Climate Profile for the Development of Bioclimatic Architecture in Colombia: a Comparative Analysis

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Climate Profile for the Development of Bioclimatic Architecture in Colombia: a Comparative Analysis

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ABSTRACT

Based on the case study of two specific climatic contexts in the Andean tropic, this article sets out to demonstrate how the development of bioclimatic strategies can support architecture design in a variety of tropical climates, all this through the use of a bioclimatic profile applied to architecture.

INTRODUCTION

From nature's harmonious balance to the deterioration of the natural environment is a common path mankind has marked out through history. It's been this path on which architecture since the mid-twentieth century has left an aggregate ecological footprint with dire consequences for environmental balance and quality of life. The pursuit of human comfort in architectural design spaces at any price has been the main subject of debate among architects. The style and spectacle of architecture design has amply overridden (outstanding considerations regarding) the long-term sustainability of natural environments (López Morales, 2008).

It is from the foregoing background that the need for a more environment *responsive architecture* is drawn; the kind that can ensure quality of life going forward; one that allows for being permeated by climatic and geographic phenomena at all levels (Serra & Coch 2008); that is, one conceived from environment sustainability criteria to create conditions that promote healthful surroundings in comfortable living spaces (Givoni 1997; Serra 2009). In light of the above, it is safe to infer that moving away from an exclusively anthropocentric approach toward an ecological one represent an important challenge for modern-day architecture design.

The lack of Colombian research into the systematic design of bioclimatic strategies is the fundamental motivation for the study of a methodology of development of *bioclimatic profiles for architecture design*, which is the subject matter of this article.

AIM AND OBJECTIVE

Building a methodological reference, an ARCHITECTURE BIOCLIMATIC PROFILE, for climate analysis and a definition of bioclimatic strategies (for the Andean tropic), to be applied in two different Colombian climatic contexts.

CONCEPTUAL AND METHODOLOGICAL GUIDELINES

The work of this project takes an ecological approach to the design of passive strategies for building living spaces, which are conditioned by its surrounding variable environmental parameters and diversity of geographic phenomena. This as opposed to the design and construction of static environments in closed, airtight and rigid spaces, where sunlight and natural ventilation are replaced by mechanisms of artificial lighting and air conditioning (Serra, 2009 speaked about).

Colombia: Geographic and Environmental Context

Colombia lies in the Torrid Zone, which is characterized by high temperatures. Geographical factors and environmental parameters of the territory neutralize radiation received, making it possible for a variety of climates and ecosystems to coexist in a place, which would otherwise be remarkably hot, with a very high rate of radiation levels throughout its territory.

An abundance of geographic features, such as the Andes Range (Figure 1), mountains, lakes, swamps and rivers, sculpt the Colombian territory / topography. These make it possible for Colombia to enjoy a great variety of climates, which in turn make for the option of zoning the country strata and weather conditions, a decisive factor in achieving a better use of the solar energy resource in the construction of living spaces. This variety of conditions calls for very accurate information on the geographic and environmental determinants of each place, for the purpose of its bioclimatic characterization.

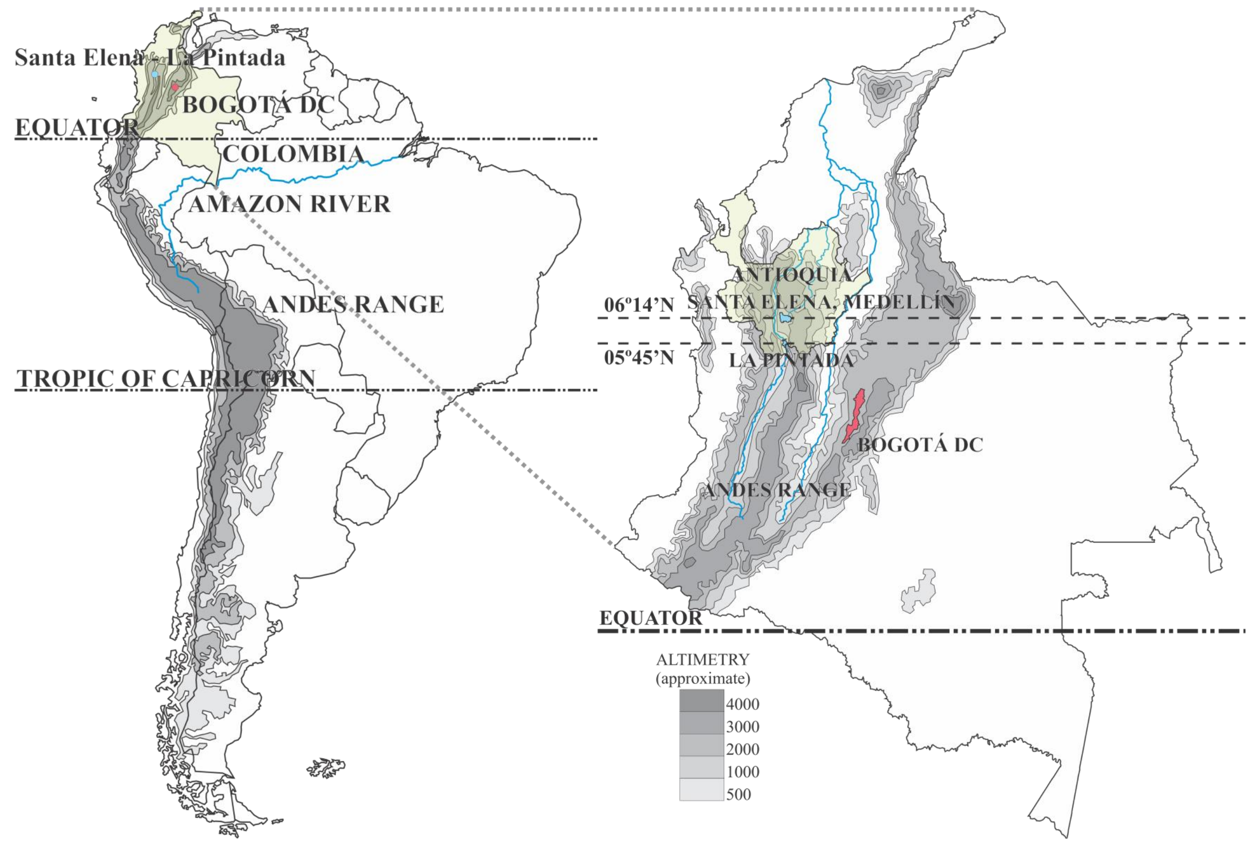

Figure 1 (a) Andes in Southamerica and (b) the Andes in Colombia.

Geographical factors related to latitude, altitude and orientation are required information, as they closely relate to the design of bioclimatic profiles in each context of the Andean region. Latitude, for instance, affects the angle of sunlight fall in both the dry and wet seasons, determining the risk of heat exhaustion and heat stroke. Altitude, on the other hand, affects the range of variability of air temperature throughout the year, which has an impact on ecological conditions (see Figure 2). The country's topographic orientation helps define the angle of incidence of sunlight, as well as the degree of exposure to the prevailing winds, which together account for the specific characteristics of ecosystems.

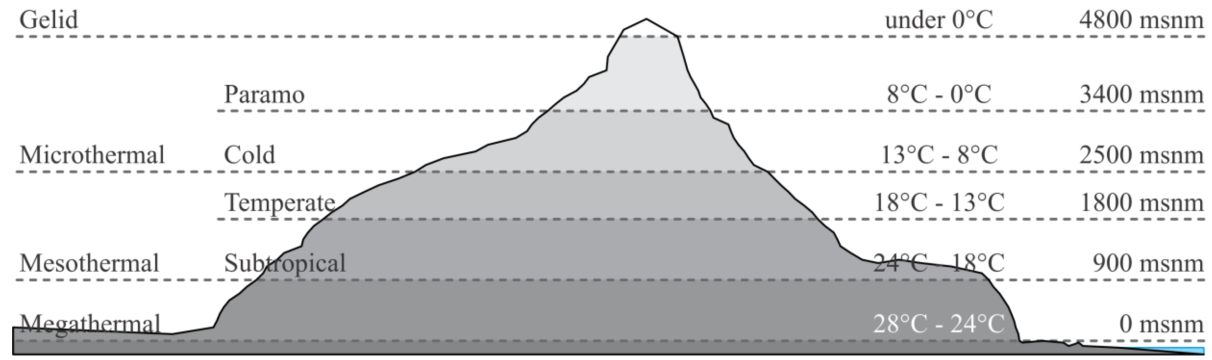

Figure 2 Schematic of geological strata by temperature.

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Equally important are the environmental parameters that account for energy efficiency, which give rise to climate characterization of a territory and call for an adequate level of comfort and a decrease in pollution levels, allowing for a better experience of housing, appropriate to the climatic conditions that make up their environment.

This context presents us with the current problems faced by environmental design in architecture, especially how to resolve situations from the first developmental stages of a project, considering the efficient use of energy for a given set of geographical and environmental parameters of a project's location. The challenge is to build homes as close to the comfort zone as possible, regardless of location, whether located in climate areas as extreme as the high moors (see Figure 2), where temperature and radiation levels can be fairly low during periods of precipitation, or in the case of high temperature, low precipitation areas such as the ones found in deserts.

In terms of comfort, this work observes the rating scale proposed by McIntyre (1978) and further developed by Auliciems and Szokoloay (1997), which determines the range of temperature that can be considered comfortable for the user, known as the comfort zone, and by which it can be stated that the human body should make no metabolic effort to adapt to the environmental conditions of its surroundings, in order to feel well.

Considering the regulation of the indoor climate of buildings, has led to two different methodological approaches to addressing architectural design. One favors active strategies for climate control of buildings, with standardized criteria in design. The other favors passive strategies and considers the user as an active subject in the building, one who interacts with the environment through his relationship with architecture elements. Consequently, the definition of comfort zone is different for each bioclimatic profile, given that environmental conditions and variables are the subject of study that make up the profile.

In considering the regulation of indoor climate conditions, whether in a warm or cold tropical context, it is final orientation, which maximizes the solar resource as a source of heat and light energy, as well as, the need for ventilation. In short, the proper orientation, which is determined by the thermal bioclimatic profile, depends on which floor the project is located.

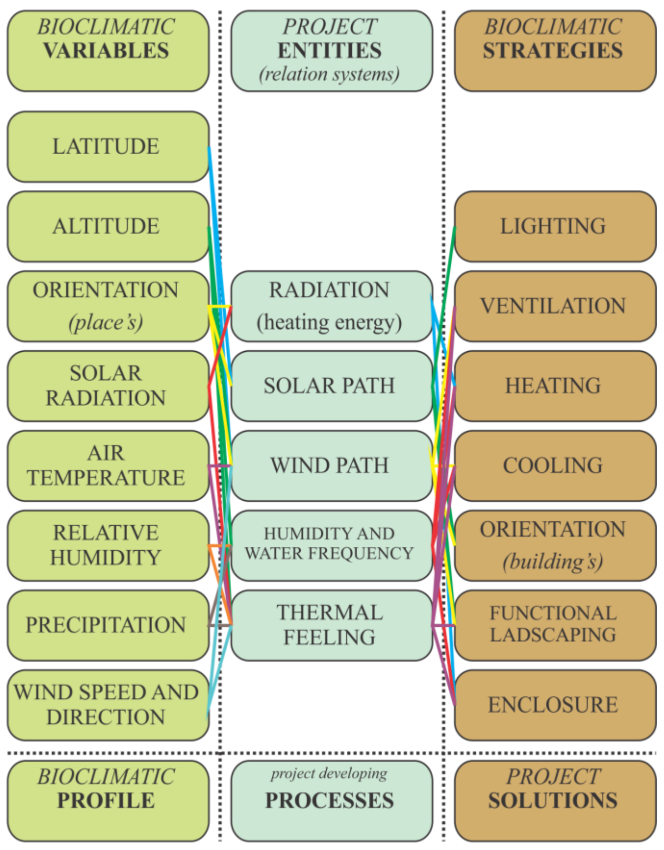

Figure 3 Methodological schematic.

Architecture Bioclimatic Profile

The purpose of an ***architecture bioclimatic profile*** is to identify the environmental variables that determine climate context, in order to analyze them in consideration of bioclimatic criteria necessary for making decisions at each stage of the architecture design process.

A project's architecture bioclimatic profile begins with the identification of those variables considered relevant, by virtue of their being constitutive of the climatic context, which affects directly the comfort of the project itself, namely, latitude, altitude, orientation, radiation level, (sunlight exposure), air temperature, relative humidity, precipitation, wind direction and speed. (see Figure 3). Climate data found through different national and international organizations are used to configure the climatic characterization of a place.

Data gathered on each of the above variables (see fig. 3, left column) become meaningful for an architecture project, once contextualized for its location, and analyzed from categories (see fig. 3, mid column) that take valuable information out of the data.

The information obtained from the characteristics of each variable reveals the energy potential available for the development of a particular architectural project. This constitutes the basis for determining the type of strategies to be implemented for energy efficiency and comfort, such as lighting, ventilation, heating, cooling, orientation, functional landscaping, and weatherization (see Figure 3).

As can be inferred from the above approach, the methodological structure of an architecture bioclimatic profile consists of a system of relationships that moves from raw data to meaningful information regarding the available energy resource, and from this, to the strategy. This proposal is a starting point to further developments concerning its subject matter.

APPLICATION OF ARCHITECTURE BIOCLIMATIC PROFILES TO DESIGN

Two towns located in northwestern Colombia serve as hosts and provide the context to implement the proposed architecture bioclimatic profile: The township of Santa Elena and the City of La Pintada, two territorial units attached to the Department of Antioquia, whose capital is Medellín.

Comparative Analysis of two Climatic Contexts

Prepared bioclimatic profile of each of the contexts to be developed (see Figure 4) A considerable climatic difference can be appreciated. It is attributable to the difference in altitude between one territory and the other (2000 m in total). Santa Elena is located atop a mountain ridge that divides two valleys, the Aburrá Valley, to the northwest, and the San Nicolás Valley, to the southwest, whereas La Pintada is nestled in the lower part of a valley which is crossed by one of the largest rivers of Colombia, and a section of whose is contoured by formidable canyons. The above characteristics are influential when analyzing the climate of an area in the Torrid Zone.

As a result of the differences identified in the bioclimatic profiles, the recommendations for bioclimatic strategies, that is the project design solutions, propose architectural designs whose adaptations vary between climates and territories. For example, lighting in St. Helena can use both direct radiation and scattered radiation, depending on air temperature and the time of day. So on the one hand, the need for solar energy is met. On the other, people can enjoy a convenient sunbath at certain times of day, when there is a chill factor. In contrast, in La Pintada, direct lighting is not recommended for a number of reasons, as it entails uncomfortable temperature increases, which are unnecessary in this place, and adversely affect the comfort of users.

As for ventilation, in Santa Elena active user intervention is recommended to ventilate the interior of living spaces, whereas in La Pintada, it is recommended that the architecture design incorporate constant ventilation systems to prevent overheating of units, and contribute to user comfort.

On the other hand, if we consider building orientation, alignment is done with taking into account the solar arc and air temperature, regarding the need for either ventilation, heating or cooling in the building, according to the characteristics of its bioclimatic profile. In short, all of the above decisions are interrelated thanks to the analysis of the architecture bioclimatic profile.

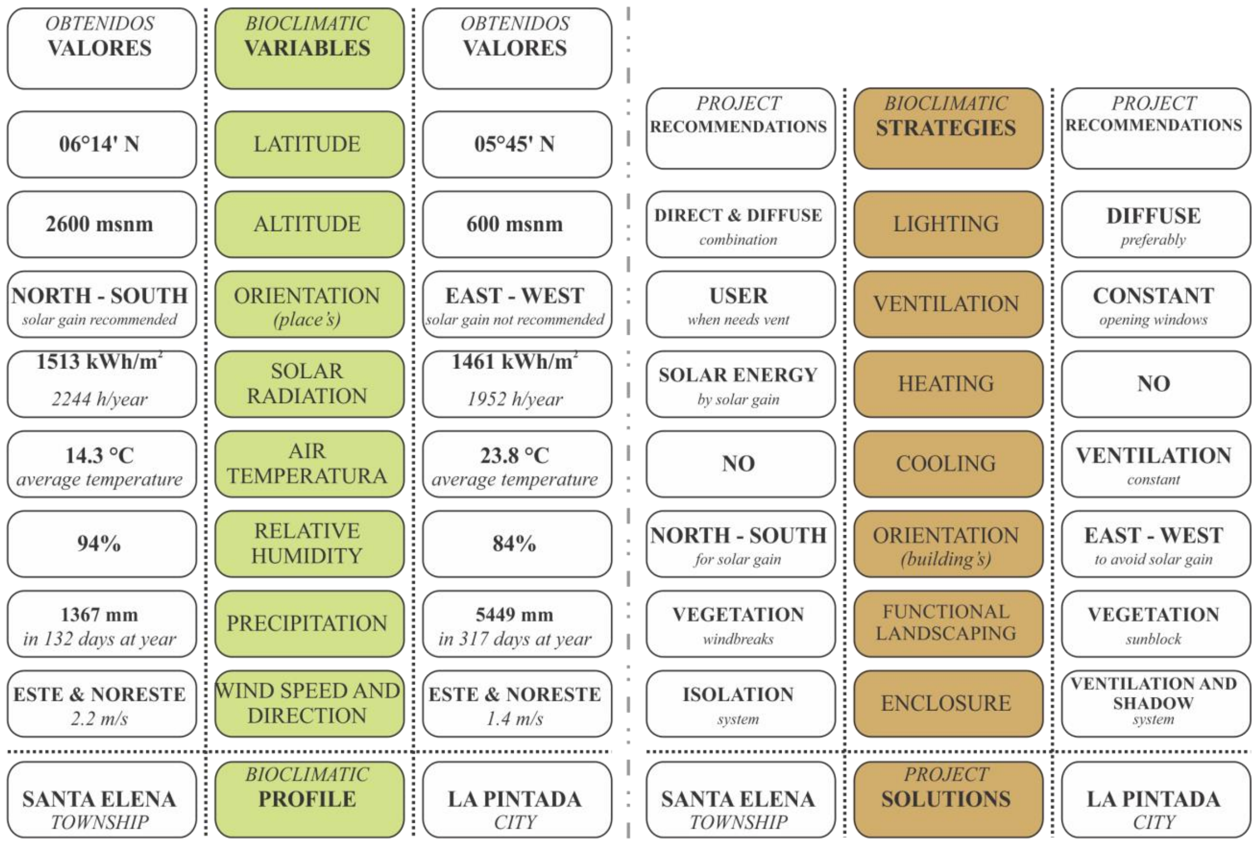

Figure 4 (a) Architecture bioclimatic profiles of Santa Elena and La Pintada; and (b) bioclimatic strategies of Santa Elena and La Pintada (climate values from IDEAM 2005; UPME & IDEAM 2005).

Based on the formula proposed by Auliciems and Szokoloay (1997), the temperature comfort zone for housing units in Santa Elena is lower than that in La Pintada (see Figure 5).

Santa Elena	La Pintada
Tn = 17.6°C + (Tm * 0.31)	Tn = 17.6°C + (Tm * 0.31)
Tn = 17.6°C + (14.3°C * 0.31)	Tn = 17.6°C + (23.8°C * 0.31)
Tn = 22°C	Tn = 25°C
Where	Where
Zc = Tn ± 2.5°C	Zc = Tn ± 2.5°C
Being	Being
Tmin = 19.5°C	Tmin = 22.5°C
Tmax = 24.5°C	Tmax = 27.5°C

Figure 5 (a) Calculation of comfort zone for Santa Elena and (b) calculation for comfort zone for La Pintada.

MAKING INFERENCES AND DRAWING CONCLUSIONS

Making way for an ecological approach to architecture is akin to harmonizing the comfort of living spaces with the potential of its surrounding environment, to ensure the preservation of the planet and improve the quality of life of people.

The findings of this research lead us to summarize:

The architecture design of a project should start with the climatic characterization of the environment where it will be located. This approach stands in contrast to the principles of standard architecture design, in the case of different climatic contexts.

The architecture bioclimatic profile is the basis for building a system of relations between the bioclimatic characteristics of the environment, its energy potential and the strategies proposed for achieving comfort, (besides representing a methodological reference for the customization of each architecture project within its context).

In different climatic contexts, before implementing passive strategies, it's necessary to figure how to apply the available energy sources to the generation of human comfort.

Putting together an Achitecture Bioclimatic Profile for each project means creating responsiveness to expectations of users and conditions of the environment, consolidating the two into adequate living spaces, within the criteria of durability, comfort, and efficiency in the use of natural resources, and environmental sustainability.

The field of bioclimatic architecture should a more creative, interdisciplinary endeavor that is socially responsive. Therefore, the challenge lies in transitioning from a mindset predatory of the environment to one concerting of vital living spaces in harmony with its surroundings.

NOMENCLATURE

Tn = neutral temperature
Tm = average temperature
Zc = comfort zone
Tmin = minimum temperature of the comfort zone
Tmax = maximum temperature of the comfort zone
Gelid = is the climate level located from 4800 msnm, known as gelid because of its icy temperatures and corresponds to the perpetual snow height. Presents temperatures below 0°C.
Paramo = is the climate level located between 3400 and 4800 msnm presenting temperatures from 8°C and 0°C respectively.
msnm = meters above sea level

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