ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24AUG143

Toward an Affordable Sustainable Housing Model in Yaoundé Rooted in Traditional and Colonial Architectural Heritages

[1]NDE KEULEK Sidoine Baudrel; [2]ABA NKASSE Alain; [3]MEMPOUO Blaise
[1,2,3]Department of Architecture, Ecole Nationale Supérieure des Travaux Publics Yaoundé, Cameroon

Abstract:- The objective of this article is to integrate vernacular construction techniques to address current housing needs in the Cameroonian capital. It highlights traditional and colonial knowledge in vernacular architecture to develop accessible and sustainable housing solutions adapted to climatic and cultural conditions. The research tackles the issue of economic and ecological housing while preserving local architectural traditions. It analyses the use of local materials such as earth and bamboo for their cost and sustainability benefits. Traditional techniques, such as rammed earth walls and palm leaf roofs, are presented as viable alternatives to often costly and less eco-friendly modern materials. Additionally, the colonial influence, combining European and local elements, is explored for its complementary contributions. This work proposes a synthesis of best practices to create housing that respects cultural heritage and meets contemporary demands for sustainability and accessibility. This approach offers viable solutions for the communities of Yaoundé, in harmony with their environment and history, and contributes to the reflection on the future of housing in African urban contexts.

***Keywords**:- Vernacular Architecture, Heritage, Affordable Housing, Sustainability, Yaoundé, Cameroun.*

I. INTRODUCTION

Egyptian architect Hassan Fathy points out, "We must learn from vernacular architecture, not only to save it from oblivion, but to understand how we can build buildings that meet the needs of our communities without plundering the environment and wasting resources." [1]. This quote perfectly embodies the idea that, in the face of the critical challenges facing our cities, it is urgent to rethink our approaches to housing. This reflection is all the more relevant in the context of Yaoundé, the capital of Cameroon, home to different ethnic groups, where the issue of affordable housing is crucial. Thus, this article proposes an exploration of Yaoundé's vernacular architectural system, viewing it as a precious resource for constructing a sustainable architecture, adapted to the needs of the population while preserving the environment and resources.

II. PRESENTATION AND EVALUATION OF EXISTING TRADITIONAL AND COLONIAL CONSTRUCTION TECHNIQUES IN YAOUNDÉ

A. Traditional Approaches to Housing Construction

The traditional construction approaches in Yaoundé emphasize the use of local materials and construction techniques inherited from ancestors. This approach nowadays primarily uses earth, bamboo, wood, and corrugated metal sheets as illustrated in Figures 01 and 02. Earth is used for the foundations and walls, wood and bamboo are used for the building's frame, roof trusses, doors, and windows, and corrugated metal sheets are used for the roof covering.

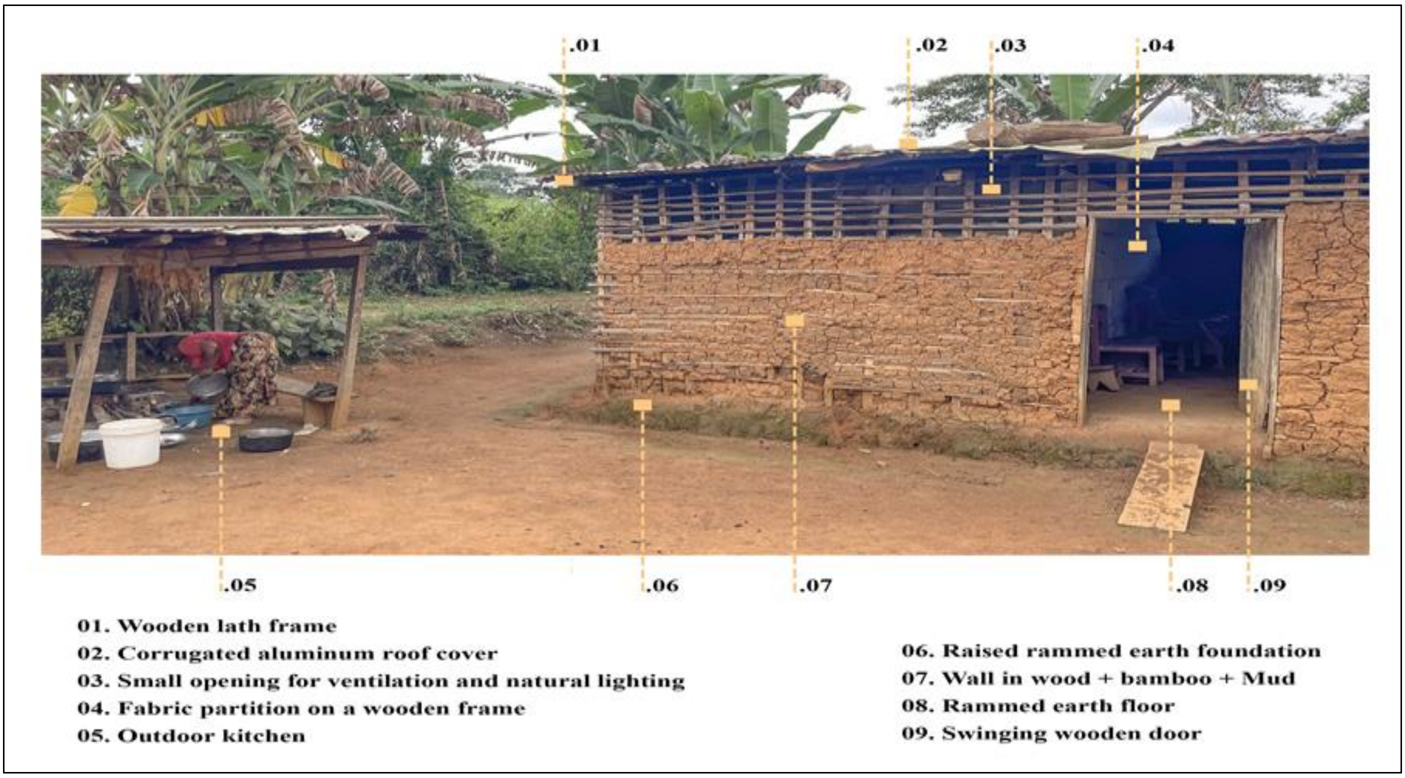


Fig 1: Traditional Style Housing 01 in Yaoundé-Nsimalen (10/2023)

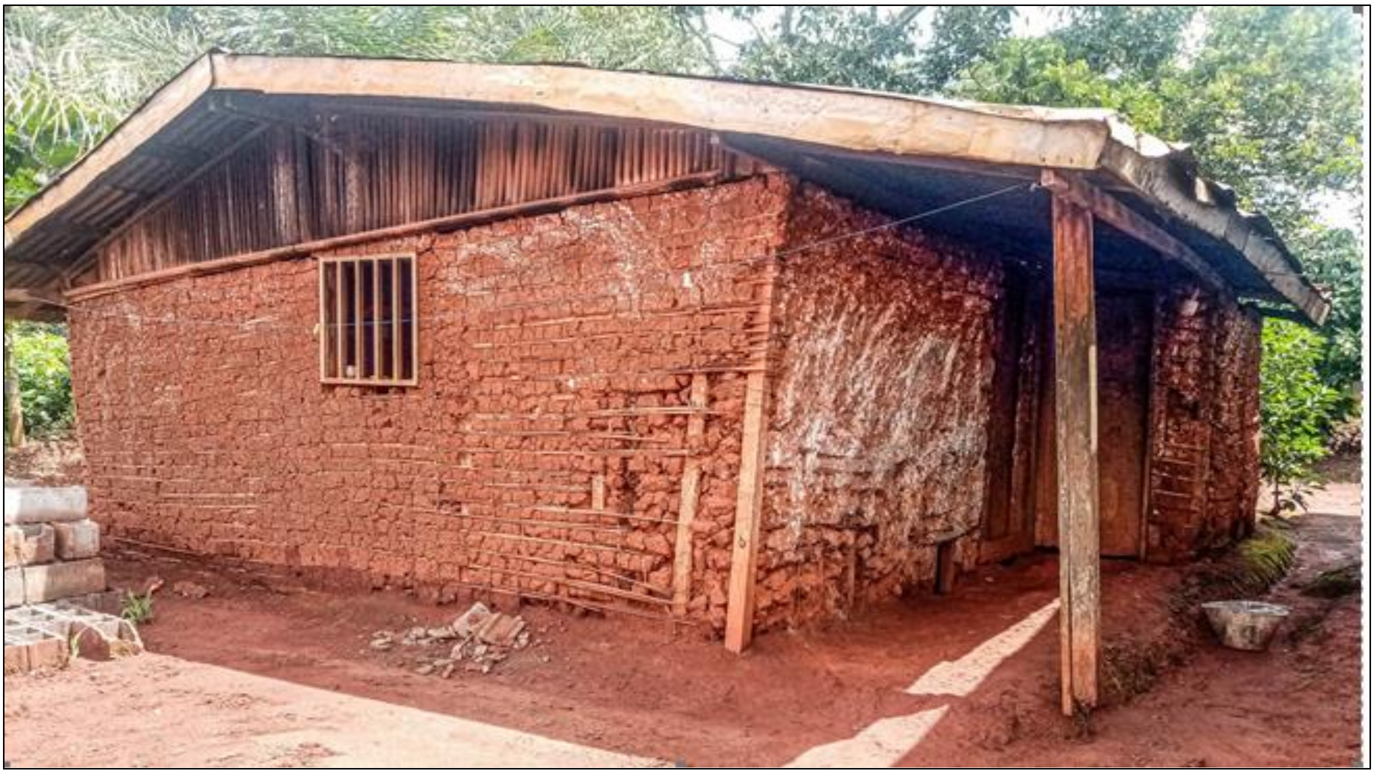


Fig 2: Traditional Style Housing 02 in Yaoundé-Nkolfoulou (10/2023)

The main traditional construction techniques can be summarized in Table 1, described from the foundations up to the roofs.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24AUG143

Table 1: Description of Traditional Construction Techniques Collected in the Field

Techniques	**Description**
Rammed Earth Foundations 	Creating a solid base using compacted earth to avoid flooding and have a livable floor. The area where the foundation is to be built is prepared by removing the topsoil layer, a first layer of earth is added and carefully compacted using manual tools, then successive layers are added and compacted until a raised elevation of about 30 to 60 cm is achieved.
Walls made of wood + bamboo + mud 	An ancient traditional technique that requires the use of wood (posts), bamboo, and earth. The wooden posts are carefully driven into the ground with regular spacing of about 20 to 40 cm, the bamboos are fixed horizontally onto the posts using binding wire or vines with regular spacing of about 10 cm. A manual plaster of "poto-poto" (a homogeneous mixture of clayey soil, water, and sometimes animal manure) is added.
Natural Painting using Cassava 	A traditional technique for making non-toxic and durable paint using cassava tubers. The tubers are cleaned and washed, then soaked in a tightly sealed container for about 7 days. After the time has elapsed, the tubers are removed and used for food purposes, while the water is recovered, to which natural pigments such as colored earth are added to obtain a homogeneous mixture.
Traditional Wooden Roof Structure 	A traditional wooden frame structure typically consists of purlins fixed on the load-bearing frame of the building and rafters on which the metal sheets are fixed. The elements are connected by nails.
Bamboo Gable 	It is important to select bamboos that are sufficiently strong and straight. They are cleaned to remove small branches, then dried in the sun for a few days to reduce moisture. After drying, the bamboos are measured and cut to the desired size. The vertical posts are fixed using raffia ties or wire. This technique is also used in the construction of interior partitions.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24AUG143

Roof Covering in Palm Leaves 	The palm leaves are generally harvested when the palm trees are mature, avoiding damage to the health of the tree. It is important to choose dense and resistant leaves. They are then woven into rows in a longitudinal manner. This can be done by weaving or braiding using palm rope or thread. Once woven, the panels are fixed on the roof structure by attaching them using rope or bamboo ties.
Ventilation Openings 	These empty openings at the top of the walls allow fresh air to penetrate into the building, while hot and stale air escapes, thus promoting natural air circulation. This helps maintain a comfortable temperature, light and ventilate the interior spaces.

B. Colonial Approaches to Housing Construction

The colonial approach blends elements of European architecture with local influence, inspired by traditional forms: rectangular with two-sloped roofs. The main materials are fired clay, stone, concrete, wood and corrugated metal.

The foundations are made of stone, fired clay brick or concrete. The walls, generally around 30 cm thick, are made of fired clay brick, and the framing, doors and windows are in wood. The roofs use fired clay tiles or corrugated metal, with tiles being more common on older buildings and metal on more recent constructions [2].

Figure 03 shows a German housing unit from 1948 in Yaoundé (Nsimalen), primarily using fired clay. Figure 04 presents a French model in Djoungolo, Yaoundé.

Fig 3: Colonial Style Housing 03 in Yaoundé-Nsimalen (10/2023)

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24AUG143

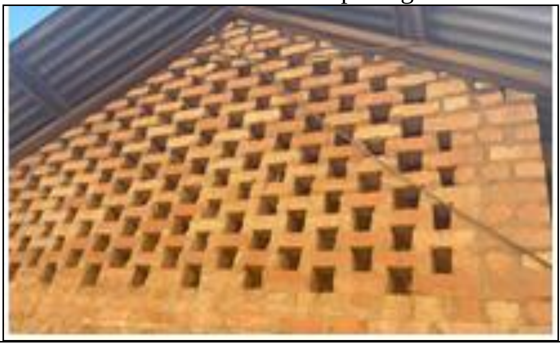

Fig 4: Colonial Style Housing 04 in Yaoundé-Djoungolo (10/2023)

The main colonial construction techniques can be summarized in Table 2.

Table 2: Description of Colonial Construction Techniques Collected in the Field

TECHNIQUES	DESCRIPTION
Foundations and Walls in Fired Clay Bricks 	The fired clay bricks were primarily composed of clay, sand and water, with dimensions of 220x102x60mm. The foundations, which were not very deep at around 40 to 60cm in depth, were laid in a linear row configuration with a thickness of around 40cm, while the walls had a slightly thinner thickness of 30cm.
Roof in Clay Tiles 	The tile-bearing structure is made of wooden slats, consisting of purlins, rafters, and battens with a mortise and tenon construction. This is a traditional construction technique where the frame elements are assembled by creating notches in one piece (mortise) and projecting ends on another piece (tenon). The clay tiles are carefully aligned and positioned on the battens.
Corrugated Metal Roof 	The roof is simplified, consisting mainly of purlins, rafters, and corrugated metal sheets. The framing elements are connected using nails and sometimes with mortise and tenon joints. The use of wood is limited, as we note the absence of trusses. The metal sheets are fixed to the rafters using screws or specialized roofing nails.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24AUG143

Wooden Jalousie Doors and Windows 	The windows and doors with wooden louvers are designed to be easily opened and closed. The louvers can be adjusted as needed, allowing outdoor air to enter the interior spaces, creating a through-flow of air that promotes natural ventilation across the facades.
Small ventilation openings 	Small rectangular or square openings of 10x10cm or more made in the walls located at height to allow for better air circulation, natural lighting, humidity control, and aesthetics. They were sometimes designed with artistic patterns or wrought iron grilles, which contributed to the overall aesthetics of the buildings.

C. Strengths and Weaknesses of Vernacular Architecture Techniques in Yaoundé

By understanding the strengths and weaknesses of traditional and colonial construction techniques, we can valorize and preserve this cultural heritage. Moreover, we can identify the elements that require improvements.

Table 3: Analysis of the Strengths and Weaknesses of Traditional Construction Techniques

TECHNIQUES	**STRENGTH**	**WEAKNESS**
Rammed earth foundation	-Very low cost -Availability of materials -Adaptation to conditions -Involvement of local communities	-Sensitivity to weather -Less stable than other techniques
Wall made of wood + bamboo + mud/clay	-Affordable cost -Availability of materials -Involvement of local communities	-Regular maintenance -Vulnerability to pests -Sensitivity to water
Natural painting using cassava	-Environmental friendliness -Resistance to insects -Unique and traditional aesthetics -Involvement of local communities	-Sensitivity to water -Limited color options -Regular maintenance
Traditional wooden framing	-Good natural resistance -Durability with proper maintenance -Aesthetics: natural beauty	-Sensitivity to insects and rot -Sensitivity to humidity
Bamboo partitions and gables	-Renewable natural resource -Warm and natural aesthetics -Bioclimatic solution for natural ventilation -Involvement of local communities	-Sensitivity to insects -Sensitivity to fire -Poor acoustic and thermal insulation
Palm leaf roofing	-Natural and renewable resource -Good thermal insulation -Easy construction -Affordable cost -Involvement of local communities	-Sensitivity to weather -Risk of fire -Limited pest resistance -Regular maintenance required
Ventilation Openings	-Adaptability to climate -Affordable ventilation solution	-Limitation of ventilation -control

Table 4: Analysis of the Strengths and Weaknesses of Colonial Construction Techniques

TECHNIQUES	STRENGTH	WEAKNESS
Fired Clay Brick Foundation	-Local Material Good -Compressive Strength -Excellent Thermal Insulation Low -Environmental Impact	-Sensitivity to Humidity -Low Resistance to Vibrations
Fired Clay Brick Wall	-Excellent Thermal -Insulation Humidity -Regulation Low -Environmental Impact	-High Initial Cost -Requires Expertise
Fired Clay Tile Roof	-Good Thermal Insulation -Durability Fire Resistance -Low Maintenance	-High Initial Cost -Heavy and Difficult to -Repair Sensitivity to Moss
corrugated Aluminum Sheet Roof	-Lightness -Ease of Installation -Availability Longevity	-High Thermal -Conductivity Noise from Rain
Louvered Doors and Windows	-Good Natural Ventilation -Light Control -Aesthetic Touch to the Facades	-Limited Sound and Thermal Insulation

III. POTENTIAL CONSTRUCTION MATERIALS AND TECHNIQUES

A. Foundations

The foundation, a term most often used in the plural to refer to the set of buried structures on which a construction rests. Drawing inspiration from traditional construction approaches and taking into account the parameters of durability, Table 5 presents the potential techniques.

Table 5: Potential Construction Techniques for Foundations Inspired by Traditional and Colonial Approaches

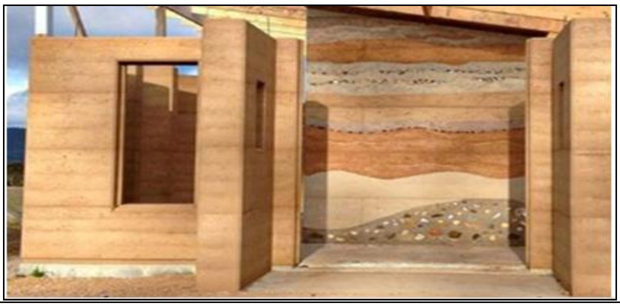
The Super Adobe Foundation 	The ground is levelled and compacted to ensure a solid base. Polypropylene bags are filled with lateritic soil, allowing for a structure that is resistant to rainwater and durable. Then, after each layer of bags, it is manually compacted. This technique will allow us to have a foundation that is affordable and adapted to the local context.
The Dry-Stone Foundation 	The use of local stones for the foundations is a sustainable and affordable alternative option. The stones are carefully stacked without any binder. This technique is commonly used in the Bamiléké villages of West Cameroon and offers good stability, resistance to weather, and helps fight against capillary rise of groundwater.

B. Walls

Rammed earth is a wall construction technique that is durable, thermally efficient, and very similar to the wood+bamboo+mud technique used in the city of Yaoundé. (See Table 6)

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24AUG143

Table 6: Potential Construction Techniques for Walls Inspired by Traditional and Colonial Approaches

Rammed Earth 	Rammed earth, also called compact raw earth construction, is a technique similar to traditional poto-poto but does not use a load-bearing frame (wood and bamboo). This technique requires a mixture of clay soil, sand, and compacted water between wooden formwork. This technique is durable, economical, and allows the construction of walls offering good thermal and acoustic insulation.
Compressed Laterite Brick 	Lateritic earth bricks are manufactured using locally available lateritic soil by compressing it in a mechanical press to form solid and uniform bricks. These bricks are then used to build walls of different sizes and shapes, it is a contemporary, environmentally friendly, flexible and economical technique.

C. Roof Framing

Table 7 presents the construction techniques for roofing framing elements to design while reducing the number of materials required while maintaining strength and durability by opting for environmentally friendly practices throughout the construction process.

Table 7: Potential Construction Techniques for Roofing Framing Elements Inspired by Traditional and Colonial Approaches

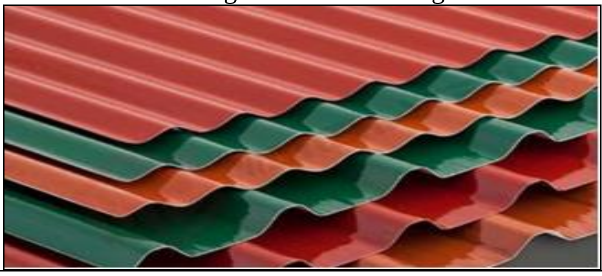
The Bamboo Roof Frame  .	A bamboo roof frame consisting of bamboo main beams, connected by bamboo rafters, forming a solid structure. The joints can be fixed with screws, wire or with attachment knots. This is a durable and affordable technique offering incredibly strong structural resistance, natural flexibility and an attractive aesthetic touch.
The Purlin and Rafter Roof Frame 	This technique involves the use of horizontal purlins that rest on gable walls, partition walls or posts, and rafters that support the roof. This technique is simple, economical and durable.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24AUG143

D. Roofing Elements

When it comes to choices for roofing elements in Yaoundé, there are two potential options to consider based on preferences, as summarized in Table 8.

Table 8: Potential Construction Techniques for Roofing Elements Inspired by Traditional and Colonial Approaches

Corrugated Metal Roofing 	These materials are widely used in the urban area of Yaoundé for their durability and relatively low cost. They are lightweight, easy to install, require little maintenance, and offer a variety of colors to adapt to the local architectural style.
Palm Leaf Roofing 	The material is natural, available and affordable. It is essential to maintain the roof in good condition by performing regular maintenance. The application of a natural protective coating can help extend the lifespan, such as banana leaves, palm shingles or woven palm fronds.

E. Doors and Windows with Louvers

The most common are solid wood windows and metal doors. Table 9 presents the possibilities of doors and windows with louvers. Louvers are protections that can be installed on a door or window to regulate the lighting and ventilation of the rooms while preserving privacy.

Table 9: Potential Construction Techniques for Door and Window Elements Inspired by Traditional and Colonial Approaches

Wooden Doors and Windows with Louvers 	Traditional doors and windows with louvers are made from local wood, offering an authentic aesthetic while being relatively affordable. They allow for the regulation of the quality of natural light that enters the rooms, facilitate air circulation in the rooms, and provide an additional level of privacy and security.
Metal Doors and Windows with Louvers 	Metal doors and windows are the most widespread in the city of Yaoundé, due to the security they provide and their local availability. The costs are affordable, they can be adapted to different styles and offer good durability and excellent resistance to the elements.

F. Flooring

They are selected based on their aesthetic, functional, and technical characteristics. Drawing inspiration from traditional and colonial practices, the interior flooring in rammed earth or terracotta tiles seems to be ideal choices in terms of cost, accessibility, and durability, as summarized in Table 10.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24AUG143

Table 10: Potential Construction Techniques for Flooring Elements Inspired by Traditional and Colonial Approaches

Rammed Earth Flooring 	It is economical and environmentally friendly. To create a rammed earth surface, a mixture of clay, sand, and sometimes straw is mixed with water, then compacted firmly onto the floor. Once dry, it forms a solid and durable surface.
Terracotta Tile Flooring 	This type of flooring is popular due to its durability, natural beauty, and rustic style. An affordable and durable alternative option for flooring is terracotta tiles. They are made from raw earth, shaped into tiles, and fired in a kiln. They are durable and easy to maintain.

G. Ceilings

Bamboo ceilings are a beautiful natural alternative to the commonly used materials in the city of Yaoundé, such as plaster and wood. They offer a unique aesthetic and a warm ambiance to any space. Table 11 presents the potential bamboo techniques for the suspended ceiling.

Table 11: Potential Construction Techniques for Ceiling Elements Inspired by Traditional and Colonial Approaches

Bamboo Pole Suspended Ceiling 	Bamboo is a durable, environmentally friendly material that is available in the city of Yaoundé at an affordable price. This technique involves using thin bamboo poles to create a suspended ceiling. The bamboo poles are attached horizontally using nylon rope or wire.
Woven Bamboo Suspended Ceiling 	This technique involves weaving bamboo strands to form panels or tiles that are then attached to the main ceiling. The weaving can be done in different patterns to create decorative designs. The woven bamboo provides a unique and rustic appearance to the suspended ceiling and is also durable and affordable.

IV. SUSTAINABILITY EVALUATION MATRIX FOR POTENTIAL TECHNIQUES

The potential techniques inspired by the vernacular architecture of Yaoundé have been evaluated according to ten sustainability criteria: initial cost, maintenance requirements and costs, longevity before major repairs, complexity of implementation, local availability of materials, recyclability and reuse of resources, carbon footprint, embodied energy consumption, social impact in terms of inclusion and local employment, and the transmission of cultural knowledge. These criteria allow for a comprehensive evaluation of the sustainability of the studied techniques. (See Table 12).

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24AUG143

Table 12: Sustainability Evaluation Matrix for Potential Techniques

Nº	**Techniques**	**Initial Cost**	**Maintenance**	**Longevity**	**Complexity**	**Local Availability**	**Recycling and Reuse**	**carbon footprint.**	**embodied energy**	**social impact**	**knowledge transfer**	**potential of the technique**
	Percentage Evaluation	**10%**	**10%**	**10%**	**10%**	**10%**	**10%**	**10%**	**10%**	**10%**	**10%**	**100%**
0	***FOUNDATION***											
0.1	Super adobe	8,5	6,5	6,5	7,5	8,5	6,5	7,5	8,0	7,5	8,0	**75**
0.2	Dry stone	6,0	8,0	8,5	7,0	7,0	7,0	7,0	6,5	7,0	8,0	**72**
1	***WALL***											
1.1	Rammed Earth	8,0	5,0	6,5	6,5	8,5	6,0	7,5	7,5	7,5	8,0	**71**
1.2	wood + bamboo + mud	7,0	5,0	6,5	5,0	7,0	5,0	6,5	7,0	7,5	8,5	**65**
1.3	Compressed Laterite Brick	7,0	5,5	6,5	6	8,5	6,0	7,5	6,0	6,0	6,0	**65**
2	***ROOF FRAME***											
2.1	Bamboo	8,0	6,0	5,0	6,5	7	2,0	8,0	8,0	7,5	7,5	**65,5**
2.2	Panne et chevron	6,0	7,0	5,5	6,5	6,5	5,0	6,0	6,0	6,0	5,0	**59,5**
3	***ROOFING ELEMENTS***											
3.1	Corrugated Metal Roofing	4,5	8,0	7,5	7,5	5,0	5,0	4,0	3,0	4,0	3,0	**51,5**
3.2	Palm Leaf Roofing	8,0	2,0	5,0	4,0	6,0	1,0	7,0	8,0	7,5	8,0	**56,5**
4	***DOORS AND WINDOWS WITH LOUVERS***											
4.1	Wood	5,0	5,0	5,5	5,5	6,5	4,5	5,5	6,5	5,5	5,5	**55**
4.2	Metal	4,0	6,5	7,0	5	5	5,5	3,0	3,0	4,0	5,5	**48,5**
5	***FLOORING***											
5.1	Rammed Earth	8,0	5	6,0	6,5	8,5	6,5	7,5	7,5	7,5	7,5	**70,5**
5.2	Terracotta Tile	4,5	6,5	7,0	7,5	6,5	6,0	5,0	5,0	5,5	4,0	**52,5**
6	***CEILINGS***											
6.1	Bamboo Pole	8,0	6,0	6,0	6,5	7,0	2,0	8,0	8,0	7,5	7,0	**66**
6.2	Woven Bamboo	7,0	5,5	5,5	6,0	7,0	1,0	8,0	7,5	8,0	7,5	**63**

V. TOWARDS THE ARCHITECTURAL PROJECT

A. Site

➢ *Site Selection and Location*

This project does not require a localized intervention but rather the design of solutions that can be replicated in different contexts. We use the city of Yaoundé and its seven districts as a reference (see Figure 05). Our project is located in Cameroon, in the city of Yaoundé, in the Yaoundé I district, in the neighborhood known as Olembé (see Figure 06). This is a new neighborhood under development and an area dedicated to the creation of new housing according to the city's master urban planning plan [3].

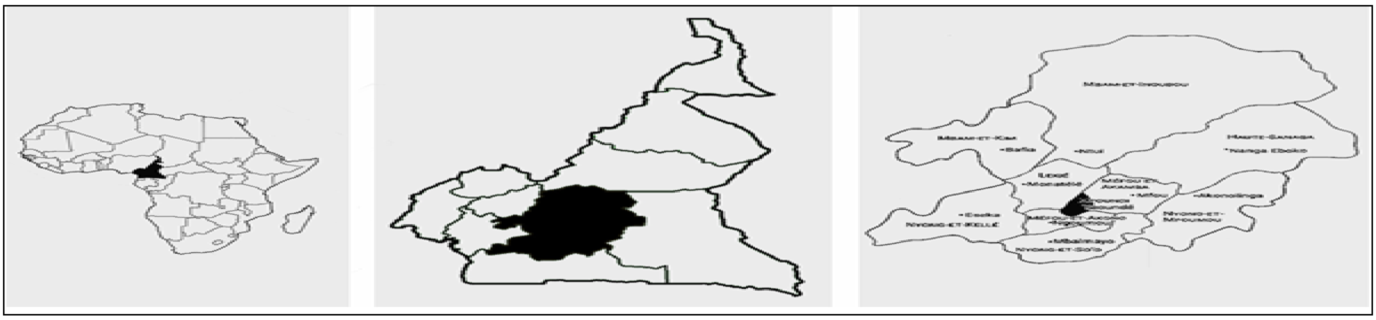


Fig 5: Localize the Central Region from Africa

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24AUG143

Fig 6: Site: Olembé, Yaoundé I

- *Climate Data*

The temperature in the city of Yaoundé has an annual average of around 24°C. The seasons are not very distinct and can be categorized into two main periods:

- A rainy season (April-November): This is a cool and humid period with an average air temperature of about 19°C to 24°C and a relative humidity of 65% to 75%.
- A dry season (December-March): This is a warm and humid period with an average air temperature of about 23°C to 27°C and an average relative humidity of 55% to 70% [4].
- Precipitation is distributed throughout the year, ranging from approximately 1000 to 1700 mm per year, as frequently illustrated in Figure 07.

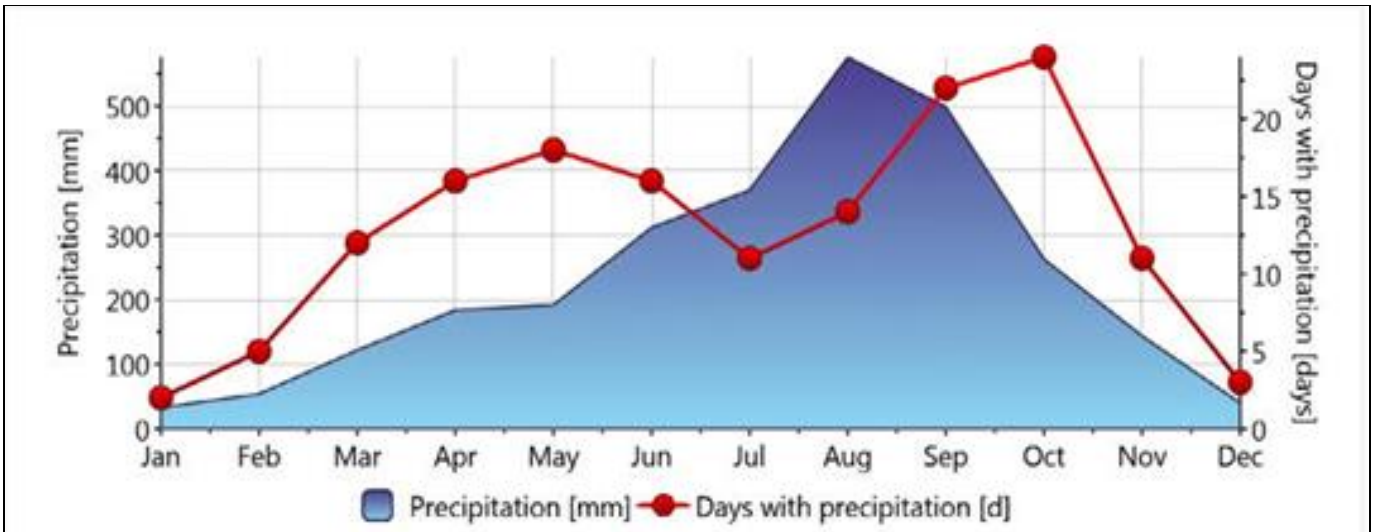


Fig 7: Monthly Precipitation in the Yaoundé Area

The global solar radiation on a horizontal surface in this area ranges from 5.0 to 6.4 kWh/m²/day, except on cloudy days, as shown in Figure 08 [5].

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24AUG143

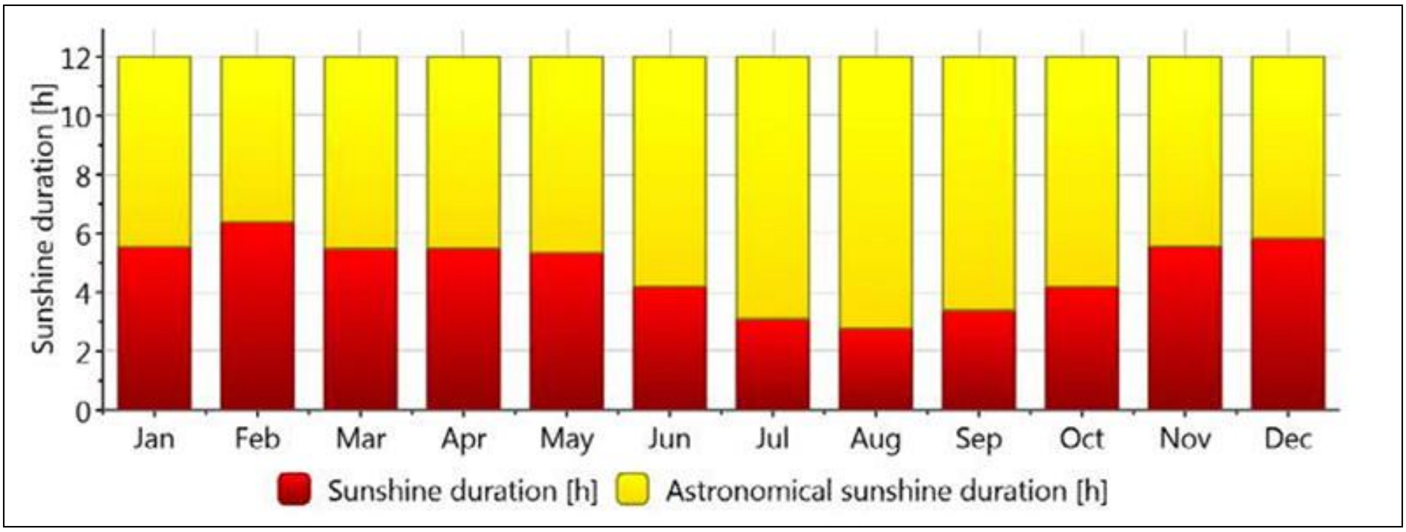


Fig 8: Average Monthly Sunshine Duration in Yaoundé Area

The dominant wind speeds in the area range from 0.3 to 2.2 m/s, with a direction from the Southwest, as illustrated in Figure 09 [6].

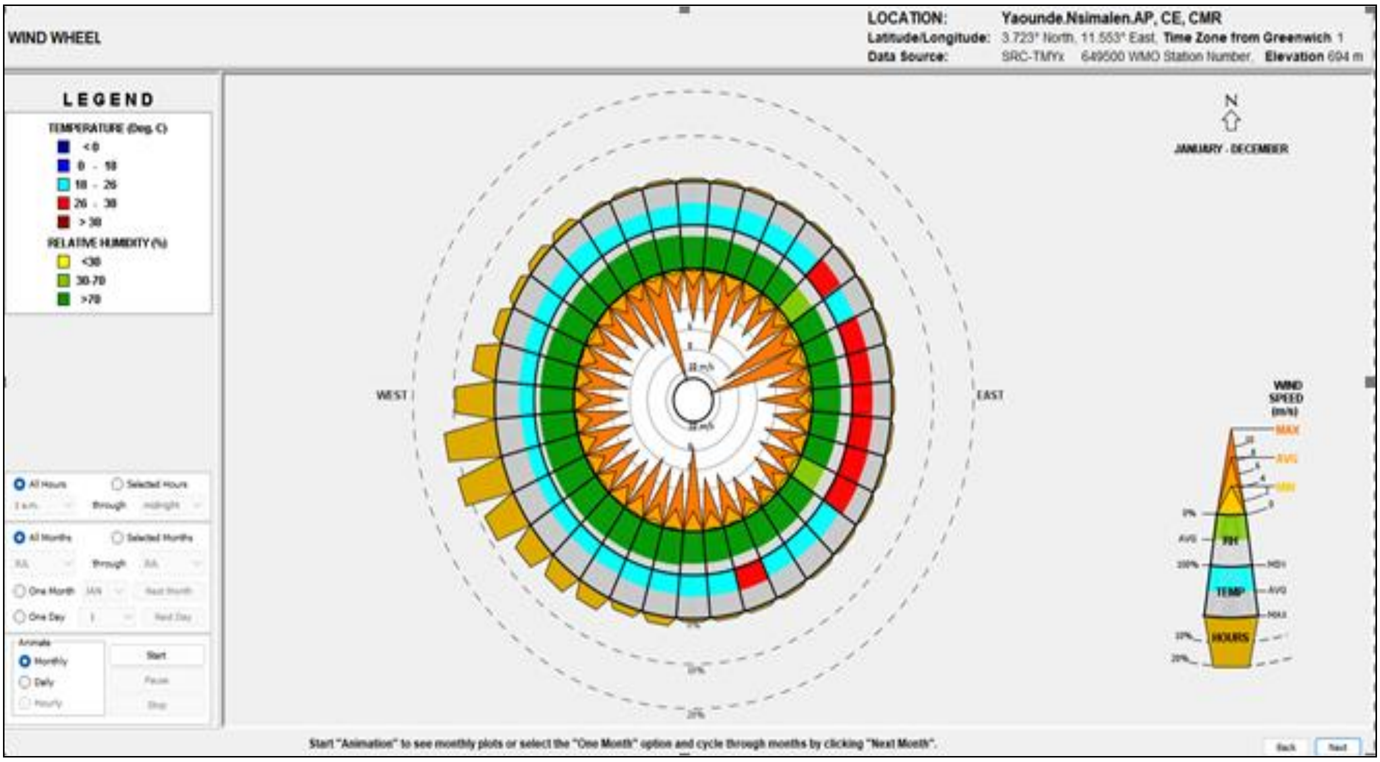


Fig 9: Wind Rose (Climate Consultant Capture)

B. Target Audience

Welcome to households with modest incomes seeking affordable housing solutions!

We understand how challenging it is for individuals with a monthly income of 200,000 FCFA (332.17 USD) to find affordable housing in Yaoundé. Whether they are dedicated teachers, private or public sector employees (such as nurses, laboratory technicians, etc.), our mission is to design affordable housing that meets the needs of modest-income families in the city of Yaoundé.

C. Architectural Program

Our affordable housing proposal is designed to accommodate a family of five (two parents and three children) and will focus primarily on the following aspects:

- Space Efficiency: A straightforward layout that allows for the effective use of available space, avoiding unnecessary clutter.
- Cost Reduction: Housing estimated at less than 7,000,000 FCFA (11,158.46 USD), requiring minimal complex and costly construction.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24AUG143

- Flexibility: Housing that offers the possibility to easily customize and modify the interior layout over time.
- Sustainability and Environmental Respect: Promoting the rational use of resources and a reduced carbon footprint.

To achieve these objectives, we propose the following program, as detailed in Table 13.

Table 13: Surface Area Program for the Model

Level	Spaces	Rooms	Area (m^2)
Ground floor	Residential Spaces	Veranda/Ceremonial Space	22 m^2
		Living Room	23 m^2
		Kitchen	9 m^2
		Kitchen Balcony	6 m^2
		Master Bedroom	11 m^2
		Master Bathroom	5 m^2
		Daughter's Bedroom	10 m^2
		Son's Bedroom	10 m^2
		Shared Bathroom	5 m^2
		Corridor	7 m^2
		Guest Toilet	2 m^2
		Total Residential Spaces	110 m^2
	Auxiliary Spaces	Laundry Area	---
		Dryer	---
		Vegetable Garden/Green Space	---
		Total Auxiliary Spaces	---
	Total Plot Area		315 m^2
Net Usable Floor Area = Total Ground Floor Area			*110 m^2*

D. Functional Diagram

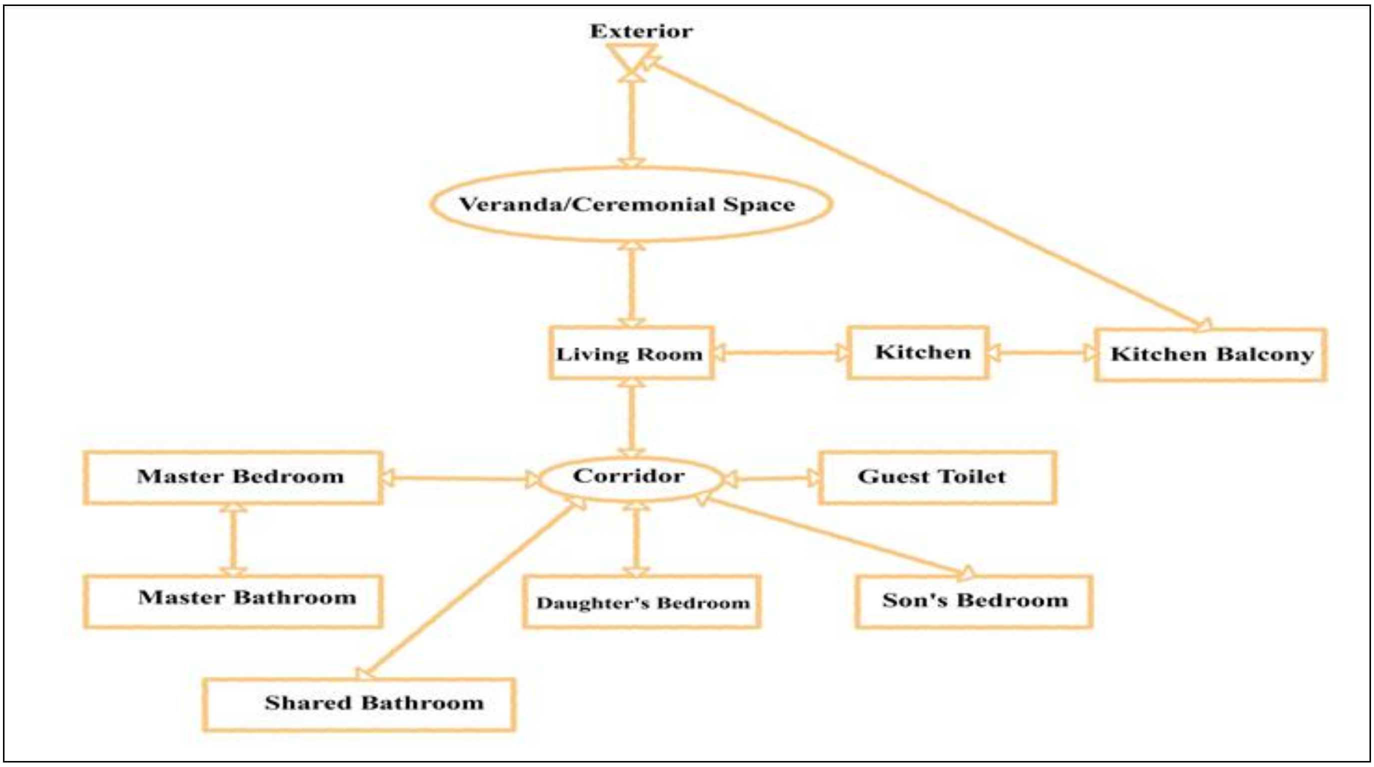


Fig 10: Functional Diagram of Housing Model

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24AUG143

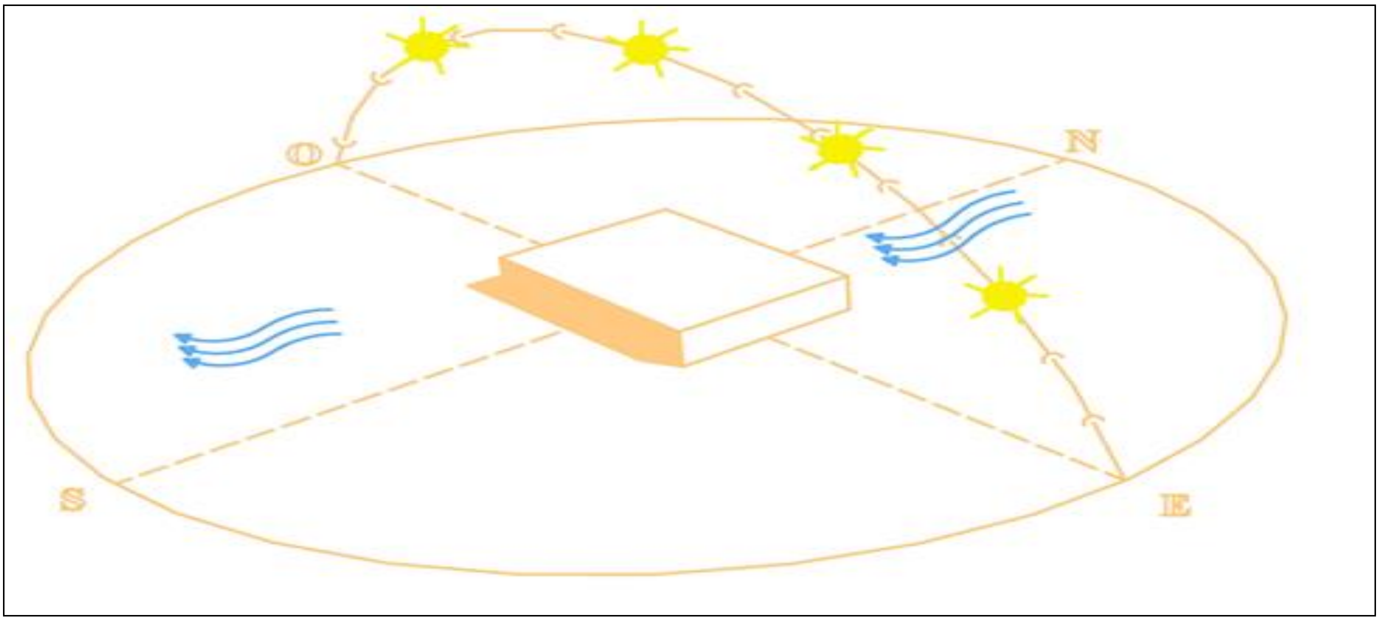


Fig 11: Building Orientation

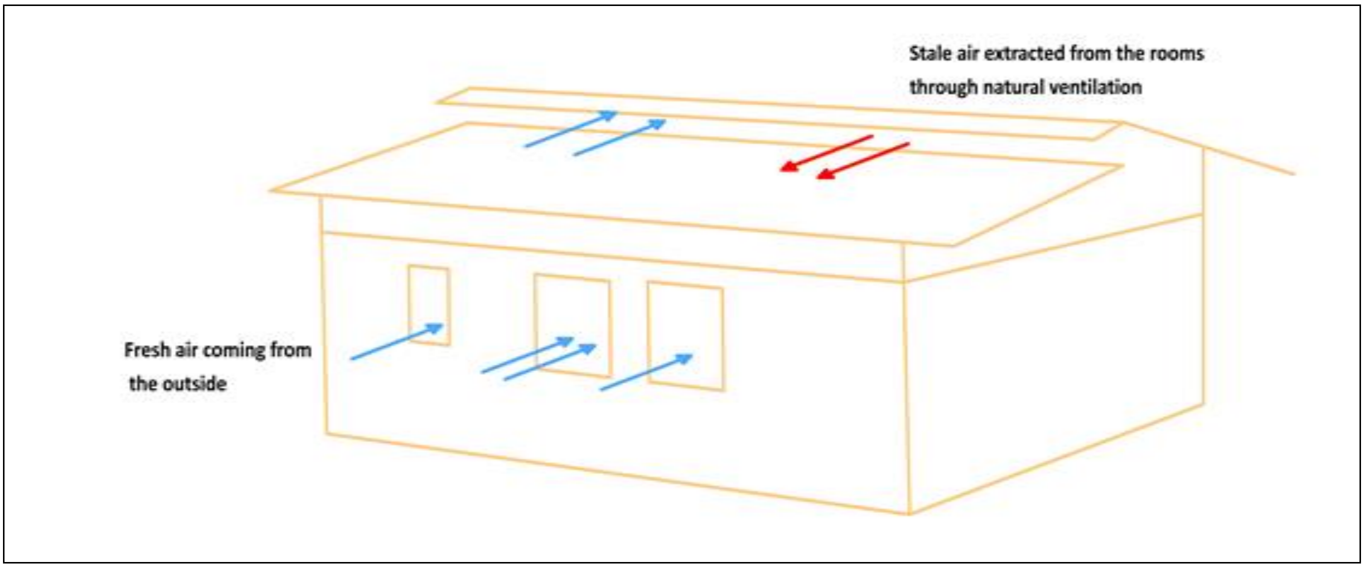


Fig 12: Building Shape

To optimize space, enhance circulation, clarify the objectives, and ensure coherence and cohesion between the different functions, we have proposed the functional diagram shown in Figure 10.

VI. DESIGN STRATEGIES

A. Building Orientation

The longest side of the building is oriented along the East-West axis so that the longest façades face North and South [7]. This orientation will help reduce heat from direct sun exposure. We also consider the direction of the prevailing winds for optimal ventilation, as illustrated in Figure 11.

B. Building Shape

The rectangular shape facilitates natural air circulation and allows for even distribution of natural light inside. The choice of a gabled roof with ventilation between the roof layers helps improve indoor air quality, as shown in Figure 12.

C. Openings

The windows sizing is designed according to the prevailing climatic conditions, with a window-to-wall ratio (WWR) of 0.16. This helps reduce heat transfer areas and limits energy losses, contributing to better energy efficiency of the building. The openings on the walls, as illustrated in Figure 13, allow for improved natural light entry into wet areas, thereby reducing humidity levels. Removable sunshades or blinds are used to control solar radiation during the day and reduce heat loss at night.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24AUG143

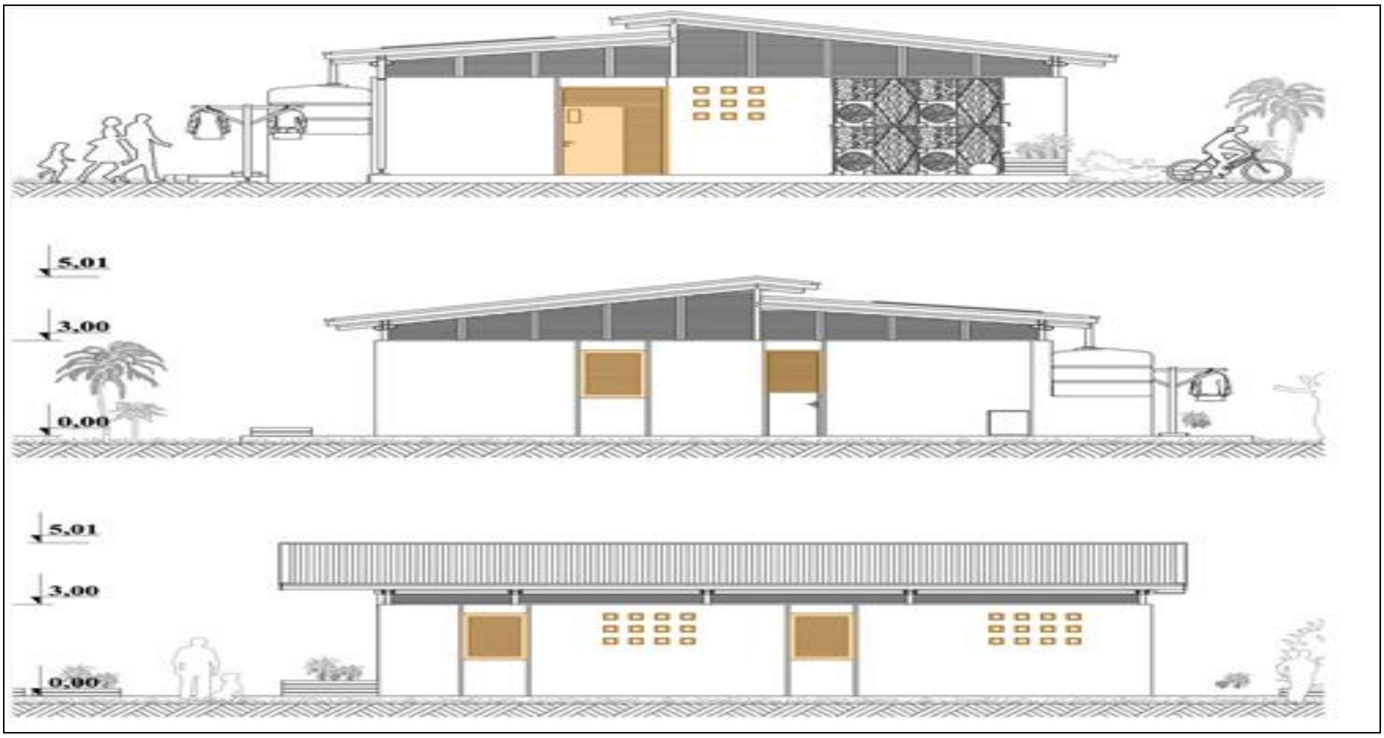


Fig 13: Illustration of Openings on Building Facades

D. Natural Ventilation and Lighting

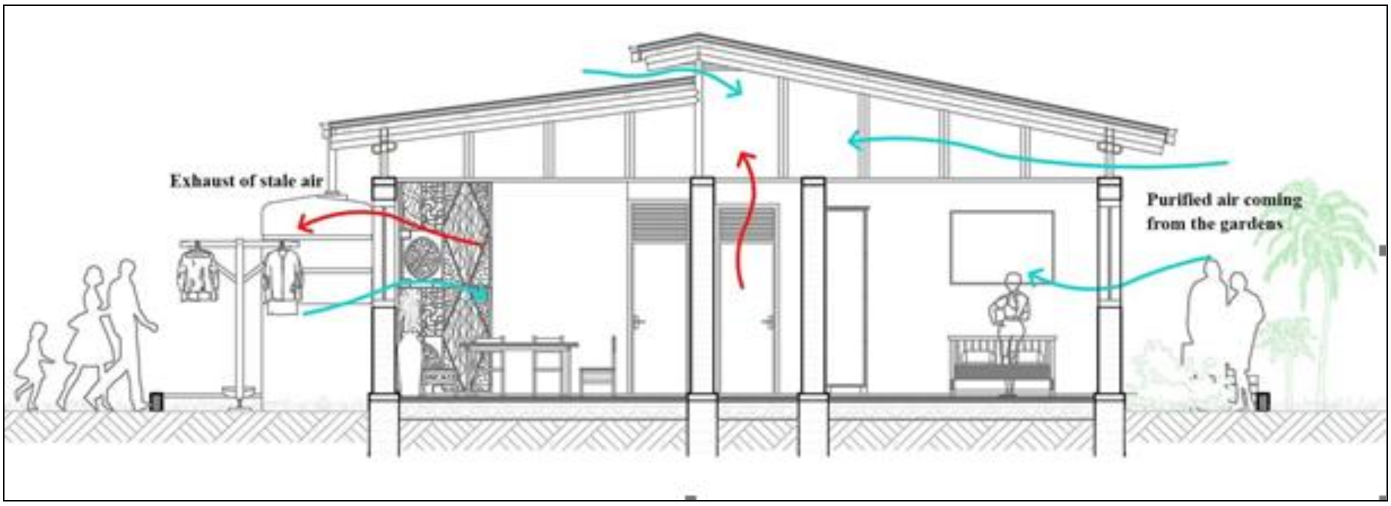


Fig 14: Illustration of Natural Ventilation System

- Corrugated metal sheet
- 2 cm layer of palm leaves
- Bamboo purlins Ø8 cm
- Bamboo rafters Ø10 cm
- Gutter
- Edge metal sheet
- Bamboo beam Ø10 cm
- Upper chain 30x10 cm
- Rammed earth wall 30 cm x 2.90 m
- Lower chain 30x10 cm
- Polypropylene sack + lateritic soil
- 2 cm plaster
- Terracotta tiles 30x30 cm
- 25 cm layer of gravel
- Wooden half-louvered door
- Woven bamboo ceiling

A double cross-ventilation and longitudinal ventilation system is achieved through a gabled roof with ventilation between the roof layers, along with louvered windows and openings. This system ensures effective air circulation within the building, as illustrated in Figure 14.

The project benefits from morning and evening light, provides balanced light distribution throughout the day, and controls solar heat gain. See Figure 15.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24AUG143

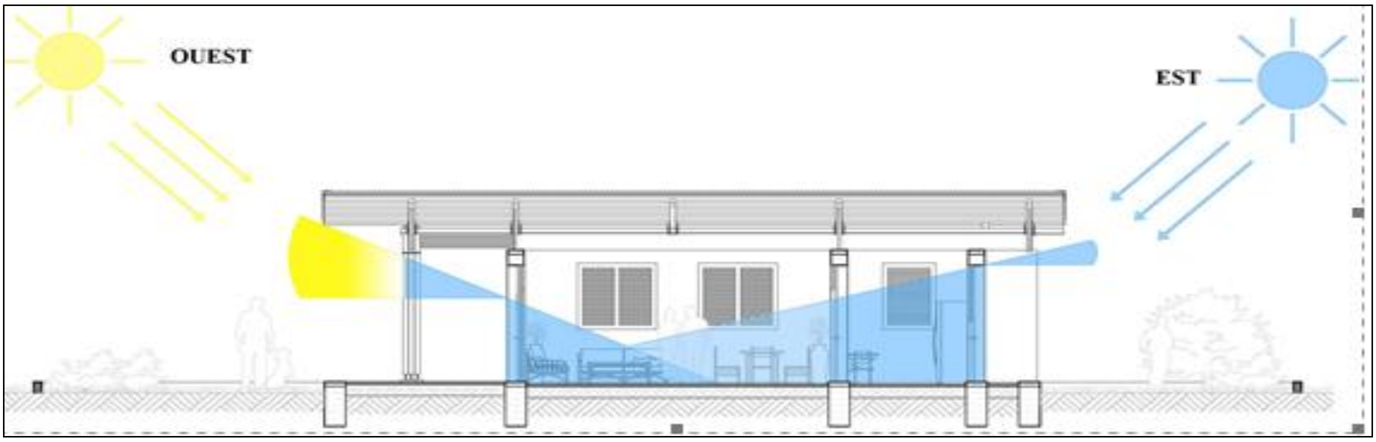


Fig 15: Illustration of Natural Lighting with East-West Orientation

E. Material Selection

The choice of materials has been guided by environmental, economic, social, and cultural sustainability parameters. The materials used for the housing model are illustrated in Figure 16.

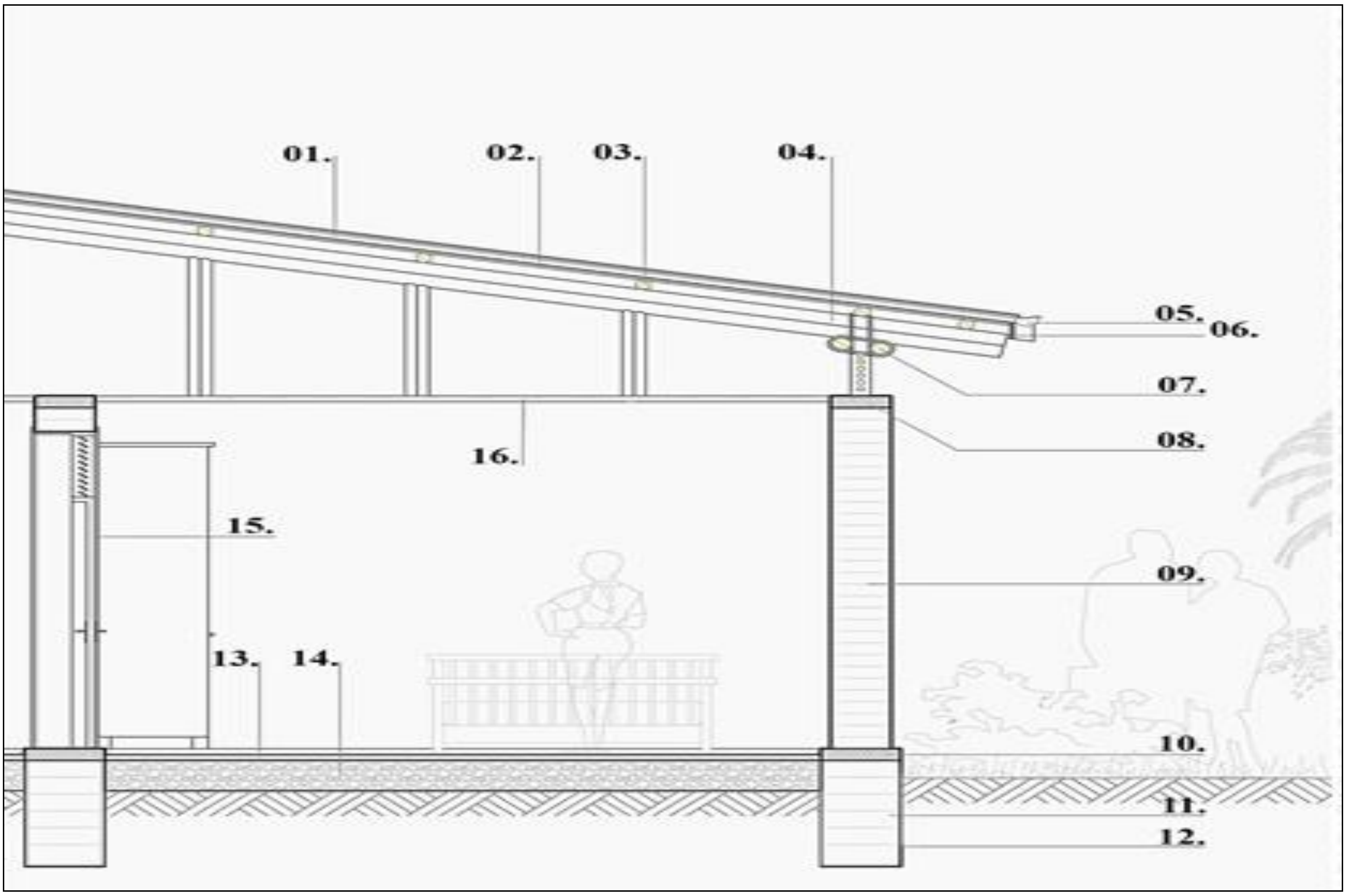


Fig 16: Materials Detail for the Housing Model

F. Renewable Energy

The integration of renewable energy, such as photovoltaic solar power, allows for cost-effective electricity production over the long term. By utilizing this energy, we also reduce our reliance on fossil fuels and contribute to combating climate change. See Figure 17.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24AUG143

Fig 17: Illustration of the Solar Panels on the Model

G. Rainwater Management and Water Efficiency

Rainwater is collected and reused for laundry, green spaces, and toilets, as illustrated in Figure 18. Similarly, wastewater will be collected and reused, as shown in Figure 20.

To maximize water efficiency, we opt for the installation of water-saving fixtures, such as low-flow faucets and showerheads, and water-efficient toilets.

Fig 18: Illustration of Rainwater Harvesting System

Figure 19 shows the distribution of water points within the layout of our affordable housing model.

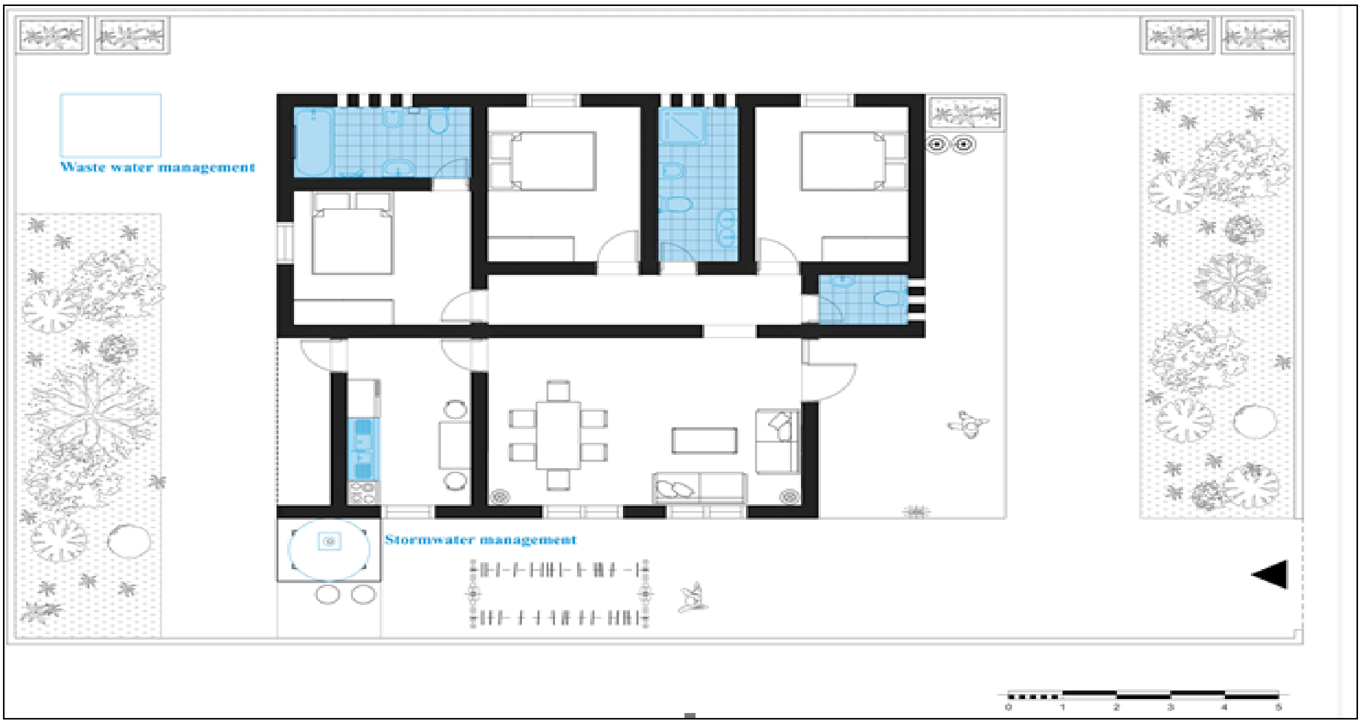


Fig. 19. Distribution of Water Points

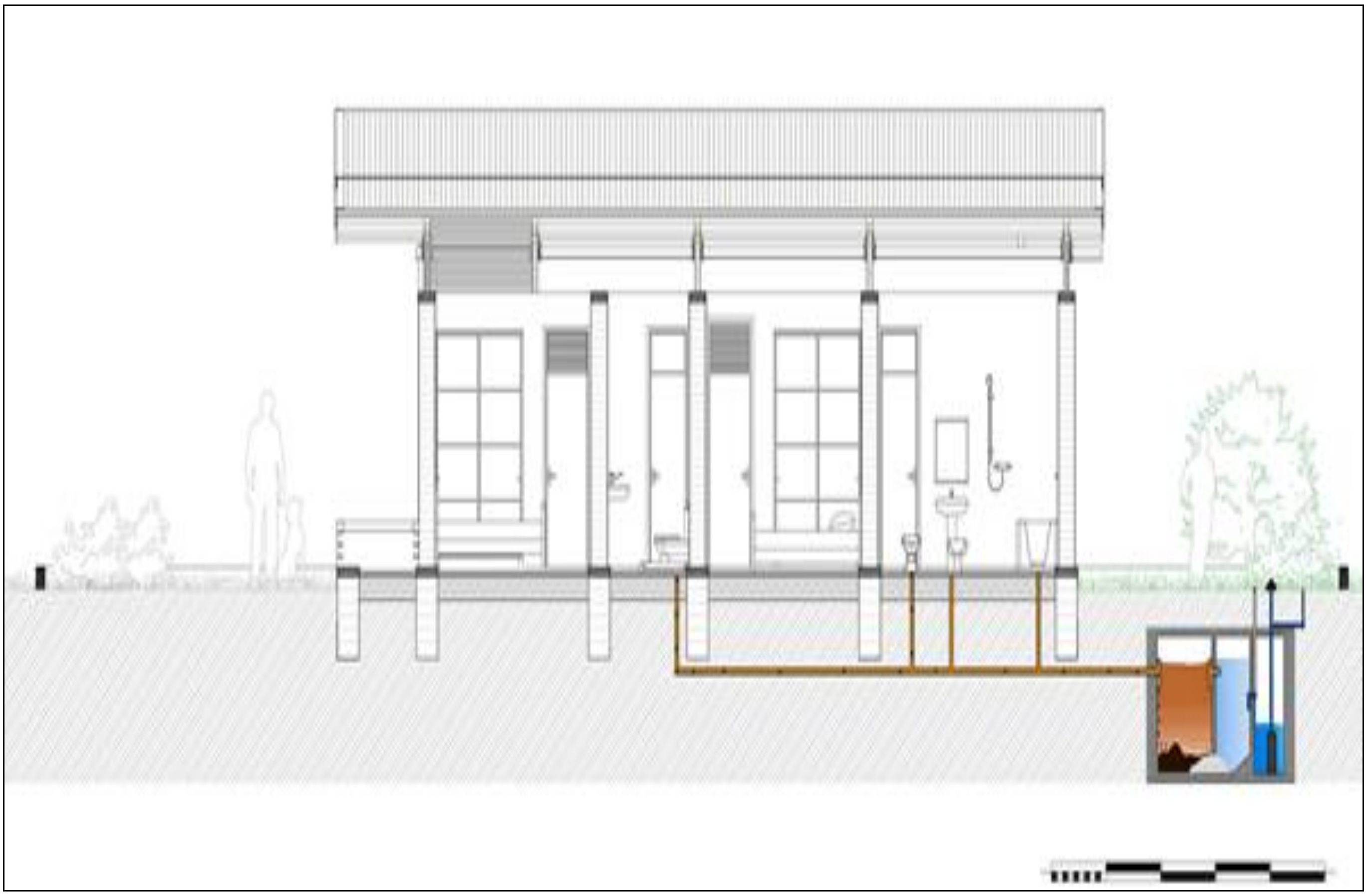


Fig 20 : Illustration of Waste Water Management System

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24AUG143

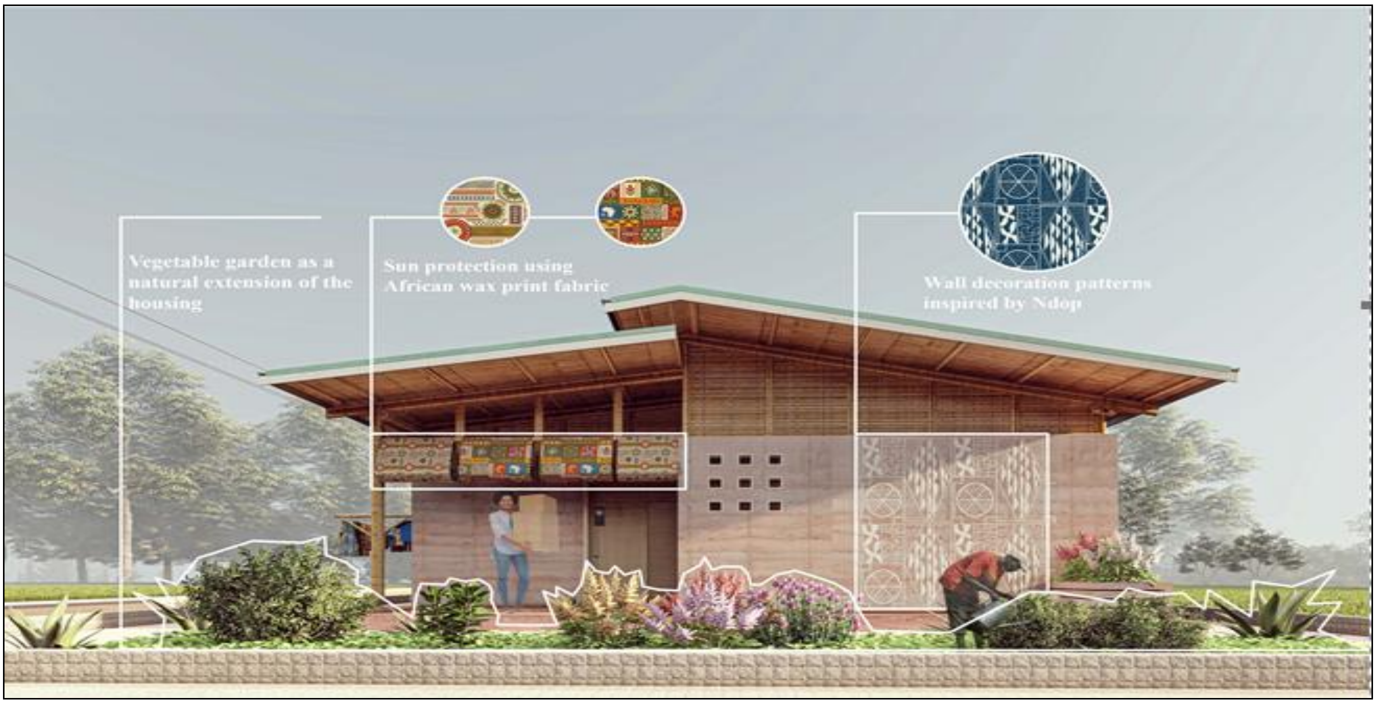


Fig 21: Illustration of Cultural Elements in the Housing Model

H. Cultural Element

By integrating design elements that represent local cultures, such as using sustainable local materials, creating versatile living spaces, and incorporating patterns inspired by traditional African and Cameroonian textiles—such as the "Ndop" and fabrics, along with specific architectural features—we can create an environment that is both inclusive and sustainable. This approach considers the unique cultural characteristics of the region while adopting environmentally friendly practices. In doing so, we foster harmony between residents, their traditions, and their environment, while preserving and celebrating the community's rich cultural heritage.

VII. SUMMARY COST EVALUATION

To estimate the costs of our project, we conducted a survey of local market prices. We examined the costs of locally available materials as well as traditional construction techniques, drawing on the knowledge of local communities. This approach allowed us to obtain an accurate estimate of the necessary expenses. Table 14 provides a summary of this overall cost estimate.

Table 14: Summary Evaluation of the Project's Overall Cost

Designation	Unit	Quantity	Unit Price (FCFA)	Total Price (FCFA)
Super Adobe (Sack + Soil)	m³	38,89	1 500	5 8335
Rammed Earth (Formwork + Soil)	m³	65	2 500	162 500
Bamboo	ml	870,2	100	87 020
Wood (Doors and Windows)	m²	31,04	29 000	900 160
Palm Leaves	m²	170	1 000	170 000
Corrugated Aluminum Sheets	m²	170	2 500	425 000
Earth Plaster	m²	43,2	1 000	43 200
Terracotta Tiles	m²	108	4 500	486 000
1.1 Construction Materials Costs				*2 332 215*
Double Sink	unit	1	32 500	32 500
Single Sink	unit	2	25 000	50 000
Double Basin Sink	unit	1	35 000	35 000
Toilet	unit	3	45 000	135 000
Bidet	unit	2	40 000	80 000
Rectangular Shower	unit	1	40 000	40 000
Bathtub	unit	1	75 000	75000
1000L Rainwater Tank	unit	1	70 000	70 000
1.2 Sanitary Equipment Costs				*517 500*
1.3 Solar Energy Equipment Costs				*1 650 000*
1.3 Wastewater Management System Costs				*900 000*
Summary Evaluation of Overall Project Costs				*5 399 715*

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24AUG143

The estimated total cost for our housing model is approximately five million four hundred thousand FCFA (8990.37USD). This amount is provided as an indicative estimate to give a rough idea of the commercial value. A detailed quotation will be prepared by quantity surveyors before the commencement of the construction work.

VIII. PROJECT IMPACT ASSESSMENT

Following the presentation of this affordable housing project, it is essential to evaluate its social, economic, cultural, and environmental impacts:

A. Economic Impacts

The use of local materials and traditional techniques reduces construction costs, making housing more affordable. Additionally, promoting traditional craftsmanship creates local jobs, stimulating the local economy.

B. Social Impacts

Sustainable housing improves the quality of life by providing better thermal comfort and air quality, which enhances residents' health. Participatory design and the use of local knowledge strengthen social connections and a sense of belonging.

C. Cultural Impacts

Incorporating traditional architectural techniques preserves the cultural heritage of Yaoundé and reinforces the cultural identity of residents. It also encourages the transfer of knowledge between generations, ensuring the continuity of traditional skills.

D. Environmental Impacts

Using local materials reduces the carbon footprint of construction. Vernacular architecture promotes sustainable management of natural resources and improves building resilience to climate change.

IX. CONCLUSION

In summary, this work has allowed us to provide a comprehensive overview of existing approaches to vernacular architecture, highlighting traditional and colonial construction methods along with their strengths and weaknesses. Finally, we presented our affordable housing model and its economic, social, cultural, and environmental impacts, paving the way for a discussion on the viability and sustainability of housing in Yaoundé.

REFERENCES

[1]. Hassan Fathy. (1973). Architecture for the poor: An Experiment in Rural Egypt. Chicago (United States): The University of Chicago Press. 369p.

[2]. L’office de la Recherche Scientifique Outre-Mer (1952). L´habitat au Cameroun. Paris (France) : L´Union Française. 155p.

[3]. AUGEA International. (2008). Yaoundé 2020 plan directeur d’urbanisme.

[4]. B. Mempouo, M. Kone, V. Kitio. (2015). UN-Habitat project “Promoting Energy and Resource Effciency in Buildings in West Africa”. Report 01: Compilation of climatic data according to climatic zones of Cameroon

[5]. M. Kone, B. Mempouo, V. Kitio. (2015). UN-Habitat project “Promoting Energy and Resource Effciency in Buildings in West Africa”. Report 03: Energy and Resources Effciency in Building Codes in Cameroon

[6]. Climate.OneBuilding. (2021). climate data for building performance simulation. https://climate.onebuilding.org/WMO_Region_1_Africa/default.html

[7]. ONU-Habitat (2015). Conception de bâtiments durable en milieu tropical : Québec (Canada). 426p

[8]. NDE K. S. B, Mempouo B., Aba N. A. (2024). Repenser le logement abordable à Yaoundé : le système architectural vernaculaire au service dune architecture interculturelle durable à Yaoundé . Non-publié.

[9]. NDE K. S. B, TSAFACK D. L. M, Mempouo B., Aba N. A. (2024). La crise du logement abordable a yaounde : problemes, enjeux et action publique dans la ville de yaoundé. Non-publié.