Bioclimatic strategies in a rural house in the district of Moyobamba

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Abstract

The objective of the applied project is to propose a design applying Bioclimatic strategies in a rural house in the district of Moyobamba Lima Peru, taking into account the problems related to local construction systems, seismic vulnerability, climatic phenomena such as the flooding of the Mayo River and Water Pollution. As constructive strategies, bioclimatic criteria were applied considering the climatic variables and their construction systems of the place, for the proposal they were supported with digital tools, likewise, the future proposal is based on solving the security, comfort, and vulnerability of the houses and that it serves as a model that allows adapting for its implementation of the same, respecting its identity of the population and the care of the environment, being that the house is considered with a natural air conditioning.

Keywords: Local construction, systems, seismic safety, environment.

I. INTRODUCTION

In the city of Moyobamba, the flooding of the Tonchima and Mayo rivers is the leading cause of the deterioration of the structural system of local housing, especially in the surrounding rural areas. The current construction system is not conditioned to face the constant problem, and in some cases, the structure of the houses has been totally lost. On the other hand, the architecture of the zone is not the typical tropical architecture of the jungle, in which palafittes are used to rise above the water level or to allow the flotation of the houses when the river rises, on the contrary, they have an architecture that resembles the architecture used in the highlands, due to the inheritance of its Chanca past. The fact of suffering this type of unfortunate event causes the structural system of the local houses in the affected areas to deteriorate in a short time and have to be replaced [1].

Likewise, the seismic safety of buildings in the city of Moyobamba is deplorable, considering that it is located in seismic zone 3 of high seismicity, standing out even more in the periphery. Traditional local construction techniques show no knowledge of seismic aspects. The wall materials are tapial without any structural reinforcement for the reasons described. Due to the large number of constructions that follow the vernacular typology of the area, they are greatly affected when telluric disasters occur, frequent in the region [2].

Finally, the discharge of sewage directly into the river causes discomfort for the citizen due to foul odors and visual pollution that brings discredit to the local population that plans to remain tourist, and this is generally because the houses do not act as the ecosystem that does manage to filter the water. If correct water treatment is achieved in the locality, these will bring significant benefits [3].

II. LITERATURE REVIEW

A. Bioclimatic design strategies

Can be defined as those seeking to take advantage of the climate and environmental conditions to achieve a situation of thermal comfort inside [4]. It plays exclusively with the design and architectural elements, without using mechanical systems or energy inputs [5][6][7].

B. Bioclimatic design

It consists of the design of buildings taking into account climatic conditions, taking advantage of available resources (sun, vegetation, rain, winds) to reduce environmental impacts, and reducing energy consumption [8].

C. Rural housing in the bioclimatic zone: Humid Tropical

It can be understood that in this type of climate, to cool down in the heat of the area, the body produces sweat which, when evaporating, absorbs heat producing a decrease in body temperature. However, when the humidity is high, it is more difficult to evaporate the sweat, which the wind can favor. For this reason, in future proposals, the prevailing winds are sought, with openings oriented so that cross ventilation can be established, in addition to wide overhangs for protection from the sun and rain [9][10].

III. MATERIALS AND METHODS

A. Elaboration of methodological scheme

IEECP'23, July 11-12, 2023, 3rd European Conference

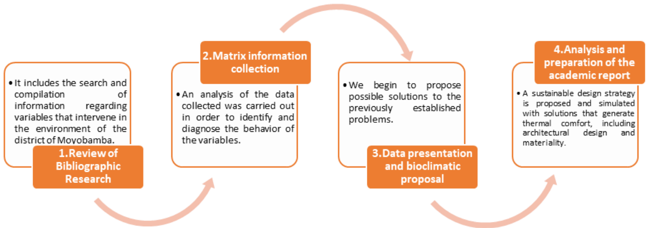

Figure 1. Study phases.

Figure 1 evaluates the phases of the study, contrasting initial data with a series of procedures to achieve strategies that guarantee an architectural solution to the initial problem [11].

B. Study site

The district of Moyobamba is located in the northern part of the department of San Martin, is located on the Alto Mayo valley; on the east and west flanks of the valley, there are Amazonian Mountain ranges that allow the city to have a pleasant and cool climate. [12] The district of Moyobamba was chosen for the project because the province of the same name covers an area of 400,776.81 hectares, being the largest with 280,814.79 hectares, representing 70.07% of the entire region [13].

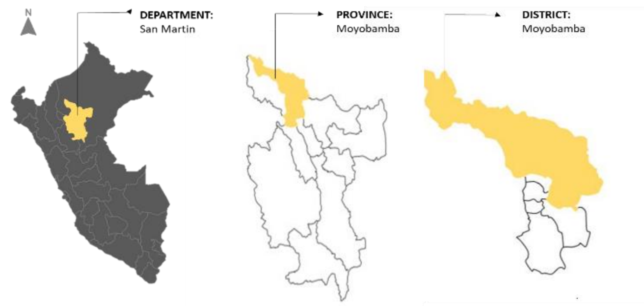

Figure 2. Map of departmental, provincial, and district locations.

Figure 2 shows the delimitation of the study area from the macro to micro-level. Likewise, the following points were taken into account; the limits of the urban area are found to the North with the flat surfaces, destined for agricultural use, it has the Mayo River as a natural limit, to the South with ravines that separate it from the forest (adjacent to the thermal baths) to the East, with the Rumiyacu ravine, and to the West, with the Indañe ravine. The topography of the territory is typical of the mountains. 74% of the region has slopes more excellent than 25%, and the remaining 26%, located mainly on the right bank of the Mayo River, has a 5% slope (relatively gentle and undulating), which is why most of the population centers are located in this area [14].

1) Climatology

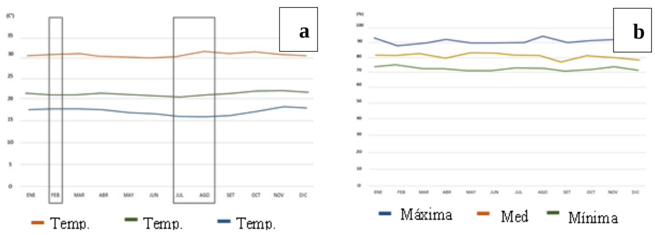

Figure 3. Maximum, average, and minimum temperature graph (a). y Relative Humidity-Maximum, average, and minimum humidity diagram.

Figure 3(a) shows that the coldest month is February, with an average temperature of 21.8°. The warmest months are July and August, with an average temperature of 24.5°. The maximum temperature reached during the day is August. And the minimum temperature went night is in August -12.8° [15] and the (b) shows that the most humid months are April and May (85%). The lowest humidity is September (78%). The maximum moisture reached night is in December (93%). And the minimum humidity reached during the day is in May, June, and August (71%).

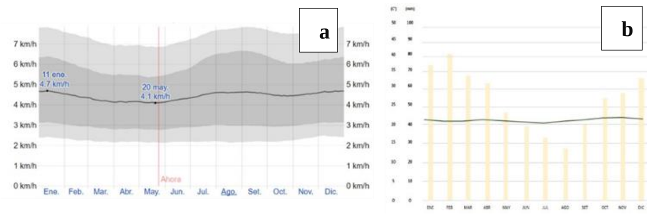

Figure 4. Wind speed, orientation, and frequency graph (a). y Precipitation diagram -Ombrotemic Chart.

Figure 4 (a) shows that the average hourly wind speed does not vary considerably during the year and remains within a range of plus or minus 0.3 km/h to 4.4 km/h. For example, January 11 presents the windiest day of the year with an average of 4.7 km/h. Conversely, may 20 shows the calmest day with an average speed of 4.1 km/h and 4 (b), it is observed that in Dec/Jan/Feb/March and part of April, there is more precipitation in the summer solstice; in the rest of the months, there is less precipitation in the winter solstice.

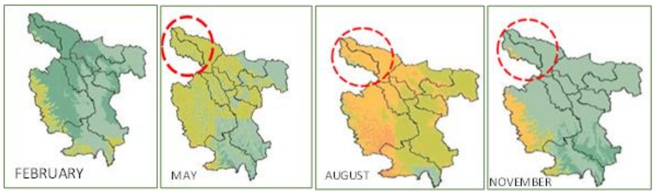

Figure 5. Solar Radiation Graph

Figure 5 shows the solar radiation in February, May, August, and November. For example, in February has solar radiation of 4.0 kW h/m2, in May has solar radiation between: 5.0-5.5 kW h/m2, in August has solar radiation that varies from: 4.5-5.0 kwh/m2, and in November has a solar radiation income that goes between: 5.56.0 kwh/m2.

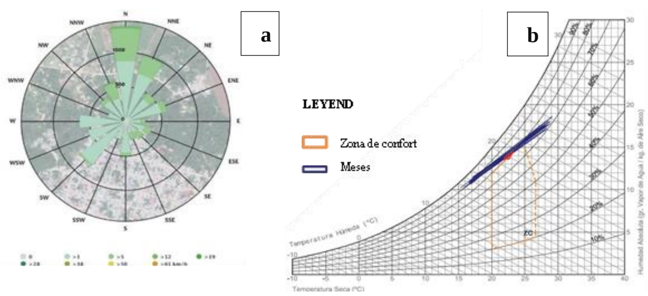

Figure 6. Wind rose(a) Psychometric abacus (b)

Figure 6(a) shows the predominant winds from north to south with an average speed of 5 km/h.

Figure 6(b) also shows the average annual conditions and the average monthly oscillation of temperature (ºC) and relative humidity (%) of the air in the capital of Moyobamba. From the above data, a closed line (red color) representing the monthly average conditions throughout the year and twelve lines indicating the needs of a typical day of each month are plotted on the psychrometric abacus.

IV. RESULTS

A. Architectural proposal

1) Relationship with the environment

The chosen lot is located on Calle Interoceanica, it has an approximate area of 13400m2 and is considered a typical area of the area, with uniform soil and climatic characteristics throughout the area, it is considered as a starting point for the realization of the proposal of typical house. Likewise, the low flow of vehicles and pedestrians can be seen, having a context where the houses that surround it are in very poor conditions, endangering the citizens of the area.

Figure 7. Proposed land.

Figure 7 shows that the proposed site is located 112 m from the river's edge, located in the rural area of the district with large extensions of wooded areas—generally residential, ecotourism, and ecological protection zones [16].

Figure 8(a) showed the cross-section A-A of the land adjacent to the fluvial border of the Mayo River and surrounded by an agricultural zone; the slope varies from 812 m altitude to 801 m altitude, thus showing a very long slope. Likewise, figure 8(b) shows the cross-section B-B of the terrain where the rural and agricultural zone is observed; the pitch varies from 809 m to 801 m of altitude.

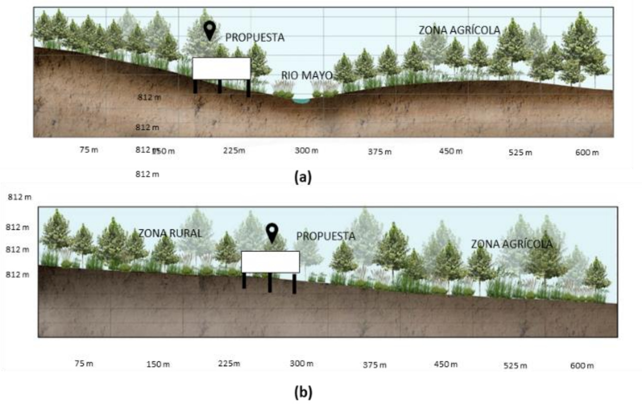

Figure 8. Moyobamba-Corte A-A (a), y Moyobamba -Corte B-B.(b)

B. Plans

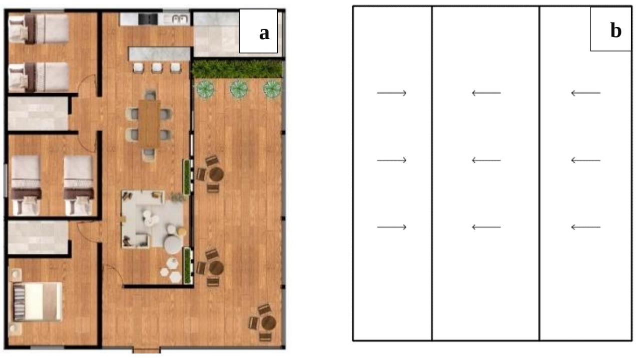

Figure 9. Floor plan (a), and Roof plan. (b)

Figure 9 shows that the social area is strategically ventilated and illuminated using openings and vertical vegetation in the mornings. In contrast, the private room will be kept warm for the humid nights. Figure 9(b) also shows the roof plan where the use of green roofs can be observed and the use of solar panels to take advantage of solar radiation to generate electricity [17][18].

Figure 10. Cross-section: a - a"

Figure 16 shows the first cut, passing through the transverse center where we observe the dining room, kitchen, main room, and terrace.

Figure 11. Longitudinal cut: b- b"

Figure 17 shows the first cut, passing through the longitudinal center to see the primary and secondary bedrooms.

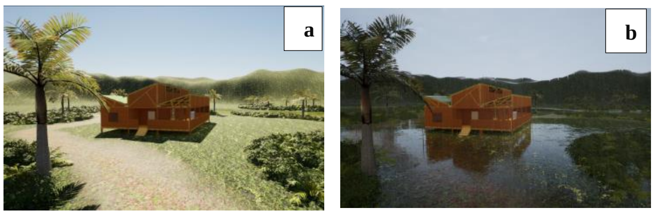

Figure 12. Outdoor views on sunny and rainy days

Figure 12(a) shows the volumetry on a sunny day and its easy accessibility. Figure 12(b) also indicates the volumetry on a rainy day with piles that raise the volumetry and protect it from possible flooding.

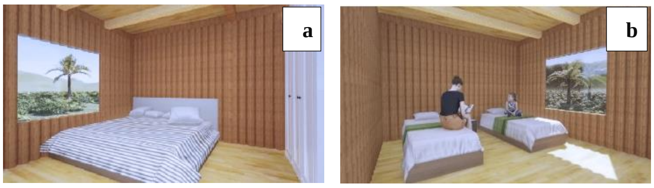

Figure 13. Mosquito netting system

Figure 13 shows the entry of lighting through the openings and the use of mosquito nets to control the access of small insects.

C. Environment Construction system

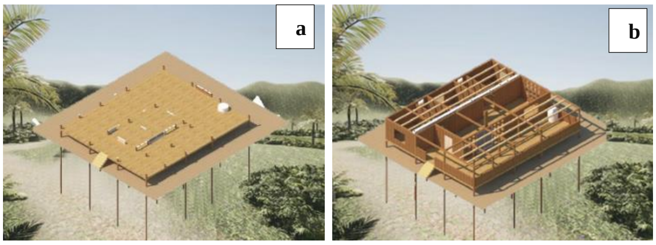

Figure 14. Axonometry of the cemented platform. (a) Axonometry of the corridor roof axonometry. (b)

Figure 14(a) shows the axonometry of the cemented platform. It is possible to see a platform elevated on stilts in case of any river flooding, the wind that crosses the platform generates a new and pleasant space. Figure 14(b) also shows a double height in the social area to ventilate by thermosiphon effect.

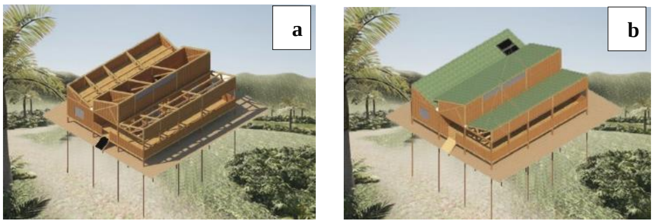

Figure 15. Axonometry floor plan one walls and zenithal illumination (a). Proposed axonometry (b).

Figure 15 (a) shows the roof to control thermal comfort in the private area and the use of zenithal lighting using an east-facing lantern, smaller openings to avoid temperature losses, and a structured corridor roof as a scissor-shaped roof for more excellent ventilation. Figure 15(b) also shows the use of sloped ceilings to control rainfall and polycrystalline panels that can absorb heat at a higher rate for daily consumption, with a sloped roof covered with local vegetation to direct solar radiation [19].

1) Columns and beams

Bamboo was used because it is resistant, light, and flexible. In addition, it generates spaces with greater height and adapts to different trusses because it can function as a structural reinforcement or as a substitute for wood in some construction processes; it is also a renewable material and does not generate a negative impact on the environment, such as deforestation [20].

2) Roofs

Bamboo, a typical material of the area, was used throughout the structure and placed on a slope for rainfall; it is a material with excellent seismic behavior and low construction costs, making it a very economical material.

3) Walls

Based on chestnut wood, it acts as a thermal and acoustic insulator. It also absorbs or transfers humidity to the environment. It is a very stable and durable type of wood for carpentry and construction.

4) Flooring

Made with chestnut tongue and groove wood material, it is a wood of great stability against humidity changes due to its resistance.

D. Climate control strategies

1) Lighting Scheme

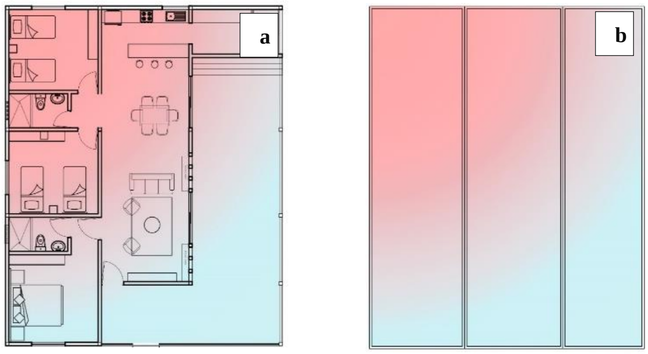

Figure 16. Lighting scheme

Figure 16(a) shows the illumination entering through the openings. Figure 16(b) also shows the description entering through the roof.

2) Fog catchers

Technology was applied at the site to capture the fog in the study area, which is present in the early hours of the day. The operation of this technology consists of trapping water from the mist using a net that transfers the moisture to a reservoir for storage. The possible use of the water helps wash clothes, hands, and dishes and improves agricultural productivity [21].

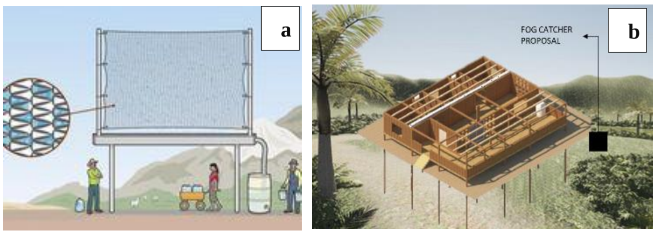

Figure 17. Fog catcher system

Figure 17(a) shows the mist trap system and the collector using a storage tank. Figure 17(b) also offers an exterior view of the mist trap for better collection.

3) Solar panels

Solar panels can absorb heat at a higher rate and are less affected by overheating [22].

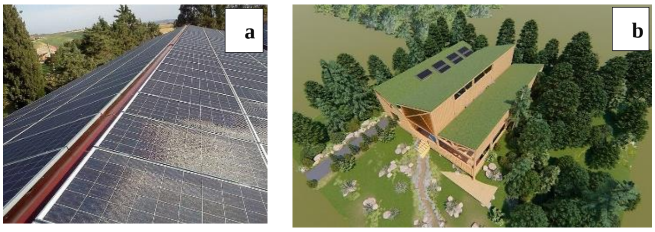

Figure 18. Roof panels for rural housing (a). polycrystalline panels (b).

Figure 18(a) shows elements such as solar radiation collectors for power generation; seven polycrystalline panels are used on the roof of the rural house. Figure 18(b) shows the polycrystalline panel 320, which produces about 9 watts per day. The energy required will be calculated using the following table in a rural house.

Table 1. Electric power requirement.

Electric Power Calculation						
Item	Description	Power	Quanti-ty	Installed power (watt)	Time of use (hours/day)	Energy consu-mption (W-h/day)
1	Saving spotlight	15	10	150	6	900
2	Radio	18	1	18	6	108
3	Television	90	1	90	10	900
4	Charger	5	4	20	4	80
			TOTAL	278		1988

Table 1 shows the energy requirement in a rural house. To estimate the demand, an analysis of energy consumption per house will be made, taking as appliances used in rural areas.

For them, the use of 4 useful devices is determined, which are:

Saving light bulb = (360 W-h/day)

Radio= (108 W-h/day)

Television= (900 W-h/day)

Cell phone charger= (80 W-h/day)

Therefore, it can be concluded that the energy demand required for a daily consumption per household is (1988 W-h/day) or (1.45 kW-h/day).

Table 2. Calculation of polycrystalline panels.

Calculation of polycrystalline panels				
Item	Description	Power	Quantity	Energy consumption (W-h/day)
1	Polycrystalline panels	320	7	2240
			TOTAL	2240

Table 2 shows the energy demand achieved by a polycrystalline panel with an energy production of 320 watts per hour. To cover the energy demand of the house, it is necessary to install 7 polycrystalline solar panels of 320 W 24 V, producing a total of 2240 watts per day, thus covering the energy demand of the rural house.

4) *Rainwater Filtration System*

Figure 19. Location of gutters in a cross section (a). Rainwater collection systems. (b) Rainfall filtration system.

Figure 19(a) shows the cross-section and the location of the rainwater collection gutters. Figure 19(b) also indicates the rainwater harvesting system and its storage in a water tank, which will be a temporary reserve that helps regulate the inflow of water to the tank according to the intensity of the rainfall. The use of gutters for water collection is one of the best alternatives to save water and not to waste it [23].

5) *Domestic water recycling systems.*

Collect used water from washing and reuse it in the toilet. The water is filtered and disinfected, and stored in a tank under the sink, keeping only what is necessary for filling [24].

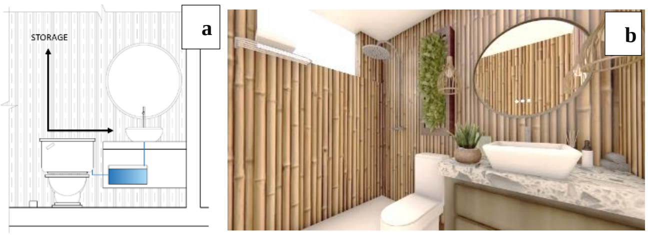

Figure 20. Domestic water recycling system.

Figure 20(a) shows the domestic water recycling system diagram where the wash water is stored and then used in the toilet. Figure 20(b) also indicates an isometry of the domestic water recycling system and the interior of the space where bamboo, a typical area material, is used.

6) *Ventilation through gardens*

Figure 21. Garden ventilation

Figure 21 shows the planters next to the large windows that will allow regulating the internal temperature of the environment using vertical vegetation through a mesh wall, thus circulating the air throughout the social area of the house.

E. Solar Path

1) Solstices

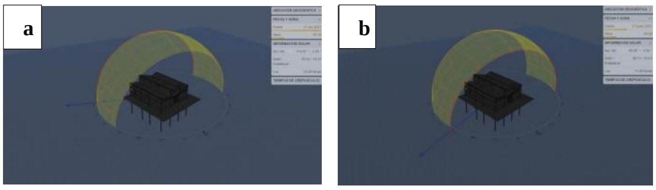

Figure 22. Summer solstice 6:00 a.m. (a). Winter solstice 6:00 a.m. (a).

Figure 22(a) shows the ingress of light at 6:00 a.m. on December 21 at the summer solstice. Figure 22(b) also indicates the ingress of sunlight on June 21 at the winter solstice.

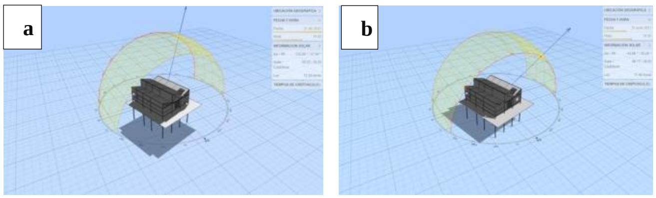

Figure 23. Summer Solstice 2:00 p.m. (a). Winter solstice 2:00 p.m.

Figure 23(a) shows the ingress of light at noon around 2:00 p.m. on December 21 at the summer solstice. Figure 23(b) also indicates the ingress of sunlight on June 21 at 2:00 p.m. on the winter solstice.

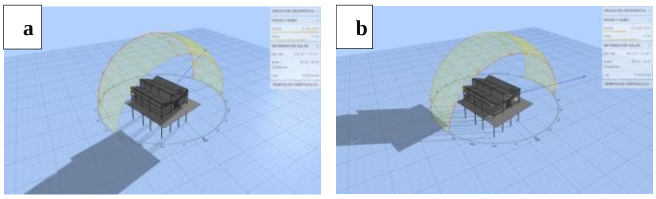

Figure 24. Summer Solstice 6:00 a.m. (a). Winter solstice 6:00 a.m. (a).

Figure 24(a) shows the ingress of light in the afternoon around 5:00 p.m. on December 21 at the summer solstice. Figure 24(b) also indicates the ingress of sunlight on June 21 at 5:00 p.m. on the winter solstice.

2) Equinoxes

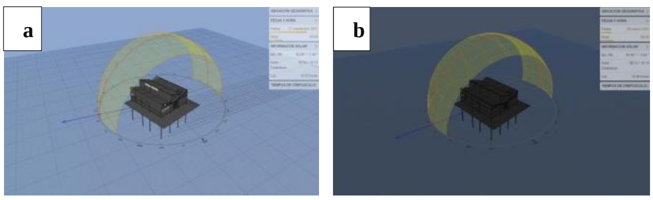

Figure 25. Spring Equinox 6:00 a.m. (a). Autumnal Equinox 6:00 a.m. (a).

Figure 25 (a) shows the incoming sunlight on the morning of the vernal equinox on September 21 at 6:00 a.m. Figure 25 (b) shows the incoming sunlight on the morning of the autumnal equinox on March 21 at 6:00 a.m.

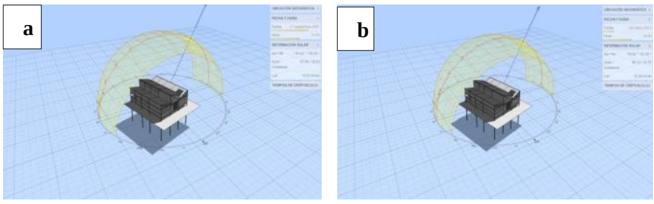

Figure 26. Spring Equinox 2:00 p.m. (a). Autumnal Equinox 2:00 p.m. (a).

Figure 26(a) shows the incoming sunlight at midday on the vernal equinox on September 21 at 2:00 pm. Likewise, figure 26(b) shows the incoming sunlight on the morning of the autumnal equinox on March 21 at 2:00 p.m.

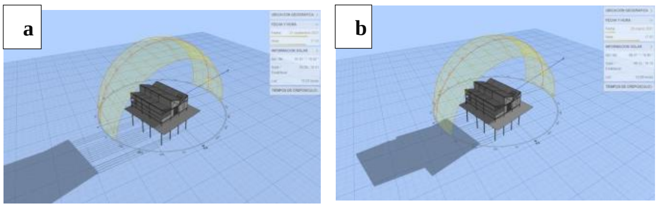

Figure 27. Spring Equinox 5:00 p.m. (a). Autumnal Equinox 5:00 p.m. (a).

Figure 27(a) shows the incoming sunlight in the afternoon of the vernal equinox on September 21 at 5:00 pm. Likewise, figure 27(b) shows the incoming sunlight on the morning of the autumnal equinox on March 21 at 5:00 p.m.

V. DISCUSSION

It aims to generate comfortable conditions inside living spaces in hot, humid climates using natural ventilation and solar protection [24]. Analysis of the induced ventilation in living space by means of a Hydro-Solar Chimney system. An analysis of bioclimatic design and architecture was carried out, taking as a premise the sustainability between user, environment, and built space [26][27][28]. The efficiency of "pit light" traps with LED for sampling nocturnal Coleoptera (Insecta) in tropical rainforests. (Insecta) in tropical rainforests.

The study's main objective was to answer the following questions: in terms of abundance, richness, and diversity of species [29].

VI. CONCLUSIONS

- ✓ Sustainable housing was proposed to solve those points in which the traditional typology of local housing could not. This is the case of the prevention of river overflows and the use of a suitable structure for the type of soil, piling.
- ✓ The interior thermal oscillation of the house is higher than 10C° throughout the year, so the architecture is designed to ventilate during the day and in turn, allow the heat received by walls and ceilings. along it to be transmitted at night through the use of thermal inertia construction systems that have this type of flexibility. Thermal comfort criteria were applied in the housing proposal considering cross-ventilation based on the direction of the prevailing wind from the north, and sunlight, considering the solar gain in the afternoons to the west.

- ✓ The use of energy technologies such as photovoltaic panels, which supply energy to the home, was considered; the "Aquis" system to save water consumption, and fog over collectors and rainwater harvesting systems.

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