Chapter 16

Landscape Architecture of the Atacama Desert

Jose Guerra Ramirez

Additional information is available at the end of the chapter

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Abstract

This work focuses its reflection on the spatial and formal relationship between the conditions of extreme aridity of the Atacama Desert and the expression of an appropriate architecture where the contemporary notions of desert landscape and sustainable architecture intersect. The conditions of the desert environment are presented and differentiated between the different ecological levels that, by altitude, distinguish and determinate the architectural response. The notion of the desert landscape linked with the occupation of the Andean cultures is mentioned, contrasting this analysis but not under the traditional concepts that understand the desert landscape as an inhospitable landscape or a place that is not favorable for living beings. On the contrary, we propose to understand the desert as an ecologically fragile landscape of high scenic value, in which a desert culture has been developed, in the archaeological field, in the agriculture of the oases, and a great productive activity of the sustainable mining industry. Finally, the environmental invariants that are considered at the architectural design level are established as attributes or environmental properties integrated in an ecological framework allowing us to distinguish how these significant entities in a certain context organize in an unprecedented way how to inhabit the desert.

Keywords: desert landscape, architecture, arid zones, passive system, Atacama Desert

1. Introduction

The Atacama Desert is recognized as the most arid region of the planet; however, faced against this dry, inhospitable and hostile climate, the desert has revealed itself as a favorable environment to life under conditions of austerity and scarcity, where unpublished proposals for environmental conditioning have been implemented. These developments are what we highlight in this chapter. They are recognized as sustainable architectures, strategies that

have allowed to deploy on this extensive territory small human settlements of agricultural origin such as the ayllus, industrial origin as the saltpeter offices, the same as mining and urban camps as cities ports, each one of them with characteristics of remarkable adaptation to this territory, here are vestiges of more than 10,000 years sheltering life from atacameña tradition and perfecting the culture of the desert from small Andean villages, foothills oases, to saltpeter camps and city ports there is a chronology of territorial occupation from the Andes to the coast, which is diverse and complex through the pattern of high mobility and ecological complementarity that, with a history of prosperity and decadence, undergo processes of transformation, evolution and social-environmental conflict up to the present [1, 2].

In its diverse scales each ecological floor of the desert allows to identify units of landscape, micro-environments for example the ravines, they are transformed into natural shelters, their protected hillsides are considered discrete areas of landscape, which allow occasional occupations in relation to the presence of vegetables, more favorable environmental conditions, water availability and quality. This precision allows us to understand the desert landscape not as a void, but as a full territory where each rock, each hill has a name in the diverse toponymy of the Andean culture.

On a territorial scale, the Atacama Desert follows the pattern of high Andes-coast mobility, today full of mining roads, yesterday traces and caravan routes that crossed the wide and open landscapes of high visibility, associated with roads and paskanas (caravanner shelter), that have allowed to delineate roads that articulate the various environments of the desert. The geomorphology of the Atacama Desert offers a spatial continuum that connects the western edge of the Andean range with the eastern edge of the Coastal range. This is a dry world, with minimal groundwater resources, which are manifested in gouaches or utility wells for crossings through a territory of hyper-arid conditions [3].

The choice of certain mountains and hills along the transect, selected with the purpose of transferring the representation of icons inserted in the caravanserai ritual, symbolized the sacralization of the landscape where the geoglyphs marked the character of a sacred hill, in that space is that, making an obligatory transit passage, it was a landscape marked as a ceremonial altar as well [4].

It is necessary to distinguish on a spatial scale, the value of the oases that arise within the monotonous dryness of the desert, environments that offer protection and a favorable climatic condition for life, giving shape to a spatial order pattern relevant to extreme weather conditions, lifestyles, and transhumance of desert societies that are still a key component in the development of existing "islanders" settlements like the agricultural settlements of Chiu-Chui, Peine, Toconao or Socaire in the ecological floor of the Puna Atacameña, enclaves associated with the industrial development of the saltpeter, copper, and lithium mining or port cities of intermediate scale with developments far from the reality and built with styles and types of housing and buildings not consistent with the current challenge of sustainability, energy design, and architectural identity.

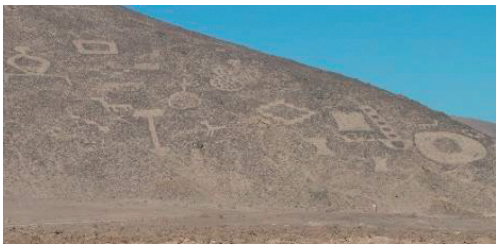

Figure 1. Andes-coast mobility, petroglyphs in route caravans.

The traditional architectural culture of the different ecological levels of the Atacama Desert is productive in examples that allow us to understand the relationship between the architectural form and climate conditioning, the bioclimatic strategies are based on the adoption of an orientation to sunrise, location on slopes protected from the wind, in situations of landscape mastery, use of building systems and local material resources that are manifested as adaptations to face the extreme climatic conditions of the desert. The adaptation practices have been categorized in the following invariants: to inhabit exteriority, to build the shadow and to inhabit the dark (**Figure 1**) [5].

2. Architecture in extreme weather

The Atacama Desert is the region with the greatest radiation and aridity of the planet; it is a territory characterized by the absence of rain and lack of surface water. The causes that determine these conditions of extreme climate are: the climatic stability produced by the subtropical anticyclone of the South pacific. The thermal inversion made by the Humboldt polar current creates a layer of cold air of low humidity called camanchaca establishes a wedge of high pressure between the 1500 m above sea level obstructing the approach of the hot and humid air mass from the South Pacific and the geomorphological condition given by the abrupt elevation of the coastal terrain (Costal Range) that is formed as a closed and continuous wall that prevents the penetration into the interior of humid air masses [6].

These are the conditions in which the architecture that expresses a sensitive approach for the weather is developed, we classify it as extreme, having to respond equally to the high intensity of daytime solar radiation and low night time temperatures, in this thermal contrast, the traditional architecture of the desert creates its formal expression using passive strategies. On one hand, building a thermal solar and light protection with a shadow envelope that shelters the daily activities unfolded in the external environment, as an extension of the interior. On the other hand, building compact inwardness that isolates and protects from the cold with thick stone or adobe walls that perform the function of storing thermal energy that is released at night.

The body perceives the extreme environmental contrasts that happen every day, the body manifests itself by expanding the senses to the enjoyment or the rigor of the thermal (heat or cold), the sharpness and light intensity (full light or deep darkness), and the experience of exteriority and the delimited interiority.

The relationship that the architectural space builds with exteriority, as the most remarkable dimension of the desert space is open, the exterior offers the possibility of growing, expanding, and arranging the open-air environments to carry out daily diurnal acts such as cooking and eating, the spaces of intermediation interior-exterior shelter multiple functions to be in relation with the outside, thus for example hallways, pergolas, terraces, and backyards, besides fulfilling the function of climatic control, allow direct contacts with the elements of the landscape that disrupt and change the sense of inhabiting the desert.

The territorial dimension of the Atacama Desert has always been a visual experience, since the first inhabitants, since the first caravanners, the desert has been related to great distances; a journey through vast territories without limits, a journey through immensity, through emptiness, a path that runs through the last skin.

"Nos sitúa como en ningún otro ambiente en la unicidad, entre el yo y la soledad del ultimo paisaje, en el último extremo, se experimenta la condición de estar sobre la piel más exterior en el último confín, en el límite donde solamente la corporeidad conecta esos dos océanos, acariciando los límites de la exterioridad." – *Author's inspiration, meaning might get lost in translation.*

They are intangible and tangible qualities that provide architecture with new esthetic and creative concepts, whose use requires careful consideration, as it is demonstrated by the vernacular architecture and the informal architecture of the desert [7].

The contemporary architectural culture of the Atacama Desert presents some remarkable examples of this adaptation. Places such as the ESO Paranal hotel, The Museum of the Desert, or the facades of the Court buildings are good examples of this mutation, works that create new expression language building a new esthetic of energy design, a new physiognomy that integrates and reinforces the regional identity, forms that are a contemporary reinterpretation of languages that evoke a patrimonial architecture where the design of an envelope that acts as sunscreen, light sieve, ventilated double skin, shade covers stands out and skylights that fragment the light intensity.

Architecture as part of ecological systems evolves along with the needs and requirements of its inhabitants, recognizing the impact on spatial and formal matters of these factors is part of the interaction and coherence of architecture with the preexisting values of the place, establishing a combination of new identifiable forms which are typical of the desert, with that, the aim is to achieve the integration with the ecological system using the natural energies that flow and impact on the building, in order to achieve the well-being and thermal and luminous quality of the inhabitable interior space where walls and windows, roofs and floors are not only observed as limits to protect against the weather, but as energy-capturing components [8].

The varied strategies of environmental conditioning of the architecture of the Atacama Desert in its various ecological levels are notable examples of the functioning of environmental conditioning strategies in its passive mode. The processes of "acclimatization" are

highlighted as actions and the effect that seeks to transform the architectural fact, to dispose it to a better condition of well-being especially in thermal and light matters. These processes which seem natural are not always present, and it is common to find foreign architectural and construction typologies that do not respond to these standards of cultural identity or energy efficiency.

In terms of matter and energy, the features of architectural design that affect the thermal performance of a building are above all its solar load and heat gain in summer, as well as the potential for ventilation and shadow construction. Consequently, the architectural design of warm weather places must consider the following aspects:

to achieve thermal insulation, mass of thick adobe and/or stone walls must be used, to control the direct radiation systems of ventilated facades and roofs should be preferred, and to control the intense natural light and solar protection of windows, blind systems should be chosen, for the sieve and filter among other variants such as incorporation of vegetation according to the ecological floor.

Here the participation of the user or home automation systems is required to operate, for example, the closing or opening of windows and/or shutters during the day, ensuring the darkening and cross ventilation of the interior spaces in the hot or cold periods.

With an adequate selection of passive strategies, habitability conditions are achieved naturally, and by taking advantage of solar energy, it is possible to provide up to 90% of the heating required by normal size building (**Figures 2** and **3**).

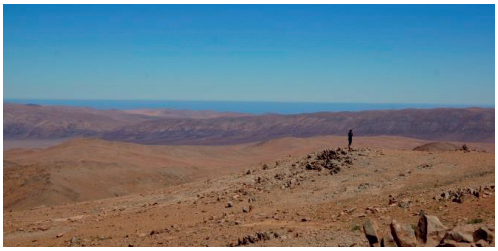

Figure 2. Infinite horizons, stony landscapes.

Figure 3. Spaces of loneliness, full luminosity, extensive landscapes.

3. Ecological landscape and architectural form

The altitudinal factor or geographic verticality defines the heterogeneity of the Atacama Desert, and this is the fundamental feature that defines the microclimatic profile and ecological system, in its transept from the low or coastal floors to the upper floors of the foothills and highlands of the Andes.

The climatic classification of Golubev distinguishes a great variety of ecological landscapes; however, for the purposes of the present analysis, we unify them into three large territories, three great landscapes, and three deserts: (1) ecological flat-littoral desert, (2) ecological flat-intermediate depression or longitudinal valley, and (3) ecological flat-high altitude foothill desert [9].

The altitudinal gradient is the characteristic, which shapes the landscape of the Atacama Desert, distinguishing it as one of the most fragile and inhospitable ecosystems on the Earth due to the combined effects of high solar radiation, low night temperatures, and extreme aridity.

It represents a great challenge of high environmental patrimonial value that in this environment stable habitats of more than 10,000 years of activity and human presence were built [10]. The strategies of adaptation and use of natural resources in each ecological floor are linked with an ancestral knowledge, which constitute an adaptive condition of the desert cultures. The manifestation of this domain occurs because of the productive activities developed in these territories, from the more traditional activities such as agriculture and Andean livestock, the development of small saltpeter mining and the large extractive industry of copper and currently the singular developments of scientific activities such as the important astronomical observatories of ALMA, Paranal, and Armazones to the thriving boom of the renewable energy industry based on the development of solar energy that has occupied large areas of photovoltaic farms, vital to understand the settlement model we find today.

In each ecological-geographical flat, we distinguish a singular occupation pattern of high mobility and Andes-Coast ecological complementarity since pre-agricultural times, this is verified in numerous archeological remains that define a dispersed occupation model following the structure of the streams that offer a natural shelter condition with thermal, hydric and vegetation qualities favorable to mobility between ecological flats.

This is an explicit variable for environmental sustainability, in the ecological, cultural, human and significant matters, understanding this means to overcome the importance of renewed and appropriate actions, where the implementation processes require adaptation to this reality that is inhospitable, with an environment of absolute solitude and where isolation is part of the self-absorbed personality of the desert man (**Figures 4–6**) [11].

The architecture of the desert of greater relevance is understood as a sensitive manifestation for the environment and weather, which connects the work with the landscape, the significance of this relationship establishes a constant interaction referred to the thermal and light aspects of the architectural space.

This circumstance is analyzed below and will be reflected in the ecology, the desert microclimate and the architectural form in the context of the Atacama Desert (**Table 1**).

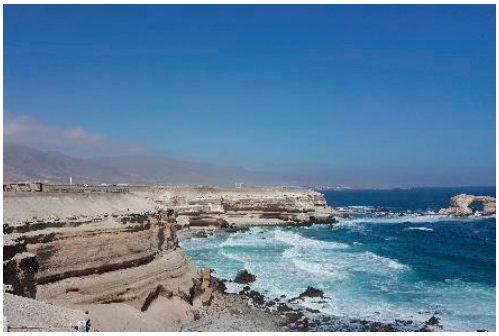

Figure 4. Geographic verticality – coastal desert.

Figure 5. Geographic verticality – desert intermediate depression.

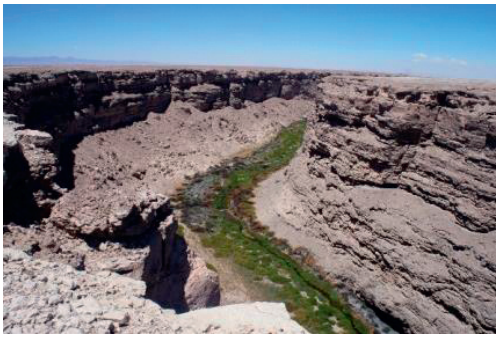

Figure 6. Geographic verticality – high altitude foothill desert.

Ecological landscape	Coastal Desert Coastal range	Desert Pampa Central depression Intermediate Plain	Andes range Foothill Highlands
Altitudinal factor	0.000–3.000	1.200–2.600	2.600–6.100
Features of the weather and environmental conditions	Tropical desert of marine or coastal plain appears without vegetation in low areas and vegetation like cacti in the high summits because of the presence of camanchaca High humidity Relative Presence of SW wind offers natural ventilation	Tropical desert full of alluvial plains Inter mountains No vegetation Extreme dryness No water Low relative humidity High thermal oscillation (day-night) Environmental dryness	Tropical desert with vegetation of jaral and tolar. Cold highland Andean steppe Oases Elevated temperature difference during day and night time Summer rain during the so-called altiplanic winter
Passive conditioning strategies	Natural ventilation Control of solar radiation on the west facade Control of natural lighting Capture of solar energy on horizontal surface Outside filter Eaves Covered backyards Covered terraces	Humidification Ventilated envelope Vegetation Capture of solar energy Shadow Extreme dryness	Thermal isolation Night cold Thermal mass Small vans Solar energy capture Day shadow Exteriorization of daily outdoor activities

Table 1. Eco-environmental characteristics and passive conditioning strategies.

3.1. Coastal Desert architecture

The geographical profile of the coastal desert corresponds to narrow plains delimited by the abrupt eruption of the Coastal range, reaching heights of more than 3000 m above sea level, such as "Cerro Paranal" of 2600 m above sea level and "Cerro Armazones" of 3046 m above sea level. The weather is characterized by a great atmospheric stability, with abnormally low temperatures for latitude, explained by the presence of the cold Humboldt current and of a characteristic coastal cloudiness (camanchaca) that dissipates at noon, which produces the greenhouse effect produces the "fog oases" between 600 and 1200 m above sea level which allows suitable conditions for the development of an endemic flora.

In the coastal desert architecture, it is possible to maintain an appropriate interior thermal comfort, involving only passive environmental conditioning solutions, and this is possible with the correct application of passive strategies such as an orientation of the building which

allows to take advantage of cross ventilation coming from the south west winds, use of passive cooling with double cover systems and ventilated wall, a form of the building that considers the control of the sunlight in the design of west facade envelope and a cover that limits the direct gain on those surfaces [12].

In this latitude, from the tropic of Capricorn, the high solar radiation hits almost vertically, which influences the thermal gain of the horizontal surfaces; hence, the importance of integrating energy-gathering roofs such as solar roofs, and solar control systems on the west facade, in the same way, the great impact of light is a factor to be considered in the architectural design of private and public spaces. The element that provides the greatest comfort in the coastal desert weather is natural ventilation, the constant presence of the sea breeze acts as a thermal regulator, modifying and moderating the temperature and relative humidity [13].

The most effective and efficient passive design strategies are: the design of a ventilated envelope, the solar protection that integrates a double skin on roofs and facades, covering with shadows intermediate spaces such as terraces, corridors and interior patios.

The intense luminous flux that produces visual fatigue and glare requires lighting control strategies of both the direct and diffuse component, here blinds or external filters, screens, skylights, and plant walls are particularly effective in producing light flow fragmentation and generating luminously comfortable interiors.

The building tends to be porous, the form tends to a fragmentation of volumes and openings; eaves, corridors, and terraces as extension of the interior. It has the objective of minimizing the heat gain by direct solar radiation or by conduction (**Figures 7** and **8**).

Figure 7. Shaded patio with cane weave.

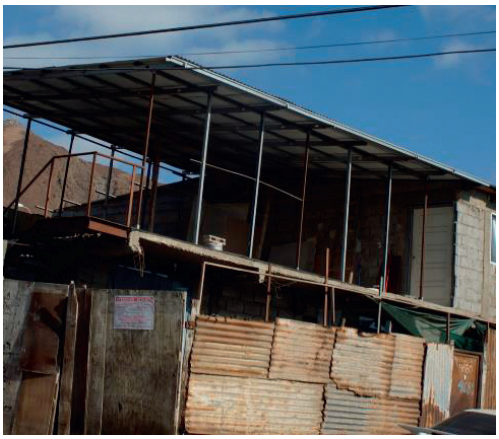

Figure 8. Covered terrace.

3.2. Architecture of the Atacama Pampa or intermediate desert

The pampa or desert of the intermediate depression is a plain that rises gently from 1200 m above sea level to 2600 m above sea level. The weather is totally desert, landscapes of extreme aridity, great atmospheric dryness, clear and clean skies, with absolute lack of precipitation, the highest solar radiation indexes of the planet-around 275 W/m^2, it has strong winds and large thermal oscillations from day to night time, during the daytime hours high temperatures are reached and during the night the energy loss by long wave radiation is particularly intense with large temperature drops.

In this uninhabited place, human settlements have a transitory nature (saltpeter offices and mining camps) and linked first to the exploitation of saltpeter, then copper, and today solar energy. The only and largest permanent settlement is Calama, which is located in the oases that is naturally generated by the Loa River and its development is linked to the proximity to the Copper Mine of Chuquicamata at 2900 meters above sea level.

The architecture of this area is prefabricated, and standardized models appropriately adapted to withstand the rigors of the weather which is expressed with generous corridors, eaves, pergolas that build deep shade sheds, that protect the facades of the shadow building from exposure to direct radiation. The high illuminance is controlled with a light envelope of low thermal capacity that allows ventilation that generates shade and diminishes the intense luminosity, and to increase the low humidity, water is used for the vegetation in grapevines and creepers (**Figures 9** and **10**).

3.3. Architecture of the Andean foothill or Puno region

Ecological foothill floor, known as the low and high atacameña puna, goes from the 2600 m above sea level where the gorges, salt flats, and high summits stand out that can exceed 6000 m above sea level as the Llullaillaco Volcano that reaches 6739 m above sea level.

Figure 9. Double cover shadow.

Figure 10. Shadow under the windows.

Puno region presents the most stringent climatic conditions of the Andes in terms of aridity and the reproduction of flora and fauna. The physical-climatic profile that distinguishes the region is characterized by the tenuous atmospheric layer and a low relative humidity; both factors allow to achieve high solar radiation indexes during the hours of insolation (230–290 W/m^2 annual average) and high loss by long-wave radiation from the Earth's surface 24 h a day.

The greenhouse effect in the Puno region is weak; during daylight hours, high temperatures in the ambient air are not reached, and during the night, the loss of energy by long-wave radiation is particularly intense with large temperature drops. The relationship between global radiation in summer and winter is 2:1; this makes it necessary to use passive systems of accumulation of the day for the night. This implies the use of passive systems using thermal mass, a north-east orientation to collect the first rays of sunlight and a protection of the norponiente wind that is intense at dusk, reaching greater intensity during the winter months in which it develops speeds superior to 60 km/h.

The average temperature has a high thermal oscillation between 21 and 4°C, the lowest temperature in the winter months can reach −2° C. Relative humidity usually low, fluctuates annually between 30 and 50% and, even though there are no many rain events, those are concentrated in the summer months in response to the high plateau winter.

The vegetation in this area is expressed in the oases and the formation of tolar vegetation in the bottoms of fertile ravines and hillsides typical of the ecological floor 3000 m above sea level, significant for its forage potential, favorable for hunting and/or grazing activities.

The vernacular architectural proposal that we observe in the Atacameña Puna is naturally linked to provide a minimum shelter for extreme weather conditions, with the resources that are available in the environment; consequently, the physiognomy of architecture is associated with a direct correlation between ecological and behavioral aspects. The main characteristics assumed by households in the face of climate determinism are: their solar orientation, location in environments protected from the wind and use of local resources as basic building materials, in this case stone or adobe.

Different typologies are found in the use and constructive technique for the construction of walls with thermal mass, black natural stone wall without mortal is used for premises such as corrals and outdoor fireplaces, walls of large white natural stone which is available in the corners, and lintels as structural reinforcement and significance.

From the microclimate point of view, the structure of the house, its arrangement and the order of the backyard work like a solar clock because the solar position establishes the moment of the diurnal-nocturnal cycle.

The structure acts as an energy collector which is open to the East, toward the morning Sun and close to the west where the cold and dry wind whips, where the Sun declines, letting the night emerge, when the "shadow passes through" the cold arrives.

The compact form is an appropriate model for settlements in arid areas, narrow streets, buildings with small intertwined backyards contribute to generate a microclimate or "a cool island," moderating the temperatures in relation to the external weather. The effect of the urban heat island, in general, in arid cities is mainly a nocturnal phenomenon, and has less relevance than in more tropical regions.

The exposure of the building's mass to cooler afternoon air could get increased by maintaining a compact configuration during the warmer hours. The walls act as a storage mass, helping to stabilize the large daily temperature fluctuations and increase the thermal delays between the maximum external temperature and the minimum internal temperature, a closed envelope with a high thermal capacity helps to control the loss of energy and the internal/external energy flow and vice versa.

Figure 11. Kitchen and dining room outside.

Figure 12. Vernacular house in Alto Loa.

The envelope in contact with the outside must be as small as possible to minimize the flow of heat into the building. The possibility of transforming the area of the effective surface of the envelope of the building, in relation to the station or the daily climatic condition (**Figures 11** and **12**).

4. Spatial-environmental invariant features

The environmental invariant features integrated in an ecological framework allow us to distinguish invariant qualities as significant entities in a certain context of related variables that articulate ways of inhabiting:

1. To inhabit the desert as an experience of living the exteriority
2. To inhabit the desert as the construction of the shadow
3. To inhabit the desert like living the darkness or semi-darkness

4.1. To inhabit the desert as an experience of living the exteriority

We define the natural desert space as pure exteriority; the condition of the architecture is forced to manifest this condition in its form. The link between inhabiting the desert with the exteriority has the following formal consequences: on one hand, it brings the elements of the exterior landscape in a controlled and fragmented way into the interior, through elements that filter the light and build shadows; on the other hand, the interiority projects diverse outdoors acts, being confused with it.

To inhabit the desert environments, has as a primordial quality this possibility of inhabiting exteriority as interiority, that is, a great diversity of daily activities can develop fully in the open sky, a circumstance commonly observable in the ways of occupation and exteriorization of inhabiting. However, this quality of the desert space, of an apparent simplicity, involves a subtle complexity, since the temporal condition determines the form of use of outer space. If we notice the form taken by the building, in the occupation of outer space, we will verify

that the relationship of the interior with the exterior is based on a dynamic understanding of space, in other words, the shape of the building can grow and/or decrease, it can incorporate or separate spaces, from every point of view, the form is being transformed and interacts with its environment.

From this point of view, the construction of the limit in the desert space, despite having the safety function, is, above all, a response to the need to size exteriority. Likewise, as happens naturally in areas where the relationship with exteriority is mediated by the arboreal mass, constructing the interface of mediation between inside and outside, in desert environments, this notion of mediation or limit does not exist naturally. Therefore, it is necessary to build and configure it, to conquer a distance or size [14].

Indisputably associated with energy parameters, the desert architectural space is determined by the dimensions of an immeasurable landscape deprived of vegetation. To inhabit the desert is to inhabit the immensity; it is to be in the extension to build an order in relation to the tectonics of the Earth, the stone and the sand. In a landscape of infinite horizons, the construction of the vertical to configure the shelter and the shade is an unprecedented fact in this desolate landscape, a wall defines the side of the Sun and the side of the shadow; light and shadow are the binding qualities that found the order of the desert space. The environmental conditions of the outdoor space allow that the interaction between people and their built environment become dynamic so that the interior space is overturned on the outside.

The formal qualities of the desert space are determined by the ways of using the interior-exterior space and by the way of performing the lighting conditioning of the interior. A delicate architecture of filters, of shadows and darkness, of semi-open or semi-covered spaces, an architecture in which daily acts unfold under the shade, in coexistence with the order of exteriority. These qualities have been the architectural material of notable contemporary architects who have succumbed to the magic of the elements, reflecting in their forms the influence of these sunny territories.

Each one of these architectural works is an act of creation that fuses the body and the landscape through the senses and movements, which adapt and respond to that great availability of the Sun and light of the desert territories (**Figures 13** and **14**).

Figure 13. Outdoor yard.

Figure 14. Exteriorizations of daily activities.

4.2. To inhabit and construct the shadow

For every architectural form, the Sun is an element of essential order, but for the architecture of the desert, according to Thomas Herzog, the Sun offers the highest degree of technical efficiency in direct uses (natural light or passive thermal application) and indirect forms of free emission (wind towers, photovoltaic installations or thermal collectors) [15].

In arid areas, the environmental conditioning needs of the building depend on the type of desert climate, but usually are ventilation, cooling and heating requirements, for which various strategies have been developed and they consist of minimizing the solar gain or heat load through the architectural design, isolate through natural means to reject or capture and store heat for future needs or capture energy. The protection of the intense luminosity with the application of filters in the windows and/or the darkening of the interiors in the daytime hours, to maintain thermal and visual comfort, are some of these strategies.

The preference for energy design represents a unique option for the progress of developing economies, the environmental orientation of the desert architecture implies the integration to local conditions and specific needs, rather than a regulation, the work should be aimed at knowing creative processes and skills, as shown by the solutions proposed by users and architects in the references. In these transformations, new architectural concepts are developed, but without forgetting the traditional proposals. The transformation of housing makes unprecedented possible prototypes, which have the hallmark of informality and "vital architecture" [16].

The process of transformation or conditioning of the households identifies dominant actions in the climatic design for the coastal desert climate, in the fact of building double envelopes such as double covered or double facades. These elements participate in a decisive way in the defensive action, as a passive system of climate control and also, in the spatial definition of the built event, being relevant in the topics of natural ventilation, insulation, and solar protection.

In this constructive action, we distinguish as a founding act in the definition of the desert space, the construction of the shadow, rather than defining the walls, at the beginning the definition of a shadow, an ephemeral shed, almost immaterial, it is significant. This constructive fact establishes a formal, singular, and decisive language for the architecture of the desert, in poetic terms, we can say that the architectural corporeity dresses itself as immateriality, where the limit is diluted in the light of the desert.

To construct the shadow is to construct a form in movement, in constant change, which defines limits and spaces. The shadow is directly linked to the characteristics of the envelope, participating in the definition of the duality of the interior-exterior space. The construction of the shadow involves determining the characteristics of the envelope; in this case, we are not talking about a hard, cold and dark shadow, but rather a dim shadow that filters the light.

The definition of this double envelope in facades and roofs implies a dynamic spatial development, which as a system must respond to the function of solar radiation isolation, allowing also natural lighting and ventilation of interior spaces. In most cases providing spaces of habitable intermediation, spaces of attached extensions such as corridors, portals, shaders, sheds and covered terraces, which also allow environmental regulation in the development of human acts (**Figures 15** and **16**).

4.3. To inhabit the darkness

The regulation of visual comfort in the light field in desert climates is one of the less developed aspects of contemporary architecture, which seeks transparency and luminosity. However, in the vernacular architecture, the care for these aspects was clear, and the different graduation of light and shade in the premises was a function of the degrees of privacy or retreat.

When we observe the transformation made by people in their own homes, we find ourselves with a lighting control strategy appropriate for the local weather, even though the measurements of the lighting level of the indoor areas express values below the recommended, the light perception in these environments is comfortable, because inhabiting the darkness does

Figure 15. Light fragmentation in market in Maria Elena.

Figure 16. Railroad garage roofs in Antofagasta.

not mean living in the dark but being in a cool environment, in a half-light atmosphere, with pleasant and adequate light in relation to the intense external luminosity.

Today when artificial lighting fills everything, eliminating the last few shadows, it is remarkable to find environments in the homes of the desert where, the light concept of spaces is defined in the coexistence with semi darkness, in the soft twilight.

The discovery of the use of cold and dark colors in the interiors; spaces painted blue-green colors when interacting with dim lighting, they manage to build a smooth exterior-interior graduation through the transition spaces, which contrasts with the external glare offering luminous and thermally comfortable environments in a cool darkness, which is a pleasure from another time [17].

For a long time, the architecture of the desert neglected the environmental and energy efficiency aspects in desert cities, nowadays, there is a growing trend that reverses this attitude, the climatic aspects in the design of housing have been taken into account, the same as solving thermal problems of heating or cooling with renewable energy especially solar and passive strategies and energy, these practices are more frequent and they show a clear signal of the cultural change of comfort and well-being (**Figures 17** and **18**).

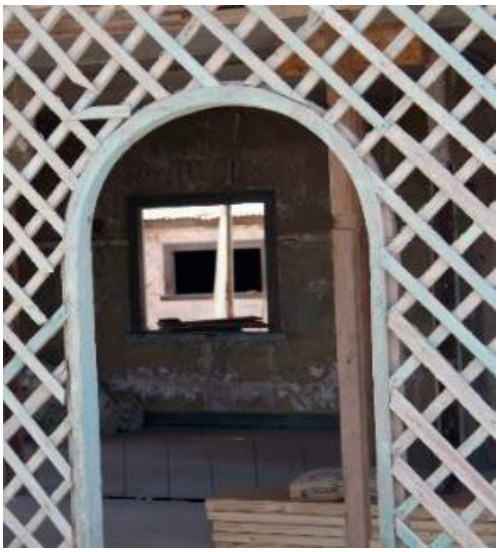

Figure 17. Shadow transitions.

Figure 18. Filter and interior darkness.

5. Conclusions

In the words of Peter Reyner Banham, in the book Scenes in America Deserta [18, 19]. Modern cities in the desert seem out of place, clumsy anomalies in a place where nature must prevail properly.

This is a statement that we share, since it can be seen when we see that the development of recent architecture in the cities of the Atacama Desert repeats constructive typologies that are not related to or linked to local climate conditions.

In that sense, it is very clear to establish that the architecture of the desert needs unprecedented and creative responses that answer to environmental invariants, in which the recovery of traditional values is designed, with the incorporation of appropriate technologies, so that the architecture and cities of the desert do not appear uprooted or out of place, without the environmental consideration determined by the landscape.

The interpretation made of the landscape is linked to a proposal of action that is expressed in the constructed form. The recognition of this formal impulse is not exclusive to desert environments, the seduction which the elements of nature manifest themselves with in this landscape makes the expressive language austere and of greater determination.

The qualitative aspects are linked to the appreciation of the desert landscape, especially in relation to the immensity, the extension of its limits, and with the vastness, the tectonic roughness of the skin, or the intense luminosity to which the environments are exposed, among other features.

The relationship that people establish with the built space is linked to the quality of the existential experience of the environment that surrounds us, all of which makes us belong to a social and cultural totality [20].

Our spatial perceptions and experience are associated and stored in our memory, along with the environmental qualities of a certain temperature and luminance quality. In the case of the desert space, these characteristics impact on the quality of the habitat, as well as the experience of satisfaction when contemplating a sunset in the desert, it will be associated to the atmosphere and light quality, to the silence that surrounds us and overwhelms the beauty of colors that lights the desert.

Consequently, the assessment we make of sustainable architecture in desert areas is not limited to highlight energy savings or lower maintenance costs of a building.

The greatest importance of a sustainable building lies in the positive impact and change of the conditions of habitability, which are housed in the levels of well-being in our existential satisfaction matrix of "being," which are ultimately the most important attributes for our existence.

The incorporation of new unpublished and creative proposals with high standards in the architectural quality of the interior environment, and integration of passive environmental conditioning strategies and the technical specification of first quality materials have a positive impact on the construction of a desert architecture with an identity.

This identity leads to the construction of a new esthetic in relation to the physiognomy and expression of the envelope, which integrate the concepts of "energy capture facade," "active facades,"

Figure 19. Cover in new school of Tocopilla city.

"green facades" or "solar roofs" in all of them there is a purpose of integrating renewable energies for solar capture, which ultimately renew the architectural language and urban landscape.

The energetic design is changing the expression and language of the architecture in the Atacama desert, expressions of a new esthetic, a new physiognomy that integrates and strengthens the regional identity, forms that are a contemporary reinterpretation of languages that evoke a heritage architecture, where the design of an envelope that acts as a solar filter, light sieve, double skin, ventilated intermediate space, shade covers, and skylights fragment the light intensity of the desert landscape (**Figure 19**).

Author details

Jose Guerra Ramirez

Address all correspondence to: jguerra@ucn.cl

Universidad Católica del Norte, UCN, Antofagasta, Chile

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