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Tesis

Achieving Thermal Comfort Through the Design of a Tourist Hotel - Huancayo

Marisol Arroyo Inga
Helio Sebastian Balvin Huanuco
Jorge Luis Poma García
Claudia Rossana Poma García

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Achieving Thermal Comfort Through The Design of a Tourist Hotel – (Huancayo)

Marisol Arroyo Inga[1,*], Helio Sebastian Balvin Huanuco[2], Jorge Luis Poma Garcia[3], Claudia Rossana Poma Garcia[4].

[1,2]Faculty of Engineering, Professional Academic School of Architecture, Universidad Continental, 12001, Huancayo, Peru,
[3]Science teacher, architect and research professor at the Continental University, 12001, Huancayo, Peru
[4]doctor, economist, research professor at the University of Callao, 07001, Lima, Peru

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Abstract At present, there are numerous studies of methods that evaluate indoor thermal comfort of buildings incorporating energy efficiency criteria in the design and architecture. All bioclimatic planning in buildings is to grant comfort conditions to the occupants, because a negative impact could be generated if sustainable tourism is not planned. This paper presents the results of a design proposal of the Tourist Hotel inserted in the area of regional conservation of Huaytapallana. Therefore, the use of thermal comfort indices suitable for the study of climatic conditions in tourist places is analyzed, in addition to the study of representative cases of places with the greatest influx of tourism, also because they have similar climates and cultural contexts. The methodology to be used is experimental for the proposal, of a descriptive and applicative type, for having contributions of information, for applying tools and techniques of design for the proposal. Three tools are used: Mahoney Tables, Psychometric Abacus and the Bioclimatic Chart, which are executed and then contrast the results with each other, to later discuss them and determine if the tourist hotel responds to the thermal comfort needs of tourists in Huaytapallana snow mountain.

Keywords: Bioclimatic Architecture, Thermal Comfort, Sustainable Construction, Energy Efficiency in buildings, Tourism development.

1. Introduction

Internationally, there is a high level of competition in tourist attractions. In the case of Peru, they have numerous natural attractions, which is why it is logical and necessary to promote tourism in the country. Developed countries have an efficient infrastructure, where tourists use top quality services, which further stimulates their return.

For Hans Kinzl (1970), Peru is one of the privileged countries of South America, there are natural landscapes of great beauty, in addition to the presence of high-Andean glaciers, the highest mountain ranges are there and the most glacier covered of the tropics. The glaciers in Peru are constituted by skullcaps and high mountain snowdrifts; these glaciers are scattered, distributed among the coordinates 07°06' and 17°55' South Latitude and between 69°13' and 77°53' Longitude West [1] . Peru is the third most vulnerable country to the effects of climate change, after Bangladesh and Honduras, because a large percentage of the population is engaged in economic activities that depend on weather conditions [2]. The country's vulnerability is identified in the accelerated retreat of its glaciers [3]. These glaciers are affected by climate variability and the high susceptibility of their ice and snow masses [4] .

Studies carried out at the Geophysical Institute of Peru (IGP), the National Meteorology and Hydrology Service (SENAMHI) and the Ministry of the Environment (MINAM) have shown that, in recent decades, many of these glaciers have shrunk considerably, which implies the reduction of

water resources in the various basins, as well as impacts associated with the melting of glaciers [5] .

71% of the world's tropical glaciers are found in Peru, which, due to the effects of climate change, have registered a loss of 40% of their glacial mass, which would generate a shortage of water resources in many cities, generating a problem in the future, since the decrease in the glacier mass directly affects the availability of water that is used in various economic activities, even causing a series of conflicts between regions for the disposal of that resource. Climate change in the Junín Region has been occurring as in many glaciers in Peru, many of these glaciers have reduced their glacial mass by 50%, representing a serious danger to the water reserve [4].

Glaciers in tropical zones such as Huaytapallana are very important because it is a source to provide water for 70% of the population from the Metropolitan area of Huancayo; but due to the problems that are currently being caused by global warming and greenhouse gases, they are rapidly decreasing their mass glacier.

According to the National Inventory of Glaciers and lakes carried out by the National Authority of the Water [6] ; Huaytapallana snow mountain, in 39 years has had a decrease of 58.4%, as can be seen in Table 1.

Table 1. ***Analysis of loss of glacier Surface with regard to the year 1970***

No.	MOUNTAIN RANGE	GLACIER SURFACE			LOSS OF GLACIER SURFACE	
		HYDRANDINE SA (1970)	UGRH		km2	%
		km2	km2	YEAR		
1	Huaytapallana	59.08	54.58	2009	34.50	58.40
2	Vilcanota	418.43	279.4	2009	139.03	33.23
3	Carabaya	104.23	34.53	2009	69.70	66.87

Source: ANA, Inventory National of glaciers and lakes, 2014

Glacier retreat is a global problem that has been affecting all those who have this natural resource, showing a decrease in the extent and volume of the glacier mass. Being the root of the current environmental problem, global warming due to human actions, known as an anthropic phenomenon. Being the construction sector with its inefficient buildings one of those responsible [7]. Global warming is a phenomenon that requires urgent attention through a paradigmatic change in the construction industry and in the ways of life of our contemporary society. That change must reduce greenhouse gas emissions and thus reduce the environmental impact [8] .

Throughout history, the relationship between climate and architecture has been always intimate, establishing a dependency with the materials, the techniques, the constructive systems and the design of buildings. In the present study we will analyze the proposal of the Tourist Hotel within the Huaytapallana Regional Conservation Area with a sustainability approach, applying bioclimatic design strategies that respond to the climatic context in which it is located. In other words, the applied research is based on a proposal for the bioclimatic design of a Tourist Hotel, where bioclimatic principles and criteria are applied in its conception which must satisfy the thermal comfort of its occupants, taking into account the rule MS 110 [9], [10] , for better design criteria.

Bioclimatic design is one that takes advantage of its arrangement in the environment and its architectural elements to take advantage of the climate, in order to achieve interior thermal comfort without using active strategies and systems that consume energy [11].

For the project proposal, in summary the appropriate use of the natural resources available will be applied in terms of construction materials, soil, vegetation, and wind, in order to get the maximum benefits of these items to implement them in energy gains in the building, achieving adequate thermal comfort for its users in the context and climate of Huaytapallana.

The building generates a thermal exchange with the environment in which it is located, as it can be seen in Figure 1.

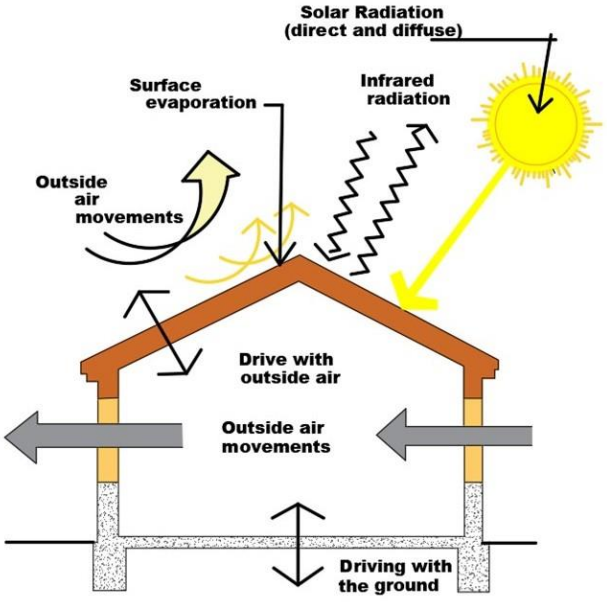

Figure 1. Synthesis of the basic principles of the bioclimatic conception.
Source: Bioclimatic construction criteria for houses in semi-desert regions, 2015

Tools of bioclimatic conception will be used.

Mahoney tables, is a method that allows a thermal analysis and that proposes strategies of bioclimatic design. This method is based on comparing the different climatic data of a

certain place with the boundaries of day and nocturnal comfort [12]. These tables propose an analysis of monthly meteorological data, as well as the comparison of that data with comfort zones that contemplate variations according to the annual average temperature considering an adaptable model of comfort, the results are a record of months with warm, comfortable or cold conditions, day and night. Identification of indicators that arise from the analysis of climatic conditions with comfort or discomfort, such as heat with high humidity or low thermal amplitude, etc. Definition of design guidelines with different indicators.

Psychometric Abacus, It is one of the most used graphs for the evaluation of thermal comfort. This graph shows the relationship between the temperature of the air and the humidity. It means human beings need to have a comfort zone with bearable conditions, [13]. It is one of the most used schemes for the evaluation of thermal comfort due to the simplicity of its handling, it is a reference point for the calculation of thermal comfort of buildings located in the peninsula.

Bioclimatic Chart , this method is proposed by the pioneers in deepening the thermal comfort incorporating other parameters such as temperature and humidity, as well as for example the speed of the wind in their analysis. .[14], [15].

1.1 Problem

The contemporary buildings in the country, as well as in the high Andean region, the problem that is identified is the low efficiency of their buildings against the climatic rigor of the place and therefore an inadequate conditioning on thermal comfort. The strategies learned from vernacular architecture, so wise, year after year this empirical knowledge is being lost in replacement of contemporary architecture. Contemporary architects leave aside the knowledge of vernacular architecture, as well as the fundamental criteria of bioclimatic architecture. Based on what has been described, the following question arises to guide our study.

How to achieve an adequate architectural response that guarantees thermal comfort in the design of a tourist hotel that will be located in the Huaytapallana snow mountain conservation area?

1.2 Research Objective:

Make an architectural proposal for a tourist hotel in the regional conservation area of Huaytapallana with conditioning methods and techniques of bioclimatic architecture.

1.2.1 Specific Objectives:

• Determine the place and area of intervention of the proposal with the best use of solar energy collection.

• Determine which bioclimatic factors and criteria are essential and applicable to this territory.

• Identify the materials that will be used for the construction of the infrastructure of the Tourist Hotel in order to bring an appropriate thermal comfort.

2. Methodology

For the investigation of the design proposal, tools of bioclimatic diagnosis will be used such as Mahoney tables, whose result provides recommendations of design, besides of the analysis of graphics as the technique of the psychometric abacus of Givoni, solar geometry, address of winds.

The climatological data that will be used will be from official sources obtained by [16] that will be analyzed and processed for the tourist hotel design proposal; likewise, data will be taken in that place.

2.1. Research Desing

The research is experimental, of a descriptive and applicative type, because it has contributions of information due to the application of tools and techniques of design.

By obtaining the acquired data, it will be possible to design the proposal of the Tourist Hotel. For that, many aspects will be taken into account, mainly the arrival of tourists who daily visit the snow mountain, with the purpose of being able to welcome them and offer them a good comfort.

The present chosen design to carry out the study consists of underground levels, with unevenness for a better thermal comfort, one of the aspects that has to have to be bioclimatic is that it has to be prioritized and taken into account the materials of the region where the project will be developed, and as a second option materials produced in the country will be considered. It will be within an approximate area of 400 km of distance as it is observed in the figure 2.

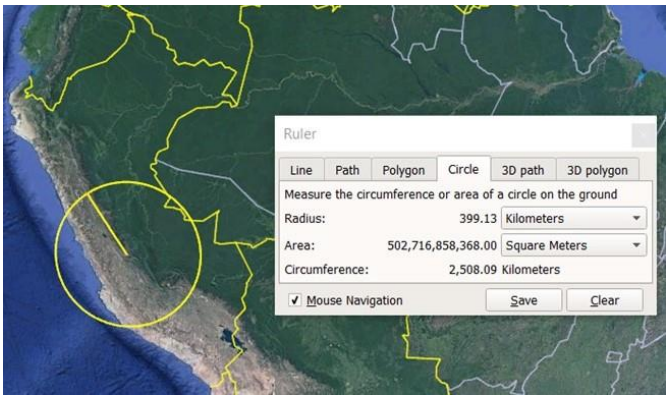

Figure 2: Radius of influence with regional consideration
Source: Google Earth

2.2 Development of the Proposal

2.2.1. Site Data.

Huaytapallana snow mountain is located in the Junín region,

Huancayo Province, Huancayo District, between 4532 meters above sea level and 5555 meters above sea level; it is considered as the Huaytapallana regional conservation area from February, 1st 2011 according to the regional ordinance No. 106-GRJ/CR. (2)

It counts with a meteorological station located at 4,648 meters above sea level, at the foot of Huaytapallana snow mountain. SENAMHI installed the highest meteorological station in the country, which will serve to evaluate the behavior of glaciers due to climate change. The hydrological component located in the lower part corresponds to a drainage channel of the Lasuntay lake, which serves for the hydro-energy, agricultural and human consumption variable. As shown in Figure 3

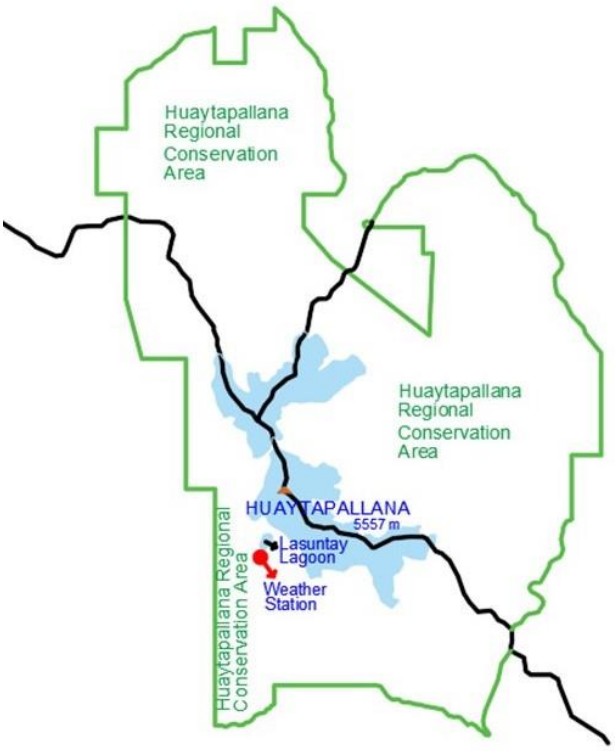

Figure 3: Location of Huaytapallana automatic weather station
Source: Senamhi

Huaytapallana snow mountain has approximately 26 km2, it is located in the Central Mountain range also known as center eastern of Peru. Huaytapallana had 105 glaciers until 2014, but currently it has been decreasing, due to the global heating that causes the deglaciation of these. This being one of the smallest, having as reference the Vilcanota snow mountain, see Table 2.

Table 2. Amount of glaciers and location height in the Central Macro

N°	Mountain range	Amount N°	Surface KM2	Year	Maximu Altitude	Minimu Altitude
1	Huaytapallana	105	26,40	2009	5555	4532
2	Vilcanota	374	279,40	2009	6364	4592

Region
Source: ANA, Inventory National of glaciers and Lakes, 2014

For Huaytapallana snow mountain, there are two accessible areas for the tourists and a zone that is restricted, as we can see in figure 4.

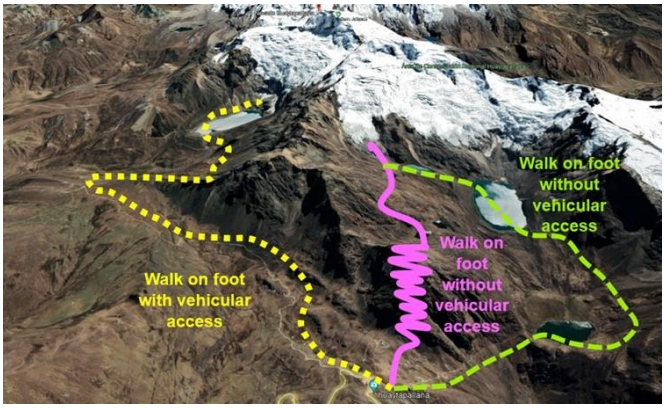

Figure 4: Huaytapallana Snowfield
Source: Google Earth

Legend:

Lakes routes (long)

High route (There will be)

Car route, meteorological station, dam (long)

Analyzing the roads, the accessibility, and also the proximity to the snow mountain, we find three possible options where you can locate the project. The first option is located in Cocha Grande lake, the second option is located near a small lake and the third option is located in Lasuntay lake. For the choice of the place of intervention that meets the necessary criteria for the comfort of the professionals, the use of solar rotation and the hours of incidence that it would have in the space of the land were taken into account, which are from 6:30 a.m. to 6:00 pm, always when there are no clouds, which is why the best location is the first option. In figure 5 you can see the solar incidence. Figure 5.

Figure 5: Photographic Solar incidence
Source: Suneart

Data, Station: HUAYTAPALLANA		
Department: JUNIN Province: HUANCAYO District: HUANCAYO		
Latitude: 11°55'37.81"	Length: 75°3'42.7"	Altitude: 4648 m.s.n.m

Source: Own elaboration

2.2.2 Results

Development of bioclimatic instrument

2.2.2.1 Mahoney Tables

This method is based on comparing the different climatic data of a certain place with the limits of day and night comfort. First, the six Mahoney indicators have to be found, which are based on indicators of wetness and dryness. Mahoney's tables allow to evaluate the duration of comfort and discomfort conditions, in response to the needs at different times of the year. At the end of the process, with the use of these indicators, a series of recommendations or design strategies for the place studied is obtained. For our study we will take data from the year 2018 to 2022, which will be shown in the tables 3 and 4.
With the data obtained from table 3, an analysis is carried out using the bar graph as shown in figure 6.

Table 3. Development of climatic instruments. Mahoney

HUAYTAPALLANA	Jan	Feb	Mar	Apr	May	Jun
Maximum	6.9	6.92	8.8	7.4	8.6	6.3
Half	3.05	2.91	3.91	3.325	4.03	3.4
Minimum	0.8	1.1	0.98	0.75	0.54	-0.5
Oscillation	6.1	5.82	7.82	6.65	8.06	6.8
HUAYTAPALLANA	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Maximum	9.2	7.6	6.5	4.8	5.2	5.4
Half	5.1	4.5	3.15	2.1	2.9	3
Minimum	-1	-1.4	-0.8	0.6	0.6	0.6
Oscillation	10.2	9	7.3	4.2	4.6	4.8

Source: Own elaboration

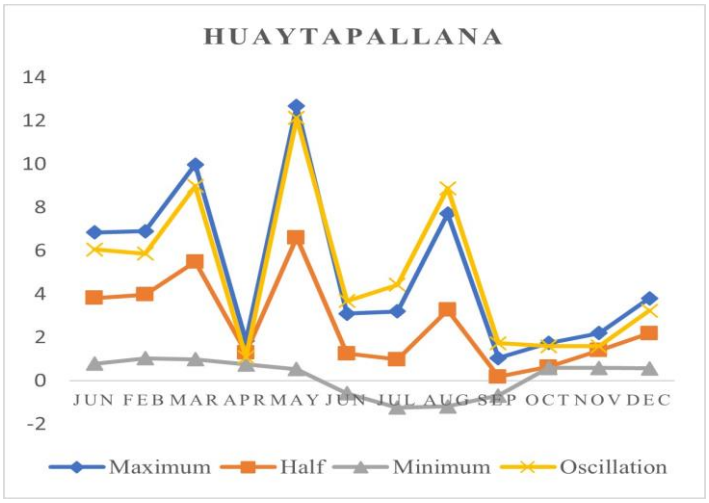

Figure 6: Photographic Solar incidence
Source: Own elaboration

Table 4. Mahoney Design Recommendations

City	HUAYTAPALLANA
	Recommendations
Distribution	Orientation North - South (long axis EO)
Spacing	Compact Configuration
Ventilation	Ventilation NO required
Openings Size	Medium 15 - 20%
Walls and floors	Heavy - Higher capacity
Roofing	Heavy, well insulated

Source: Own elaboration

The recommendations proposed by Mahoney are obtained in table N° 4, and they are: The orientation has to be North – South (Long axis E – O), spacing should have a close-packed configuration to prevent loss of heat during the nights, ventilation is not required, the size of the openings must be medium to 15 – 20%, the walls and heavy floors of high thermal capacity, its roofing heavy and well isolated.

2.2.2.2 Givoni's Psychometric Chart

It shows us the lines that represent the monthly averages of temperatures and relative humidity averages of Huancayo city. To achieve the comfort, it is necessary to use firstly the internal gain strategies (GI), also have heat sources such as lighting, stove, people, etc., the second strategy is to use passive solar gain (GSP), also fundamentally, the good orientation and the collection of solar energy through the materiality of the buildings, and finally use the active solar gain strategy
(GSA) which is to employ, for example, the use of thermal solar energy, which will allow heating and the obtaining of hot water.

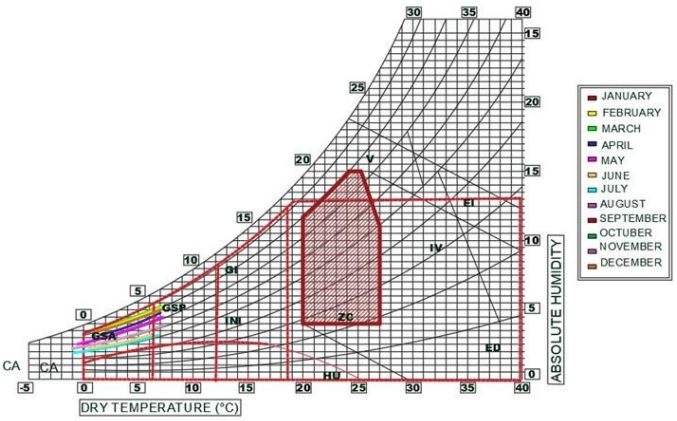

Figure 7*:* Lines of analysis by monthsSource: Own elaboration

Source: Own elaboration

As it can be noticed in the graph of Givoni, figure 7, the lines of analysis for months fall into the GSA sectors, AC and GSP which mean: Solar Active Gain, Heating and Passive Solar Gain.
This graph allows to have reference of the water content in the environment and the ambient temperature of the place.

2.2.2.3 Olgyay Bioclimatic Chart

In the same way, we graphed the data of relative temperature and humidity for the Huaytapallana conservation regional area.

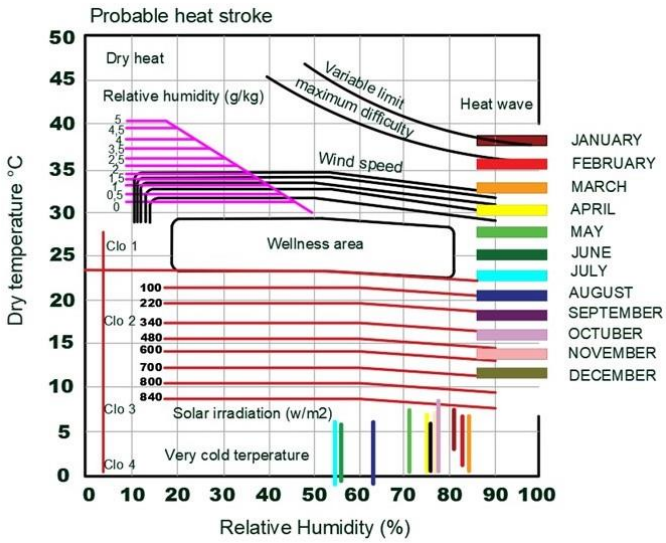

Figure 8*:* Analysis of the Olgyay chart

Source: own elaboration

In Olgyay's bioclimatic chart, it can be seen that the data entered represents each month of the year, which gives us as a result that the proposed building must have solar irradiance. Figure 8.

It is a bioclimatic chart in which the comfort or well-being zone is defined, the variables that affect it and the corrective mechanisms.

2.2.3 Proposal

Tourist Hotel

The design of the proposal is oriented to give thermal comfort to the visiting users of the snow mountain who wish to stay in the natural attraction of great tourist potential, however, its sustainability will depend on a set of factors that requires the concerted participation of the social actors, local and national governments.

For this, it must have the following indicators to become a bioclimatic building with a minimum architectural program to reduce the visual impact, the use of strategies (indicators) with a minimum of 10 points is proposed, which means a bioclimatic proposal, see Table 5.

Table 5. Indicators that the proposed design has to achieve

Indicators	Description	Parameters	Points
sustainable site	Ideal location for the project, access for public and private vehicles.	access to the place	4 p.
		Public and private transport.	
Efficiency in the use of water	Adequate use of water resources and sanitary devices with low consumption	Proper use of rainwater	3p
		low consumption toilets	
		Efficient use and reuse of water.	
energy and atmosphere	It must have an energy saving of 12 to 48% or more	Energy savings from 12 to 48%	3p
materials and resources	The selection of materials must be regional, within a radius of approximately 390 km, recycled, renewable or certified with a green seal	The materials are regional	4 p
		Materials are recycled	
		Materials are renewable	
		Materials have green seal certification	
Internal environment	Internal environments must	adequate ventilation	3p

quality	have adequate ventilation and lighting with thermal comfort for the user.	adequate lighting	
		Adequate thermal comfort	
design innovation	Innovation in sustainable construction, that is not in the aforementioned items	Uses an unconventional type of energy	3p
		Use non-contaminable segregation sanitary elements	
		Use energy-saving materials	

Source: own elaboration

Three possible places of intervention were determined, taking into account the accessibility and proximity to the snow mountain, see Figures 9 and 10.

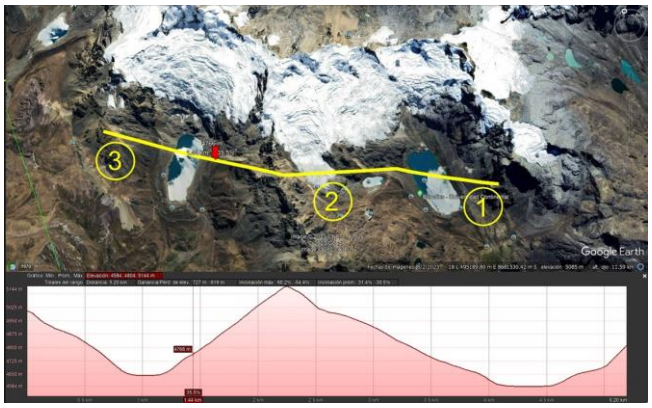

Figure 9: Location of possible intervention sites
Source: Google Earth

Figure 10: Location of possible intervention sites
Source: Google Earth

Location 1 is found in Cocha Grande lake, location 2 is near a small lake, and location 3 is found in Lasuntay lake. These three places are analyzed according to these criteria to choose the place of intervention, as shown in Table 6.

Table 6. Indicators that the proposed design must meet

Criteria	Location 1	Location 2	Location 3
Vehicular accessibility			x
Water supply	x	x	x
Proximity of snow mountain	x	x	x
Panoramic view			x
Access to solar resource	x		x
TOTAL	**3**	**2**	**5**

Source: own elaboration

The choice of the land where the proposal will be located will be done by the following e criteria:

- Capture the sun for as long as possible.
- That the land is protected against the natural wind.
- Direct accessibility
- The criteria mentioned must be achieved minimally to take advantage of the climatic aspects of the place and achieve a good bioclimatic design.

The best choice of location for the proposal is location 3, because through the analysis it is shown that this location has the main criteria for good access and a good panoramic view of the snow mountain, which is why certain additional criteria were chosen in place to analyze the solar rotation and the time of incidence that is in the land.

2.2.4 DESIGN

The design of the tourist hotel is based on the analyzes and results of the studies carried out in the regional conservation area of Huaytapallana, its objective is to be a bioclimatic building which will allow tourists to stay, adequately satisfying thermal comfort.
As can be seen from the exterior views (figures 14 and 15), the project is integrated into the topography of the place.

GENERAL FLOOR

The architectural envelope will be surrounded by heavy 50 cm walls so that it can accumulate heat during the day; the interior walls will be light 35 cm; The windows will be

double glass with wooden frames, as well as the tall ones and the normal ones; The floors will be heavy with the capacity to capture heat so that it accumulates as much as possible, the doors to the environments will be made of wood. Figure 11

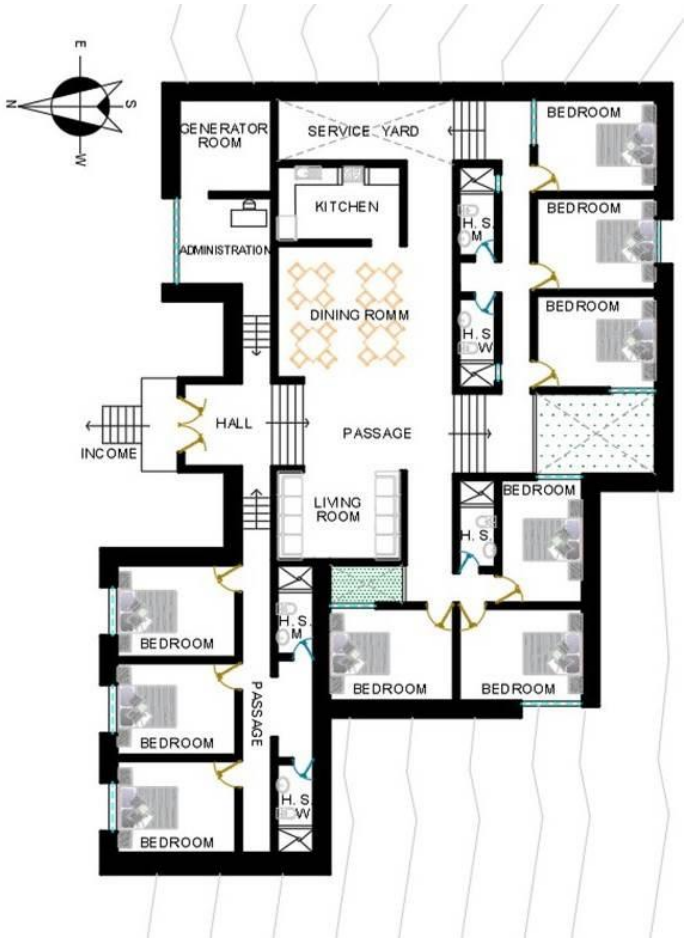

Figure 11: Plant Project

Source: own elaboration

ARCHITECTONIC PROGRAM

The architectural program that is proposed has the endowment of the necessary environments, which will make the people who are in the place feel comfortable and satisfied.

ARCHITECTONIC PROGRAM			
ZONE	**ADMOSPHERE**	**AREA**	**AMOUNT**
Administrative	Administration	8.50 m2	1
	Hall	6.00 m2	1
Publish	Star room	11.40 m2	1
	Doning room	17.80 m2	1
	Kitchen	9.60 m2	1
Lodging	Bedrooms	11.50 m2	6
	Bathrooms	3.50 m2	4
Service	Generator room	6.00 m2	1
	Service yard	11.40 m2	1
Total Land area		**353.00 m2**	

Source: own elaboration

- **CUTS**

The longitudinal section shows us the entry of solar rays through the high windows, these will allow heat to accumulate in the wall and on the floor, during the day these windows will be open and at night they will be closed. Figure 12.

The cross section shows us that the project is slightly buried, which allows greater heat accumulation, prevents there from being much wind inside the hotel, and the roofs are gabled for a better interaction with the place. Figure 13.

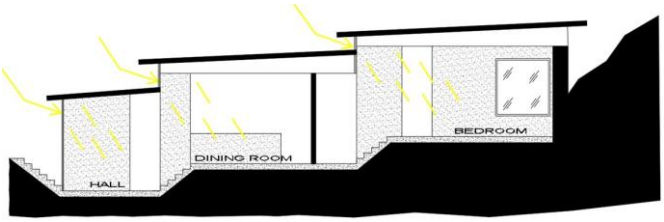

Figure 12: Longitudinal cut

Source: own elaboration

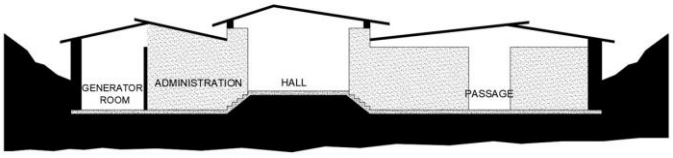

Figure 13: Cross cut

Source: own elaboration

➢ **VIEWS**

Figure 14: Front view
Source: own elaboration

Figure 15: Left side view
Source: own elaboration

3. Discussion

As it is shown, the instruments of Mahoney, Olgyay and Givoni were used, and these give priority to bioclimatic strategies of solar control and natural ventilation in cold climates, the solutions are diverse depending on the type of insulation that can be proposed, it has the advantage of being located on a hill, which allows to introduce a little the design of the proposal to better conserve the heat; For this reason, tongue and groove wood materials were chosen for the walls and ceilings to obtain spatial and thermal comfort in the environment as a result; Unlike the floor, it is covered by ceramic which does not allow moisture to filter quickly. It is also taken into account that to avoid heat leakage through the windows, it is proposed to have a special type of glass that has thermal resistance, as well as the triple glasses that are known as the Sosoares ST series Bautec technoform, this type of system helps to conserve heat, and is also ideal for buildings seeking Leed certification.

This tourist hotel tries to have the minor impact possible to the location zone, for this reason, the basic services are ecological and reusable; rainwater and melted snow are collected to be able to use it, it also has a drainage system with a biodigester and the energy is collected from the solar energy, its construction is carried out with adobe, brick mortar and concrete.

4. Conclusions

Based on this research work, it is recommended to carry out bioclimatic studies for the purposes of building for the high Andean regions, it is essential to use the conditions of the snow mountain; at first, it has permitted us know and synthesize the main diagnostic tools, but which are not very widespread, this type of work is recommended with emphasis on the strategies of bioclimatic design, all of them agree that internal strategies of heat gain, heating, must be applied, and then the storage of passive and active solar heat, which is why that due to the fact that the weather conditions that are extreme in the regional conservation area of Huaytapallana, it is decided to bury the proposal design at 40 or 50% to have a greater thermal inertia, thus working with high openings and on the roof, the unevenness will help us gain heat in specific places of the proposal, because of directing the acquired heat to the higher areas.

Finally, it is considered that both the design and the conditioning of the buildings must incorporate as one of their main objectives the contribution of these well-being conditions to their users, within the framework of the well-known bioclimatic architecture with the aim of achieving a certain harmony between the architecture, the environment and man, so it is necessary to apply methods and systems that involve environmental conditions, not only from the aesthetic or spatial point of view, but also from the energy point of view, therefore the conditions of thermal comfort could improve for those who inhabit the buildings.

Future research should influence the use of new materials that guarantee the comfort of users. materials experimentation
Also, to speculate with more structure for the tourist purpose.

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