

3) ECONOMY_3.5 Architecture, Engineering and Construction

A Self-Sustainable Boutique Lodge in Mount Meru, Tanzania

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Abstract

A unique, self-sustainable boutique lodge has been developed in Tanzania, integrated in the sloped landscape of the foothills of Mount Meru, which fulfills demands of the tourism industry while respects and enhances the natural landscape, exploring three strategies towards sustainability: Matter, Energy and Water. The goal of the project is to set up a milestone in the current practices regarding the built environment, which directly or indirectly endangers the rainforest in Tanzania, a country among those with highest deforestation rates. Building with renewable and locally available materials, producing and consuming food within the project realm, using the sun as source of power, collecting storm water and using purification devices to recycle water are the concrete measures taken in the project with feasibility of implementation for local communities. Bamboo and Interlocking Stabilized Soil Blocks (ISSB) mean transferred alternative technologies to the local community involved in the project. Using these materials instead of timber and burnt clay bricks reduces the pressure on rainforest as a first step in the walk to invert the current trend and let the rainforest expand instead of vanish. Storm water is channelled from every roof to collecting tanks in order to guarantee water supply. Once used in consumption points, it goes to an Anaerobic Baffled Reactor to settle solids and then led to a Constructed Wetland planted with local species which purifies the water before being recycled. All the power consumed by the users is solar energy generated by photovoltaic panels allocated within the intervention. Water heaters are solar too. There is a kitchen garden and an orchard to provide fresh, locally produced food for the users.

Resumen

Un hotel-boutique único y sostenible ha sido desarrollado en Tanzania, integrado en las inclinadas lomas de la falda del Monte Meru. Un hotel-boutique que cumple con las demandas de la industria del turismo al mismo tiempo que respeta y ensalza el paisaje natural, explorando 3 estrategias hacia la sostenibilidad: Materia, Energía y Agua. El objetivo del proyecto es ser un punto de inflexión en las prácticas habituales en relación al medio construido, el cual directa o indirectamente pone en peligro el bosque tropical de Tanzania, país que se encuentra entre los de mayor tasa de deforestación del mundo. Construir con materiales renovables y disponibles en el entorno cercano, producir y consumir alimentos dentro de los límites físicos del proyecto, emplear el sol como fuente de energía, almacenar el agua de lluvia y usar dispositivos de depuración para reciclar el agua son las medidas concretas adoptadas en el proyecto con la posibilidad de ser replicadas por las comunidades locales. Bambú y bloques de tierra (BTCs) compactada son ejemplo de transferencia tecnológica hacia la comunidad local implicada en el proyecto. Usando estos materiales en lugar de madera y ladrillos de barro cocido, se reduce la presión sobre los bosques locales. El agua de lluvia es canalizada desde las cubiertas hasta depósitos para ser usada posteriormente. Una vez usada, gracias a un reactor anaeróbico y a un humedal construido, es posible purificar el agua lo suficiente para ser reciclada. Toda la energía consumida por los usuarios es generada por paneles fotovoltaicos y los calentadores de agua son también solares. Se cuenta con un huerto y árboles frutales para suministrar alimentos locales y frescos a los usuarios.

1. Timeline

1.1. Assignment

Back in 2012, during the 9th World Bamboo Congress in Belgium, the architect Jaime Espinosa, now referred as the architect, met Ms Hjordis Fammestad, now referred as the client, who at that time wanted to build a second home for her in Tanzania. Right before the start of the discussions on how to design and develop the project, Jaime was awarded with a scholarship by Fundación Caja Madrid in Spain to read his second master's programme in Sustainable Urban Design at Lund University, Sweden. This master's programme lasted 2 years and in the meantime the architect and his client held several meetings to shape the brief of the project. During those meetings, the request of the project evolved from a private second home to a boutique lodge open to public (Figure 1).



Figure 1: Visualization of the outdoor space of the proposal showing how the public buildings of the proposed lodge (bungalows and common area) are located following the natural slope of the terrain and then not blocking the views from one another. Due to the hexagonal plan of the bungalows and the setback of 2 of their sides creating a roofed niche preceding the indoor space, two visual axis are generated in front of each one of them, one facing the long distance view of the Masai Steppe, the other facing the forest reserve.

1.2. Phase I

In October 2014, after a few days in Spain, having presented his master's thesis in Sweden right before, the architect and the client head to Tanzania together for the first time. The idea was to spend 2 months, gathering information of the site, the building materials available and potential agents to get involved in the making of the project (Stulz et al. 1993). However, after 2 weeks, the first house on the plot was started, which would work as base camp while the rest of the project is completed and as the manager's house once the lodge became operative (Figure 2).

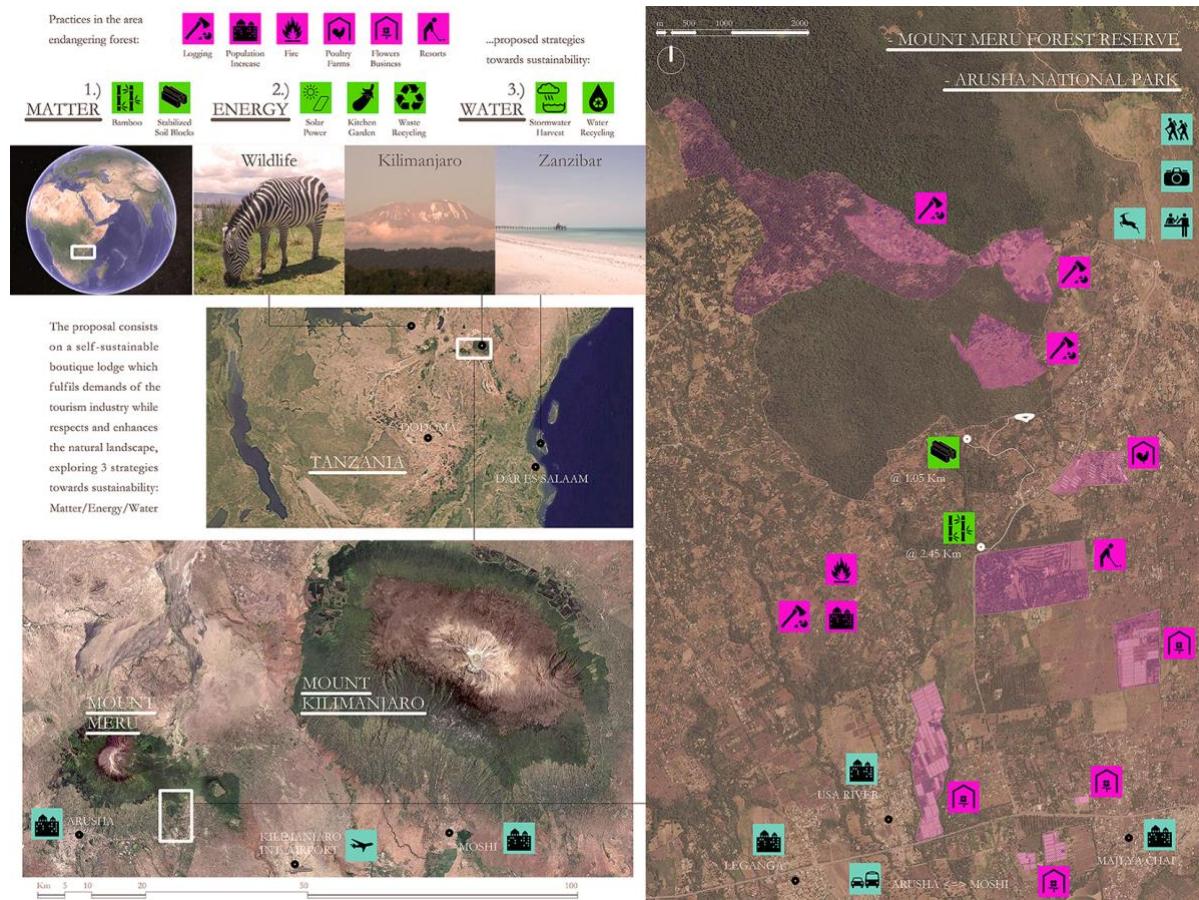


Figure 2: Context of the project showing location, nearby threats, and the main tourist attractions the country offers.

1.2.1. Setting up Base Camp

At the same time the architect was designing the so called Manager's House, he was scouting for bamboo to be sourced for building the lodge, given that bamboo is a building material that up to date is out of the Tanzanian building market. Fortunately, the biggest clamp of a species suitable for construction (*Arundinaria alpina*) found was located just a couple of kilometres away from the actual building site. A harvest schedule was set up and half of the bamboo stems needed. Cut stems remained for 2 months in upright position sitting on the bottom part of the stem, away from direct contact with the ground, the so called 'curing stage' of the preservation process. This curing stage gave the architect and the client time to finish the first house, which was already highly challenging.

The plot is bordering the Mount Meru Forest Reserve, with no public power grid, water supply or sewage collection. Thus, the Manager's House had to be on its own self-sustainable: a 25,000-liter ferro-cement tank was built behind the house to collect storm water (UNHCR 2009), a septic tank and a filtration pit were built next to the house to manage sewage, and solar panels were installed to provide power and hot water. The ferro-cement tank would not only collect storm water from the roof of the manager's house but it would also work as pressure tank once the lodge would be finished. Together with the house and associated systems, an open tank was built in order to treat all the bamboo to be used in the construction of the project (Figure 3).



Figure 3: Plan and elevation of the project incorporated into the landscape.

1.2.2. Treat of the 1st Batch of Bamboo

Bamboo had gone through its curing stage was it was delivered in the plot (Minke 2012). Then an assembly line was set up to properly treat bamboo stems as follows (Pauli 2010):

- They were sorted out by diameter and curvature;
- They were cleaned up from small branches;
- They were washed in order to remove lichens and mosses from their surface;
- They were drilled through all along to open up every cell between knots so any water inside would be release and there would be room for the preservative solution to penetrate and therefore permeate not only from the outside, but also from the inner part of bamboo stems;
- They stayed submerged in borax and boric acid solution for a week;
- They were dried by the sun and then stored, away from direct contact with the ground, protected against sun and rain, and allowing ventilation between the stems.

1.2.3. Build up Storehouse

With the bamboo sourced, so already cured for months, which didn't fit in the treatment tank, a temporary storehouse was built to keep the bamboo stems in perfect conditions while waiting to be used in the building of the lodge.

The architect himself together with an assistant who was a local person, totally inexperienced in working with bamboo, built up within a week a 30 sqm storehouse consisting of 6 parallel trusses which were prefabricated on site. Up to date, the storehouse is still up, working as a carport.

1.3. Phase II

While some legal issues regarding the land status were resolved and the building permit was updated, the draft of the Basic Project Design was done (Le Corbusier 1923). By then, the lodge to be would consist of 5 self-contained bungalows, a common area which included reception, kitchen and dining room, a water tanks system to harvest storm water from the roofs and the manager's house.

1.3.1. Draft of Basic Design Project

Bungalows were designed as a system of 6 trusses each, rising from the ground level as columns describing a hexagon. The 6 trusses would merge in the centre composing a reciprocal structure which would define at the central point a six-point star (Dunkelberg 1985). The walls would be built up using pressed soil blocks (Andabati 2010).

The common area origin is the same structural core, extending every side of it in order to shape a dodecagon. As well as in the bungalows, the main roof structure would be made out of bamboo and the walls would be built in pressed soil blocks (Figure 4).



Figure 4: Inside the common area, where the dome defined by the bamboo trusses is appreciated as a whole.

The water network is based on 2 features: harvesting the storm water from the roofs and recycling used water using an anaerobic baffled reactor together with a constructed wetland or reed bed (UN-HABITAT, 2008). Storm water collection would take place in 3 water tanks built at the bottom of the plot, from where water would be pumped up to the first tank built behind the manager's house, working as a pressure to serve the whole lodge. Water from sinks and showers would go through a grease trap whereas water from toilets would go through a 6-chamber anaerobic baffled reactor as a primary treatment (Sasse 1998). Then outflow from both the grease trap and the anaerobic baffled reactor would go to a constructed wetland and then stored in another underground water tank in order to be used later on. Solar panels would power the whole lodge and solar water heaters would provide hot water, achieving this way the self-sustainability, not only desired but needed (Venturi 1996).

1.3.2. Prefabrication of the Trusses

A highly skilled local carpenter with no previous experience in working with bamboo was trained by the architect in building techniques learnt previously in Colombia using the species *Guadua angustifolia* adapting them to the species *Arundinaria alpina*. This training consisted of building together the bamboo structure for the first bungalow, and to make enough trusses to build up two more bungalows. These basic building techniques started with the most common cuts, including the 'fish-mouth cut', and joinery to take place in the assembly of the trusses themselves and on the arrange of six of them together to conform a whole structure (Stamm 2001).

1.3.3. Built up Bungalow Prototype

Using the first six trusses prefabricated on the ground over a jigsaw, the first bungalow structure was lift up and assembled in a reciprocal structure manner. Once the roof structure was up and self supportive, the ground slab was made in reinforced concrete, and the walls were set on top of it. This bungalow prototype would work as reference model to build up the rest of the structures (Figure 5).

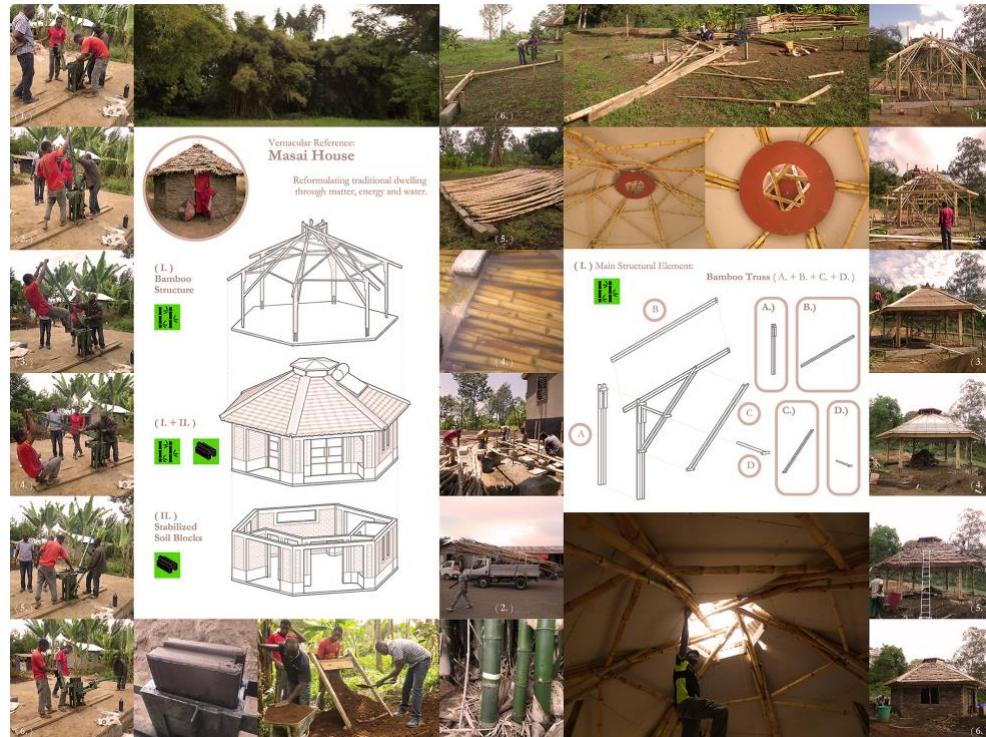


Figure 5: Detailed explanation of construction phases of the bungalows focusing on the two main materials: Bamboo and Interlocking Stabilized Soil Blocks (ISSB). Bamboo is treated and prefabricated into trusses on site.

1.3.4. Treat of the 2nd Batch of Bamboo

A second batch of bamboo, sourced from the same place as the first one, was harvested and cured for months before replicating the industry line of processing done for the first batch. Therefore, enough bamboo was already available to complete the project.

1.4. Phase III: Draft of Construction Documents

During 2016, while waiting for his work permit to be issued, the architect completed the construction documents of the assignment, which had been extended, including then an additional house, called 'the Director's Studio', a swimming pool and a laundry room which includes kitchen and bathroom for the staff.

Up to 200 plans in din A3 paper format, which scale ranged from 1/400 to 1/5, and 50-pages written report with the description and calculations of the project, its bill of quantities, estimates and timeline, were delivered to the client on December 2016. At the time this documentation was delivered, the work permit had not been issued yet (Figure 6).



Figure 6: Sections of the proposal to note adaptation to the slope and intimate relation with the rainforest.

1.5. Phase IV: Resume Building Works

Due to the delays in having the architect's work permit issued, the client contacted a local contractor in order to resume building works. After a year-and-a-half interruption, the construction of the lodge continued. During 6 months the local contractor was in charge of building works. Over this time, the client became worried about the delay in the delivery of the project so the architect was requested to come back with his work permit, which had finally been issued, in order to supervise the completion of the project and collaborate with the contractor on this regard. After a period of collaboration with the contractor, the client decided to cancel the contract with the contractor due to contract violations, and the architect took over the management of the building works.

1.6. Figures of the Building Project

Site area in m²: 5,620 m²

Gross Floor Area (GFA) in m²: 938 m²

Gross Volume (GV) in m³: 3,752 m²

Footprint area in m²: 938 m²

Floor Area Ratio: 0.17m²/m² (Figure 7).

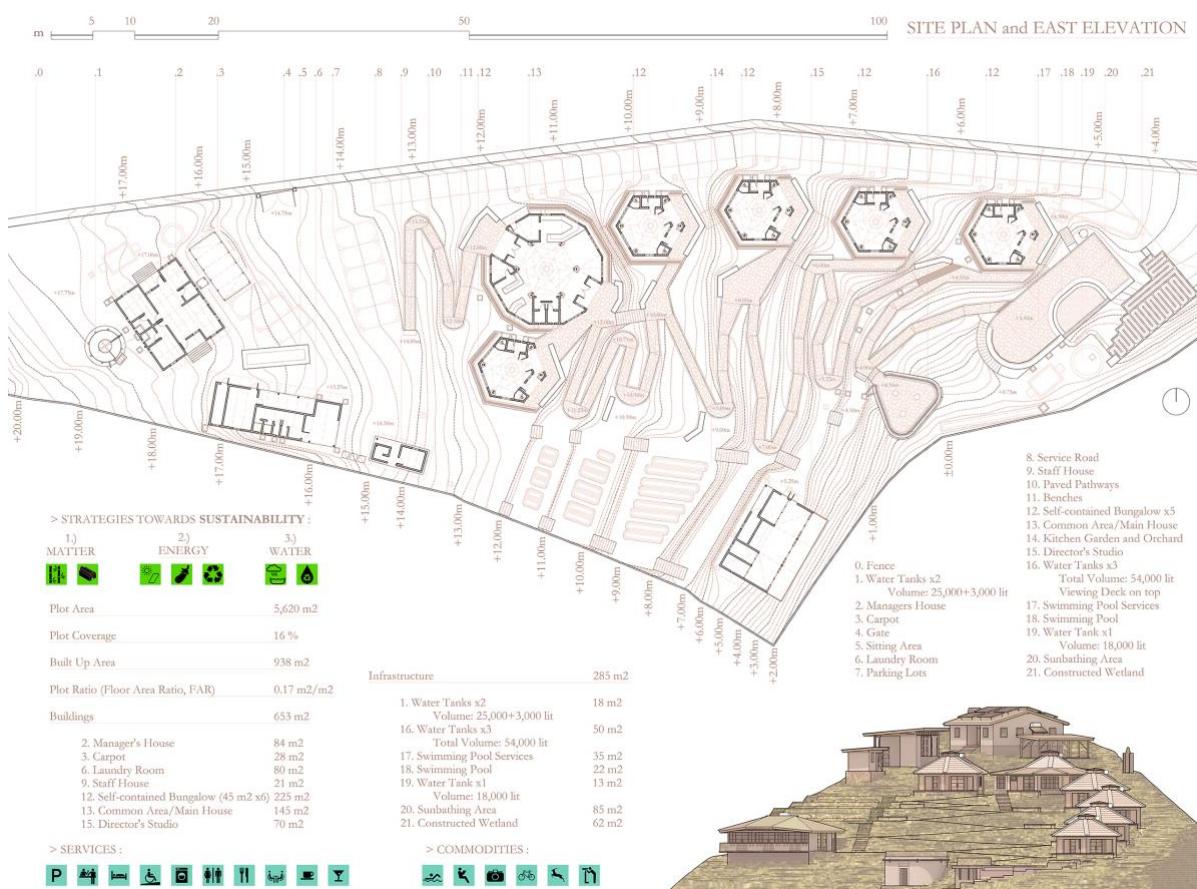


Figure 7: Plan showing distribution of functions plus services provided, and East elevation of the compound.

2. Project Principles

2.1. Overall Description

A self-sustainable boutique lodge which meets the needs of the tourism industry while respects and enhances the natural landscape, exploring 3 strategies towards sustainability: Matter, Energy and Water. The goal of the project is to set up a benchmark in the current practices regarding the built environment, which directly or indirectly endangers the rainforest in Tanzania, a country among those with highest deforestation rates. Building with renewable and locally available materials, producing and consuming food within the project realm, using the sun as source of power, collecting storm water and using purification devices to recycle water are the concrete measures taken in the project with feasibility of implementation for local communities (Figure 8).

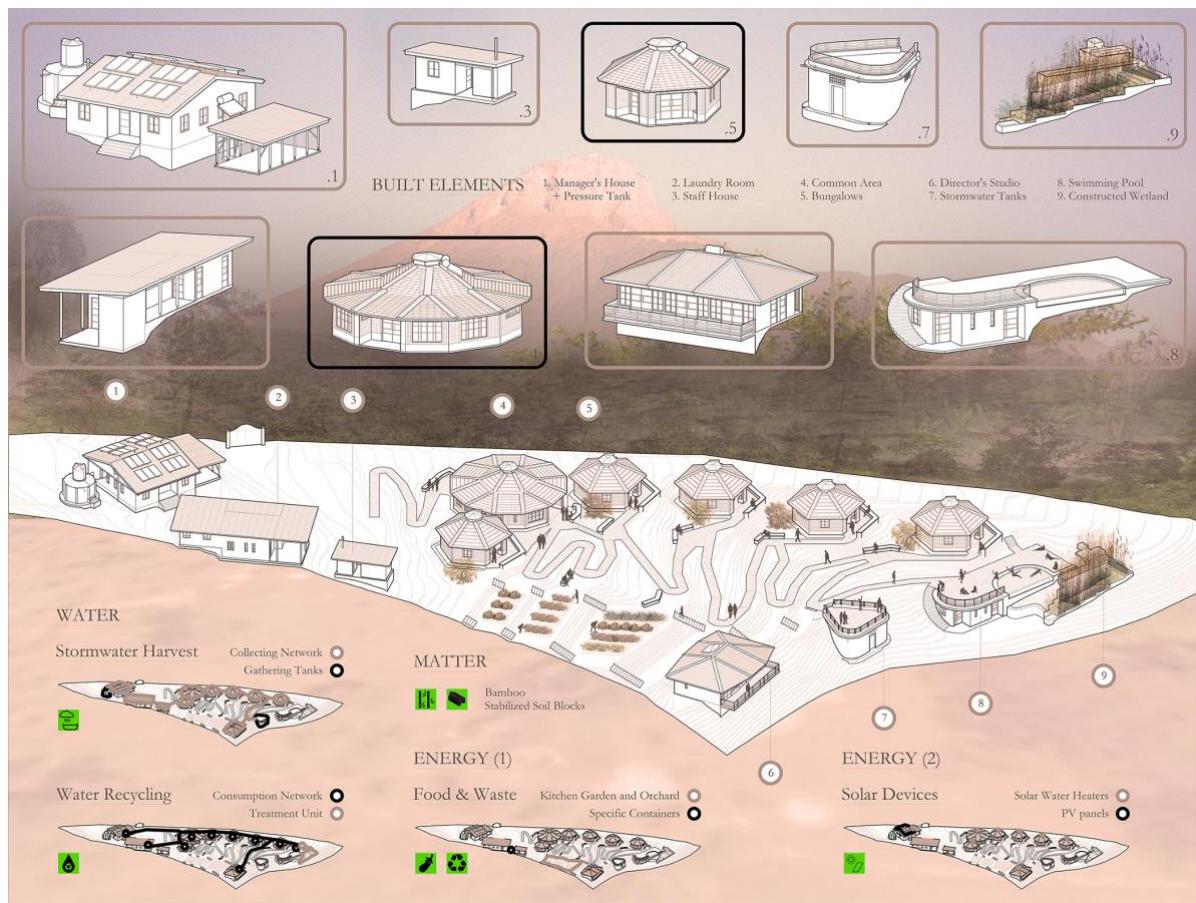


Figure 8: Summary of applied strategies towards sustainability and catalogue of buildings within the proposal.

2.2. Project Proposal

The whole project proposal is structured around three principles which are explained below. These principles are matter, water and energy.

2.2.1. Matter: Bamboo and Interlocking Stabilized Soil Blocks (ISSB) as building materials

Timber and clay bricks are the most common materials in Tanzania, representing a great pressure on rainforest due to logging, either to use the wood straight or to use it as fuel to burn clay bricks. Bamboo, being a grass and therefore highly renewable, is proposed as main structural material for roofing (Hidalgo-López 2003). Interlocking Stabilized Soil Blocks (UN-HABITAT 2009) using a compression machine minimizes the use of cement since the shape of the blocks allows interlocking both horizontally and vertically (McDonough et al. 2002). Bamboo and ISSB mean transferred alternative technologies to the local community involved in the project. Using bamboo and ISSB instead of timber and burnt clay bricks reduces the pressure on the rainforest and it is a first step towards conservation of natural resources.

2.2.2. Water: Storm water harvest network plus in-situ water purification and recycle

Storm water is channelled from every roof to collecting tanks in order to guarantee water supply. Once used at consumption points, it goes to an Anaerobic Baffled Reactor to settle solids and then led to a Constructed Wetland planted with local species which purifies the water before being recycled. The subsurface flow of the Constructed will make the water odourless and free from mosquitoes. These 3 water-related devices (Storm water collecting tanks, Anaerobic Baffled Reactor and Constructed Wetland) might be replicated at different scales in rural and urban communities because of its relatively inexpensive construction and operating costs. Current water networks for supply and for sewage are not reliable or sufficient to meet increasing population demand.

2.2.3. Energy: Solar power, food production and solid wastes classification

All the power consumed by the lodge is solar energy generated by photovoltaic panels allocated within the intervention. Water heaters are solar too. There is a kitchen garden and an orchard to provide fresh, locally produced food for the guests. Organic waste from garden and kitchens is composted and used as fertilizer. Other solid wastes generated at the lodge are separated into specific containers for paper, plastic, metal and glass in order to be collected regularly and to be recycled in larger facilities in the neighbouring town of Arusha. Therefore, no pollutants are emitted to the atmosphere while generating power or heating up water; no processing or transportation is required to get food to the site; and no solid waste is diminished as garbage (Figure 9).



Figure 9: Visualization of the outdoor space, looking top-down with Mount Kilimanjaro outstanding over the neighbouring rainforest.

Acknowledgements

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I would also like to acknowledge all the men and women involved in the project, because without their hard work this project would remain only as paper work.

Last but not least I would like to thank the World Bamboo Organization for providing the network and dissemination platforms which made this possible.

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