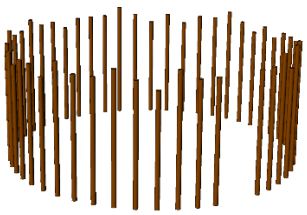

Figure 13. Planting piles.

The ***fourth operation*** was to level the location of the rugo with a pick and it also consisted of tracing the circumference of the hut. For the tracing of the circumference they were choosing a tall man who was laying on his stomach on the ground and arm raised, this man lying was considered as a unit of measurement called "intambwe". For example, for the habitation of a young household, the man was lying down and holding in his hand the handle of a billhook, which gave a radius of about 2.50 m. For dwelling for a large family or for a rich man, the man who was lying down, for example, held in his hand the handle of a hoe, which gave a radius of about 3 m. And for the richer chiefs the radius could reach 5 m. These measurements gave a living area of about 20 to 28 m² and a volume of 50 to 60 m³ of the hut. The hut had an average height of 3 m. (Figure 12)

The ***fifth operation*** was to plant piles all along the circumference. To do this they dig holes of 50 to 60 cm deep separated between them at a distance of 30 to 40 cm between. This gives a number of 45 to 60 piles and these piles had a height of about 2 m. (Figure 13)

Figure 14. Setting up poles.

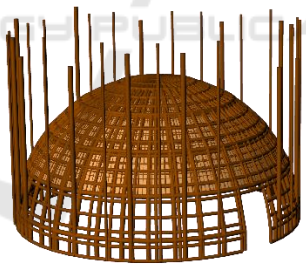

Figure 15. Ceiling braiding and bending poles.

The ***sixth operation*** consisted first of all in planting vertical poles between the piles 120 to 200 poles of about 4m high were planted to support the roof. An entrance of about 80 cm was left free. After the piles and poles were linked by doubled horizontal torus. These torus encircled the entire construction and consisted of a reed core wrapped in finely woven papyrus. (Figure 14)

The ***seventh operation*** consisted in making the roof part and bending poles, and these operations was done simultaneously with the exterior construction of the hut. Two different teams took care of these operations. This inner part of the roof is called "igisenge" and it was made using papyrus or palm reed. In Upper Basketry from the center of igisenge was added a spiraled coil, finely adjusted with papyrus ties, and this part was the most original part of the hut. This spiraled pudding inside the hut is called umutente and for the richest this pudding could go from the top to the main torus. This

spiral coil was made on the ground, then fixed to the bottom of igisenge and this coil could have a length of about 200 m. (Figure 15)

Figure 16. Installation of supporting pillars.

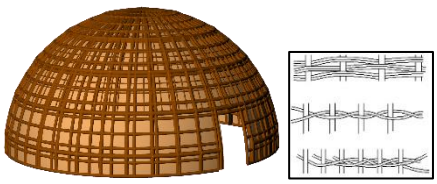

Figure 17. Walls braiding.

Figure 18. Thatch covering.

The ***eighth operation*** was to raise the igisenge dome gradually by longer and longer poles. This operation was done simultaneously with the seventh operation. And the igisenge was finally erected at a desired height with the help of 8 to 13 pillars ending with hooves of pegs finely decorated by pyrography. And just after that is when we folded the outer poles on the dome to bind them together at a height of about 3 m, determining the curved and rounded frame of the hut. This pole folding operation is commonly called "guheta". (Figure 16)

The ***ninth operation*** involved the finalization of the weaving of the broken bamboo exterior and interior walls and this operation could take place simultaneously during the assembly and installation of the dome. (Figure 17)

The ***tenth operation*** was to cover the entire hut with thatch, build the door frame and the decorative lintels of the door and finally to plant the woven topknot with papyrus fixed by a wooden keel to the top of the hut. To cover the hut with the stubble they unrolled 5 or 6 strips of javelins to form a bound bed and they finally covered everything by the stubble from the top without binding while looking for a good dressing effect [3] (Figure 18)

4.2. Floor organization and section

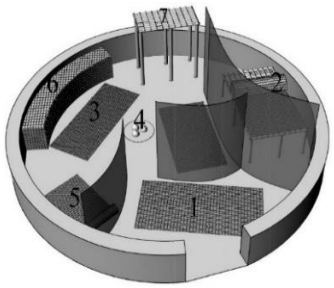

Figure 19. Floor organization.

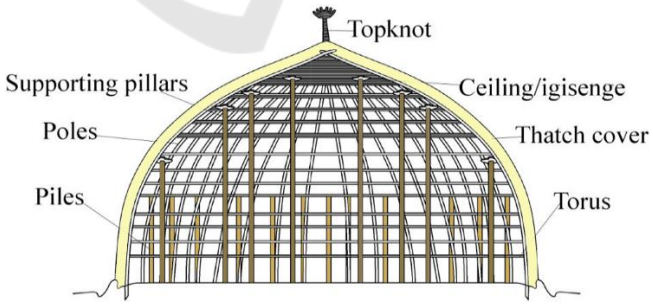

Figure 20. Section Detail.

1.Welcome lounge (mu muryango) 2. Conjugal beds (uburiri) 3. Lounge (haruguru) 4. Fireplace 5. Children's beds 6. Shelf (uruhimbi) 7.Drying rack (urusenge) (Figure 19).

The structure of Burundi's traditional hut consisted of 4 essential parts. First there were the piles that were driven into the ground at a depth of 50 to 60 cm and there were 45 to 60 piles with a height of about 2 m. The second component of the structure was the poles; 120 to 200 poles of about 4 m and

these poles were then bent which gave the rounded to the hut. The third component of the structure is the torus wrapped in papyrus, this one was a spiraled coil that surrounded the whole house to consolidate it. The fourth component part of the structure is the supporting pillars, they supported the hut from the inside and leaned on hooves. These supporting pillars were 8 to 13 depending on the size of the hut. And finally the whole structure of the hut was covered by thatch while looking for a beautiful aesthetic effect (Figure 20) [3].

5. Construction materials

Burundi's traditional hut was entirely constructed of plant materials. The materials found mainly were straw (roof, floor,), bamboo (structure, walls), palm (mat, spiral ceiling), papyrus (ropes, braided blankets), reed (torus, walls), thorny (piles of the palisade), erythrin (piles of entry) and many others.

In our case, we will focus more on 2 building materials, straw and bamboo because of their many qualities and varied applicability nowadays.

In 1994 task group 16 of the Conseil International du Bâtiment (CIB) defined 7 principles for sustainable construction: Reduce/resource consumption _Reuse/reuse resource_ Recycle/recyclable resource_ Nature/protect nature_ Toxic/eliminate toxics_ Economics/apply cycle costing_ Quality [4].

5.1. Straw

Straw which is a well-known material in the traditional architecture of Burundi. Nowadays this material resurfaces because of its various qualities.

Advantages:

straw is in abundant resource, can be cultivated or it can be just the residue of the cereal plants, is light which reduces the loads on the foundations, is a good thermal insulator, when the straw of a building is damaged by moisture, it can be reused as fertilizer for crops, Straw is often a local building material for this it does not need to be transported long distances which would cause CO2 emissions, can be used in the raw state, it does not need special treatment and is environmentally friendly and does not release toxin [5].

Limitations:

The big enemy of straw is the water that's why when using the straw to cover the roof we must ensure a good slope to the frame for a good flow of rainwater. It is also necessary to change the part of the straw damaged on the frame, since straw is an agricultural product, its compatibility with other building materials for good finishing is restricted and if straw is not well fixed it can catch fire.

PS Although most people are worried that straw could catch fire easily several studies show that this is not the case, indeed the fire needs oxygen to spread and when the straw is stacked well it can hardly catch fire [6].

5.2. Bamboo

Advantages:

Bamboo is flexible and easy to handle, is quite resistant and used as structural elements, is not pollutant and does not release toxin, does not break easily when curved which gives it a great resistance against the earthquake; can be used for permanent or temporary constructions, is easily renewable because it grows quickly.

Limitations:

After being cut, the bamboo can be easily attacked by insects so that it must be well dried or treated, bamboo does not have the same diameter throughout its length but also when it dries its diameter decreases and it can interfere during construction, when the bamboo is dry it can catch fire but it can still be treated by fire-resistant substance [7].

6. Conclusions

The habitat of the traditional architecture of Burundi (rugo) is a product of its environment and the daily needs of the Burundians at that time. In this traditional architecture we can draw 3 great lessons for the modern world and sustainable architecture.

Dimensions: For the construction of traditional housing, the only guide line used for the dimensions of the hut was the human body and its working tools. The hut was neither large nor small, which provided a comfortable interior space and a well-regulated internal temperature. In modern architecture, internal spaces are sometimes disproportionately created for human bodies and their needs, which causes several energy losses.

Joints: From planting piles to the roof covering of the hut, the techniques that were only used for the connections were braiding, stringing and cordage, and this involved only natural processes. In modern architecture, chemical binders are often used and this is not good for the environment and human health.

Construction materials: The traditional rugo hut was entirely constructed of plant material. And these materials were local materials taken in the vicinity. In the construction of this hut we meet in abundance the straw and the bamboo which are natural products not releasing toxins. And these materials in most cases could be reused as crop manure at the time they were damaged. Modern architecture today uses mostly materials that cannot be recycled and sometimes toxic.

After all this, we see that modern architecture has great lessons to draw from vernacular architectures from where in-depth studies in this area should be encouraged for a better future and eco-friendly constructions.

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