"A CRITICAL APPLICATION OF TRADITIONAL URBAN PATTERNS AND HOUSING TYPOLOGIES IN A DESERT URBAN TOWN: THE CASE OF MAJES CITY, PERU."

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ABSTRACT

This thesis deals with a critical application of urban patterns and housing typologies through an urban design study for a new town in a desert region. The effects of an arid climate on urban life and the functional organization of a new town are examined together with the impact of cultural traditions of city building.

Majes City is to be a component of the Majes Irrigational Project planned for the coastal desert of Peru. The climatic conditions and the geographic situation of the site are seen to be major factors in defining criteria for the spatial configuration of this town. Peruvian urban traditions and urban traditions common in other desert regions in terms of urban patterns are also studied in order to define further criteria for the design proposal. In addition, the design is based on a grid-block system which is an urban pattern with specific housing types in developing Peruvian cities. Hence, the design seeks to simultaneously respond to several contextual issues including: the site, the climate, people's culture and needs, Peruvian urban traditions and modern attempts to improve the urban environment.
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I.- INTRODUCTION

As an expression of human life in desert regions, urban form and architecture have been shaped by the physical characteristics of the site, climatic condition, people's culture, life style, and socio-economic development. All these factors have allowed people to achieve specific solutions. However, there are some common characteristics in town configurations and architecture that have been shared in desert regions around the world. Therefore, it is important to establish the relationship between climate and urban layout and between climate and architecture in order to understand how cities in desert regions are often the expression of that relationship. On the other hand, cultural heritage and economic development have historically had stronger influence on the specific relations between climate and the man-made environment.

In the light of these general considerations, this study will predominantly focus on physical factors and traditional patterns in human settlements. In addition, this case study will be applied to desert zones in Peru where the Peruvian government is trying to increase the agricultural land and develop new settlements as an alternative to migration to the main coastal cities. So that the proposals dealing with that particular policy must also respond to the specific physical, economic and socio-cultural context in order to
achieve accuracy and appropriate fit. Therefore, this thesis is an attempt at a systematic approach to the environmental conditions of deserts, urban spatial configurations and housing typologies as a response to man's necessity for adaptation to a particular context.

The thesis is organized in three main chapters:

The first chapter describes the general characteristics of desert regions. Moreover, this chapter considers some factors in the solution to this problem showing ways to establish specific relationships between physical environmental conditions and urban and housing design.

The second chapter is a case study: Majes City. This part contains an analysis of the site and its environmental features, its population size and growth, and the people's socio-cultural behavior in the urbanization of southern Peru. In addition, this chapter establishes the general criteria for the allocation of activities (production, consumption, human settlement and transportation) according to the type, role and function of this new urban unit in the regional urban system and in its adjacent development area.

Finally, the third chapter contains design proposals for the spatial organization of Majes
City, including the neighborhood patterns and housing that respond to the conditions discussed in the first and second parts. In conclusion, I will make some general recommendations for urban design in arid regions.
II.- CHARACTERISTICS OF SETTLEMENTS IN DESERT REGIONS

A.- Presentation of the Problem

1.- Physical Characteristics of Desert Regions

Desert climatic regions are usually areas in which there is little rainfall; this causes the area to be arid and barren of most plant and animal life. Due to the lack of arable lands, these areas have few inhabited settlements.

While all deserts share some common features, such as aridity and extremes in temperatures, particular desert climates are determined by the following factors:

- The latitude of the area, which partially determines the amount of solar radiation and the range of temperature.
- The distance from the sea.
- The absolute or relative elevation of a given place, which affects its aridity and also the range of temperature between day and night.
- The topography and geomorphology of the place which distinguish it from its surroundings and determine its microclimate.

These variables act separately or together to first determine the general climate of desert regions and also the variations among them. Weather is primarily defined by temperature and rainfall. However, average temperatures are of little significance in some arid regions where ambient temperatures vary greatly between day and night, summer and
winter. High temperatures can cause heat damage and low temperatures limit the growing season.

While aridity is the principal characteristic of desert region, wind is an important factor of climatic conditions. Strong warm winds are often accompanied by sandstorms. During certain season there are strong winds that blow harder by the day than by night. These winds can be decreased by the presence of shelterbelts and made the place usable for plants, animals and urban development.

Agriculture and urban centers in arid and semi-arid regions need a special kind of forestation to protect plants and humans from the wind that often carries sand. The main objective of shelterbelts is to reduce wind speed in order to change or to preserve the microclimatic conditions for human and agricultural activities. In fact, in desert cities, urban open spaces also need to be shaped by dense areas of vegetation, trees and water in order to counteract the dryness, and wind and create a favorable microclimate. In addition, compact urban configuration can also protect from the wind.

Desert soils have potential for agricultural and mineral exploitation. They require special treatments in order to eliminate natural limitations not only for agricultural land use but also for its use as building materials and foundations.

Soil formations with high concentration of sand are sometimes called "dunes"; these are of aeolian origin. Dunes
are sometimes composed of quartz grains. They are moved by the wind and their shapes depend upon the wind's direction. Stabilization of dunes is very important for the development of desert settlements.

The effect of solar radiation is another general meteorological subject of particular importance to the arid regions of the earth. It affects the heat and water balance which plays an important part in establishing the level and intensity of a region's aridity.

The solar constant is the amount of the sun's energy that falls in a unit of time on a unit of area 93,000,000 miles from the sun and perpendicular to its rays. The mean value is 1.94 cal/cm²/min or 420 BTU/ft²/hr. In desert areas high rates of that energy can be reached.

Part of the incoming radiation is affected by the surface of clouds and part is absorbed by atmospheric elements, but some of this is regained as diffuse radiation. In addition, radiation raises the temperature of the air, the ground and the surrounding objects. This phenomenon is caused by reflected and absorbed radiation.

Another variable that affects human settlements and architecture in desert regions is high-glaring which brings about not only specific colors and openings in desert architecture but trees or green areas in urban spaces.

2.- General requirements for urban settlements in desert regions.
In order to reduce and counteract the particular climatic stress of an arid region, urban life requires a special architecture related to a particular urban form, because there are certain conditions in that region to which the urban form must respond. While urban form and architecture cannot change the regional climate, they can moderate the city's microclimate, especially in residential areas. Therefore, through urban configuration and architecture, it is possible to moderate the city's microclimate in these regions.

a) Human life and climate

The climate of a desert region has considerable impact on the design criteria of architecture and urban form when one is trying to save energy on heating, ventilating and air-conditioning systems. Also, in excessively hot or cold climatic areas, human energy is diminished by the biological effort of adapting to the extreme conditions.

It is possible to measure climatic effects through negative effects of climate on man, such as stress, pain and for, which may lend to disease and death.

Hence, man's efficiency is affected by extreme climatic conditions. In winter and summer, productivity declines in areas where temperatures reach low and high levels. Huntington's studies show that in periods of highest and lowest temperature, the human health and the rate of work decline.
Since man is the central measure in architecture, he limits the architectural and urban design factors which deal with the natural environment. However, air temperature, radiation, air movement, and humidity are the major climatic elements that affect human beings. They act on man in a complex relationship which can be expressed in a calorimetric scale called the "operative temperature". According to the John B. Pierce Foundation, this temperature is 66°F (19°C), with a range of 63 - 71°F (17-22°C) and between 30% and 70% of relative humidity in winter, and 71°F (22°C) optimum, with a range of 66 - 75% in summer.

How the human body is influenced by certain climatic elements and how it maintains thermal stability are explained by Winstow Harrington and Gagge who relate air temperature, radiation and air movement to a man's level of metabolism. Man is constantly producing heat through metabolism and muscular work which are mainly transferred to the skin's surface for dissipation. The main channels of heat dissipation at the skin are radiation, direct conduction, convection and evaporation.

Man's body exchanges heat with the surrounding environment through:

- The radiation process: by this way 2/5 of the body's heat is lost
- The convection process: 2/5
- The evaporation process: 1/5
However, these proportions change with variations in thermal conditions. The vital processes of the body are accompanied by a considerable energy exchange. This energy is derived from the oxidation of food and it is utilized with a gross efficiency in the order of 20%; the remaining 80% of the energy is expended as heat.

The metabolic process usually averages:
- Resting body in a warm surrounding: 290 BTU/hour
- Sedentary activity: 400 BTU/hour
- Walking 2 mph: 700 BTU/hour
- In maximum exertion: 3000-4800 BTU/hour

All this information is valuable to define minimum standards for saving energy consumption and creating a favorable microclimate for man.

b) Shelter and environment

The environment consists of topography, vegetation, animals, light, sound, climate and natural or artificial spaces. Man is affected by the environment, and he has physical and psychological reactions in his struggle for biological equilibrium.

Arid region adaptation focuses on two primary concepts, one is life cycles (growth, seasonal, daily, etc.), and the other is interactive pattern. It is simply not enough to imitate other life forms. Superficial imitation rejects the recognition of how and why man relates to the other elements in nature.

Man must adapt himself to his environment
with the minimum expenditure of energy. Social environments, where heat is dissipated by some factors, are called "comfort zones".

The shelter is the main instrument for fulfilling the requirements of comfort. It modifies the natural environment to approach optimum conditions of livability. It should filter, absorb or repel environmental elements according to their beneficial or adverse contributions to man's comfort.

However, comfort zones, or spaces with comfortable conditions, can be achieved by appropriate architecture and urban design which fits the particular climatic area and people's requirements through the use of specific materials, orientation of windows, and adequate layout and urban spatial configuration.

B.- Historical References

Cities are different according to their specific location, resources, climate, people's culture, socio-economic and governmental systems. For example, in arid regions availability of water limits the population growth and the area of green open spaces. Energy conservation is also an important variable in these regions.

A city is a group of people and a number of permanent structures within a limited geographical area, so organized as to facilitate the interchange of goods and services among its residents and the outside context.

Therefore, urban design in a specific place should reflect the urban order and its particular configuration, as
a coherent expression of the city's climatic conditions, economic and socio-cultural reality.

1.- Middle East

Due to the Middle East's preservation of its traditional values and culture, this region has a classic and simple urban pattern.

For historical classification of urban forms in the Middle East, it is necessary to establish an evolutionary pattern of urbanization which has given coherent identity to the region through the centuries. The categories of urban development in the Middle East are:

- Pre-Islamic organization Prior to - C 650 AD
- Islamic urbanization C 650 AD - C 1800 AD
- Urbanization of the economic colonial era C 1800 AD - C 1950 AD

Islamic architecture has had a fundamental influence throughout the latter history of this region. Focus on the enclosed space on the inside as opposed to the outside, is one of the most particular features of Islamic Architecture. Another characteristic is its flexibility or adaptability to a variety of uses. Also, that architecture has had a tendency to use individual units (bays, arches, columns, passages, courtyard, doorways, etc.) In desert cities, during the summer, residential roofs were used for living and sleeping at night.

In Persia, culture, climate and natural means have been important factors defining its urban
architecture. Many techniques and elements of early Persian architecture have continued uninterrupted in various forms. From Achaemenid and Sassanian styles the Persian Islamic architects inherited a sense for scale which enabled them to create grandiose forms.

On the other hand, the advent of Islam produced profound changes in the political, economic and religious life in Persia. The old Persian theory of autocracy and divine right was challenged by democracy and the new type of internationalism; then, new spiritual values, duties and principles appeared.

The true successor of the Great Achaemenid and Sassanian palaces is the mosque, but in a far more democratic way. The mosques belong directly to the people and their chosen ministrants. It is of course primarily the place of worship for the whole community.

The mosque was from the beginning of Islam not only the religious center but also a political institution as a center for government, courts of justice, educational center, and social events. Both philosophical conception and climatic features have influenced the mosque's architectonic configuration and character.

The mosque's functional characteristics are:
- To provide shelter and protection from solar radiation, wind and dryness.
- To have a courtyard and provide a suitable microclimate.
- To provide a context for a spirituality coextensive with the whole life of the city.
- To be close to the city market or bazaar.
- To be contiguous with the dense and crowded structures of the town.

In fact, it has become physically integrated into the texture of the city. In addition to these functional characteristics, the mosque has been the main and dynamic element of the urban space. It is a symbolic element which has affected the character and growth of Persian urban spaces. It has oriented and reinforced the urban configuration of Persian cities; it melts and merges into the surrounding buildings. The mosque also deals with the climate through specific architectonic form, location and orientation with respect to the Mecca and open spaces.

In addition, the frequent interaction between the palace and the principal mosque brought the main avenue of the town into existence. On that avenue was usually located the most important businesses and bazaars of the town. This urban configuration encourages compactness; narrow streets and alleys, along with courtyard houses, are used in order to create special microclimatic areas within the urban centers.

The early Arabian cities were enclosed by a protective wall and at the centre of those cities might have been either a fortress or an open space or 'square'. That urban open space served as the focus of the city; the
principal monuments were usually located in front of it, such as the most important mosque, the bazaar or the main palace. Examples of that urban configuration are found in Yazd, Nain and Zavareh in Iran.

The Persian city's systematic layout was also reflected in the highly developed water system which provided water for domestic uses, such as baths, mosque's ablution tanks, and gardens. Most houses had private gardens inside, because they were essential factors for microclimatic thermoregulation. Water, in urban settlements, was required not only for irrigation and human consumption, but also for pools, channels and waterways. Pools and channels were set up in many cities to counteract the stress of the dry climate and improve urban environmental conditions.

River sites were chosen for town locations. However, some rivers did not have enough water throughout the year to supply a whole city. In some places, wells were dug to supplement the rivers, and it was necessary to create a storage system. Rivers were therefore elements of order in the infrastructural services of these towns, as both a water supply and drainage system.

In Persian desert areas the humidity can reach zero on many days. In these hot-dry climatic areas, towns are often surrounded by a green irrigated belt in order to create a favorable microclimate. These cities have running streams which mitigate discomfort due to aridity; water sometimes flows in the cities through open channels which
provide thermal regulation along with green zones, gardens, pools and ponds.

At the residential level, Persian domestic architecture has very thick walls that provide not only stability but also protection against temperature changes.

An interesting invention of this architecture was the wind tower which extends well above the roof. The tower is open on all four sides, with colonnade or slanting vanes at the top which catch and concentrate some currents of air, and carries them down into the living rooms, one or even two stories below the surface.

Private residences were mainly formed by an enclosed court surrounded either by walls or subsidiary parts of the dwelling itself. The essence of the domestic plan was privacy, tranquility and exclusion. A house facing directly on the street is unknown in old Persia. The home was the place of protection, both physical and psychological, and the focus of the family.

The facade of a poor house may have faced a village street, but normally it opened on the garden or court.

In hot zones, people were developing their own type of house for dealing successfully with the intense summer heat. Most of the houses were built around a rectangular court with a pool in the centre. The building was oriented north and south. Also, the rear wall and roof were so thick and solid that the fiercest sun did not penetrate, and the facade, toward the north, was mostly in shadow. The rooms in one such house had high ceilings and the central room was roofed with a dome, large enough to give ample uninterrupted space.
Characterized by excessive heat, radical changes of temperature between day and night, and also glaring sun, desert regions in the Middle East impose extreme demands on buildings and urban layout. On the other hand, strong traditions and cultural values based on religious factors have established the logic of the urban layout. However, these regions require that the shelter in a man-made environment, as an architectural and urban configuration, should be oriented in order to reduce the heat, glare and to provide shadow.

2. - Pueblo Case

A "Pueblo" is small village with traditional socio-cultural patterns and vernacular architecture. "Today, housing in 'pueblo style' is the result of the evolution of style, materials, adaptation to sites, orientation and combination of all these elements."7

The major cultures identified with the Pueblo Architectural characteristics were located in the south-west region of the United States. The specific place, was the Mesa. It has a very dry and windy climate.

These people built their cities on the hills or in places where the land could not support agriculture.

Initially, the basic protective shelter against climate was the hole. The Pit House was an example of that kind of architecture. That house was partly underground and partly on the surface; it was the result of two previous experiences: the evolution of the pit and of the tent. That
house was an expression not only of the climatic conditions but also of the Indians' conception of life and their technological development.

The Pit House had an opening in the center of the roof as an entrance and ventilation hole, so there was an air shaft to let some fresh air into the house. That house was used as a shelter only during the night and for the special social functions of the family. The Pit House was eventually abandoned for above-ground comfort, but the building type was retained for religious purposes.

People in these areas had been living in caves on the sides of cliffs before they moved to the top of the cliffs. Then, for unknown reasons, they moved back into the caves and set up a new form of architecture. It is formed by systems of stepped-back terraces with inter-step connections. Traditions and social behavior established some kind of zoning for houses. For example, the separation of the kiva unit from the dwelling. The Kivas were reserved for male activities; however, that society was matriarchal with females in charge of the family.

The types of pueblo configuration can be represented by Taos and Acoma:

- Acoma pueblo was located at the top of a mountain. It was located there for the control of the agricultural land and the favorable climatic conditions (windy fresh air). Acoma's architecture was predominately of flat stone.
- Taos pueblo was built at the bottom of the valley with the mountain in back of it. The Taos' architecture was formed of adobe terrace houses, from one to five stories high, with special orientation and configuration to moderate the climatic conditions.

Another example of Pueblo Architecture is Pueblo Bonito, it was formed like a half circle with shelter around and kivas inside. This pueblo had its principal plaza in the center of the village, which was used social, cultural and religious functions. The main kiva was located here. Also, this pueblo was oriented to the south, and the adobe walls and small openings protected the inhabitants from intense solar radiation.

In general, Pueblo architecture was the result of site integration, of topographical configuration and climate. People did not use caves facing north because of the shade, wind and lack of sun.

Pueblos in that area were built in front of vertical cliffs and facing mainly the south, so that people could take advantages of the thermal effect of the cliff.

Orientation of a single building is as important as orientation of the village as a whole. For instance, the door of a hut will always face east. Along with having religious significance, this tradition is also very practical. The wind often blows from the west or south-west, and the most severe winds are from the north-west.

Most Pueblo urban configuration were based on a concentrated, dense and compact building system.
On the other hand, outdoor spaces were more important for these people, because amenity and variety were the qualities of the communal and public spaces. They consisted of plazas, terraces and balconies. In these spaces socio-communal and recreational life, which was significant in their lives, was carried out.

3.- New Towns

a) Jebel Ali and new planning cases

This new town is located in the United Arab Emirates on the coast of the Arabian Gulf. Jebel Ali will accommodate over half a million people by the year 2007. It is the largest new city currently being planned in the Middle East.

Jebel Ali has been planned to accommodate the industrial center's work force and their families. The work force for this sector will be 15% of the total employed population at the beginning of the city's development and 48% by 2007. So the development of the phasing program was an important aspect in the development of Jabel Ali, since it is important to provide enough facilities for the growing population.

The industrial area is located at the North East; most of the residential areas are at the South West, and in between these is the Jebel Ali downtown. The airport and the harbor define a perpendicular axis to the coast-line, and it is between the heavy and light industrial areas.

The Central District is shaped by the use of
two to three story buildings as a protective wall around the outside of the central area. This wall will provide a special sense of place and protection and create a moderate microclimate. In addition, it represents a symbolic governmental area.

Traditional behavioral patterns and climate are defining the housing typology for this new city. Courtyard is used with the residential units around an open area.

b) The City of Kabul, Afghanistan

The latest city arrangement was planned to achieve high density construction at the city's centre and the two microregions which consist of series of houses of large panel construction. The city was planned in response to microclimatic division into districts and taken into account historical factors, behavioral patterns and economic variables which could affect the development of the city.

High density construction at the centre of the different microregions and the building's conformation were planned in order to reduce the effect of climate. In addition, the central part of the city is shaped by a dense areas of buildings and large number of horizontal areas as transportation routes. These horizontal areas increase the temperatures in downtown and the opportunity for ventilation is limited, so three main axes were developed in order to provide channels of ventilation. They are:

- The banks of the river Kabul
- Maivad Street
- The highway linking the government facilities with the airport.

The principle of close construction in the downtown supports the three ventilation channels or routes. In addition, the network of water channels, reservoirs and cascades decreases the thermal burden of the environment. Moreover, subterraneean spaces were created for providing comfortable conditions for vehicular and pedestrian circulation, and also serve as parking facilities.

For protection from dust storms this city has a necklace of hillocks which have special effect on the landscape. It is an interesting way of using the topography for improving the microclimate.

c) Tucson, Arizona

Tucson is an arid city with potential for benefits from energy system conservation.

The Tucson Case Study shows that the effect of innovative energy systems in conjunction with good planning measures can conservatively produce a declining rate of energy use approaching 60% for each additional ft² or dwelling unit of land use.

Most of the housing in inner-city areas would be in multi-family groupings. Densities could be 12 du/acre to 25 du/acre from town houses to garden apartments and mid-rise units. The density must be high in some node areas, and the facilities and services should be concentrated here. Careful consideration was given in the placement of important nodes, such as a dynamic shopping area so that they
would be close to speedways, residential areas, facilities and service areas. The main idea is to create multi-dynamic use of land involving commercial retail and office buildings, as well as multi-family housing and central heating-cooling plants.

For energy-saving transportation the plan proposed walking and public transit systems. The street system uses orientation and vegetation in order to establish some limits to the circulation of cars and to moderate the climatic stress. In addition, the proposal has a hierarchical pattern of roadways which are based on the mile grid. Each square mile would be bisected in both directions by secondary streets.

The square mile is divided into four quadrant neighborhoods. Each one is served by fewer existing streets but each has automobile access to every house via some streets and all back alleys. There are circulatory pedestrian walks and bikeways which feed into the new multi-family nodes and intensify neighborhood retail centers.

The commercial areas remain on principal automobile routes. The additional land for institutional uses would be limited to schools and community facilities. Commercial growth to accommodate planned population increases would be limited to these existing areas and integrated into the areas of higher densities.

The main idea was to reproduce similar nodes on the opposite side of the major avenues, so as to create
clusters and dynamic avenues. Therefore,

In order to conserve energy, future planning should be directed toward reducing transportation requirements, increasing the energy consumption efficiency of building configuration, and promoting a shared energy-utility system among various land uses to maximize mutually compatible heating, cooling, electrical, and waste product disposal needs.

4.- Chan Chan, Peru

Chan Chan is located (at lat. 7 5' S, long. 78 W) on the desert coastal plain about 550 north of Lima, Peru. The ruins of the site stand on a low rise northwest of the Moche Valley.

The City of Chan Chan covers six square kilometers and is dominated by huge compounds. Every one was surrounding by thirty foot-high adobe walls that protected and isolated the people within. Each compound has a single gate that allowed the inhabitants to go through narrow passages to a gigantic audience area, a series of courts, a reservoir, or a vast number of storerooms.

Chan Chan consists of ten large rectangular enclosures, nine of which share many formal architectural characteristics in common. Those enclosures are oriented along an approximate north-south axis and arranged around a center. The enclosures were shaped like big superblocks with enormous walls which provided protection from the inclement weather of the arid region and to provide favorable microclimatic conditions for human life. They are also called 'Ciudadelas'. Most of them have the main entrance on the
north side. In addition, a complex system of narrow corridors connect the whole enclosure, specially the courts of U-shaped structures which have small courtyards. There are small rooms around these courtyards.

The areas at the south end are called "canchones", which produced a precarious spatial organization.

Canchones apparently housed a resident population of low-status retainers, probably service and maintenance personnel.\(^3\)

Chan Chan shows a clear urban social stratification through its urban organization and different qualities of architecture. In the compound are buildings with the best architectural expression of this culture. Each compound was like a palace where a noble family lived with priests, servants, etc. Furthermore, the compound had plazas, gardens, churches, public buildings, burial grounds and houses. Surrounding the superblocks or 'ciudadelas' there were low-cost houses where poor people lived.

Chan Chan's urban configuration was based on its socio-political organization, as well as its arid climatic conditions. Architecture and urban spaces were shaped in order to counteract the effects of this arid climate. Its main characteristics are: orientation to the north, protection against dusty winds, narrow passages with labyrinthine configurations, plazas, wells, gardens, enormous walls (for possible microclimatic effects), and special interior walls (with holes on them) for ventilation.
As we have seen, the above cities share the common characteristics of courtyard principle, orientation to the sun and winds, narrow alleys or streets, plazas, vegetation, arcades or balconies, and sometimes waterways or ponds.

C.- Factors in the solution

1.- Climatic implications of the site

In arid regions more than humid regions, the physical factors are socially and economically important in selecting the site. A poorly selected site may not only have an inappropriate microclimate but may also interfere with the planned socio-economic use of the site and its possibilities for urban growth. In addition, urban life requires careful site selection and adequate urban layout, in order to avoid the negative effect of desert climate and to achieve a physical planning properly adjusted to the climate's conditions.

With regard to site selection in an arid region, Gideon Golany, has defined some physical criteria for an urban site:

- Land sufficient to accommodate the planned population.
- Water resources plentiful enough to meet the daily consumption by homes, industry and services.
- Accessibility via standard transportation systems.
Local resources to employ at least part of the city's population.

Comfortable microclimatic conditions for healthy living and working.

In the process of site selection for a new settlement in an arid region, planners should be most concerned with the last criterion.

Moreover, in so far as human comfort and building design are considered, the climate of a given region is determined by the patterns of variations of several elements: aridity, air temperature, solar radiation, longwave radiation to the sky, winds and precipitation.

a) Aridity

Aridity is the principal characteristic of desert regions. "Aridity" means a lack of moisture, or dry and barren conditions.

In addition, Aridity not only is lack of moisture in the form of rain the chief factor causing desert conditions, and the temperature, but low air humidity in itself has an adverse effect upon plants and animals, because the rate of evaporation is so great at high temperatures. More water is required to saturate a given volume of warm air than to saturate the same amount of cool air. Consequently, at night, when considerable cooling takes place and the relative humidity rises, saturation deficiency may drop to such an extent that the dew-point is reached.

Hence, humidity is lower in these regions, so it is necessary to create dense green areas, pond or pools and greenbelts in order to produce a favorable microclimate.
b) Air temperature

The rate of heating and cooling of the surface of the earth is the main factor to determining the temperature of the air above it. Solar radiation has an indirect effect on air temperature. The air in direct contact with the ground is heated by conduction. This heated air is transferred to the upper levels mainly by convection. Winds force masses of air into contact with the earth's surface to be cooled or warmed.

The annual and diurnal patterns of air temperature depend on the variations in temperatures of bodies of water and ground surfaces. Large bodies of water are affected less than land masses under the same conditions of solar radiation. Therefore, large bodies of water can act as thermoregulators in their zone of influence, because the mean air temperature is higher in summer and lower in winter on land surfaces than on them.

Also, the variation of diurnal temperature depends on the state of the sky. On sunny days, the incoming radiation produces a wide range of daily temperatures. This condition increases the temperature differences between day and night.

Site characteristics can help to increase the air's temperature. A city's temperature is affected by its orientation with respect to winds, bodies of water and solar radiation. For example when hot and dry air blow over water, the humidity of the air increases and its temperature
decreases; bringing more comfortable temperature and humidity to the surrounding areas.

In addition, the earth's altitude variation alters the temperature of the air. When a mass of air rises up a mountain, it moves from higher to lower pressure region and so expands and is cooled. On the other hand, if a mass of air descends, it is compressed and is heated. This process is called an adiabatic cooling and heating process. The temperature changes 1 C per 100 mts (5.4 F per 1000 ft).

The lower air tends to be closer to the ground and it is heavier than the warmer air above it. This surface inversion is caused by long nights, clear skies, dry air and an absence of winds.

Cold air near the ground tends to concentrate in low areas, such as valleys. Moreover, pressure differences on the earth causes the flow of air masses.

Otherwise, air temperature may be most tolerable at a site located above the surrounding low lands, where more frequently the wind and the air is relatively cooler. This kind of site has some advantages, such as a possibility for a favorable microclimate, and several orientation and landscaping alternatives; however, it needs a greater investment for accessibility and seismic studies. (Structural reinforcement may be necessary in some desert regions.)

Therefore, air temperature can be reduced by topography and urban configuration in cities. Moreover, the relationship of total shaded space to space open to solar
radiation can affect the temperature in those spaces.

c) Solar Radiation

Solar radiation is defined by insolation, which is the total solar radiation falling on a surface. Radiation can be divided into three components: (ID) direct radiation from the sun, (Id) diffused radiation from the sky's hemisphere and (IR) reflected radiation from the ground and nearby buildings.

\[ I = ID + Id + IR \]

In hot-dry climatic regions, absorption and emissivity are especially important. The terrain's surface color gives a good indication of its ability to absorb solar radiation which decreases.

Another important consideration is the orientation of the site with respect to the sun. According to its physical structure's orientation, the site's exposure to radiation is affected.

The high levels of solar radiation can provide an enormous energy resource for human settlement development in these regions. Illumination is also higher, since a high level of solar radiation is reaching the ground. For this reason, vernacular architecture has used small windows with special orientations and locations in order to reduce the glaring effect.

Solar control can be accomplished by special architectural forms, shading devices, or vegetation. The most successful way to control solar radiation is mobile shading.
devices which can achieve summer shading and winter heat gain. In urban spaces, high buildings in a compact area with balconies and galleries, which are landscaped using trees or special kinds of vegetation that provide shade and reduce the glaring from the sun light, are also a useful shading device.

d) Winds

Regional wind distribution and characteristics are defined by the seasonal global distribution of air pressure, the rotation of the earth, the daily variation in heating and cooling of land and sea, and the topography of a given region and its surroundings.

During the day the air over land is heated more than over sea surfaces on the same latitude. The warmer air rises and colder sea air flows inland. At night the process is reversed. The sea breezes overland are stronger than the land breezes to the sea. In valleys strong winds are generated in large mountain valleys blowing up the valley in the day time and down into the valley at night.

In some arid regions, winds are variable and are generally weak in the morning increasing toward noon to reach a maximum in the afternoon, when they are often accompanied by whirlwinds of sand and dust. Sometimes, winds must be calculated in order to reduce the negative effect of the sand and dust, so several factors should be considered, such as:

- Wind speeds decrease when measured at levels
close to the ground.
- The operative wind pattern is modified by local topography and the immediate surrounding area.
- Comfort should be reached by using desirable breezes instead of unwanted winds.

Hence, the wind's effects are modified and slowed down at low levels, and at ground surface the air is almost at rest. For these reasons, forestation is an important factor in controlling and reducing the negative effects of the wind in dry regions. However, winds are very important for ventilation in hot-arid regions, so windows and street orientation must be taken into account when designing a building in order to catch the breezes.

Trees reduce the wind at ground levels with great efficiency while also catching dust and filtering the air. Vegetation can also provide privacy and reduce annoying glare effects. Furthermore, the trees' most significant beneficial effects are their thermal performance, so that in winter, as windbreaks, they can reduce the heat loss from buildings and in summer protect them from wind. Vegetation and trees give shading and cooling and also improve the humidity, especially in desert regions. However, it is very important for good thermal performance to limit the types of trees used and their locations with regard to the sun's and the predominante winds' orientations.

e) Topography
Temperature in the atmosphere decreases or increases with altitude variations. The temperature drop in the mountains can be approximated as 1 F for each 330-foot rise in summer, and for each 400-foot rise in winter in the same region.14

Macroclimate is affected by mountains; moreover, hills and forest can provide remarkable modifications in microclimatic conditions. However, cool air is heavier than warm, so that there are temperature differences between valleys bottoms and their crests. In fact, topography can reduce wind speed and wind temperature, and it can add favorable conditions for an appropriate microclimate.

In addition, the direction and inclination of the slope of a hill side allows it to receive some predictable amount of sun on it.

f) Microclimate

In desert regions, microclimates are crucial factors for good living conditions. Besides, microclimates can be made less severe by modifying some climatic variables which are susceptible to control. For example,

In flat regions, arid vegetation encircling a site can reduce wind speed and dust storms and also lower the air temperature when it crosses this green zone's relatively cool shadows. Also the reduction of passive open space within a flatland city may help lower the air temperature.15

At ground level multiform climates exist side by
side, varying sharply with the elevation of a few feet and within the distance of a mile according to topographic configurations, vegetation and water surfaces. Deviation in climate plays an important part in urban layout and architectural land utilization. For example, a less favorable site may be improved by shelterbelts in surrounding surfaces that counteract the impact of temperature and solar radiation:

Even in some area, city, town, village or rural area there are microclimatic differences which should be recognised in the design and construction of buildings. As a result of various influences the air temperature in an urban area can be as much 8°C higher than in the surrounding countryside, while the relative humidity can be 5-10% lower.16

Also, bodies of water can act as thermoregulative or control factors of temperature variations.

Consequently, aridity as a climatic factor affects the use of water, green areas, sparse construction, along with the size of any open space. Since air temperature is affected by the earth's surfaces and water bodies, site location can make use of these possible favorable effects. Solar radiation, as energy, can be used or stored for microclimatic effects and comfort; moreover, building's materials and orientation to the sun are important in dealing with architecture and urban design. Winds can provide comfort which, however, depends on the temperature and characteristics of the winds; for that reason, buildings and their layout should fit their specific
environments. Topography can allow for a special microclimate to bring about good living conditions. Therefore, these factors are going to be taken into account in the design of Majes City.

2.- Climatic implication of urban patterns

Architecture and urban design should necessarily mean innovation in order to improve the living conditions of a people in accordance with their own style of life, physical environment and their possibilities for socio-economic development.

Furthermore, tradition among people is the only safeguard of their culture. Cultural values are very important in their development and they must be taken into account by designers and planners. Although desert regions have severe climatic conditions, urban design should also properly respond to a people's culture and technology.

In fact, the character of the physical urban structure is shaped by how natural and cultural environments interact with human life and activities. Nevertheless, in desert regions, the natural environment strongly affects the physical form of urban architecture.

Historically, compact cities were built in desert regions in order to protect against the severe climate. Those cities were specially organized to counteract the climatic stress. In addition, they have compact urban forms in order to create a special microclimate for human adaptation to the arid climate. In the Middle East, "The
narrow, winding alleys and streets, which block sunlight are relatively cool and also break stormy winds. Public gathering spaces such as bazaars or markets, which are covered, establish their own temperature and microclimate.\textsuperscript{17}

Consequently, urban fabric in these regions must provide protection against strong winds, maximum shade and allow minimum solar reflection on streets, alleys and open spaces, as well as within the houses during the day. Also, it can minimize indirect solar radiation in order to avoid heating the air and also to reduce the negative effects of winds which are hot during the day and cold at night. Moreover, urban configuration must be planned and defined in order to provide natural ventilation, proper orientation and adequate humidity.

So, compact urban forms can reduce dust, hot and cold winds, and solar radiation. For walking, this kind of urban configuration can provide shaded spaces which allow people to move, stay and adapt to the climatic stress. Public spaces must also have protective shading urban devices, such as trees, galleries and balconies. Cities must be organized as an integral whole where urban units should be connected to working, residential, shopping and facility areas and have a design which takes into account all kinds of climate variables that affect human comfort.

A compact urban form can reduce the length of utility networks, the maintenance that they require, and the expenditures of energy and thereby prove economical. However, such a form mandates special designs that may increase the construction cost. On the other hand, a compact form decreases the
traditional need for transportation systems and vehicles, further reducing construction and living costs.

Streets are channels where people and cars move and look for places, facilities and amenities. For that reason, the orientation of the streets and buildings in desert regions, with respect to winds and sun, have been a very important factor since the time of the ancient towns' physical organization.

Street configuration has mainly been shaped by the street's use and functional requirements in the urban economic and social activities. However, wind and solar radiation are important factors which have also shaped the street's orientation and its formal character.

In arid regions, street configuration should moderate the effects of solar radiation with galleries, balconies and some architectonic and urban shade devices. In some cases, verticality in buildings must be considered, because this may require some subterranean construction and it could provide some shade for dwellings and outdoor living areas, and legibility of the city.

Open spaces in desert regions have specific connotations; they must provide the oasis effect and improve the microclimatic conditions for urban living. Also, open spaces cannot be like the North American urban parks and open spaces, because the lack of sufficient water and high levels of evaporation do not allow them to have too much area. In addition, in these regions, open spaces, street and
building systems have worked together in order to set up favorable environmental conditions with appropriate thermal relation among them.

Parks, plazas, streets and courtyards should be included in the open space system which must be related to the proportion and scale of the building system so that they can limit the climatic stress. They must also have vegetation, trees and water ponds for improving the humidity. However, the relative calm characteristics of plazas, parks and enclosed urban spaces have mostly been organized according to passive recreational and extensive socio-cultural activities, and specific physical requirements for appropriate microclimatic conditions.

3.- Climatic implications of type and construction

In desert regions, it is important to establish the relationship between climate and human requirements for comfort and between climate and housing architecture in order to understand how traditional and vernacular houses not only are the expression of a cultural heritage, but also serve as an operational pattern to help to improve the housing types available in these specific climatic regions.

To treat climate as a primary factor is justifiable only if the thermal environment proves to be one of the influential factors in the regional architectural expression. Dr. Walter B. Cannon has maintained that "The development of an early thermostable state in our buildings should be regarded as one of the most valuable advances in
the evolution of buildings.\textsuperscript{19} However, the thermostable state increases greatly the building cost.

The building's skin materials play a decisive part in the utilization of control and protection from environmental variations. Walls and roofs are the building's skin which perform the role of a filter between indoor and outdoor conditions. They provide control over the intake of air, temperature, light, sounds, and odors. For example, a glass wall provides very little protection from solar radiation (12\%). Heat-intercepting glass allows the use of large window walls with less heat penetration than permitted by ordinary glass.

Control by the use of shading devices, such as brisolei, parasols, and balconies, could be the most effective way to limit and use solar radiation, while mobile shading devices are the most successful way to control it. The effectiveness of shading devices can be improved by location and orientation. These sun breakers may also improve the expression and special character of the regional urban architecture; they can create texture and color composition, rhythm, variety, light, and shadow.

Furthermore, a house's roof has the greatest surface exposure to the sun. A great amount of heat is received by the roof during the day:

The interval or 'lag' between the upper and lower temperatures for a 2 inches slab would be 1 hour 25 min., and for an 8 inches slab would be 5 hours. Increase the heat 'lag' and prolong high temperatures during hours of sleep, and the solution lies in producing low shade temperatures in the
ceiling slab and dispersing any excess of heat rapidly: in placing between the ceiling layer and the sun a parasol or protection that receives and throws off a high proportion of the sun's heat, combined with some means of letting out or carrying off any reservoir of heat that may be built up. The reserve order will not do: the sun must first be intercepted.  

A house's orientation provides a good alternative for protecting the walls from direct sunlight and reducing the amount of wall facing the sun.

The old idea was to build a wide verandah (roofed porch) on all sides and be certain that neither sun heat, glare nor rain could penetrate the rooms. This succeeded, but led to such gloomy interiors that the occupants usually preferred to live on the wide verandahs.

In these climatic regions, natural ventilation and air movement have three functions:

- To supply fresh air for health
- To cool the interior by convection
- To cool the inhabitants when required

Natural ventilation in buildings is produced by air moving in response to differences in temperature. 'Stack effect' warmer and lighter indoor air is displaced by cooler and denser outdoor air and by movement or flow produced by pressure differences. The dynamic effects of winds can produce good ventilation inside of buildings.

Historically, there have been many approaches to resolve the inclemency of arid climates. The first concern was to provide a satisfactory shelter with the least amount of physical effort. Frequently, solutions have been given
according to a people's traditions, religious beliefs, or customs.

Therefore, there are many examples of housing types for arid climatic regions, such as the typical Egyptian, Mesopotamian, Bagdadian and Persian houses. The main characteristics of these houses were a courtyard, small windows, balconies, fountains or ponds, and sometimes galleries in the main court. The general idea was to look for shade areas and small gardens in the courts to provide microclimatic effects in houses. In addition in North America and South America, there are similar climatic regions where a special architecture was developed; for example Chan Chan, a pre-Incan city in the northern part of Peru and Pueblo architecture of the south-western area of the United States. In these examples, adobe was used as a principal construction material in response to climatic requirements and technological development.

Other types of houses for the arid and hot climatic regions are terra-type housing, which are subterranean settlements. In order to reach an appropriate microclimate, they consist of underground buildings and houses with patios and windows, as for example are found in China.

Contemporary architecture in these climatic regions should involve an understanding of vernacular architecture as part of the cultural heritage, together with the economic requirements, energy considerations and the
area's technological development. Modern architecture has often forgotten the rich experience of vernacular architecture, and often it has applied very expensive technology in countries where the main problem is the lack of resources.

In hot desert areas, people spend a great deal of their time outdoors, and this is only possible when external spaces are shaded. The creation of comfortable conditions around and between buildings is extremely important in the layout of the buildings. In desert climates, buildings are normally grouped close together to give some shade to each other and to provide shaded streets and small spaces. The tendency in these areas is to use arcades, colonnades, and small enclosed court-yards; even larger public open spaces are enclosed, inward looking and shaded for most of the day. In addition, in these areas glare is reflected from the surface of the ground and light-colored walls of the other buildings. For this reason, windows in external elevations should be small and few in number; however, some windows should be oriented into the internal courtyard space. Another alternative to the external windows on elevations is a vertical slit window.
III.- CASE STUDY: Majes City's Problem Definition

Majes City will be a new urban center in an arid region of Peru. The city is need as a support center to provide service, facilities, dwelling units, and other physical structures for some complementary activities to the irrigational process which is being implemented in the Majes Project, and to act as a dynamic center for the region in general. Nevertheless, this urban center must have its own logical organization based on the site, climate, and the peoples' traditional patterns of life and customs which are now being placed in a new contextual situation. In addition, this urban center should take into account the experience that other cities have had in similar climatic conditions.

A.- Referential Information

1.- Peru: Location

Peru is located on the western coast of South America, between Chile and Ecuador. It is made up of three geographic regions: The coast, the mountains and the jungle. These three regions are longitudinal and parallel to the Pacific Ocean from south to north.

The Coastal region is next to the Pacific Ocean; almost all the coastal territory consists of very dry desert and valleys, which are deeper than the desert plateaus. From the highlands, rivers cross the desert areas and define the valleys.
The Mountain region is formed by "La Cordillera de los Andes". In fact, mountains and volcanos of different sizes have given this territory many high valleys. However, the topography is so variable and rugged that it is very difficult to use it for agricultural and settlement development. The weather is wet in summer, and dry and cold in winter.

The Jungle region is almost a completely flat territory linked to the Amazon river basin. It has tropical weather; thus, heavy rain falls during all the seasons, and there is a lot of vegetation. The main problem is the difficult accessibility of that region.

2.- The spatial organization of economic activities in Peru

The configuration of economic functional areas in Peru has changed dramatically during its long historical development.

During the Incan Empire period, the economy was based on agricultural development principally located in the highland valleys. Those valleys were along the Andes mountains, which defined the longitudinal productive areas. However, there was a minor transversal spatial articulation that interconnected the coastal valleys, mountains and jungle. In addition, the mountains as an economic area served as a spine which connected the whole Incan territory.

The Spanish "Conquistadores" changed that
economic territorial organization; they established a new one based on the intense exploitation of silver and gold mines which were connected to the coastal ports. That economic process defined new economic functional spaces which were organized without any concern for the developmental implications for the affected regions.

In the Republic era those economic spaces changed in response to new raw materials and modern means of transportation and communication. Moreover, the excessive polarization and concentration of activities and population in some urban centers have not improved the conditions for regional development and distribution of the population.

In Peru, the latest conception of regional development is based on "Compensatory Systems", which are areas of development which should reach competitive standards of life, employment, facilities and services with respect to Lima and other major regional centers in order to create conditions for public and private investment in the different regions. The Majes Integral Project is going to have multiple goals and effects which are to benefit its own region as well as the nation's socio-economic development. Therefore, the Majes Project was conceived as a Compensatory System in Southern Peru.

3. Socio-cultural implication of urbanization in southern Peru

Fifty years ago, Peru was an agricultural country with a relatively small urban population of about
20%; it is now already predominantly urban and also industrial. The rural population is decreasing. Young and even older people are still going from the valleys and villages to the cities. Today, mass communication, such as newspaper, radio, telephone and T.V. have been effecting the migrational process to the cities and they also are affecting the socio-economic integration through cultural assimilation and by producing dependable situation with respect to modern urban life. However, the migrants are preserving some of their social customs in family and neighborhood life (Communal help is called "Ayuda Mutua").

In addition, the rural areas and villages do not have a wealthy enough economy to offer not only jobs, but also enough facilities and services to provide comfortable conditions. The rural immigrant may expect to be poor for a while in the city, but he is already used to poverty. He has, however, to adapt himself to changes in lifestyle, customs and to a new physical environment. He is not at first integrated into the urban society, because he does not have the labor skills and cultural background needed in the cities. So it takes quite period of time for him to undergo his adaptation to the city.

In the south of Peru, some workers from the rural areas used to move in pendular migration from the highlands to the coastline and sometimes even to the jungle in search of seasonal agricultural jobs. Then, some of them established their houses in places where they may be able to
find a permanent job or at least may have more opportunities than in their home areas. In most cases there is a gradual migrational process which starts from the farm to the next village where the school and basic facilities are. Peasants used to go to small towns in which they can sell their goods and buy clothes, food, industrial products and supplies. Then, they move to the main regional cities, and then, looking for new opportunities in life, to the major metropolitan areas on the coastline.

The first thing which the immigrant coming to the city has to do is to find somewhere to live or, at least, to sleep and to leave his few belongings. If he is very lucky, this recent immigrant may be able to join in an organized invasion of arid land close to a work place or an area surrounding the city. In those areas, they little by little build their houses by themselves.

However, official regulations which commercial developers are bound to respect, do not allow this; legal occupancy is only officially permitted once the house is able to meet typical Western minimum standards.

In other words, the private sector has nothing whatever to offer to this population. So the only other chance these people have to obtain an acceptable dwelling by legal means is from the state, and this is a long chance. Applicants have to undergo an investigation which is incompatible with their economic situation as well as incomprehensible. Therefore, it is difficult to know about the
popular market, because this marginal economy is uncontrollable, and also the product supplied fails to meet its demand.

The people of Peru, by ancient custom and tradition, are used to building their own dwellings; modern urban society, as represented by government agencies, disrupts this tradition, and in the few cases where it provides any alternatives, they are often inadequate. Most of the buildings in 'Popular Areas', such as schools, churches, market, workshops, streets, sidewalks, facilities and houses, were built by the people for their own use. Also, they have used governmental loans only for the expansion of their houses after they have gotten into a stable economic position. However, the expansion often becomes an independent dwelling unit which is then rented out for additional income.

Clandestine settlement can take very different forms, some are highly organized, such as "Pueblo Joven". It is almost regularly laid out, building plots are relatively regular, the dwellings are almost all at least started in brick and concrete, and in the foreseeable future will become respectable modern dwellings. Electric power and lighting have been installed by the government. The water and sewer service will be completed slowly.

There are not in the south of Peru classic shanty-towns, chaotic, formless concentrations of shacks which would be difficult to improve or to convert into permanent
and coherent structures. Instead, the spontaneous settlements are based on regular layout. However, the location of these settlements (called 'Pueblos Jovenes' or 'Barriadas') are often physically inappropriate and incoherent with the infrastructural plan of the cities. So the utility implementation is more expensive than other feasible areas for this kind of settlement. This problem needs several alternatives which will respond to the people's requirements for a dignified urban life with a coherent order and beauty during the city's growth. Nevertheless, chaotic urban growths have been related to industrial and some economic growth as well as to social and cultural imbalance in urban centers.

Therefore, the specific proposal for the City of Majes should be also deal with migrational problems due to Majes' offer of jobs. This problem needs to be considered at the regional and urban planning stages in order to achieve some alternatives to a solution at the urban design level. So the barriada as a pattern of urban growth in the southern Peru might be considered as an alternative for new areas where poor or low-income people may live.

B. - Characteristics of the Majes Integral Project

1. - Site and climate

The Majes desert area is located in the Atacama-Peruvian coastal desert of South America and It is called 'El Tablazo Continental'. Its specific location is in the southwestern part of Peru; latitude-S 16° 22', longitude-
W 72g 10' and is 4320 feet above sea level, and between the Andes Mountains and the coastline.

This desert zone shares some similar characteristics with most of the desert regions of the world, such as a dry and barren environment, variable temperatures, low rainfall, winds, and sandy, saline soils.

The topography of the site is almost flat; the terrain is crossed by some small physical depressions that divide the area in sectors. Each sector will be a large productive unit with its own urban center and facilities.

According to "SENAMHI" regional center at Arequipa (Meteorological and Hydrological National Service of Peru), in Majes desert, temperatures in summer are not too hot for human habitation, and the highest temperature is around 80 F (27 C) during the spring. Also, low temperatures in winter are the result of cold winds from the Pacific Ocean. However, at midnoon temperatures are around 77 F (25 C) during the whole year. The relative humidity is lower in summer than during the other seasons. The dryness is caused by a lack of rainfall during the whole year. High evaporation takes place in summer and spring seasons. However, the intensity of solar radiation is higher in winter than the other seasons.

The prevalent wind blows from the Pacific Ocean to the N.E. in the mornings, and in the afternoons the wind mainly blows in the opposite direction (SW) from the mountains. Therefore, descending air masses produces a lack of
### Table 1: Air Temperature (°C) 1982

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### Table 2: Humidity, Rain, and Wind

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<td>SW</td>
<td>SW</td>
<td>SW</td>
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<tr>
<td>Secondary</td>
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### Table 3: Diagnosis

<table>
<thead>
<tr>
<th></th>
<th>J</th>
<th>F</th>
<th>M</th>
<th>A</th>
<th>M</th>
<th>J</th>
<th>J</th>
<th>A</th>
<th>S</th>
<th>O</th>
<th>N</th>
<th>D</th>
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<tbody>
<tr>
<td>Day comfort: max.</td>
<td>28</td>
<td>28</td>
<td>28</td>
<td>28</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
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<tr>
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<td>21</td>
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<td>22</td>
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<tr>
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<td>14.1</td>
<td>14.1</td>
<td>13.1</td>
<td>10.8</td>
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<td>14</td>
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<tr>
<td>Thermal stress: day</td>
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<td>Thermal stress: night</td>
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<td>- = comfort</td>
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### Table 4: Indicators

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<th>J</th>
<th>J</th>
<th>A</th>
<th>S</th>
<th>O</th>
<th>N</th>
<th>D</th>
<th>Totals</th>
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<tbody>
<tr>
<td>Humid H-1 Air movement (essential)</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>12</td>
</tr>
<tr>
<td>Humid H-2 Air movement (desirable)</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td>Humid H-3 Rain protection</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>9</td>
</tr>
</tbody>
</table>

**Legend:**
- **x** indicates present
- **c** indicates cold
- **H** indicates hot
FIGURE 1 TEMPERATURE VARIATIONS
rain, and ocean winds produce some humidity and cool weather in winter. (See tables 1, 2, 3 & 4 and fig. 1)

Consequently, the main problems are a lack of rain and the consequent aridity, high solar radiation, winds, and the consequences of the cold season. Thermal storage is therefore necessary through architectonic configuration and construction materials. Also, urban layout and street orientation, density, shelterbelts and pools can help the human deal with the desert's conditions.

Housing layout should be mainly oriented to the north. However, west and east orientation may be acceptable in order to catch the solar radiation from the sunrise and sunset. That kind of organization should look for wind protection and an environmental oasis effect in order to achieve an appropriate microclimate.

2.- Regional scale

The Majes Project effects several ecosystems from the highlands to the coastline. In the highlands some valleys have been affected by the infrastructure of the Majes Project (canals, new road system, dams, etc.). In addition, the region shows overpopulation in some productive areas based on agriculture. This problem involves overpopulation in relation to the available agricultural land area so the Majes Project does not only modify that site conditions but it also affects its people's expectations for new or alternative jobs.

This project is located in an empty space
surrounded by productive areas in the mountains, valleys and coastline so the Majes Project area becomes an important connecting space among these areas. Therefore, this project will establish transversal relationships between the coastline development corridor and the mountains valleys. These relationships will involve the interchange of goods, services, facilities, resources and also some flow of migrational labor.

As an irrigational project Majes will have 60,000 ha. of agricultural land for farming, ranching and fruit producing units, and it will offer 16500 jobs. Also agro-industry, collection centers, urban centers and facilities will be implemented in accordance with the Majes Project's phasing program. However, the regional context has already been modified by the development of the major infrastructure, the initial irrigation process and two rural centers 'El Pionero' and 'El Pedregal'.

In the light of these considerations, the new urban centers should have a dynamic role in the development of the area. Majes City has been defined as the principal center in the Majes Urban System. Hence, it should provide all kinds of urban facilities not only to the Majes Plan Area but to the larger regional area which will be influenced by the plan.

3.- Plan Area

The Plan Area is divided in two parts by the Siguas River; that area is bounded by two other rivers, the
Majes River as the north line and the Vitor River at the south. However, these rivers are flowing at such a deep level compared to the adjacent desert plateau that it is too difficult and expensive to use this water for irrigation and other developmental uses.

The Plan Area is the specific area in which the Majes Integral Project is located and developed. According to the Majes Normative Plan, this area should be structured by principles of integration and articulation of urban and rural spaces with respect to:

- The rational use of land and the coherent distribution of activities.
- The assignment of functions and roles to the economic areas in order to provide interdependency and complementary relationships among different economic spaces which should be generated by the dynamic of the economic activities.

The urban settlement system should include both urban centers and rural centers, which should activate and spread the positive effect of the integral development processes (in response to social and economic cost) in urban concentrations and rural centers simultaneously. In addition, that criteria should look for a balanced distribution of population, facilities, services through or by means of a gradual articulation of and complementarity between urban and rural spaces.
C. Majes City a New Urban Unit

Majes City will be a new urban center which should be organized in response to man's basic needs for adaptation and living possibilities in an arid site. In addition,

Cities and regions are influenced by ideas and concepts. The Medieval city was dominated by the cathedral and ruled by the church. Renaissance and Barroque cities were dominated by the palace and ruled by princes. The cities of today are dominated by industry, business and commerce and ruled by interest (economic or political). Some day, perhaps, cities and regions will be planned and developed according to needs of man and ruled by the reason.

In fact, this city must achieve a sense of living place and a functional entity which should be structured by its regional and local context, the physical characteristics of an arid region, future population's needs, resources, and the regional developmental policies.

Majes City, according to the Normative Plan of the Majes Project, will be the main urban center of this project's urban system. Its principal function is to be a governmental, commercial, residential and cultural center in order to provide facilities to the M. P.'s area. Therefore, this desert city must contain an adequate physical structure for commercial spaces and offices, light industry, residential and cultural activities. Its urban configuration should also be an expression of arid climate.

Majes City will have a population of 60,000. Its urban facilities must satisfy both the requirements of this city and its larger region of influence. For that reason,
the localization of some facilities should have easy accessibility by roads. In addition, the facility system will be based on both the National Facility System Plan and the Majes City's Long Range Urban Development Plan.

The specific location of this city is at the intersection of the urban axis road and Hospicio Ravine, on the Sutton Hill (see plan # 2 ), which is a plateau with a gradual slope that goes down from its highest point of 1435 to 1320. Each 200-300 m the slope goes down 5 m. The orientation of the graylines is north and the hill is oriented to north-east. The wind blows from the south-west to the north-east in the mornings, and in the reverse direction in the afternoons. Therefore, this city should be designed according to the Majes Normative and Operative Plan with its regional implications and also in response to site and the climatic conditions, and traditional urban values of a Peruvian town.

D.- Components of the Urban Structure

Today, cities have generally not found the pattern adequate to their potentialities, according to their functional and technological development. They are a mere conglomeration of unrelated parts, each disturbing the other. They are paralyzed by insurmountable traffic and parking problems. They achieve no harmony in their component parts.23

Indeed, the urban structure of Majes City should be based on site's characteristics and the logic
relationship among its component activities which are allocated in this specific site.

The components of the Majes City's urban structure are the spatial dimensions of the productive activities which are light industry and craft production; the spatial dimensions of the commercial, business and banking activities; the spatial dimensions of the human settlement; with its population and residential, facility and utility requirements; the spatial dimensions of the transportation activities; which includes both vehicular and pedestrian circulation; and the spatial dimension of government facilities: municipal and regional levels.

1.- Spatial dimension of the productive activities

The spatial dimension of the productive activities will be based on light industry and craft production. The heavy and agro-industry will be located away from Majes City and close to regional roads, so that the heavy vehicular traffic will not affect the city.

There will two kinds of industry in the City of Majes: the light industry consists of medium and small factories, and cottage industry or shop-houses in which craftsmen or artisans can live. The light industrial plants should be isolated from other urban activities, such as residential commercial and community facilities because of different urban requirements. The cottage industry or shop-houses will have to be integrated into some residential areas, because it is a complementary part of many residential
units in which people will work at home at very small private businesses. Therefore, Majes City will have two areas for productive activities: One, which is shaped to fit the needs of light industry, requires some specific physical conditions such as roads, lot dimensions, good accessibility and a special infrastructure of services, and the other, which is based on small production, does not require special conditions. So the craft production will be compatible with the residential areas. In Peru this kind of production is mainly located in areas where low income people live and it offers employment to these people.

2.- The spatial dimension of commercial and business activities.

Towns in Peru are experiencing explosive commercial growth, and Majes City, due to its role as a commercial center and strategic location, is expected to undergo similar growth. The commercial activities in Peru absorb a great number of people in a variety of jobs, from the permanent store job to street vendors (vendedores ambulantes). In addition, the commercial activity, offices for business and complementary facilities are located along the main streets and are compatible with pedestrian movement. Also, a mix of residential and commercial activities gives a more dynamic life to the street. The commercial areas grow based by car accessibility and public transportation systems.

In Majes City, there has already been proposed
a hierarchical organization of commercial activities:

- Daily or local commercial (food stores)
- Neighborhood or communal commerce
- Sectorial commerce which involves more than one neighborhood.
- Central commerce which involves the city and the region's requirements.

Therefore, the location and organization of commercial activities depend on their hierarchy, accessibility and distances from the residential areas and community facilities. Public transportation is also an important factor for commercial development.

3.- The spatial dimension of human settlements

These are areas in which people are going to satisfy their basic and complementary living necessities, such as resting, eating, sleeping, etc. Furthermore, these areas or spaces should have special characteristics and conditions in response to the climate, traditions, socio-cultural and economic development of the area. For selecting a site and shaping the desert city of Majes, it is necessary to fit particular human necessities and traditional uses of spaces in urban areas into the context of an arid environment. The principal attraction to settle in this arid area is availability of jobs and the provision of facilities.

Indeed, the Majes Project will require 20,000 agricultural workers by the end of the development of land irrigation project. Besides, these jobs, the project will
offer employment in housing construction, education, health services, transportation, government facilities and business. Other economic activities, such as commercial industrial, technical aid and banking will also provide additional jobs.

According to the Organization of American States, the initial population of Majes City will be 7,800 people. For the first four years, most of them will be agricultural and construction workers. The following phase (4 years) will be similar. The implementation of the irrigational process is going to be finished at the 15th year. Therefore, the first 15 years should be a period of great rural influence over Majes City which means special urban layout in response to this kind of population. Then the city will have its own dynamic of growth based on its capacity for supporting urban economic activities according to its role and function in the Majes area. The OAS and the Majes Project's planners recommend that the City of Majes should have several phases. The OAS team has proposed 6 phases of population growth during its 30 years of development; however, the time of each phase is not constant, so there may be a problem in planning, controlling and implementing this project. The Majes Project's team has proposed a 20 year period of development with regularly timed phases which will respond to the central government's budget, medium range plans and specific objectives for this project.
Taking criteria from both alternatives, this thesis establishes a five-phase program, with each phase lasting five years, for population growth, starting with 7500 people in the first phase and ending with a population of 60,000 by the 25th year (see fig. 2 for population growth).

b) Housing requirements

The number of housing units has been determined by the number of families that may settle in this desert city during its different phases.

TABLE 5

Housing Demand in Majes City

<table>
<thead>
<tr>
<th>PHASE</th>
<th>POPULATION</th>
<th>NUMBER OF DWELLING UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (1-5)</td>
<td>7,500</td>
<td>1,500</td>
</tr>
<tr>
<td>2 (6-10)</td>
<td>19,000</td>
<td>3,800</td>
</tr>
<tr>
<td>3(11-15)</td>
<td>32,000</td>
<td>6,400</td>
</tr>
<tr>
<td>4(16-20)</td>
<td>50,000</td>
<td>10,000</td>
</tr>
<tr>
<td>5(21-25)</td>
<td>60,000</td>
<td>12,000</td>
</tr>
</tbody>
</table>

A different number of housing units will be required by the different economic groups which will compose Majes City. According to the OAS, the 31% of the families might make less than $200 per month. The 32% between $200 and $500 dollars per month, and the 36% more than $500 per month. This possibility shows that one must deal with low-
FIGURE 2

POPULATION GROWTH (Majes City)
income people and low-cost housing in the Majes City urban design. So houses will be built in steps starting with a minimum of area, which may be a big room and including a basic unit of bathroom and kitchen.

c) Facilities and urban amenities

According to the National Facility System Plan and The Majes Project Plan, Majes City will have central facilities which should meet regional and local services requirements.

- Education

In Majes City there will be educational centers from kindergarten (20 Initial Educational Centers), through elementary, junior and high school (10 Basic Regular Educational Centers), and ESEP (6 Technical Educational Centers) and including one university. This number of educational facilities is compatible with neighborhood units of 600m x 600m size, the population and the walking distances.

- Health

There will be one regional hospital which will provide service for this city and the influence region. Also ten health centers will be located in the neighborhood units.

- Commerce

The city will have a central market, farmer's market and mini-markets for food in each neighborhood. In addition, small food stores will be at the
corners of the streets.

- Culture and amenity

For cultural life and amenities, Majes City will have a central library, museum, theater, amphitheater, coliseum, stadium, zoo, botanical garden, play grounds and neighborhood community center. pi. 17 - Religious

Traditionally the people of Peru have had a principal church in the main plaza and others in different areas. Sometimes each neighborhood has its own smaller church. In Majes City there will be a central church and perhaps small neighborhood religious centers.

- Others

As a principal urban center of the Majes Project area, it will have a central fire station, police, post office and telephone company. There will also be one post office and police station for each neighborhood.

d) Urban utilities

In order to support the creation of stable residential areas in Majes City, the utilities should be built on time and with appropriate technology.

- A water supply network needs to be designed for the whole city, with a filtration plant and the ability to distribute water to each lot.

- Electricity will be provided by the hydroelectric plants. Electric energy will therefore be cheaper than other forms of energy. Residential,
industrial, commercial and mass public transportation should be provided for by this energy. Moreover, industry will have an independent sub-station because of its specific requirements.

- Sewers will have to fit into the topography. Also, there will be a treatment plant for recycling and a residential sewer installation.

4.- Spatial dimension of transportation

This consists of vehicular and pedestrian circulation systems.

The system of circulation is one of the most important components of the urban layout, it not only channels the movement of pedestrian and vehicles but, since it is on public land, it also determines the patterns of land utilization, land subdivision and the layout of utilities.

Majes City should have a hierarchical organization of road and street systems in order to establish different levels of accessibility, intensity of land use, land values, and privacy. Therefore, this city will have a loop around Sutton Hill, which can provide easy connection and access for vehicular circulation. The main access will be established by its connection with productive areas, dynamic nodal points and regional roads. Inside the city, there will be a hierarchical system of streets which could be based on main dynamic streets which act as principal channels for vehicular circulation and pedestrian circulation. They will be bounded by mixed use areas. Secondary streets will have vehicular and pedestrian
circulation with commercial and residential land use. Tertiary streets will act as connectors of facilities and neighborhoods with pedestrian and vehicular circulation. Local and service streets; and pedestrian streets in residential areas.

This system of streets should connect the whole different areas and activities of the city into a whole, and provide short or minimum distances between housing - facilities and housing - work areas. It easily supports the installation and maintenance of utilities.

5.- The spatial dimension of government facilities

Typically the main government facilities in small and medium sized towns are located in the major plaza ('plaza de armas'), which is the central area of the town. These facilities are: the municipal government building, central governmental and sectorial offices ('sub-prefectura' and 'oficinas ministeriales') and agencies. In addition, the central authority of the Majes Project will be located in this town.

G.- Identification of Design Criteria

1.- Guidelines for the general organization

a) General objective

There is a necessary trade off between the long term benefits of a good ecological fit with the urgent demands of people for appropriate urban configuration and the costs of developing a new city.

b) Specific Objective
To establish specific solutions to the problems of the urban settlement process of the Majes Integral Project which will accommodate particular urban patterns and housing types that are a response to the Peru's specific environmental conditions and traditions.

c) General Statement

The Majes Urban Unit, organized as a complementary part of the general development of the Majes Integral Project, should have the flexibility to accommodate activities and develop programs according to the long term Majes Project and its phasing program; physical environmental factors in desert climates and traditions must be taken into account together with the socio-economic and the political connotations of that project for its urban settlements. Therefore, urban patterns and housing types in this City will be able to fit into and resolve the population's future requirements and activities, and the also site's contextual conditions.

d) Conception

Majes City should be conceived as combination of several distinct urban configurations where the spatial structure must be organized under principles of complementarity, interdependence, differencial domains, ecological fit, and social interaction. In addition, the urban systems must be limited by variables like function, economy and efficiency. Both kinds of criteria together should define the basic urban organization which
will be able to fit the desert's climate and topography with the people's requirements in order to provide an appropriate urban environment for them and their activities, and the proper linkage to the region.

2.- Specific Criteria

   a) Site: Climate and topography

    The City's urban environment must be regulated by shelterbelts, water ways, ponds, plazas, narrow streets, arcades and a compact building system which should provide microclimatic conditions for pedestrian circulation and social life in the streets and public spaces, according to the traditional uses of these spaces.

    Microclimatic conditions in housing should be created by orientation, natural ventilation, and materials. In addition the organization and proportional relationship of open spaces (courtyard or patios) and their effect upon a building's performance can reinforce specific microclimatic goals.

    The physical configuration of Majes City must have a proper topographical fit in order to have an efficient utility system, proper building and layout solar orientation and wind protection, and beneficial microclimatic effects.

   b) Access and connection

    The main access and connection to Majes City should be connected to the major regional roads and
intersections, it must also provide linkage between new productive areas and the public facilities areas of this town. According to the Majes City's local context, the main access and connection of this town is going to define the growth direction of the town, the intensity of the traffic flow, and the configuration and character of the main streets (see plan 2).

c) Urban structure

The urban structure of Majes City must deal with principles of adaptation, social interaction, order, gradual space articulation and preservation of the public and private domains.

The urban structure should be organized in order to achieve special environmental conditions for human adaptation to the arid area of Majes and to compose, as a system, an organization that is an economical way to resolve infrastructural services. It must also serve aesthetic values to give a symbolic meaning and cultural identity to the city (see fig. 5 & 6).

d) Urban patterns

In terms of the neighborhood's physical order, the urban pattern for Majes City must be shaped by taking the criterion of traditional neighborhood organization, improving that organizational criterion and fitting it with the desert's environment and modern ways of life applicable to the reality of a modern city (fig. 3).
e) Housing typologies

The various housing types must be designed to meet the traditional uses of housing in Peru, plus they must also meet the climatic and technological requirements of Majes. This can be done by improving upon native architecture and by implementing an appropriate technology to the problems of housing, so that while an economical implementation of housing may be established, it will still be possible to improve the standards and quality of life for the residents of Majes City.
IV.- CASE STUDY: Majes City's Design Proposals

A.- Proposal: Majes City, a New Urban Unit

Majes City is designed in order to fit a desert environment, to use the current architectural experiences from similar climatic conditions, to take into account the traditional use and forms of urban spaces in the south of Peru and to also provide for people's adaptation to the dryness of the site.

This city is organized in response to the traditional use of public spaces, such as plazas, street and courts. The plaza is a place for meeting people, social interaction, passive recreation and cultural, political and ceremonial activities. The street, at the urban scale, is the space where people interact, walk, and look for amenities. It is the place where people meet the car, and connects several areas of the city together. From its perspective, the residents perceive how the city works. The street expands the living space of people; it is an extension of their own living condition. The street, at the neighborhood scale, has small stores and some facilities that support the quality of life. In addition, the street corners are one of the more dynamic spaces where food stores are located and where people are accustomed to buy, meet and talk.

1.- The Basic Urban Structure

In the light of principles and criteria described above of the conception of this city, the basic urban
structure is the permanent part of the city; it gives order, recognition and orientation. It establishes a hierarchical organization of traffic, public open spaces and utility lines. So the basic urban structure connects the areas of the city such as residential industrial, commercial, recreational activities and public facilities, and forms a whole out of them. It is the public domain where the most public and dynamic activities will be allocated and where people and cars can share the life of these spaces. In addition, trees, arcades and ponds reinforce this urban configuration in order to provide favorable microclimatic effects for reducing aridity, solar radiation and glaring. It fits into topography, dry climate, and solar and wind orientation.

The basic urban structure consists of the main axis with plazas at the point where the secondary and tertiary streets intersect this axis. The nuclei of communal facilities are connected by tertiary street. The main axis should support an intense land use with a mixed use of activities, such as high-density residential use (apartments), commercial, retail, banks and offices. As a support of dynamic commercial activities on the main axis, it requires that the architectonic configuration of buildings should be flexible and adaptable to change of function. (see fig. 5)

The secondary street (commercial axis) supports residential middle density ('quinta house') and commercial
retail. This axis is a lineal linkage of neighborhood units.

The tertiary axis (communal street) is for communal facilities and will support the middle-density residential developments.

The plazas are defined by the location and character of the axis intersections. They is a major plaza, an art center plaza, a market plaza, commercial plazas and communal plazas.

At the central point of this basic structure will be the origin of the city, the square town. In the beginning, the main plaza and the orthogonal grid will start the settlement process. This area will become the heart of city. Although this area has a special configuration, it reinforces the basic urban structure, because the central area is a dynamic part of it.

Regarding land use and transportation interaction, it is compatible with the hierarchical organization of the basic structure. In addition, light industrial and recreational areas at the ends of this town also reinforce this basic organization which connects the whole city through its major road system. (see plan 3 & 6a)

2.- Urban Systems

The city of Majes is conceived as a systematic organization of its parts. The urban systems are defined by a circulatory system, an open space system, a building system, a system of facilities and a utility system.

a) Circulatory system
This consists of vehicular and pedestrian circulatory systems, which are made up of a special street configuration in order to counteract the climatic stress of arid regions and topographical features of Sutton Hill. In addition, it provides the interconnections required of activities (see plan #6a & 6b).

The vehicular circulatory system is made up of a hierarchical street organization, with a role and function for each one, they are:

- The major axis is formed by the lineal park; trees, ponds and a public transportation system (street car), double lanes for vehicular circulation, wide sidewalks with arcades and plazas at the intersection of the streets for pedestrian circulation.
- Secondary axis, defined by two lanes with trees along this street and based on commercial and residential activities.
- Tertiary axis, one lane streets which connect the nuclei of communal facilities among them and with the main axis.
- Local streets will be used as collectors between the various neighborhoods.
- Service streets will be used for access to residential areas.
- Pathways, alleys and main streets are the routes for pedestrian circulation. However, exclusive pedestrian circulation is restricted to the residential
areas. There are two levels: public circulation on the main streets and semipublic pedestrian inside of blocks in residential areas. In addition, the movement system is oriented as to reinforce movement to the streets.

b) Open space system

This system is organized in three levels: environment, physical linkage and social interaction. It is also articulated by public plazas along the main axis, the semi-public plazas in the neighborhood units, and the semi-private plazas inside of blocks. All plazas are shaped in response to the arid environment, social interaction and amenity. Most of them are small, with compact gardens, some trees, ponds and areas made up of hard floors. Therefore, the open space system provides a favorable microclimate, passive recreation and easy maintenance.

c) Building system

The building system is formed by compact masses of construction with a grid-block configuration. The main idea is to reduce solar radiation, cold night winds, dusty day winds, high glare, minimize evaporation and heat gain during the day and heat loss at night (see plan 4, 9 & 10).

The building system's configuration is also shaped by different types of houses which depend on the block allocation and urban context.

d) Facility system

This is based on a homogeneous distribution of a nucleus of communal facilities in the whole city according
to the number of people and their distances from the facilities (see plan 7).

There are two levels of facilities offered: neighborhood and civic. The idea is to provide differentiated domains in both levels; however, the community scale should be predominantly for the neighborhood in order to provide more cohesiveness to the whole city. Also, this system reinforces the criterion of compactness through a nucleus of facilities in neighborhoods and along the major axis.

e) Utility system

This system is organized according to street configuration and layout. It must be developed in four phases, and they form three different functional areas; (the main central area and two adjacent linear wings) however, they can be interconnected for a shortage of energy in one of them or other special requirements (see plan 8).

3.- Development of a residential blocks units

a) Grid - Block urban pattern

This is a systematic layout of blocks that forms a geometric orthogonal organization in order to allow for car circulation around them and pedestrian circulation within, land use subdivision, and installation and maintenance of utilities.

This urban pattern is traditionally used in many Latin American cities. In Peru the gridiron block formation is changing to the grid block formation. Subdivisions of big lots, densification, and high land values have shifted the
4 MAJES
MORPHOLOGY
old pattern which used the central areas of block for commercial or residential activities. However, the principles of courts and small plazas which preserve a favorable environmental condition are still used.

Using similar criteria, the blocks in Majes City are shaped by a central court or small plaza with pathways and dwellings around them. There are three different kinds of blocks (see plan 9, 10 & 11).

- The superblock has plazas, pedestrian streets, and residential areas, with three different types of houses; unifamiliar in the center, bifamiliar courtyard house in north-south orientation and multifamiliar "Quinta house" east-west facing a commercial and communal axis. (See plan # 12)

- Square blocks in the central area. They consist of a plaza, pathways and bifamiliar units which face inside and outside this block.

- Shop house block, which is located on the south side of the main axis. It consists of a central plaza, pathways, unifamiliar row houses, and faces the street of shop-houses. This block can be also arranged for "Talleres comunales": cooperative craftmen's production shops and houses.

b) The housing typologies.

There are six housing types that have been considered for the project of Majes City.

Housing types in Majes are in response to a dry
climate, human necessities, feasible technology and traditional architectonic configurations. In addition, the types should also be shaped by the contextual urban architectonic characteristics.

- The courtyard house with patio or court in the central or lateral area of the house.

- Row houses are an unconventionally narrow lots and they are in the shop-blocks, facing to interior pedestrian streets.

- Shop - house: Mixed craft production with housing. This type of house must have two differentiated areas; however, the articulation between them may be through a transitional space, patio, courtyard or other such an area.

- Block house. Its location in the lot deals basically with the lot's topography and solar orientation. This is a type of compact house that allows people to have more open space as a patio or backyard for multiple uses. It may be a bifamiliar unit with independent apartments.

- Quinta house: this is a multifamiliar unit that allows people to share open spaces, general facilities and maintenance. However, each dwelling is independent and they could be flat apartments or duplexes with their private services. The quinta house is facing the east and west streets of the superblock arrangement.

- Multifamily high density apartment house. This
is a dwelling unit that is organized in slab or terrace buildings along side the major axis. These dwelling units may be duplexes or flats, but they must share some common facilities.

All these housing types should fit in with the arid climate, people's traditions and basic necessities, the availability of an appropriate technology for construction materials and costs.

B.- Phasing of Majes City

According to some preliminary studies made by the planning team of the Majes Project, the initial population of Majes city will be 1,200 people in the first year. The number of houses and amount of area will be 240 dwelling units and 12 Ha of settled land. The people will be predominantly involved in facilities and agricultural activities.

- The first five year phase will consist of approx. 75 Ha for 7,000 - 8,000 people with 1,500 dwelling units. This area will be constructed on the middle part of Sutton hill, starting with the Major plaza, cultural and civic facilities. The urban layout of the square blocks could be for 75% of dwelling units in individual lots and 25% of the dwellings could be apartments along the principal streets. This phase will have two nuclei of communal facilities. In addition, the market center and the art center plazas will be started; therefore, this phase defines the initial area as a small town-square, which helps to deal
with the climate, topography and accessibility.

- The second five-year phase will consist of 150 Ha 19,000 people and 3,800 dwelling units. According to its connection with the initial square town, this urban settlement will grow in the same direction as the entrances to city are (See plan #2). So from square-town configuration the city will start to shift to a lineal town, because the dynamic tension from the two productive areas (East and West), permit an intense use of the access routes which allows the adjacent areas of the area close to the new routes to be involved in the new urban growth of Majes city. The new areas have to share some facilities and utilities with the central areas at the beginning, but only until this new area becomes in an unit plan area for utilities. (See plan # 8) In this phase the market center and the art center may be finished.

- The third phase will have 300 Ha approx. 32,000 people and 6,4000 dwelling units. The city will continue growing in the same direction as the main street (East-West). At this point, the whole main axis could be built, and the city takes on the lineal organization form. Also, by now the utilities must be completed.

- The fourth phase will have 400 Ha approx. 50,000 people and 10,000 dwelling units. The city will grow basically to the north south for densification. All the facility and utility system must be completed.
V.- CONCLUSIONS

This thesis has dealt with the abstraction and application of urban patterns and housing typologies with respect to determining design criteria for a new desert urban settlement in Peru. Moreover, for this study, it has been necessary to consider the relationship between the distinct scales of the city's general spatial structure and particular neighborhood urban patterns based on specific housing types. This spatial urban structure deals with local factors of the site (dry climatic conditions and topography), and the spatial organization of economic and socio-cultural activities. Urban patterns and housing typologies respond to microclimatic conditions of a desert environment, specific people's cultural values and way of life, and the formal expression of particular neighborhood spaces and residences. It is concluded that the architecture of the city is determined by both the general order of the city as a place of work as well as the specific residential patterns determined by people's cultural values and environmental expectations. In dry climatic regions, one must know how the urban space has been organized to respond to climate and how it affects the architecture. On the other hand, one must know how the residential urban spaces have been shaped by various housing types. It is concluded that the architecture of the city cannot be completely autonomous of peoples personal requirements, specific site conditions, and even the designer intentions. Then, distinct
physical and cultural contexts, economic constraints, dissimilar socio-cultural values give variety to that architecture which also depends on internal rules that shape the formal expression of architecture and allow it to deal with conceptual systems of order, perfection of proportions and harmony. In addition, this proposal has mainly focused on the formal resolution of factors through a disciplined organization; this discipline has derived from my theoretical research into formal synthesis in urban design, and socio-cultural identification of site, people and traditions. Therefore, it is concluded that both a systematic relationship to context at the level of urban space, and variety and the multi-valent requirements of society and individual identification at the architectural scale should both be considered as the main approach for the critical application of housing typologies and urban patterns in a new desert town in the southwestern part of Peru.

The following are conclusions in synoptic form of the general thesis investigation:

1). According to the physical characteristics of desert regions, they have natural limitations for supporting plants and animal life. Also, these desert regions are affected by considerable insolation. As the thermal conditions establish the proportions of transferred heat between man and his environment, in desert areas, shelter must deal with this particular climate in order to accommodate a stable
microclimatic condition and provide the proper comfort to man physical and cultural requirements for adaptation. Thus, it is concluded that architecture and urban design in these regions should fit climatic and socio-cultural needs in order to save energy consumption and to require only appropriate technology.

2). The organization of desert towns has showed us different ways to fit together human necessities, climate and socio-cultural values. From studies in the Middle East, Australia, and the desert regions of North and South American, it has been possible to assimilate and to look for a critical and dynamic application of various urban patterns and housing typological characteristics from these regions. Typical urban patterns include narrow streets, compactness, superblocks, pedestrian alleys, and small plazas (see fig. 3). Typically the open spaces used to have small gardens, trees and ponds in order to create favorable microclimate. In addition, in these regions, housing types are based on internal microclimates countering the desert climate, and socio-cultural needs. These housing types are the courtyard house, the row-court house, terrace house, block house and underground house (see fig. 4). In general, these urban patterns and housing types have frequently shared some common formal characteristics. Indeed, they can be applied and adapted to a specific site and a particular cultural condition. Therefore, it is concluded that the critical and dynamic application of housing types and urban patterns
Gridiron Blocks

Plazas

Superblock

Alley

Sprawl Construction

Grid Blocks

Compactness

Pedestrian Alley

URBAN PATTERNS

FIGURE 3
should be approached in terms of evolution and articulation, looking to the past and to the future, and responding to the existing conditions in order to achieve cultural continuity and a sensitive recognition of its context.

3). Distinct scales of civic continuity and cultural continuity must be the basis of the design criteria for the new desert settlement of the proposed City of Majes. As Michael Wilford said:

Urban design is architecture and not a separate activity mediating between planning and building. It is the physical expression of society's hopes and intentions and means of using and developing human and architectural potential, involving areas of concern which do not recognize boundaries between public and private domains.

In fact, the design of this city was approached in a different way from the traditional Master Plan with singular rules for order and growth. The intentions for designing Majes City have been established in order to suit the desert environment with specific urban and housing formal organizations according to climate, traditional socio-cultural values, economy and resourceful solutions to meet people's expectations of living conditions in these regions. However, this approach is capable of being accommodated in response to changes and new factors at each phase along the implementation program. Therefore, it is also concluded that the main idea for this city must be the establishment of a basic urban structure with the general guidelines for growth (see fig. 5). This basic urban structure will be the
permanent part of the city's physical organization. It can allow the city's growth to be more flexible and adaptable to change and application of different urban patterns and housing typologies as needed. In addition, this project draws from the varied experience of towns in the south of Peru and from areas with a similar climate around the world, to establish a clear relation between site (climate and topography) and urban architecture. Also, this project seeks an articulation between the Majes Project and the region involved in order to provide facilities, services and support to the colonization process.

Four major conclusions can be made from the specific proposal of Majes City.

First. Majes City has been approached by analyzing the site with emphasis on the main climatic characteristics: aridity and low humidity, high rate of temperature variations, intense glare and solar radiation and S.W. and N.E. seasonal predominant winds. Topography and local factors are defined by the configuration of Sutton Hill which is a plateau surrounded by two ravines, and the connection to the regional road system linking Majes City with its context. The design has considered the effects of these physical articulations into its own urban organization. Thus, the site and climatic factors were carefully taken into account in order to counteract the inclemency of desert climatic conditions, and to create a
favorable microclimate for human living.

Second. Majes City has been approached by analyzing both old and new practices around the world, in order to determine certain general criteria. The idea was to establish the experiential relationship between the studied cases and the Peruvian way of life in those kind of climates, and also the relation among similar climatic conditions, some traditions of urban life and architectonic and urban configurations in arid environments. The Persian experience in the Middle East, the Pueblo Architecture in North America, Chan Chan in Peru, the new experiences of Jebel Ali in the United Arab Emirates, and the planning cases of Kabul in Afghanistan and Tucson in the USA are all cases where favorable microclimatic conditions for urban life have been created. Furthermore, they have some similar ways in approaching the fit of human life with arid environments, even though they have different socio-cultural backgrounds. The latest approaches to urban design in these arid regions involve both innovative energy systems, and more complex planning measures. Moreover, in these new towns the traditional use of natural features, water, vegetation and trees help to reduce the negative effects of dryness and create a positive microclimate. Density and compact construction reinforce the concentration of facilities and rational organization of services. Pedestrian circulation requires a street orientation, special environmental conditions and a proximity of housing and work places to the
The Peruvian experiences in arid climates have been mainly developed by the spontaneous settlements or "Barriadas" which are the new population areas that are located in arid lands around or close to the major cities. These settlements have a physical configuration based on compactness at the urban and architectonic levels. The grid system is frequently the formal organization of these areas where the main street is the principal space for social and economic interaction. This principal street is always related to the access or connection with other places through public transportation. Houses have back patios for multiple uses and, in a few cases, small gardens at the front; but the construction area is compact. Indeed, there is a similarity on several scales from urban structure to architectonic motifs of these spontaneous settlements in Peru and other parts of the world.

Third. Majes City has been approached by determining the referential information for Majes City's urban design; the resulting program is the synthesis of information gathered through bibliographic research, studies made by the Majes Project and the OAS (Organization of American States) teams, and meetings in Peru which involved both the authors of the Majes Project and some authorities of the Peruvian government. According to the new town's role and location, it was necessary to design in context in order to respond to the specific conditions of the region, and people and their traditional patterns of urban life. For that reason, the
general geographic characteristics and historical organization of economic activities of Peru were examined in order to understand the meaning of the Majes Project. Majes City has been located on Sutton Hill which is the central place of the whole Majes Area Plan. These physical characteristics give special connotation to the site for this city. As a result, this project is going to change drastically the conditions in the involved area, developing an uninhabited space into a productive and strategic place for regional articulation.

Nevertheless, it should be noted that this proposal has some limitations due to the lack of several important basic studies. In particular, preliminary studies for planning Majes City have only general population information, some technical standards for physical organization and certain urban activity requirements. While this information is valuable, one also needs to be more explicit, accurate and extensive. Specific studies need to be made, such as the implications of soil conformation, energy conservation and subregional storm systems; economic studies about population, family work, labor skill, craft or industrial productive organizations (private, cooperative, social property or another); and financial aid. However, these specific factors have been anticipated in the following conclusions.

Fourth. Majes City has finally been approached by
designing on the basis of principles and criteria for the structure and systematic organization of its urban components. This proposal has also responded to human scale and urban spatial configurations familiar to the cultural experience of the future residents. Majes City has further been designed on the basis of:

1. Economy and function.
2. Location and distribution of facilities and utility infrastructure.
3. Dynamic use of urban space based on both social domain and social interaction.
4. Proper organization of pedestrian and vehicular circulation and public transportation systems.
5. Flexibility and adaptability of the urban public domain to different uses of the space without changing its general physical structure.
6. Effective accessibility to facilities and employment areas.
7. Cottage industry housing and related services.
8. Coherence and efficiency in its growth process.

The configuration of this new town must be also based on a phasing program. The town-square identifies the inner-city initial urbanization process around the main plaza, and the lineartown structure supports a directional growth of the city along the principal roads of connection and access. Supporting the general organization of this city is the basic urban structure that consists of the main
Access

Basic Urban Structure

Figure 5
axis, central areas and major plazas, and secondary transverse axes. This is the permanent and inflexible urban part which is overlapped by the grid-block system which includes areas where variable and flexible urban growth can be permitted to occur. In this general spatial organization the urban development includes improvements to the arid microclimatic conditions by its formal organization, landscape and the proper distribution of facilities and infrastructure. These criteria have allowed the city to have a generic and systematic organization involving special and specific urban patterns and coherent housing typologies. The generic organization is based on an orthogonal grid-block system which varies in multiple size from 100 x 100 mts. to 200 x 300 mts (see fig. 6). The variations of block dimensions are in response to distances to the central area of the city, and the concepts of "sudretown" and "lineartown" conformation. The distances range from walking to car distances. Nevertheless, each block attempts favorable microclimatic effects with an interior plaza or plazas and appropriate housing types. The proposal depends on the specific relationship between urban patterns and distinct housing types in order to fit together climate, density, landscape and appropriate living conditions for people. In addition, all these factors shape the configuration of urban spaces and establish the relation with traditional urban patterns. Both the generic and the specific as well as the people's personal environmental
expectations should define the character of each dwelling, neighborhood and city space with a specific urban architecture which fits into the general grid-block configuration of Majes City. Therefore these three factors will provide the physical variety of the town and the social identification of the people.

Consequently, the design proposals have been made through the critical application of urban patterns and housing types to the specific conditions of the site; through the transformation and adaptation of these particular prototypes to the new conditions, and the systematic organization and orientation of these proposals through the proper urban configuration of socio-communal facilities and utility infrastructure. As a matter of fact, from both the theoretical approach and the design proposals one can take the general criteria applied in Majes City's design, and then use these criteria in a place with similar arid climatic conditions.

I have commenced with an almost totally systematic approach and concluded with an emphasis on identification and variety to match the ideosyncratic requirements of people so important to dwellers in a new desert town.
Characteristics of solar radiation:

Design must counteract each type of radiation. Solar radiation reaches the earth's outer atmosphere at a constant rate of 1.94 cal/cm²/min or 429.2 BTU/h/ft² (solar constant).

Terrestrial radiation should be measured, because it gives the radiation so important balance for microclimate in desert regions for agriculture and human life.

Estimation of solar radiation:

\[ \frac{Q}{Q_a} = a + b \left( \frac{n}{N} \right) \]

- \( Q \) = radiation on the earth surface
- \( Q_a \) = radiation at the top of atmosphere for the day and place
- \( a, b \) = constants in a regression equation
- \( n \) = duration sunshine
- \( N \) = possible duration of sunshine

\( Q_a \) is sometimes replaced by \( Q_o \) which is radiation to the earth's surface under clear sky conditions.

Radiation and color:

Color does not define the behavior of a surface regarding its emissivity or power to emit long-wave radiation: both black and white painted surfaces lose heat to the sky at night at equals rates. Most of the buildings in these climatic regions have been painted with clear colors and some of them were set up in places which provide shadow for public spaces such as streets and plazas. On the other
hand, there are five main channels in heat transfer affecting buildings:

- Direct short-wave radiation from the sun
- Diffuse short-wave radiation from the sky vault.
- Short-wave radiation reflected from the surrounding terrain.
- Long wave radiation from the adjacent ground and nearby objects.
- Outgoing long wave radiation exchange from building to sky.
3. Olgyay V., p. 15
4. Olgyay V., p. 16
5. Olgyay V., p. 12
14. Olgyay, V., p. 52
17. Golany, G. *Urban Planning for Arid Zones*, p. 16
18. Golany, G. *Urban Planning for Arid Zones*, p. 17
19. Olgyay, V., p. 9 - 11
21. M. Fry, p. 50


23. Hilberseimer, L. p. 14


CITY PLANNING COMMISSION. Pittsburgh's Six Year Development Program. Pittsburgh, 1981.
COLEGIO DE ARQUITECTOS DEL PERU. Forum Arequipa 2,000. C.A.P. Arequipa, 1980
DOXIADIS, C.A. City for Human Development. Athens, Athens Publishing Center, 1972


Lumbreras, Luis, *Los Origenes de la Civilizacion en*
Oficina Regional de Planeamiento y Urbanismo, Plan de Desarrollo Metropolitano, Lima—Callao, Esquema Director 1970-80 ".