COLOMBIAN VERNACULAR GREENHOUSE

Our proposal is born from a state of reflection on how life is lived today in the Colombian countryside; a territory of meetings and misunderstandings, of internal movements, of productive fertility, traditions, flavours, colours and of farmers who every day look for an opportunity in this environment that for many is abandoned. According to the DANE in 2013, there was more housing deficit in rural areas than in the city, and in Bogotá in particular, the deficit reached 40%, leaving the farmer in a state of extreme poverty. This means large-scale interventions, in vast territories, pronounced geographies, diverse cultures and in many cases extreme climates, such as the paramo area in Bogotá. We must not forget that 94% of the Colombian territory is considered rural and that more than 15 million farmers live there.

We base our proposal on the trilogy Site;Topos, Life;Typos, and Technique;Tectonics, to give consistency to the architectural work. In short, these categories for us are Landscape, Community and Material.

We understand the Landscape as the cultural place where the project is located (Belonging); the Community, as the social grouping that gives it meaning (Relevance) and the Material, as the element that shapes the architecture and maintains it over time (Permanence). These three categories are essential when it comes to articulating a productive sustainable architecture project for the Colombian rural territory.

CONTEXT.

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LANDSCAPE

"THE WATER FACTORY"

The páramos are the cold tropics of the planet. A páramo can be defined as a high mountain ecosystem, which in Colombia is located between the upper limit of the Andean forest at 2700 masl and the lower limit of the glaciers at 3500 masl. It is known as the dwarf forest because its vegetation is generally low, shrubby forest.

They are vital ecosystems for maintaining water cycles, because they allow the transformation of fog into a water resource that in turn generates the birth of lakes, rivers and, therefore, the supply of reservoirs. Nearly 70% of Colombia's water supply depends on thE páramos.

With an average temperature of 5 degrees Celsius, the páramos in Colombia occupy an area of about 3% (29,000 km^2) of the continental area of the national territory, but represent 50% of the world's páramos. Only half a dozen countries on the planet have the privilege of having páramo ecosystems

The frailejon is the king of the páramo. Colombia has 68 endemic species and the country is the second nation, after Venezuela, with the greatest diversity of frailejones. This plant is key to capturing the water that feeds the dams.

The páramos are home to more than 4,700 plant species. This indicates that, although they account for less than 3 per cent of the country's territory, they are home to 17 per cent of the country's flora diversity.

The páramos are key to climate change mitigation. They help to sequester carbon and thus regulate the global warming process

It is for these reasons that it is necessary, at a time of ecological crisis, to develop housing in this area of the national territory where water is born.

COMMUNITY

THE FARMER, PROTAGONIST OF THE 21ST CENTURY.

The current situation in the world, the Covid-19 pandemic, has highlighted the importance of farmers in the current situation. Nothing worries the world more than the possibility of food shortages in a paralysed world.

While many sectors are facing a recession, Colombian farmers continue to offer their service to the countryside, avoiding food shortages. Even though they not only face problems of food distribution and production in Colombia, but also exposure to a virus that can stop them in their tracks and dam up their farms' food supply.

"Farming agriculture represents more than 70% of the country's production and may stop if an effective distribution system is not generated in the pandemic," said the Ministry of Agriculture this year.

The Food and Agriculture Organization of the United Nations, FAO, recognizes that Colombia has the potential to be a food pantry in the world, therefore, it is important to protect the lives of our farmers, invest in technology to improve the conditions of agriculture, and the supply of products to all sectors and regions. Despite the fact that Colombia is a country rich in food, the FAO carried out a survey in which some 1,086 producers in the country spoke of the difficulties they have had in times of pandemic.

In the results, according to the FAO, 87% of the producers consulted stated that they have had difficulties. The survey, which was carried out this year in 20 departments of the country, shows that the lack of tertiary roads, distribution channels, different climatic events such as droughts and windstorms, and the lack of decent housing are the main problems affecting the outlook for Colombian farmers.

Even for those who decide to make the collection, given that it is difficult to transport the items to Bogotá because many truck drivers fear that they will be infected with covid-19.

In Colombia, the agricultural sector generates 3.5 million jobs (15.8% of the total) and family farming accounts for more than 70% of production, making it essential for food security.

Therefore, the Colombian countryside needs to talk about distributing land, deprivatising water and extending the coverage of irrigation water, adapting its roads for distribution, but, above all, it needs decent housing for the main protagonist of the 21st century, the farmer.

Adequate housing, as the UN calls it, dignified housing for many people, is recognised as a right in international instruments including the Declaration of Human Rights and the International Covenant on Economic, Social and Cultural Rights. A house is something more complex than just building, as is often the case, a space with four walls and a roof. A house is more than a house, and is about the life that happens in it.

The decent housing we propose is an expression of the diversity of practices and traditions of cultural human groups. It is the expression of the farmers' way of life. It is for this reason that housing must be understood as the clearest and most representative expression of a culture and a community. This is the DNA of rural life.

MATERIAL

WOOD, THE ONLY MATERIAL THAT STORES CARBON.

Higher thermal insulation, lower CO_2 emissions and higher sustainability compared to other materials such as steel and brick are some of the reasons that have made wood a popular material in recent times.

Steel is 19th century, concrete is 20th century and wood is 21st century

Wood has been one of the main building materials in human history.

According to research, 70% of all new houses built around the world are now made of wood. In the UK, the figure stands at 25% and experts say this figure is set to rise over time as more and more people become convinced of its great benefits.

As governments continue in their attempt to combat the housing deficit, it appears that wood may provide a way of supplying affordable houses that are cost-effective to live in and can be built in half the time of a traditional brick-built home.

The traditional construction industry is responsible for 50% of polluting particles in the environment, 40% of total energy consumption and 50% of natural resources. To obtain materials such as cement, kilns are used with temperatures of more than 1,000ºC that destroy waste materials and go directly into the atmosphere, even leading to the deforestation of areas completely for the creation of quarries and toxic discharges into groundwater, in addition to the damage caused by the machinery used and the pollution it causes.

To effectively combat climate change, we need to remove CO_2 from the atmosphere and reduce carbon emissions. Responsibly sourced timber achieves both of these goals.

To produce 1 kg of wood, a tree consumes 1.47 kg of CO_2 and returns just over one kilogram of oxygen to the atmosphere. When trees are planted and used to make wood products, carbon remains stored in the wood for the life of the product. About 50 percent of the dry weight of wood is carbon.

It is preferable to have carbon stored in trees and wood products on the Earth's surface rather than in the atmosphere, where it contributes to climate change. Using wood to build efficient and durable housing will help reduce the amount of carbon dioxide in the atmosphere.

The use of this wood is controlled by agencies such as the FSC, which controls the companies that manufacture with wood, the policy is clear, one tree is felled and another is planted, and they leave areas for decades for the land to recover.

Wood has excellent static characteristics and is resistant to high temperature fluctuations, weathering and moisture, which is shown, for example, in the world's oldest buildings: wooden houses. Wood is not only stable and durable, but also offers high load-bearing capacity at low weight. That is why today we can see entire timber-framed buildings, such as the HoHo in Vienna, which, with its 24 floors, is the tallest timber building in the world. In addition, timber constructions are more resistant to earthquakes than their concrete counterparts, which is why timber structures are very popular in Japan in areas of high seismic risk.

One aspect of building construction that is increasingly being taken into account is energy efficiency, and wood is exceptional in this respect, as it has good insulating properties in itself and has low thermal conductivity. A well-insulated timber structure can save a great deal on heating costs in winter. As a thermal insulation material, wood responds slowly to temperature fluctuations and has a positive effect on the indoor climate.

Wood allows for prefabrication. This means that the components are planned in advance down to the last detail and manufactured on the production site. The prefabrication process is not affected by rain, strong winds or snow, so that it can be carried out with the maximum precision. The elements are then transported to the construction site, where they are assembled and the construction is completed. The house can be built in just a few weeks. This allows for very low impact on the site. Another advantage of prefabrication of timber is that construction costs can be better controlled. Prefabricated timber houses have a fixed cost and a delivery volume that is detailed in advance.

This natural primary material regulates the humidity of the air in the building by absorbing it and releasing it again when the atmosphere becomes too dry. In addition, on cold days when the outside temperatures are freezing, the walls of a timber construction keep the heat in thanks to their insulating properties, creating a real oasis of well-being for relaxation.

As wood is a material composed of hollow fibres, aligned axially along the length of the tree, these hollows or spaces contain trapped air which gives it excellent sound and heat insulating qualities. In terms of sound insulation, wood has values of more than 10 times that of reinforced concrete and 5 times that of drywall. Sound insulation can be increased by leaving gaps between the timbers, or by using insulating materials such as straw, rice husks, or other natural materials. In relation to thermal insulation, wood is excellent. In this respect, it is approximately six times

more efficient than brick walls, fifteen times more efficient than concrete or stone and 400 times more efficient than steel. If combined with other materials such as soil or adobe, it can satisfy insulation requirements in the most extreme climates. As an electrical insulator it is efficient when the wood is dry, when its damp content is below the saturation point of the fibre.

During 2019, 178 thousand hectares of natural forest were deforested in Colombia. Eighty per cent of the national territory is forested, but only 52 per cent is covered by forest.

The country has 530,000 hectares of commercial forest plantations. For example, Smurfit Kappa has 42,000 hectares, mainly of pine and eucalyptus.

In Colombia, a permit is required to move timber or a pass if the timber comes from the natural forest. Also, forest plantations are registered with the Colombian Agricultural Institute (ICA).

In summary, we can say that building with wood has several advantages: it is a sustainable material, because it comes from renewable natural resources; it is much more environmentally friendly, since it absorbs CO_2 from the atmosphere; and, finally, construction is much faster, it is cleaner, more resistant and the houses last a very long time.

In rural Colombia there are a total of 2,385 housing units. Of these, 2,109 houses are dispersed, equivalent to 90.9 per cent, and 211 houses are concentrated (generally in population centres), equivalent to 9.1 per cent of the total number of settlements.

The panorama today of rural housing as an architectural solution is non-existent, apart from private initiatives to extract ideas from the academies and other entities that promote the subject, the housing project that is built in rural territories lacks all dignity.

Housing on vulnerable land, massive use of materials without thermal response, electrical intermittency, and improvised sanitation systems are some of the problems that the farmer lives in a daily life. This means that when we speak of rurality we have a direct image of poverty and lack of opportunities, which has resulted in an exodus from the countryside to the city and the abandonment of productive forestry and farming activities that are essential for family sustenance.

CONCEPTUAL STRATEGY.

This stage opens the opportunity to rethink Bogotana's rural housing, from the concrete idea of resilient habitat, this means a house that as a principle adapts and overcomes the mentioned adversities by producing its own food, heating its interior, growing together with its inhabitants, respecting its architectural and spatial traditions (vernacular) and allowing it to be part of a community.

We propose as a conceptual strategy the link between: the vernacular of inhabiting a roof, a primitive typology of architecture, and the generation of heat and energy through the greenhouse, a thermal production space in the home.

DESIGN STRATEGY.

A Greenhouse is not only an enclosed spatial structure covered by transparent materials, it is also a covered yard for rainy seasons, a place to produce and protect our food from freezing, a space for family and community meetings, a thermal heating device for a house in a safe and efficient way.

We also believe that a roof is a habitable structure, a place, a spatial surface that protects from the inclemency of the weather, it is what people demand in the streets, an essential element when we think about housing. Apart from being made of different materials, it represents a longing and desire to live in dignity. A roof is a primitive element of our ancestral cultures; the Maloca in Colombia, Ruca in Chile, Choza in Central America and the Caribbean and the Marae in New Zealand, are architectures of great communal importance, mostly built with a roof. The roof is the spatial cultural essence from which we support this project.

We design a house as a thermal cover, which gives shelter inside it to the relationship between the productive and everyday life of today's farmer.

The proposal is based on an elementary principle of support that makes it possible to build a covered living space by using two inclined planes supported by each other to form a traction triangle. The wooden structure made up of triangular frames forms the volume of the house-greenhouse and reinforces the roof, which is the house.

ARCHITECTURAL SOLUTION.

The project puts the farmer at the centre of the spatial conversation today. Understanding the people who live there, their lifestyle, their traditions, their movements, is essential in order to be able to spatialise their reality. The work of the architect Alberto Saldarriaga, who in an anthropological way studies particularly farmer's housing, does just that, it emphasises the person who lives in the house, and on a parallel plane the space of the house. This seems important to us as it puts the farmer in his biocultural dimension back at the centre of the issue of rural housing.

This biocultural dimension has to do with the ways of life of the farmers in and with nature, with life inserted in the cycles of life. In the case of rural housing, this dimension is composed of a significant number of variables that need to be taken into account for the design of a sustainable and productive residential habitat: Accessibility, Vernacular Architecture, Materials, Costs, Spatial Comfort, Dignity, M3 vs M2, Topography, Slope, Progressive Growth, Climate, Replicability, Prefabrication, Less Environmental Impact and preservation of nature, Community Building, Food Production, Use of Alternative Energies, generation of economic resources.

For these variables to operate in an architectural design we have grouped them into 3 important categories which we will define:

1. Sustainable productive habitat.

2. Sustainable intimate hábitat

3. Sustainable geographic habitat.

1.- SUSTAINABLE PRODUCTIVE HABITAT.

From a holistic conception, the notion of habitat refers to being and being on the land. This goes beyond using, occupying, or sheltering under, as the dynamic process of inhabiting results from the confluence of different and distinguishable layers between the natural, the social, the economic, the cultural, the political, the emotional, the physical-spatial, the mystical and the technological among others (Chardon, 2010).

We believe it is important that when we understand production, we must also understand consumption, and therefore the life cycle inside the home. Sustainable consumption and production, according to the UN, consists of promoting the efficient use of resources and energy, environmentally friendly construction, improved access to basic services and the creation of green jobs. All of this translates into a better quality of life for all and also helps to lower economic, environmental and social costs, increasing competitiveness and reducing poverty.

FOOD PRODUCTION

We propose the construction of a greenhouse garden that produces, in a temperature-controlled space, the food necessary for a farmer's family, using the organic waste as compost to fertilise the soil. In this way, the cycle of productive food production is renewed and does not produce negative impacts on the environment.

ENERGY PRODUCTION.

We believe it is necessary to promote energy self-production in communities that are far from the interconnected electricity net. That is why we propose the installation of 8 photovoltaic solar panels on the roof of the house, for the generation of energy supply. At the same time, we propose the installation of a mini wind turbine of 3 metres in diameter which produces 18 kWh of energy. These two devices combined will allow the house to be supplied with energy at different scheduled times. This will eliminate the use of storage batteries, which are polluting elements of the environment.

We have also installed a thermal radiator on the roof of the house to provide us with clean and natural hot water. In this way we reduce the consumption of natural material for the generation of fire, the main pollutant of CO_2 in the environment.

Finally, we propose the installation of fog catchers, which will help to collect water from the fog and clouds, which will be used to irrigate the garden.

SUSTAINABLE INTIMATE HABITAT.

"The house is our corner of the world. It is our first universe".

The spaces of a house are lived from the intimate, to observe the public from there. Each place and each object inside the house are the only witnesses of the intimacy of a family, which is sheltered and protected under a roof.

By inhabiting a house, we also learn to inhabit our interior. The spaces of the house are in us, just as we are in them. This is what Gaston Bachelard proposes, who thinks of the house as a shell in which life is created, and a nest, where it takes refuge.

The experiences that a house stores are the memories of an intimacy connected with smells, materials, sounds, light, warmth, humidity, spaciousness, flexibility.

MATERIALITY / VERNACULAR ARCHITECTURE.

We propose a house where there is a direct experience with the material, as it is this that keeps the smells, marks the light, plays with the sound, gives the temperature, and is built according to the logics of the vernacular tradition. By means of a prefabricated wooden structure, the whole structure of the house is built, which functions as the earthquake-resistant skeleton. This completely covers the walls, floor and roof with wood, a material that contributes to the thermal comfort of the house. On the outside, as another skin and covering the whole volume, we propose glass, as a material that closes the thermal skin system of the house. These two elements work together perfectly in cold high mountain climates.

Inside the wooden structure of the roof, we have prefabricated a thermal and acoustic insulation system based on soil, straw and wood. This system, called bareque, is one of the main construction techniques of the Colombian countryside. This technique has been used for many years for the construction of houses especially in indigenous peoples of America, even before the adobe.

M3 VERSUS M2 / THERMAL COMFORT.

We have designed a rural house that is not only understood in terms of its M2, this means that it is not only a ground plan design, but by involving its height, due to the fact that we are building a roof, we begin to perceive the complete volumetry of the house, therefore the m3 of it, the volume of air that exists in the interior.

First of all, this allows a more precise control of the indoor climate of the house, as the volume of indoor air is understood in relation to the number of inhabitants. And the upper ventilation and lower air intakes of the house are efficiently controlled.

Working under this logic, which is the architectural section, the geographical variable is also introduced and with it the topographical adaptation that the project proposes. We understand housing as part of the topography and not against it.

PROGRESSIVE GROWTH

We propose a rural social housing with a progressive, controlled growth and clear parameters of spatial expansion. For this we design two types of growth. The first is determined by the internal spatiality of the house and the second by the modulation of the structure.

The first allows the second level of the house to grow from 60m2 to 84m2 if half of the second level is used and 94m2 if the whole area is used. For this, the design of the house contemplates the installation of master beams as a floor structure for the second level. This expansion area adds 2 more bedrooms and a bathroom. This results in 5 bedrooms for a family or an economical income if these 2 rooms are rented for ecotourism.

The second expansion proposal has to do with the modulation of the structure. This was designed modularly, which allows the addition of 2.5 metre wide modules to the volume of the house, making it possible to easily increase the m3 of the house.

REPLICABILITY / PREFABRICATION.

We believe that the high housing deficit that exists today in the capital's countryside does not allow us to act on a case-by-case basis. That is why we propose a prefabricated wooden design system. The use of this system makes the process more sustainable and efficient, without losing architectural quality, as proposed by the French architect Jean Prouvé. The project defines 4 stages of construction, prefabrication, foundations, installation of structure, glass roof cladding, internal finishes.

In this way, the work is carried out in a reduced time schedule, reducing the negative impact on the site, while at the same time reducing labour costs as well as material waste.

SUSTAINABLE GEOGRAPHIC HABITAT.

To live geographically is the first condition of a farmer. For them, the size of the house depends on the size of the land, its extension, the topographical conditions, the winds, the rivers, where the sun rises and where it hides, the views and the control of the relationship with their neighbours and the community, nature and their production areas. This condition becomes even more important when we know that it is in the paramos that water is born

The geography marks the design of our proposal. As the house is a greenhouse, it is oriented towards the sun to receive the greatest amount of radiation and thus be able to heat its interior. It is installed in favour of the slope, reducing overhanging supports and large foundations, resulting in long structures. It is prefabricated to provide a solution to a complex geographical variable, which is accessibility to the land. It is raised from the ground to generate the minimum environmental impact in conservation areas.

TOPOGRAPHY

It is a fact that there is no flat land in nature, and finding it in the foothills and mountains is a difficult task. The city has flattened what for nature will always be an inclined plane.

Topography is key in our proposal. From the minute we start thinking about the house in section, assuming its m3, the topography begins to be a design information. This led to the house being longer than it is wide, which favours positions in favour of the contour lines, reducing the size of the foundations, a value that is no less important when building in nature. Thus the house can grow in a more harmonious and organic way over the topography and not against it.

DETACHED HOUSES.

One of the most important variables to consider when designing a rural house is its distance from population centres. It is not depreciable to take the material to open road areas with extreme climates and intermittent energy. That is why the project we propose is solved in a prefabricated way, dimensioned in the factory, specifying each element, with the sizes and weights so that they can be transported by 6 people and carried by a two-axle tractor truck, with a length of 18.5 metres.

CLIMATE

We propose a greenhouse house that takes advantage of the effect produced by solar radiation passing through a glass pane to heat the interior environment. The thermal roof that we propose for the house is a passive solar collection system that has no moving parts. This alternative enhances the solar energy received by the roof and converts it into a simple heating system. Its main component is the roof with a double translucent skin, built with materials that allow it to absorb heat, orienting itself towards the most favourable position of the sun throughout the day.

This system is based on direct solar gain and air circulation resulting from the temperature difference. Properly managed, it delivers heat in cold areas and improves cooling in the warmer months through upward ventilation.

COMMUNITY PRODUCTION.

We observe that the rural communities that are resisting the industrial monopoly with their work today are part of a natural production cycle, guided by geographical and socio-cultural conditions. In this network, each family supports the development system from its own needs and interests in the different production times of this living cycle. We propose to strengthen this reality through a community spatial management plan for organic food production with low environmental impact in the páramos.

We propose a community that lives according to the production cycles. Preparation and fertilisation of the land, 2.-Weeding, re-fertilisation and fertilisation, 3.-Sowing, 4.-Growing time, 5.-Harvesting, 6.-Washing and drying of food, 7.-Post-harvest and packaging, 8.-Organisation of orders, 9.-Food distribution, 10.-Treatment of animal waste, 11.-Waste and excrement production of compost, to start the cycle again.

Every family can be part of this system as the design we present allows the interior space of the house to be adapted to various activities related to rural production. Air-conditioned organic vegetable gardens, training rooms for community workshops, places to store products, community meeting rooms, a restaurant for ecotourists are some of the activities that our proposal allows to develop together with the house. We propose a symbiotic relationship between the daily life of a farmer today in transformation, with the production of its resources.

By promoting the idea of community inscribed in the living cycles of agricultural production through an architectural object that is spatially flexible to the daily realities of Bogota's farmers, this proposal seeks to make a contribution to the development of productive solutions for the generation of opportunities.

In order to provide a solution to the real problem that rural Bogotá is experiencing today, we have presented a proposal that aims to provide a flexible and comfortable response to the changing productive life of the rural territory.

Residential Habitat: Productive, Intimate, Geographic.

For a world in constant change and currently disturbed by a pandemic, we believe that the response to housing must be a thermal, adaptable, communal, productive and resilient proposal, in this way we approach to mitigate the quantitative and above all qualitative deficit of rural housing in Bogota.

PROGRESS

1.- Innovation and transferability - Progress

Our prototype IVC (Invernadero Vernaculo Colombiano) takes advantage of the knowledge of the people who still live in the countryside in the Sumapaz region, where it is common to use agricultural greenhouses to grow flowers, fruits and vegetables. The greenhouse is an architectural space that allows the cultivation of crops in extra-urban areas, it is an everyday space in complex territories, and helps to air-condition the peasants' houses, improving their living conditions. (as shown in our study)

In this region the greenhouses are built with agro-industrial plastics of transitory use, which are not very ecological and sustainable. This is why we transform the greenhouse into a more sustainable and healthy solution for the farmers and the place, avoiding territorial pollution.

We propose to integrate interdisciplinary knowledge between architecture and agriculture, creating a system to inhabit rurality. Our IVC prototype works in the same way as the architecture of farmers, it is useful and elemental because it is born from the functional: everything serves and contains. It is designed to solve the basics, food security, with materials that are recyclable and integrated into a circular economy.

In our IVC prototype the structural elements are the architecture. We avoid materials that need maintenance, and if they do, they are found in the same place. We propose traditional and vernacular materials such as wood and earth, whose use is circular, efficient and proven to last over time..

The project proposes the coexistence of ancestral, peasant and indigenous materials with materials and products from agricultural production, such as irrigation systems, storage, wind turbines for the project's energy production.

We use wood from renewable forests, and earth from excavations on the site, with the aim of recovering and promoting building traditions such as tapia pisada and bahareque, thus seeking to connect architecture with human beings.

The earth is a living material close to the life of the farmer. That is why the prototype is contained in the wooden structures of Patula pine. This allows to increase the thermal inertia of the house, making the house more cosy, useful and sufficient for the farmers.

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Our prototype is an open, adaptive and configurable architecture, which can be tested with the help of its users. It is versatile to solve complementary issues to housing, such as productive spaces, sheds, warehouses, stables, garages, high mountain shelters, etc.

The advances incorporated into the process relate to prefabrication. All components of the prototype are built in workshops and shipped by truck for assembly on site. In the case of the timber structure, the carpenter's joints and couplings in the trusses are the product of robotisation.

As it is a system for living in rural areas, the house is a prototype for testing. It is necessary to carry out a user education process that starts with the construction of the house itself. The user must know how to build, maintain and repair his house. They must learn how to use the bioclimatic devices correctly, for which it is essential to draw up an operational manual that guarantees the correct and sustainable use of the project.

On the other hand, the implementation of a home automation system that uses measuring instruments to telemetrically verify energy consumption and behaviour according to variables such as climate, and to be able to make decisions to modify or adjust the habitability of the prototype and its efficiency.

Everything must be implemented through consultation workshops that involve the community, supported by professionals and community leaders, who help to transmit the project's contribution to the development of the region. Digital marketing for its dissemination will be decisive when it comes to convincing sponsorships from companies linked to the sustainable development sector and for accessing government subsidies and social policies that promote its implementation.

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PEOPLE

2.- Ethical standards and social inclusion - People

We propose to rethink the development of the contemporary countryside from the search for the essence of housing, from the vernacular and primitive villages. We understand the rural territory as a map of opportunities, for the meetings and exchanges of traditions that happen there and this is exactly how we wanted to conceive housing: a residential space that wants to build relationships and opportunities in the heart of a natural cultural landscape. This is not just a romantic vision of the past, but a learning derived from a series of ancestral knowledge that is intrinsic to the countryside and housing as an essential space)

We observe that the rural communities that are resisting the industrial monopoly with their work today are part of a natural production cycle, guided by geographical and socio-cultural conditions. In this network, each family supports the development system from its own needs and interests in the different production times of this living cycle. We propose to strengthen this reality through a community spatial management plan for organic food production with low environmental impact in the páramos.

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SUSTAINABLE GENERAL CONTEXT IN COLOMBIA

Towards the constitution of the Sumapaz Farmer Reserve Zone in the world's largest páramo (ref), as part of the Sustainable Development Plan for Sumapaz. The Farmer's Reserve Zones have been part of the OT Land Use Planning in Colombia since Law 160 of 1994. However, today, thanks to the end of the conflict in Colombia, the ancestral communities rooted in the territory are promoting this proposal.

The Sumapaz Farmer Reserve zone proposes to benefit 1,733 people so that 80% of the Sumapaz will continue to be used for conservation and 20% can be used for associated and sustainable productive projects. This initiative is also framed within the Sustainable Development Goals (SDGs) for Sumapaz (UNDP 2020), such as: sustainable cities and communities, end poverty, climate action, end hunger and achieve food security; through specific targets such as:

SDG 9: Industry, innovation and infrastructure

Develop reliable, sustainable, resilient and quality infrastructure.

Significantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in the least developed countries by 2020.

SDG 11: Sustainable Cities and Communities

Redouble efforts to protect and safeguard the world's cultural and natural heritage.

SDG 13 Climate Action

To strengthen resilience and adaptive capacity to climate-related risks and natural disasters in all countries.

THE PROTOTYPE: MATERIALS AND SUSTAINABILITY

The prototype is composed mostly of materials such as wood, glass, clay (tapia pisada), which allows a large proportion of the materials to incorporate reused materials, and then the building can be 100% recycled.

The materials chosen satisfy the following criteria:

Guarantee indoor air quality by not releasing volatile organic compounds or toxic fibres that pose a risk to the health of the people who manufacture them and the occupants of the houses.

Promote outdoor air quality by not increasing pollution, generating minimal environmental impacts and not consuming scarce natural resources.

Promote minimum energy use by preventing heat loss or gain, reducing electricity and simplifying maintenance.

Low energy consumption during manufacture

Durable, reusable, recyclable and/or biodegradable features.

Materials that will not increase waste generation because they do not need quick replacement.

Locally produced to support the local economy, minimal transport use and associated energy consumption.

The following is a description of materials from a sustainability perspective:

Metal: Roof elements such as flaps, anchorages and support tube

Knowing that steel manufacturing involves high CO_2 emissions, strategies such as recycling and reuse, possible in Colombia thanks to Law 1630 of 2013, and the use of inputs that close their life cycle (cradle to cradle), metal is one of the recycled and locally produced materials, which reduces the ecological footprint due to transport, given the possibilities of being transported by land, in addition to the benefits associated with the material such as ease of installation, low weight and unskilled labour for assembly.

The recycling of steel can be done as many times as required, and its performance reaches almost 100% thanks to its magnetic qualities that make it easy and economical to collect, which contributes to reducing the negative impacts on the environment, given that for every kilo of recycled steel, savings of up to 1.5 kilos of CO_2 (carbon dioxide), as well as gas related to climate change, are achieved.

Glass: Vitrolit cover

The Vitrolit glass cover material is manufactured in Colombia by Uglass sas. This material has thermal and dry installation benefits thanks to its flap system, in addition to the environmental benefits of being able to be recycled entirely, over and over again without any loss of properties in new products such as bottles, kitchen tables, artificial grass and other construction products, which can have a closed life cycle model.

Vitrolit's large Uglass surface requires less structure to support it, as well as being easy to maintain. It allows visual and acoustic comfort with a considered insulation in simple situation of 27 decibels (dB).

Pine wood: House structure, floors, decks, stairs, railings and window and door frames.

Wood, like all products of natural origin, will have a negative carbon footprint. Wood, an organic material, can close its useful life in a natural way, leaving it in the ground for its decomposition process or crushing. It is important to consider that the treatment to be carried out on wood to further guarantee its useful life, is proposed based on resin or varnish against pests and humidity, but not immunised, given the high toxicity of this process as it involves materials such as arsenic and copper among others.

In Colombia there are several companies that are part of the Colombian forestry chain that lead the campaign "Choose legal wood, buy responsibly" and among these are several companies with pine plantations, such as the company Madera Inmunizar with a plantation of Patula Pine in Antioquia and in the Eastern Plains, with a reforestation programme of 500 hectares, such as the company El Guasimo SAS, among others.

Through this initiative, it is expected to maintain sustained timber yields in Colombia, provide high quality products, increase the productivity of forest assets, protect workers and make rational use of financial, natural and technological resources.

This process identifies forest areas that contain globally, regionally or nationally important biodiversity values and forest areas that are very important for satisfying the basic needs of local communities (S.A.S 2018).

Walls in laminated guadua + 10 cms with wool or rice husk.

The use of guadua was born out of the concern to promote the maximum use of renewable and sustainable resources; and as an alternative to the demand for tropical timber forests, typical of latitudes such as Latin America, Asia and Oceania. Guadua is known as "vegetable steel" because of its high resistance to axial loads due to the direction of its fibre. It is a material of high resistance, durability and easy handling, also characterised by its rapid growth and the low energy required in its cultivation process.

Tapia (Mud): Wooden roof walls with 10 cm of earth filler.

In addition to being an ancestral and local technique, it is a technique with high environmental benefits such as low CO2 emissions, low maintenance costs, durability, fire resistance, good thermal, acoustic and economic performance. It is worth noting the speed of the construction process, as well as having local labour trained in the technique.

The composition of the soil suitable for this technique is: gravel (0 to 15%), sand (40 to 50%), silt (20 to 35%) and clay (15 to 25%).

Water Storage: Polyethylene Tanks

Polyethylene is a plastic resin, with an adequate performance. Its construction process is very acceptable, it does not need resins or solvents, which reduces its environmental impact. The tanks in this material are more favourable compared to other materials of more rigid condition such as concrete against earth movements, as it does not fracture as easily as concrete, also unlike traditional concrete tanks, it is easy to maintain, easier to install and transport. In Colombia there are companies that manufacture it such as Rotoplast, which part of its raw material is recyclable based on flexible shampoo and detergent tubes.

Water conduction: Polyethylene piping.

High Density Polyethylene or HDPE pipes are the best option to traditionally used materials such as PVC, which are more readily available on the market, however they require a complex process for degradation and high energy to manufacture. Polyethylene is favourable for its low weight, non-exidizing, non-corroding, long service life and unlike PV pipes, it is a 100% recyclable material at the end of its service life.

It should be noted that the use of this material is minimal in the project. However, its use in the project is punctual and minimal.

Solar panels

The solar panels belong to the international TIER 1 ranking for meeting certain sustainability indicators. In addition, this ranking has a seal that guarantees that once the useful life of the project where the panels are located is over, the recycling or reuse of the panels is guaranteed.

This transfer of knowledge and its application is done in Colombia through a multinational company PVCICLE, which is in charge of collecting the panels, using those that are still useful in another project and repairing those that need to be repaired. The panels can be reused and recycled for other fabrications up to 90% or more, depending on the conditions.

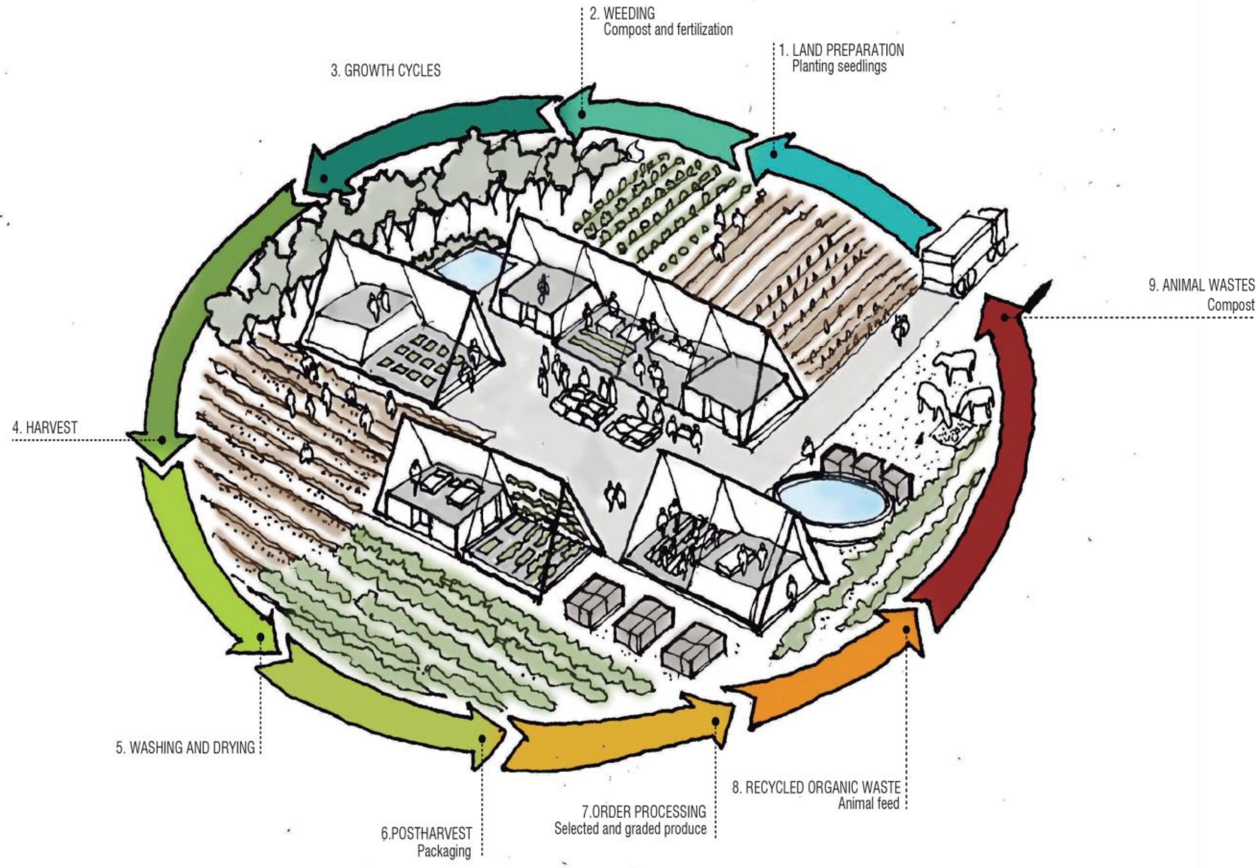
It is common that after the end of a project's lifetime, panels continue to operate for up to 20 to 25 years, producing approximately 80 to 85% of their lifetime.

4.- Economic viability and compatibility - Prosperity

The costs as we know are established by the subsidies provided by the housing ministry. Even when we consider them scarce, these are the ones that today allow us to exercise public policy within the framework of rural housing.

To give an efficient and real response to these costs and at the same time improve the interior spatial quality of the house, we propose a house that is mainly built with a roof as a large envelope, this allows us to reduce the joints of architectural elements, systematize construction, saving costs in transportation and assembly time, labor and materials.

The construction of the greenhouse is built with the same logic of the roof house, but we propose to take advantage of the economic benefit from the district, directly from the secretariat of economic development, who in 2017 implemented a policy of construction of greenhouses in the capital. This benefit sought to consolidate productive units so that they could diversify what the Bogota peasants sow. It was expected that in 2018 80 of these productive units would be implemented in the capital's rural territory.



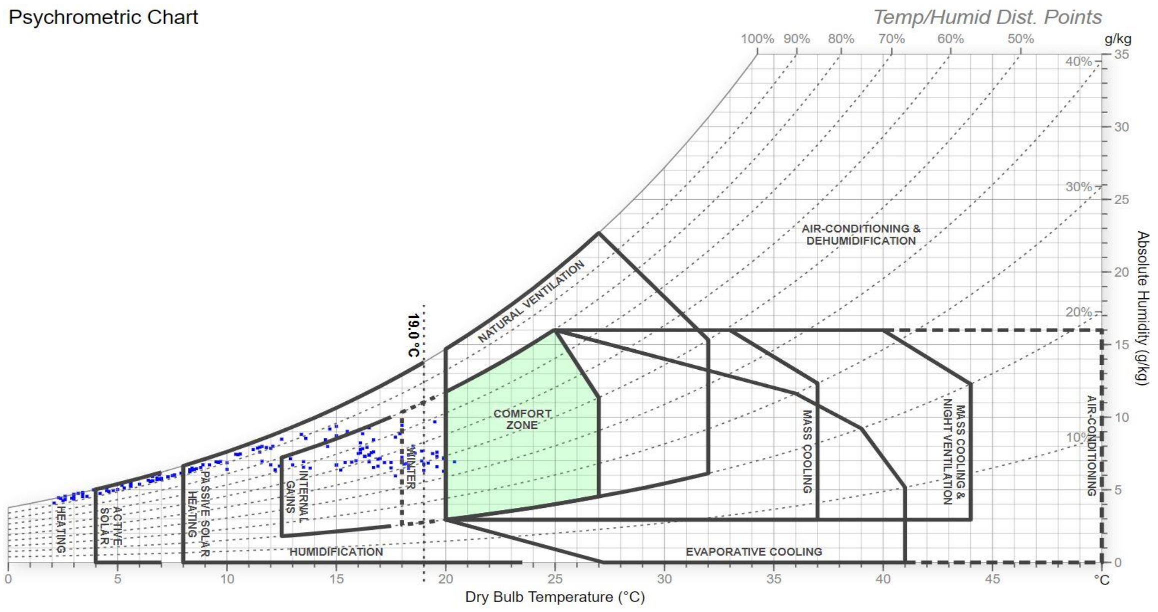
5.- Contextual and aesthetic impact - Place

INDOOR ENVIRONMENT QUALITY: THERMAL, VISUAL AND ACOUSTIC COMFORT

CLIMATE DIAGNOSIS

The prototype is located in a cold climate environment, with summer periods from January to December, rainy periods in April, October and November, and a dry period from December to May. Average temperatures are 11°C, with maximums reaching 20°C and minimums of 2°C. The average relative humidity is 75% and varies between 25 %RH and 97%RH. On the other hand, precipitation ranges from 228 to 1,011 mm. These climatic conditions are relatively homogeneous throughout the year.

Solar luminosity in the páramo is characterised by low levels due to the high presence of clouds that impede the direct passage of solar radiation.



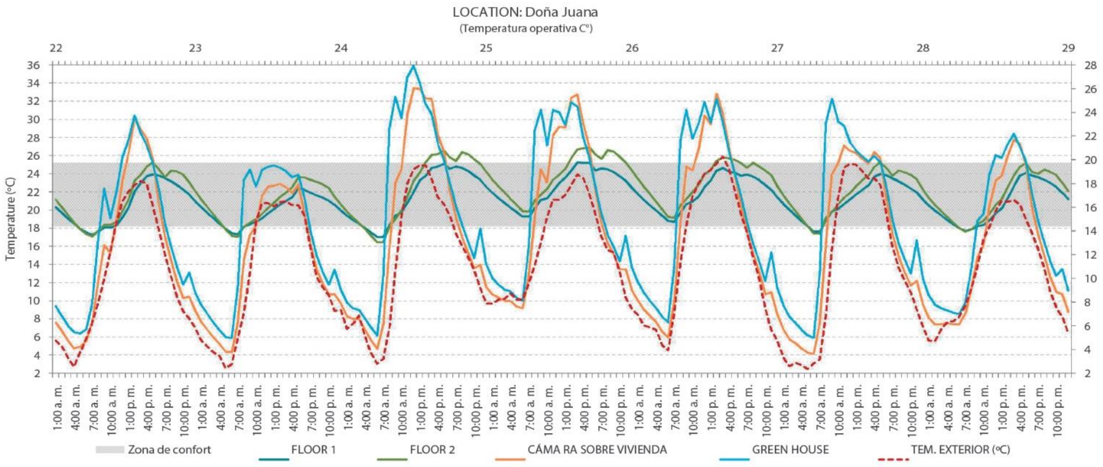
PSYCHOMETRIC CHART AND STRATEGIES

The analysis of bioclimatic strategies based on the elaboration of the psychrometric chart with temperature and humidity data from the typical week showed the need to incorporate strategies to increase heat gain during the day through exposure to direct solar radiation and the use of materials with high thermal inertia combined with other insulating surfaces in such a way as to favour heat retention at night and in the early hours of the morning. In addition, the use of heating is not ruled out.

From this point of view, a reinterpretation of the Trombe wall in longitudinal direction is proposed, reinforced with thermal insulation on the upper floor to avoid overheating. This reinterpretation involved the generation of an air chamber that reaches high temperatures and favours the heating of water that passes through black pipes before reaching the side walls with high thermal inertia. This strategy is called heating through encapsulated water. Finally, the integration with the greenhouse generates a " mattress " of warm air which, regulated through easily manipulated openings, guarantees optimal thermal conditions inside the house.

THERMAL PERFORMANCE

What the table indicates is that the living spaces on floor 1 (workspace, bedroom and toilets) and floor 2 (bedrooms) manage to remain thermally comfortable most of the time, determined between 18 to 25°C in the morning, afternoon and evening hours. It is also possible to observe that both the air chamber and the conservatory have wide thermal fluctuations, similar to the minimum temperatures that go down to 2°C, however, these two spaces have a drastic increase in temperature up to 36°C, which is evidence of the success of these spaces as a thermal "buffer" that keeps the living spaces within the comfort range.



Both the air space above the house and the conservatory show a higher percentage of discomfort due to cold (59% and 51%) and heat (20% and 30%), consistent with the behaviour of "cushion" or protective spaces that absorb high and low temperatures, which in the present context are more severe than the previous ones, in order to keep the living spaces comfortable.

BIOCLIMATIC STRATEG IES FOR THERMAL COMFORT

Heat collection: Greenhouse

The greenhouse oriented at an angle of 45° to the south/north allows heat to be distributed by convection through doors and windows that open/close between the house and the greenhouse. The greenhouse has, as is logical, large temperature fluctuations, but the massing strategy of the house allows the indoor temperatures to be kept within the comfort range. Finally, the integration with the conservatory generates a " mattress " of warm air which, regulated through easily manipulated openings, guarantees optimal thermal conditions inside the house.

Having glass surfaces in the shade in cold weather is not convenient because they lose too much and gain too little.

Insulation: In walls (wool or husk) and in the roof of the house (Tapia).

Protection against thermal fluxes coming from the outside or from the inside, necessary to guarantee thermal comfort conditions.

Trombe cover/wall:

From this point of view, a reinterpretation of the Trombe wall in the longitudinal direction was proposed, reinforced with thermal insulation on the upper floor to prevent overheating. It allows heat to be captured indirectly through materials with thermal inertia, in this case the stepped wall. The success of this strategy is evidenced by a gain of 7% of the total heat gained, compared to a loss of 8.7%, with an adequate energy balance.

This element is oriented towards the sun behind the glass façade, a suitable strategy in cold weather to reduce thermal demands. Windows and holes that can be operated as louvres allow heat to be released or transferred to the occupied spaces at the required times.

Heat storage walls:

In the air compartment, which reaches high temperatures, solar collectors are installed to heat water through black pipes. This hot water is stored and during the hours when it is not comfortable due to cold conditions, it is circulated between the walls of the rooms, taking advantage of the heating power of the water, which is 4 times greater than that of concrete.

Thermal inertia

Materials in the envelope such as mud through the stepped wall, insulation in the middle of the interior walls, hot water pipes inside the walls, are all strategies to increase and guarantee the thermal inertia of the prefabricated timber walls. This allows the heat gained from radiation through the trombe wall and greenhouse, a gain represented by 5.9% of the total heat gain, to be used for the night and early morning hours when the losses are 4.9% and do not exceed the thermal gain, reaching thermal neutrality.

Solar gain

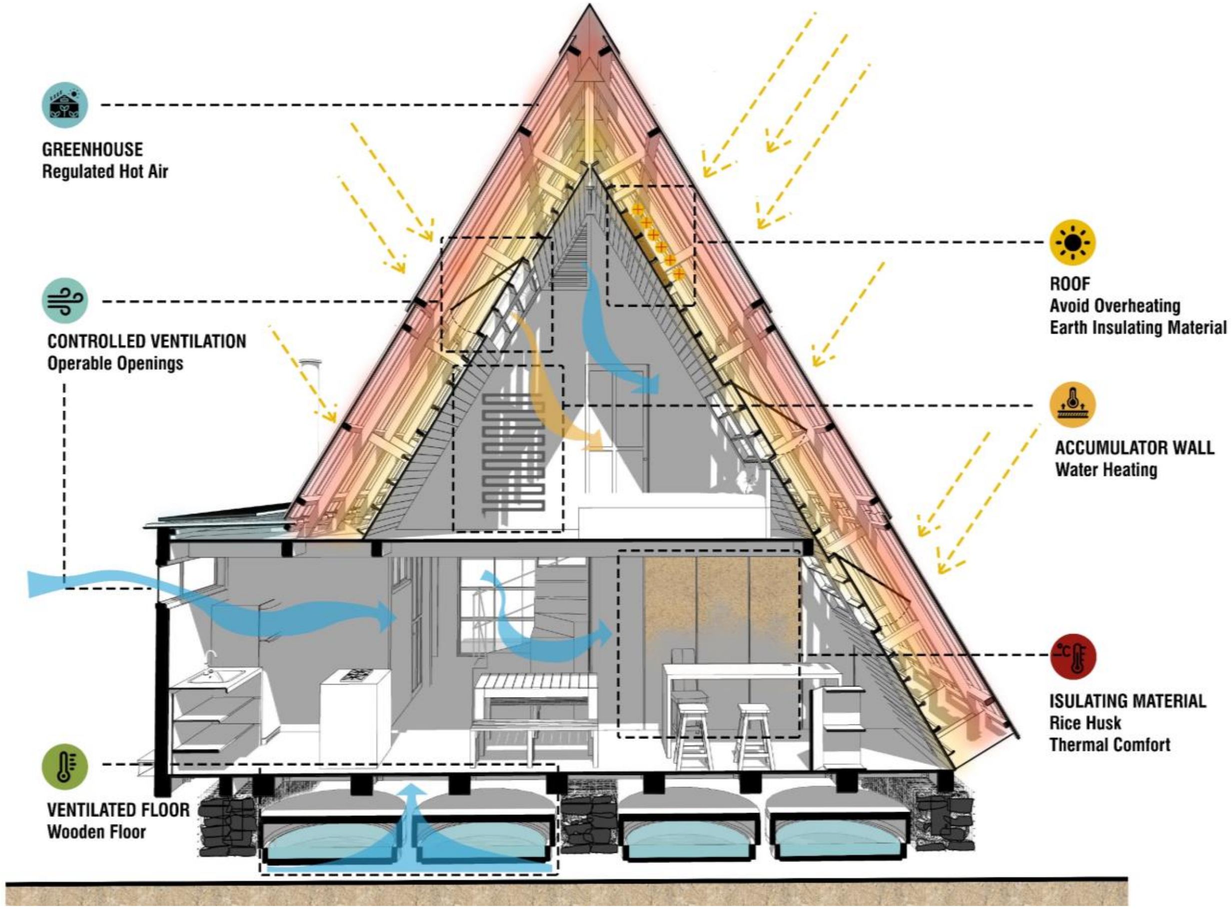
The orientation, greenhouses, trombe walls, are all complementary strategies to take advantage of solar radiation and ensure comfort inside the house.

Controlled ventilation

It allows the inhabitants of the house to adapt the thermal conditions of the space through operable openings. The ventilation of the house is controlled with 1/3 of its operable glass surfaces to guarantee thermal comfort.

Floating floor:

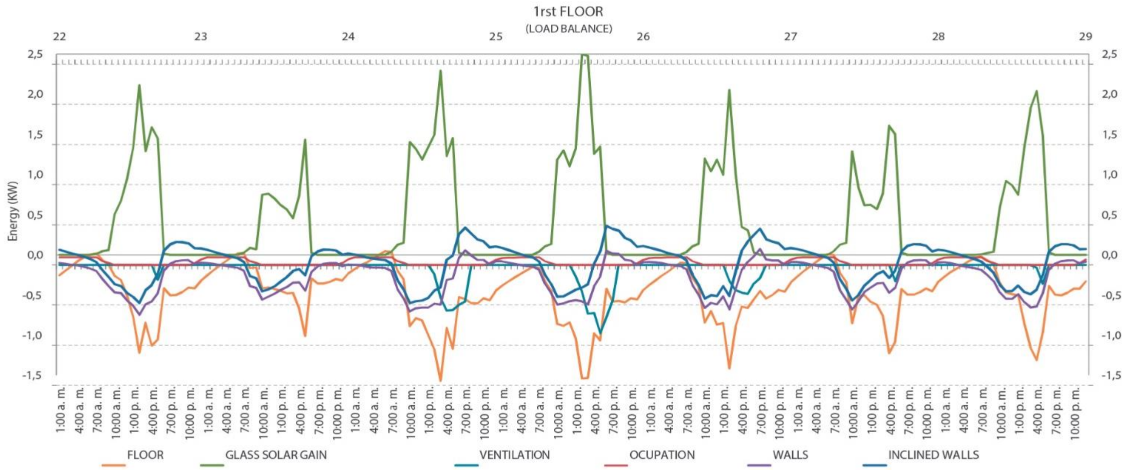
The wooden slab on the first floor is a great heat sink, which provides the proper thermal balance. Rainwater storage tanks are located under the floor to increase thermal inertia and avoid cooling by contact with the ground.

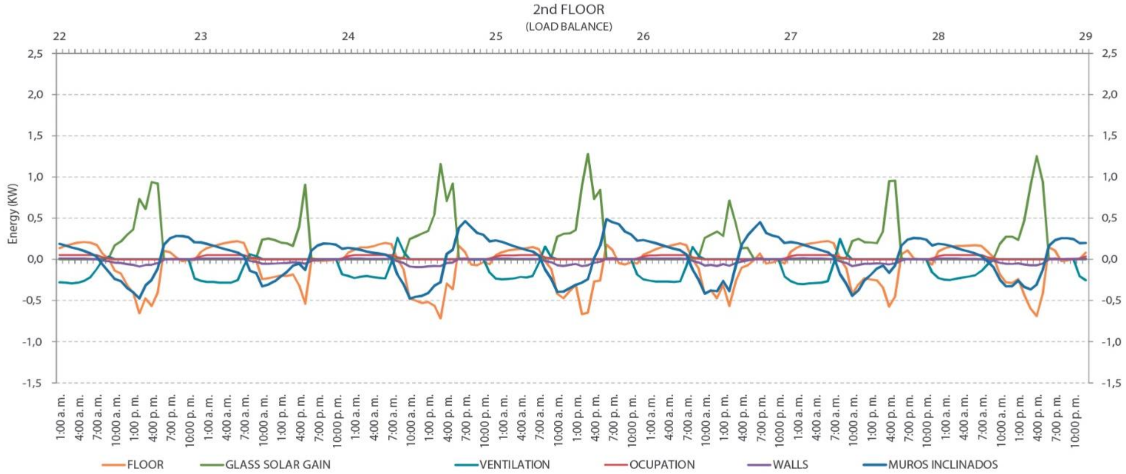

GREENHOUSE
Regulated Hot Air
CONTROLLED VENTILATION
Operable Openings
VENTILATED FLOOR
Wooden Floor
ROOF
Avoid Overheating
Earth Insulating Material
ACCUMULATOR WALL
Water Heating
ISULATING MATERIAL
Rice Husk
Thermal Comfort

ENERGY BALANCE

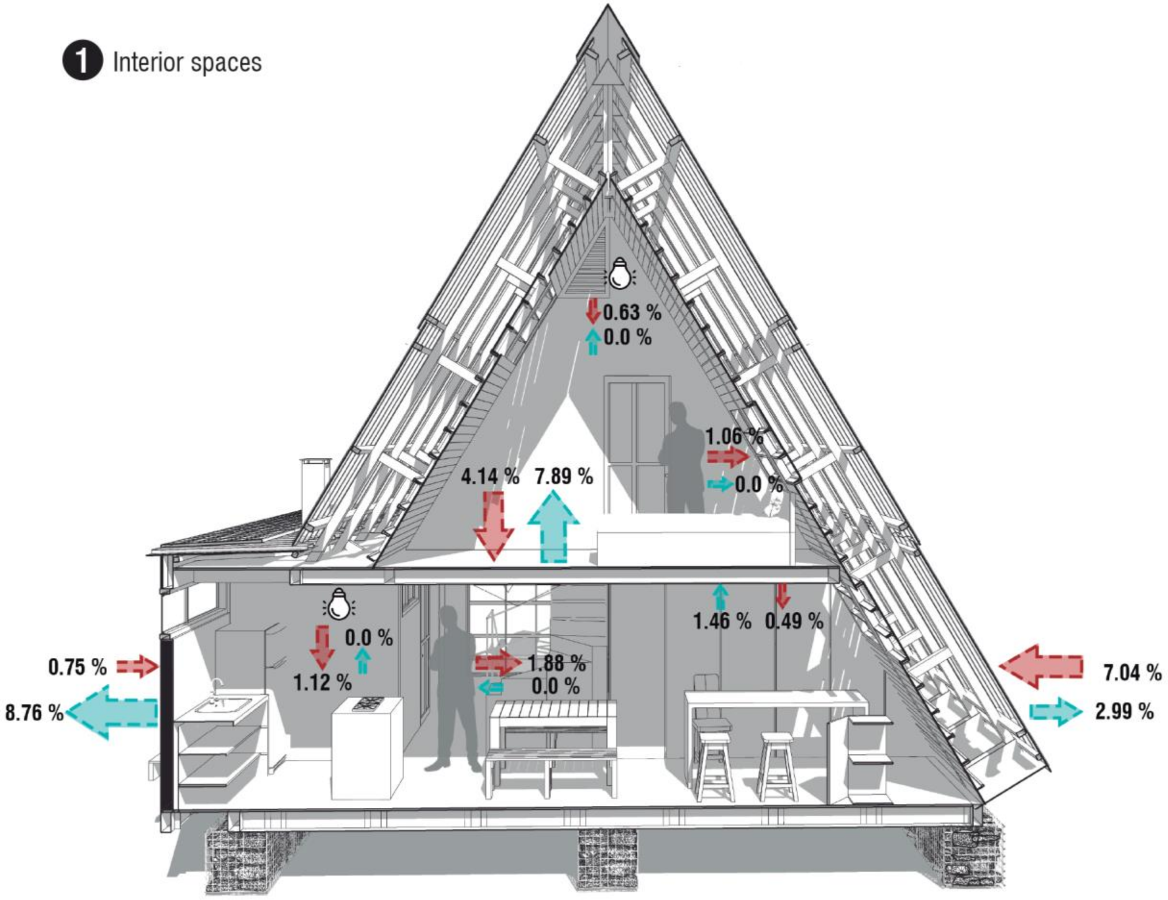
In the general balance, the greatest energy losses are represented by the exterior glazed surfaces and the slab (wooden floor) of the first floor, which, being elevated from the ground with an air chamber, dissipates heat. However, the solar gain from glass, the roof and the walls in contact with the greenhouse, are sufficient to achieve the proper energy balance. In addition to the above, natural ventilation, which in these types of climates almost always dissipates, in the prototype is very controlled preventing the space from losing heat, necessary in the coldest moments, which is evidenced in the comfort conditions achieved inside, which remain in comfort most of the time.

The above demonstrates the success of applied strategies such as the greenhouse, the bahareque walls in contact with the greenhouse and the roof, and the air chamber in the house, when not only achieving comfort, but also achieving an adequate energy balance.





❶ Interior spaces



ENERGY BALANCE 1rst FLOOR

Total energy exchanged (kw) Item 1rst Floor	**306,4** gain	**100%** dissipation
Shaded glazed exterior surfaces	2,60%	19,21%
Walls perpendicular to the ground in contact with the outside	0,75%	8,76%
Sloping roof in contact with the air chamber	7,04%	2,99%
First floor slab	1,33%	19,34%
Wall in contact with the greenhouse	5,97%	4,95%
Contact with the floor of level 2	0,49%	1,46%
Artificial lighting	1,12%	0,00%
Occupation	1,88%	0,00%
Solar gain from glass	22,11%	0,00%

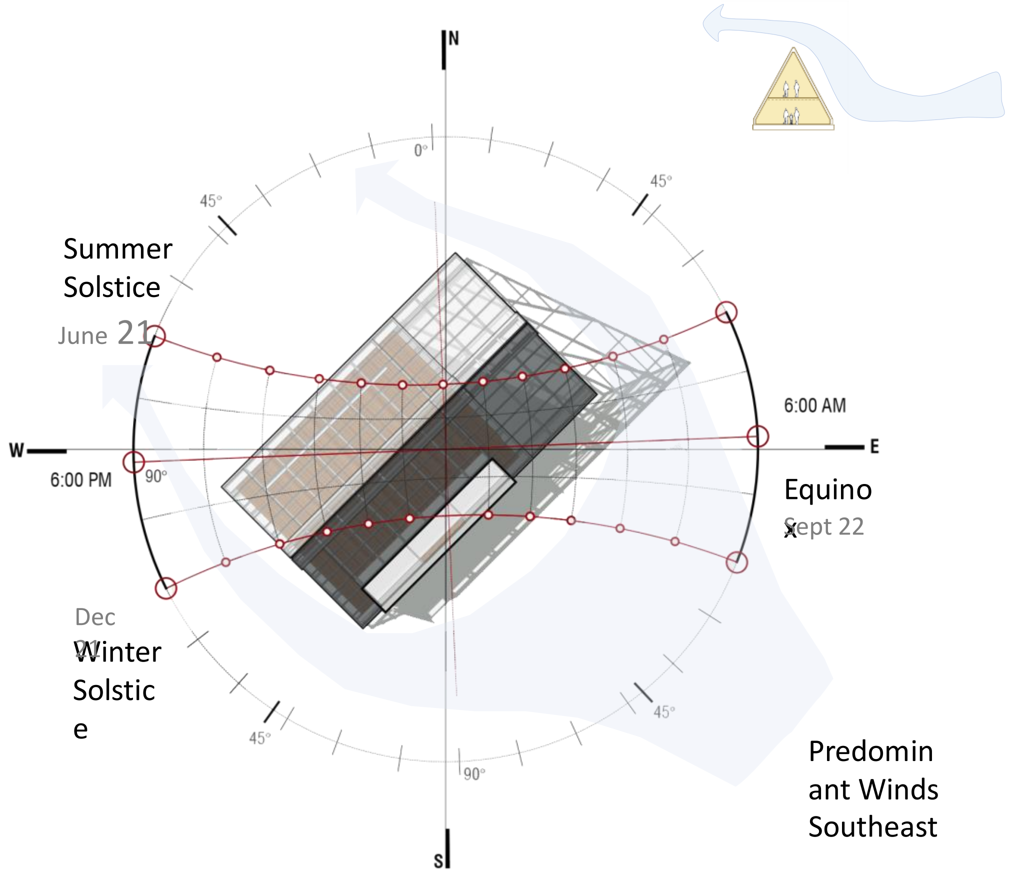
ENERGY BALANCE 2nd FLOOR

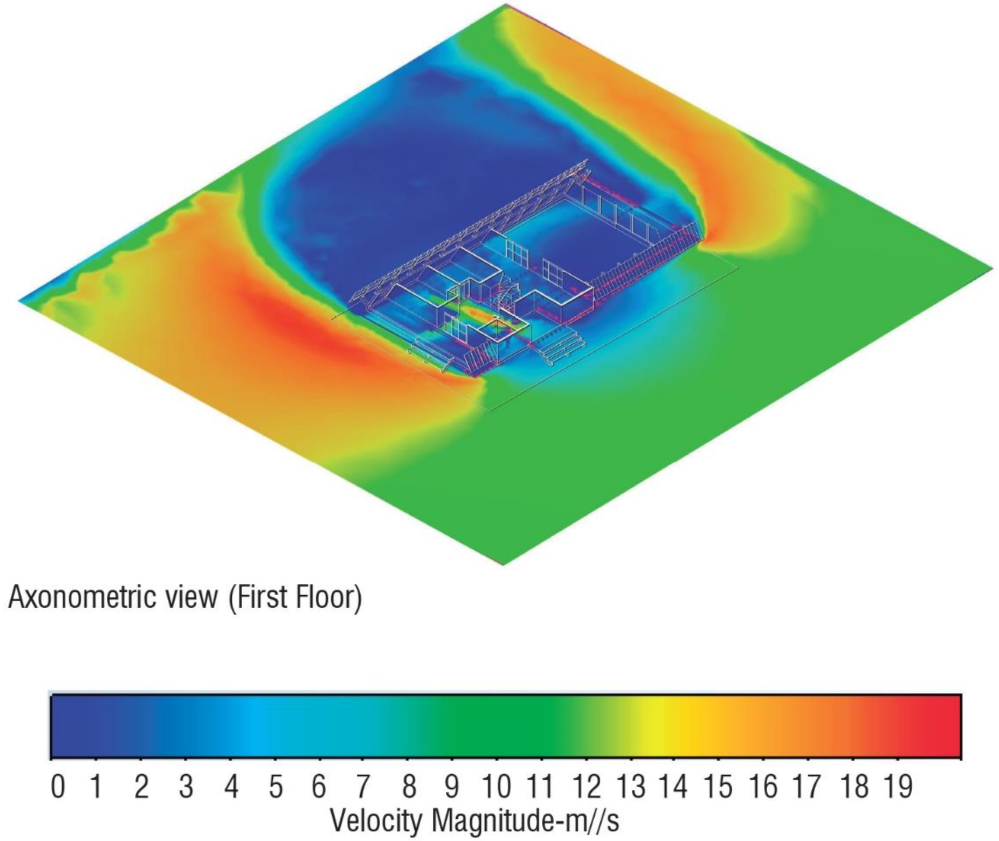
Total energy exchanged (kw) Item 2nd Floor	**198,1** gain	**100%** dissipation
Shaded glazed exterior surfaces	2,60%	19,21%
Walls perpendicular to the ground in contact with the outside	0,75%	8,76%
Interior floor	4,14%	7,89%
Wall in contact with the greenhouse	11,37%	11,82%
Natural ventilation	0,46%	4,76%
Artificial lighting	0,63%	0,00%
Occupation	1,06%	0,00%
Solar gain from glass	8,92%	0,00%

WINDS BEHAVIOR

The greenhouse house is oriented at 45º with respect to the North, to face the prevailing winds that come from the South-East with the inclined surface of the glass envelope. Due to the triangular section, with this orientation it is possible to generate a greater wind shadow area in surrounding areas.

As can be seen in the graphs, there is a greater circulation of winds on floor 1 in the workspaces and in the kitchen, leaving spaces such as bedrooms and the greenhouse with greater protection from cold winds, in a suitable way for the habitability in the Páramo.



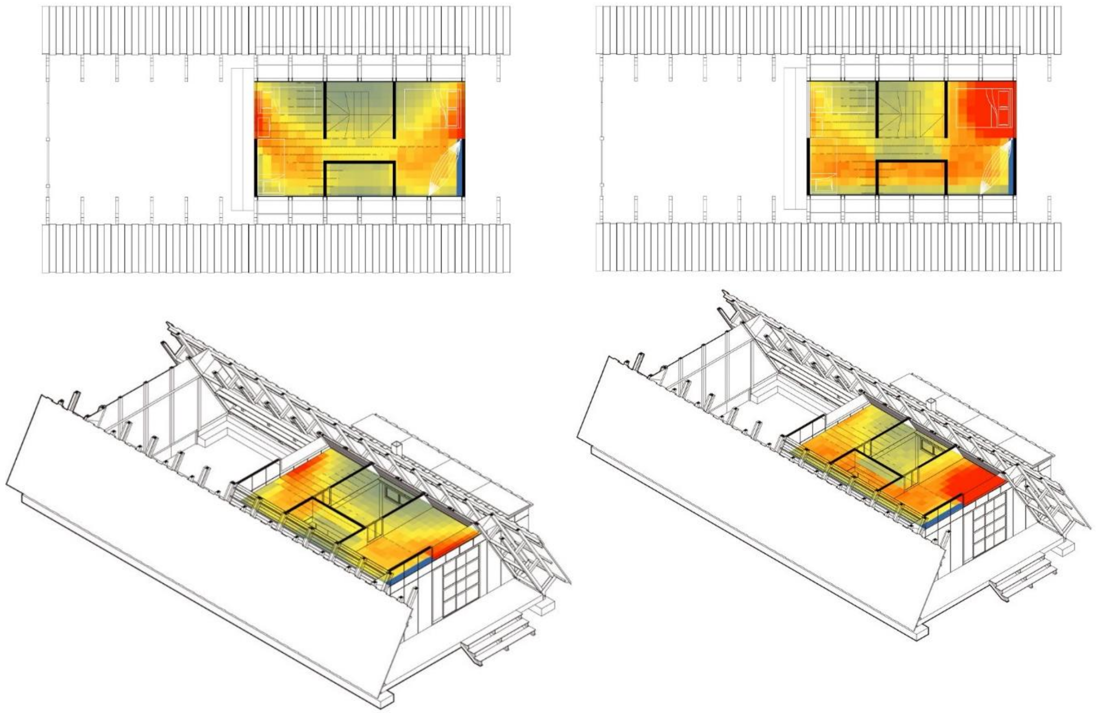


LIGHTING BEHAVIOR

Although in cold climates the use of glazed surfaces on the façade is usually restricted to favor the thermal performance of the buildings, the House has sufficient and adequate light levels for the activities carried out inside the house.

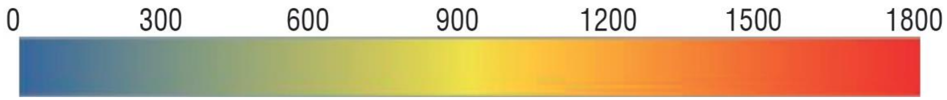
The images show the result of a computer simulation for a partially cloudy sky type without sun, that is, a pessimistic situation with little availability of outside light. Despite this, the results show that in the social area and on the second level there is abundant natural light, more than 500 lux, and that in the rooms on the first floor, areas intended for rest, light levels of around 150-200 lux.

Natural light is not only important from the point of view of energy efficiency, to minimize the use of artificial light, but to guarantee comfortable and healthy spaces.



September - 21 - 9:00 AM (Southward Equinox)

September - 21 - 3:00 PM (Southward Equinox)



ACOUSTIC BEHAVIOR

From an acoustic point of view, due to the location in the rural area of Páramo, with a low external noise condition and the typology of the project, the strategies to isolate between the interior spaces according to the uses become relevant. From this point of view, the accesses to the rooms were arranged away from the kitchen, dining room and work spaces, areas that concentrate noise. In addition to this the interior partitions have enough capacity to isolate annoying noise. Along the same lines of analysis, the toilets were arranged far from the rooms to avoid annoying noises

In addition to the isolation of all the interior walls and the incorporation of sealed doors so that the rooms become a place of rest, the acoustic quality can be improved through the very habitability of the home by incorporating absorbent materials on the walls, or from the use of furniture.

Other recommendations:

An absorbent material can be incorporated into the staircase so that the vibration is not transmitted to other spaces in the home.

The pumps for water reuse can be separated from the structure, to avoid the impact of vibrations, as well as placing insulating material that covers the place where they are.

CARBON FOOTPRINT SYNTHESIS

In the production of each house there is a balance in favor of carbon footprint. Considering the life cycle and the timber's capacity to capture and store Co2, the house achieves 1.4 tons of Co2 in favor. Considering that the wood used in the project represents a Co2 bank of 5.6 tons of Co2 in contrast to the 4.0 tons generated with its other materials. Considering the above, the project could be classified as a carbon neutral or even plus construction.

Although energy production in Colombia is considered sustainable 164.38 grams of Co2 per kWh, the implementation of photovoltaic panels commits only 15% (25 and 32 g/kWh) of the emissions generated by each KWh in Colombia. This guarantees the highest standard of sustainability in energy generation.

The contribution of renewable energy could lead to a cumulative saving of greenhouse gases equivalent to between 220 and 560 Gt of CO2 in an estimated projection between 2010 and 2050.

For the CO2 generation estimate, considering that most of the prototype materials are of natural and local origin such as wood, guadua and glass, in addition to having a 100% recyclable condition, it resulted in low CO2 emissions.

BUILDING ELEMENTS	ELEMENT	MATERIAL	QUANTITY (M3)	RECYCLED MATERIAL (%) INCORPORATED	POSSIBILITY RECYCLING AFTER USE	TRANSPORT DISTANCE (KM)	MANUFACTURING CITY	TRANSPORT
FOUNDATIONS	GABION	STONE/STEEL MESH	22,69	50%	100%	62.5	BOGOTA	TRUCK
	FOUNDATION	TIERRA COMPACTADA	22,97	0%	100%	0		TRUCK
STRUCTURE(S)	GALVANIZED METAL SHEET	METAL	0,07	25%	100%	62.5	BOGOTA	TRUCK
	CONECTION	METAL	0,22	25%	100%	62.5	BOGOTA	TRUCK
	TIMBER FRAME TRUSSES METALLIC SUPPORT	METAL	0,13	25%	100%	409	PUERTO LOPEZ	TRUCK
	TIMBER FRAME TRUSSES	TIMBER	9,51	0%	100%	409	BOGOTA	TRUCK
ROOF	ROOF	GLASS	2,33	0%	100%	150,6	VILLAVICENCIO	TRUCK
	TIMBER PANEL	PINO TIMBER	0,41	0%	100%	409	PUERTO LOPEZ	TRUCK
	PORCH ROOF	SOLAR PANEL	0,21	0%	100%	62.5	BOGOTA	TRUCK
	10CM EARTH ISOLATION	EARTH	5,52	0%	100%	0		TRUCK
	FACADES: BLINDS, DOORS AND WINDOWS FRAMES	PINO TIMBER	1,07	0%	100%	62.5	BOGOTA	TRUCK
ENVELOPE	TIMBER PANEL	PINO TIMBER	0,41	0%	100%	409	BOGOTA	TRUCK
	10CM EARTH ISOLATION	EARTH	3,21	0%	100%	0		TRUCK
	WINDOWS	GLASS	0,28	0%	100%	62.5	BOGOTA	TRUCK
	TIMBER INTERIOR FLOORS+STRUCTURE FRAME	PINO TIMBER	6,9	0%	100%	409	PUERTO LOPEZ	TRUCK
INTERNAL WALLS	INTERIOR: STAIR AND RAILING	PINO TIMBER	0,29	0%	100%	62.5	PUERTO LOPEZ	TRUCK
	LAMINATED GUADUA WALLS	GUADUA	2,82	0%	100%	374	MANIZALES	TRUCK
	RICE HUSK 10CM ISOLATION	RICE HUSK	5,36	50%	100%	62.5	BOGOTA	TRUCK
	HOT AND COLD WATER TANKS	POLYETHYLENE	0,1	20%	100%	509	ITAGÜI	TRUCK
	HOT AND COLD WATER	POLYETHYLENE	0,25	0%	100%	62.5	BOGOTA	TRUCK

For the use of indispensable renewable energies in the rural context of the moorland of the prototype, such as solar panels, they do not yet have information on Co2 in Colombia. For its estimation, international literature was reviewed to estimate the production of Co2 during its manufacture. The other renewable energy strategy such as the wind turbine, is proposed to be manufactured by the community from recycled parts, so its impact is only represented in the used polypropylene, which can be 100% recycled.