HOUSING IN HOSTILE PLACES
Controlling adverse weather through architectural design in extreme climates: cold, hot/arid and tropical.

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ABSTRACT
This Architecture Master’s Degree dissertation studies housing projects located in regions of extreme climatic conditions and analyzes how climate influences spatial design. Studying the importance of spatial design and considering the necessary techniques to guarantee the welfare of individuals living in hostile climates and normally unsuitable for human establishment, is presently an extremely relevant subject in Architecture, considering that mankind is constantly being challenged to occupy the least suitable places for human presence.

The goal is to perceive how architectural components/elements can be synonymous with comfort-inducing conditions which can make human presence in extreme climate conditions possible. Considering humidity as an underlying factor which greatly influences human homeostasis, distinctions were established when dealing with hot climates, as hot/arid climates imply different needs than tropical climates. To clarify this topic, case studies were taken into consideration, located in three distinct climate typologies: cold, hot/arid and tropical.

The housing construction in these climate regions is strongly influenced by extreme meteorological/climatic conditions of the outside environment, so the constructive techniques are of major importance. Vernacular architecture will also be a reference used to understand the architectural design and construction methods used on the buildings within the presented case studies.

Seeking the best architectural form from a climatic point of view is essential to optimize living conditions in such extreme cases. Bioclimatic architecture (bio = life + climatic = climate) which, by definition, applies the most sustainable materials and technologies available to create a more adequate ambience for the inhabitants, takes advantage of the best nature has to offer to improve individuals’ wellbeing.

Architectural Design as a comfort producing tool is this dissertation’s main subject matter. The comparisons between different solutions to the different climatic adversities will allow us to understand what makes these buildings suitable for human occupation.

Key words: Bioclimatic Architecture; Architectural Design; Adaptation; Homeostasis.
INTRODUCTION
This Architecture Master’s degree dissertation is an exposition of how effective architectural design can control adverse geo-climatic, and meteorological factors enabling the creation of near optimal human comfort conditions, thus allowing occupation of extreme weather localities.

The aim of this thesis is to illustrate effective architectural design with geo-climatic/meteorological restrictive factors as a basis for projecting through the analysis of various case studies where the observation of design techniques applied to living spaces made suitable for the climate they are inserted within, as well as the complementary study of architectural principles used, especially when applied to vernacular architecture.

The pursuit of ideal comfort has long been the main key point within the minds of architects and builders alike, in Jean Dollfus’s vision (in Olgyay, 1963), the constructive typology is far more influenced by climate zones than it is defined by cultural/country boundaries, despite the existence of culturally influenced architectural form and taste. Bioclimatic influenced architecture gains a prominent role when the goal is to reduce the impact of meteorological/geo-climatic hostility on housing, regardless of its surrounding environment, through the reduction of unnecessary ambience stress while employing, at the same time, all the natural resources available that enhance comfort.

Through in-depth studies of local meteorological conditions, it is possible to produce effective and specific design strategies which allow for much higher comfort standards. The role of the projecting architect is a determining factor not only in defining and designing the structure but, consequently, the grade of comfort and overall welfare of the occupants. According to Olgyay (1963) the construction process of climatically balanced housing can be divided into four stages, the last of which would be architectural expression. This should be preceded by studies of the variables pertaining to climate, biology and technology (p.10).

Considering that there are several ways to model space with comfort and climate as primary concerns, outlined within this dissertation will be various detailed case analysis into different housing situations, contemporary architecture, as well as an additional and complimentary counter point analysis of traditional architectural design and solutions.

HUMANS, ENVIRONMENT AND ARCHITECTURE
Climate, meteorological phenomena as well as geological conditions are factors which directly affect human lifestyles and the ability to occupy and effectively inhabit locations. Understanding the mechanisms capable of helping withstand adverse weather and suboptimal geo-climatic conditions, which can greatly improve or even permit the establishment of human occupation, is the first and primary procedure to be taken in any study of human bioclimatology (Freire, 1996).

HUMANS AND CLIMATE
The human metabolism was evolved in line with the biological necessity to effectively adapt to the environment whilst minimally mobilizing/consuming energy and resources. One of the many factors which condition the success of said process, when regarding humans, has been extensively studied and refined into the contemporary term Human comfort zone (Olgyay, 1963). In an effort to adjust and better adapt to environmental conditions the human body catalyzes several physical and chemical measures, an example of which is the process that controls the temperature equilibrium known as the thermoregulatory system. This system presents
involuntary and voluntary measures to achieve its perceived goals, architecture being a voluntary behavioral process that represents a psychological response to the immediate environment (Freire, 1996).

According to the Köppen-Geiger climatic classification, Climate is divided into 5 major groups, graded from A to E, ranging in classification from warm (equatorial locations) to cold (Polar Regions). Considering the amplitude of climatic genres, as well as their diversity, there are also vast, numerous and wide ranging effective ways of maintaining and establishing what can be termed as thermal equilibrium for humans via architectural design. Just as the body reacts and catalyzes different adaptation strategies depending on the thermal/meteorological stimuli, so must architecture respond to climatic necessities in similar fashion. Within this dissertation, the climatic groups considered will be of more extreme natures, with particular emphasis placed on Cold Climate conditions, where the average temperature of the warmest month is less than 10°C, as well as Hot Climate conditions, where the average temperature of the coldest month is equal to, or situated above 18°C (Strahler, 1978).

The impact ambience temperature has on Human health is further conditioned by the presence of scalable relative air humidity, it is of marked importance to fully grasp the effects caused when studying singular climate aspects (temperature) against associated (humidity + temperature) on human health (Shapiro and Epstein, 1984). Comprehending the influence humidity/temperature combinations have as a whole is crucial to Human comfort parameters, however, it should be noted that in colder climates this combination does not result in such extreme conditions for Humans as compared to those observed in hot climates, where the relative humidity plays a fundamental role, as the physiological needs and thermoregulatory response are quite different in hot environments with high/low humidity indexes (DGS, 2008). Due to this physiological factor, in this study there is a clear distinction placed between Hot/arid Weather versus Hot/Humid Climates.

HOUSING

According to Olgyay (1963) housing is the main area of intervention when considering comfort manipulation, as the area fully allows us to meet the appropriate requirements thanks to our ability to produce changes in the natural surroundings, filtering, absorbing or rejecting elements of the environment according to its positive or negative influence on human comfort parameters. Norberg-Schulz (1975) adds that housing is a human necessity associated with the need to set down permanent residence, as such proves to be of central importance to human existence. The choice of architectural housing typology within this study was based and conditioned by the lifestyles of each individual and the roles that these lifestyles play as a regulatory element of human comfort.

In order to verify conditions of comfort and respect the physiological welfare of the occupants within a housing structure, it is vital that said structure be designed and constructed in a way which respects and establishes temperature equilibrium, relative humidity control, light and ventilation incidences - all within the comfort conditions predetermined for each location and its respective climate (Freire, 1999). Olgyay (1963) presents a diagram which determines the thermal comfort conditions in a given climate, linking the two main climatic elements: dry bulb temperature and relative humidity. This chart will be presented and used throughout this dissertation to classify the three regions’ climates where the case studies analyzed are located.
Traditional architecture exemplifies the relationship between individuals and their environment, as it presents a high grade of sensitivity to regional and local meteorology/geo-climatic restrictions (Freire, 1999). The spaces constructed in traditional architecture are specifically tailored to respect and incorporate social and cultural contexts, as such, they are not arbitrary but rather an expression of a reality, slowly developed over the centuries, performed with local media and technologies that express precise function and meet social, cultural and economic needs (Supic, 1982). Thus, these buildings serve as inspiration for contemporary architecture projects, when incorporating a bioclimatic approach.

THE SITE
Studying the conditions of a building’s surrounding environment involves having knowledge of the climatic characteristics of each region and consequently interpreting them from an architecturally significantly point of view resulting in formal approaches that mitigate the conditions. Within a bioclimatic architectural approach there are several key factors which need to be accounted for, the choice of deployment and orientation of a building, the design of interior space, the treatment of exterior spaces, the thermal behavior of the materials and its rate of absorption and reflectance. A building’s orientation also includes many other factors such as local topography, privacy requirements, sight, noise reduction, wind and solar radiation isolation. Thus, this study will discuss some factors that affect the deployment and orientation of a building, the latter being related to the sun, wind, water and vegetation.

THE BUILDING
In terms of architectural design, planning, projection and construction techniques applied when developing buildings, the use and implementation of natural solutions to better improve the interior conditions of the edifice, avoiding the use of mechanical devices is greatly desired. The shape of the building can provide solutions for various problem all on it’s own, as the form can be conceived in a way that establishes mutually beneficial relationships with the surrounding environment, taking advantage of the climatic elements that are favorable while disregarding and eliminating the non-desirable.

Mmeticulous planning of a housing project, its shape and orientation, the organization of its interior space and how it protects or is exposed to the outside elements, the choice of materials and colors applied, defining the number, size, shape, location and orientation of the windows and their contribution to adequate ventilation, size, slope and orientation of its coverage, and also of the influence of its surroundings, such as vegetation, is essential for the general improvement of comfort inside buildings, it is the result of a bioclimatic architectural approach, focusing on individuals' comfort while actively preserving the environment (Freire, 1999). So such aspects will be central in the discussion of the elements that play a key role in a bioclimatic architecture projections, such as the control of solar incidence, the materials employed, ventilation, and, finally, the overall spatial disposition of the building, so that one may understand the influence these parameters have on achieving comfort.

LIVING IN COLD CLIMATE
One of the main factors undermining the health of an individual is exposure to colder ambiences, housing is the key element, because more energy efficient buildings are associated with better housing conditions and thus comfort. An unsuitable thermal environment leads to a stark degradation of human health where excessive heat loss negatively affects the thermoregulatory
systems and causes discomfort associated with the feeling of heat loss (Vasconcelos et al., 2010).

**CLIMATIC CONDITIONS**

According to the climatic classification of Köppen-Geiger, there are three types of cold climates where the mean air temperature in the warmest month is below 10 °C and the summer is poorly defined or nonexistent. Two of these depend on the latitude climates, the tundra (sub-polar) and polar, while the third depends on the altitude, the climate of high mountains. However, in high-latitude continental regions, there are sub-arctic continental climates, which have short, cool summers and very cold winters. Considering that these regions also register very low temperatures, the implanted housing in places with these weather conditions should be prepared to protect individuals from the cold and are therefore considered in this analysis (Strahler, 1978). In short, in cold regions the temperatures are low throughout the year, precipitation is low and appears primarily in the form of snow (Delgado, 2006).

The main aim of housing in these particular cases is to reduce heat dissipation to the exterior, this tendency becomes more pronounced as latitude increases (Olgyay, 1963). In addition to efficiently responding to thermal requirements, the architectural design should be projected to reduce the action of the wind within the house as it enhances the feeling of cold (Rapoport, 1969). The choice of materials must have in consideration snowfall and ice formation as these factors represent a major threat to the integrity of the construction’s coating materials (Building America1, 2006).

**VERNACULAR ARCHITECTURE**

The solutions presented by traditional architectural form when dealing with cold climatic conditions all express compact construction dispositions, which minimize the area exposed to external conditions. Maximize exposure to sun light and the consequent orientation of the construction/the openings according to solar trajectory, promoting heat gain, and by appropriate sealing of the indoor air and careful control of the ventilation in order to prevent thermal losses. As is usual within vernacular architecture there is a marked employment of locally available materials, of which dense materials used, due to their low thermal conductivity, provide better insulation. It is also noteworthy that the materials employed within the composition of the outer coating have darker colors, in order to increase heat gains (Rapoport, 1969; Supic, 1982).

The buildings established in these climates must prove greater likeness of resistance to wind forces, and the need to protect the housing structure may even override the need for maximum exposure to the sun (Rapoport, 1969). Deploying the hillside takes advantage of higher solar exposure; establishing balanced heat distribution within the structure while allowing the topography of the site itself and the surrounding vegetation to further protect the enclosure from Eolic force (Olgyay, 1963). In traditional architecture there are two options for the deployment of a building: above or below ground level. Constructions that are made above ground, usually present themselves as isolated by increasing the area exposed to solar radiation and heat gains, with larger openings in the front and relevance in relation to the North- South façade where the gaps should be minimized so as to prevent a serious loss of heat to the exterior (Rapoport, 1969; Turner, 2003). However, due to Eolic action, which in some regions may be strong, it is necessary to reduce the surface area exposed to outdoor conditions and in these cases it is advantageous to agglomerate housing structure or even recur to burying,
totally or partially. In addition to Eolic force protection, the implementation of housing below the ground level presents advantages concerning the use and conservation of heat within the enclosure, benefiting, to a degree, from “Earth heating” (Olgyay, 1963)

CONTEMPORARY ARCHITECTURE
In cold climates, housing and buildings are normally in tight lock dispositions, adjoining the advantages of both smaller amounts of wasted heat as well as less exposure to the wind, however, detached housing verifies it’s own set of advantages which include reception of continuous sunlight which consequently maximizes heat gain through the primary/none primary usage of solar radiation. In order to control exposure to the outside elements, isolated buildings must be compact, with volumes which minimize it’s outer surface, so building one or two floors prove to be the best adaptations to these climatic conditions, thus favoring compact housing (Olgyay, 1963).

The orientation of the building is designed according to the prevailing wind direction and solar trajectory. The longitudinal axis of the building should extend along an East-West direction, as the best orientation in the northern hemisphere is the south, and inversely so in the southern hemisphere, the best orientation is north. Having these factors in consideration, the openings to the exterior should be small, with the exception of the facade with a higher incidence of solar radiation (Olgyay, 1963).

The outer walls are essential to filter the surrounding elements, as such it is necessary for these structures to present high thermal mass. The insulating capacity when dealing with low temperatures must be integrated into the design so as to withstand a high thermal gradient and thus the interior wall structures must have a large accumulation capacity to balance the extreme thermal fluctuations (Olgyay, 1963). Regarding the roofs, these must also present high thermal insulation capacities, with regard to form, the most suitable roof tops are inclined, which effectively allow the removal of snow accumulation by wind force.

To demonstrate how the principles of vernacular architecture can be applied to contemporary architecture, the Shelter Los Canteros, designed by DRN Architects, located in the city of Farellones, Andes, Chile, proved to be relevant to the subject matter on many grounds.

LIVING IN HOT/ARID CLIMATE
In arid regions, the psychological comfort requirements are broader than in moderate climates, individuals can better tolerate a wider range of temperature fluctuations as well as dismal levels of relative humidity (Fardeheb1, 2000). During the day, physical comfort depends mainly on the reduction of intense solar radiation, direct and reflected from the soil, buildings and the terrain alike. The aim of the architect in such conditions is to primarily generate, within the housing interior, temperatures gradients below those observed on human skin surfaces through adequate design, having special concern when projecting the outer surfaces of the structure (Koenisberger, 1980).

CLIMATIC CONDITIONS
The hot, arid climates, which can be categorized as semi desert like or desert like, covering one fourth of the earth’s surface, are found mainly in subtropical latitudes, about 15 to 30 degrees north or south of the equator (Givoni, 1989; Strahler, 1978). They are characterized by high temperatures and by the low relative humidity of the air and in particular by a single season which is predominantly arid all year round, a consequence of reduced and uneven precipitation. Being these the main elements
that characterize arid regions, it is essential to grasp that there are other characteristics which exert a large impact on human comfort and architectural design, examples of which include the brightness of the sky, solar radiation, the occurrence of sandstorms and the lack of permanent water sources (Koenisberger, 1980; Givoni, 1989; Strahler, 1978).

According to Köppen-Geiger’s climate classification, hot climate typologies are divided into either step arid climates (semi-desert like), and desert. Considering the duality of the aforementioned climate classification (may be be applied to both cold and hot desert like regions), it is relevant to assert that within this study only housing pertaining to hot climate typologies will be addressed (Strahler, 1978).

**VERNACULAR ARCHITECTURE**

In such areas it is fundamentally necessary to establish adequate protection for buildings against sand storms. Building structures must present spatial geometry which is as compact as possible, organizing the implementation of housing in large groups in order to shade the streets and houses thus allowing maximum volume with minimal surface area exposed to outdoor heat (Rapoport, 1969).

Proper orientation of a building is essential, it may represent a difference of 3 °C between the best and worst orientation. Indoor air cooling proves to be, under such climates, of maximum utility in conditions of extreme heat. In these regions, the roof is the design element that receives the most solar radiation intensity, followed by the walls facing east and west (Fardeheb, 2000). In an urban planning perspective, it is usual to arrange the housing in rows which extend laterally from east to west, almost totally cancelling out the radiation falling on those sides, allowing only the north and south facades to receive the impact of solar radiation (Olgyay, 1963).

However, if these dwellings are isolated and are built above ground level, the best orientation would be east-west as it minimizes the exposure to greater intensities of radiation.

Resolutions to thermal problems via vernacular architecture consist primarily in the employment of compact shapes when dealing with form, utilization of thick-walled structures with few openings to the exterior, underground construction in order to achieve maximum thermal inertia, so as to combat temperature variations characteristic of such climates (Delgado, 2006). The most common building typologies in this climate typologies are the patio homes, densely agglomerated so as to reduce the areas exposed to solar radiation, with exterior walls sans windows or adjacentely connected to other dwellings, thus presenting considerable thermal advantages. The connection is made with the outside through courtyards facing the center of the housing structures, which serve as activity centers for the resident occupants, restricting openings to the exterior to a bare minimum of necessity (Fardeheb, 2000). It is relevant to mention that within Traditional architecture, several time tested techniques under which passive cooling is established can be adapted to contemporary housing structures, such techniques and mechanisms are mentioned extensively in this paper and include controlled solar convection cooling, evaporative cooling, solar radiation cooling and ground cooling (Fardeheb, 2000; Givoni, 1989).

**CONTEMPORARY ARCHITECTURE**

Streets and houses should adopt a dense form, neighboring buildings should be banded and arranged in compact sets, reducing the exposed surface area through the creation of one voluminous structure, which in climates such as the aforementioned is of great importance considering reductions of solar exposure to the surfaces of housing structure is advantageous. However, when dealing with
isolated housing structures, where the beneficial effect of agglomerated volumes is not possible, the solution often encompasses the use of ground level floors where direct contact with the soil serves as thermal insulation or alternatively through partial or total burying of the structure itself thereby taking advantage of the earth as the cooling medium due to its thermal mass (Olgyay, 1963; Koenisberger, 1980).

Reducing the set of limitations, which hinder the appropriation of exterior spaces, imposed by this climate typology proves to be of primary concern when dealing with urban planning in such regions. High incidences of direct radiation, reflected radiation as well as an abundance of sandstorms are all problems which can be greatly mitigated through the creation of shaded exterior areas, thus allowing the use of these spaces even in extreme heat, giving greater freedom of movement to both occupants and pedestrians, providing housing and refuge against the above mentioned hostile elements and taking advantage of said inner courtyards which are protected from dust storms and where solar reflectance is controlled (Givoni, 1989).

As heat dissipation is the primary goal of these constructions, the orientation of the building is made around a patio element, an open space, enclosed from the outside, usually incorporating vegetation and/or small masses of water, which add the advantage of evaporative cooling to the housing structure as well as thermal loss through exposure of the patio to nocturnal temperature drops. The importance of these outdoor areas in warm climates is due to the fact that these same structures provide relief throughout the day against intense atmospheric conditions (Olgyay, 1963; Turner, 2003).

The western facade is subject to greater thermal gains as this is where the radiation intensity peak coincides with daily high temperature registries, hence the importance of these facades’ protection. However, there should be integrated elements that provide solar protection shade throughout the building with special consideration placed on openings. The introduction of projections on the facades, the extension of coverage, proper placement of trees in exterior spaces, or the use of walls and surrounding buildings as a means of blocking solar incidence are some of the strategies that protect fenestrations and nearly the entire length of the outer walls against solar radiation/reflectance, also reducing possible glare (Olgyay, 1963; Koenisberger, 1980; Givoni, 1989).

Special attention to exterior openings is required, as the diurnal and nocturnal conditions are quite distinct and the configuration of the openings must respect said differences. During the day, the openings must be closed, shade and ventilation should be reduced to the minimum necessary to ensure the renewal of the air, forcefully minimizing the input of heat and dust. The fenestrations should be located on the tops of the walls, so as to receive winds, whilst avoiding the entrance of surface dust. The air flow within these housing structures is directed at areas where it is necessary to maximize the efficiency of ventilation. Overnight the heat accumulated during the day is dissipated, however, the cooling effect verified on the outer surfaces is not sufficient for this purpose and, as such, the dispersion of heat must be supported by a proper nocturnal ventilation where there should be a total opening of all windows (Koenisberger, 1980).

The primary method of using wide temperatures ranges when establishing thermal equilibrium is through the use of structures with high heat capacity, which absorb as much heat through the outer surfaces during the day while keeping the
interior surfaces cooler until the heat penetrates the walls several hours later (Olgyay 1963; Koenisberger, 1980). The construction of the roof and outer walls with materials of high thermal mass, such as concrete, considerably reduces solar thermal gain during peak high temperatures.

The use of light colors, with observable low thermal absorption rates, reduces the dissipation of heat towards the interior surfaces of the structure. White paint applied on surfaces exposed to direct sunlight possess a very high reflective index, however when treating exterior spaces, it must be understood that the choice of colors for the exterior walls not only influences the climate changes in the interior, as it is also necessary to consider controlling possible glare caused by solar radiation reflected from the soil and the building.

Consideration will be given to the project Desert City House in Phoenix, Arizona, U.S.A., designed by Marwan Al-Sayed Architects as a means of exemplifying how traditional architectural principles can be integrated into contemporary projects.

LIVING IN TROPICAL CLIMATE

In hot climates, the air movement does not reduce the temperature but causes a sensation of freshness which is due to convection heat loss and to gradual increases in water evaporation throughout the body. Consequently, as the movement of air increases, the upper limit of predefined comfort also increases due to the restitution of comfortable temperature parameters and the feeling of freshness caused by the referenced evaporation is an adequate solution to counter high temperatures. Therefore, openings to the exterior, through light structures that allow the maximum possible flow of air is a plausible solution (Olgyay, 1963; Slavid, 2009).

CLIMATIC CONDITIONS

Hot and humid climates are typical of the intertropical zones, defined as the area between the tropics of Cancer and Capricorn which occupy approximately 40% of Earth’s land surface and host about 50% of the world’s current population (Ossen et al., 2008). This climate is essentially characterized by having little registered annual temperature variations, where the mean temperature of the coldest month is greater than 18°C do not have defined winter and summer seasons, having relative air humidity above 60% reaching peak values situated between 90 and 100%, high annual rainfall which is greater than the annual potential evapotranspiration (Turner, 2003; Strahler, 1978). To respond effectively to climatic conditions, building structures should prioritize the employment of shade, maximize ventilation and minimize heat absorption, as the relative air humidity is so high and registered temperatures remain constant throughout the day (Olgyay 1963; Rapoport, 1969).

VERNACULAR ARCHITECTURE

In tropical climates, air circulation is a key element when attempting to achieve comfort. Hill tops, highlands as well as windy mountain faces prove to be an ideal choice for building deployment, as valley areas in such climates are not favorable due to high incidences of precipitation (Olgyay, 1963). In areas of heavy rain or coastal areas, buildings are often elevated, with all floors constructed above registered water levels in order to prevent flooding within the ground floors, providing at the same instance, air circulation, which by itself reduces heat accumulation (Delgado, 2006; Building America³, 2006).

Traditional architecture is characterized by lightweight construction materials with low heat absorption rates which do not block ventilation but add protection to the edifice from solar radiation from all directions. When
regarding the building’s form, the desired characteristics are, displaced geometry and form with as bare a minimum of wall structures is possible, maximizing cross-ventilation; high ceilings and ventilated roofs with large overhangs which captures breezes to further facilitate ventilation and expel hot air, expelling rainwater from the structure enabling ventilation of spaces even under heavy rain (Rapoport, 1969; Delgado, 2006; Stouter, 2008).

**CONTEMPORARY ARCHITECTURE**

The orientation of the housing structure should be designed according to the sun-air factor, where the wind is perhaps the most important climatic element. Strong radiation effects in the east and west facades determine the tendency to adopt slightly extended forms, which are developed on this axis because the ideal orientation is one that exhibits the least possible area of incidence of solar radiation and, on the contrary, exposes the facades of greater dimensions to the wind (Olgyay, 1963; Ossen et al., 2008).

The architect should project ventilated spaces with large fenestrations in each room, even adjoined to the floor, so as to facilitate air circulation inside. The areas of housing where heat/humidity are predominantly produced, exemplified by the kitchen, must be located in places where the wind is more intense, however all divisions must have high ceilings that allow hot air to rise above the level of the occupant’s circulation. The airflow through the divisions should be maximized; however it is essential to put a woven or knitted protective screen against insects in fenestrations (Ossen et al., 2008; Slavid, 2009).

Relatively light materials with low conductivity/thermal storage capacity able to rapidly absorb and release heat, such as wood and aluminum, are one of the main methods used to achieve comfort. The knowledge of material behavior when exposed to high humidity is essential because it is utterly necessary to prevent deterioration of the materials used, especially those in direct contact with the ground (Olgyay, 1963; Stouter, 2008).

The roofing is the design element which requires a greater need for thermal insulation due to strong thermal impact as well as acoustic insulation due to the occurrence of torrential rains. It should be the architect’s prerogative to project roofing which incorporates and effectively neutralizes the aforementioned problems (Olgyay, 1963; Ossen et al., 2008). Ventilated double roofing bars and prevents incident solar radiation/hot air from directly infiltrating into the housing structure’s interior, thus reducing conductive heat gains. Pitched roofs are recommended, however, the use of flat roofs, duly insulated, with overhangs able to drain intense rainwater may also be employed. Whereas the shading of the cover is an accessible and easy way to reduce thermal gains, its shape can be designed so that there is an element, integrated into the structure which projects shade. Another solution is to use elements built, detached or integrated into the building, vegetation, and solar control devices which may be either internal or external primarily used to prevent solar radiation from penetrating the building, thus ensuring effective blockade of direct radiation through its design, location and proper handling, all of which improve thermal comfort and quality of lighting (Ossen et al., 2008; Eco-housing, 2009).
The use of white or light color which reflects both solar and general thermal radiation on roofs, walls and floors directly exposed to sunlight is also a method of reducing thermal gains, due to minimal heat absorption associated with such colors, heat flow transmitted to the building is also considerably reduced.

The house chosen as an example of an approach that takes into consideration bioclimatic architectural principles based on vernacular architecture was the residence RR, Morettin Andrade Architects, located in the coastal town of Ubatuba, in the Brazilian state of Sao Paulo.

CONCLUSION
Architecture can greatly improve upon the comfort level of any housing structure located in hostile climatic conditions at the early stage of development. If the design is created in accordance with the principles of vernacular architecture, taking into consideration the geo-climatic conditions of the implantation site, it is possible to control the climatic adversities, even in extreme climates. Although some factors, such as the architect’s and the client’s individual tastes, can result in very different formal solutions even in similar climatic situations, a series of measures can be taken in order to create a building that can provide a host of better living conditions and at the same time adapt itself to the environment all through the use of a bioclimatic architectural approach.

Some of the underlying principles are illustrated in the following table, which aims to guide building deployment according to the climatic conditions observed in hostile climate typologies: Cold, Hot/Arid, and Tropical, more specifically.

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The house chosen as an example of an approach that takes into consideration bioclimatic architectural principles based on vernacular architecture was the residence RR, Morettin Andrade Architects, located in the coastal town of Ubatuba, in the Brazilian state of Sao Paulo.

**CONCLUSION**
Architecture can greatly improve upon the comfort level of any housing structure located in hostile climatic conditions at the early stage of development. If the design is created in accordance with the principles of vernacular architecture, taking into consideration the geo-climatic conditions of the implantation site, it is possible to control the climatic adversities, even in extreme climates. Although some factors, such as the architect’s and the client’s individual tastes, can result in very different formal solutions even in similar climatic situations, a series of measures can be taken in order to create a building that can provide a host of better living conditions and at the same time adapt itself to the environment all through the use of a bioclimatic architectural approach.

Some of the underlying principles are illustrated in the following table, which aims to guide building deployment according to the climatic conditions observed in hostile climate typologies: Cold, Hot/Arid, and Tropical, more specifically.

**BUILDING AMERICA**1 – Habitat Congress Building America: Cold Climate Case Study. Massachusetts: Building Science Corporation. 2006.


