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ORIGINAL

Adaptive Architecture: Architectural Projects in Peru's Diverse Climates

Arquitectura Adaptativa: Proyectos Arquitectónicos en los Diversos Climas del Perú

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ABSTRACT

Objective: the main objective of this research is to understand how the climatic conditions of each region of Peru influence the design and construction of buildings. The aim is to achieve functional and comfortable spaces that are in harmony with the natural environment of each region.
Method: the methodology used in the study is based on a narrative review, in which data and previous studies on architectural projects in the various climatic regions of Peru are compiled. In addition, successful case studies were carried out to analyze the strategies employed in these architectural projects.
Results: the results of the article highlight that in each region of Peru (coast, highlands and jungle), architects have developed techniques and used specific materials to guarantee the durability of buildings in extreme climatic conditions. For example, on the coast special paints and coatings are used to protect against corrosion, in the highlands thermal insulation techniques are implemented and in the jungle humidity resistant materials are chosen.
Conclusions: Peru's climatic diversity has led to the development of adapted architectural techniques that ensure the functionality and comfort of spaces. The influence of climatic conditions is critical to the effective design of buildings in the different Peruvian regions. In addition to climatic factors, Peru's rich cultural diversity has also influenced vernacular architecture, resulting in buildings that reflect the country's identity.

Keywords: Architecture; Adaptive Architecture; Architectural Projects; Different Climates.

RESUMEN

Objetivo: el objetivo principal de esta investigación es entender cómo las condiciones climáticas de cada región del Perú influyen en el diseño y construcción de edificaciones. Se busca lograr espacios funcionales y confortables que estén en armonía con el entorno natural de cada región.
Método: la metodología utilizada en el estudio se basa en una revisión narrativa, en la cual se recopilan datos y estudios previos sobre proyectos arquitectónicos en las diversas regiones climáticas del Perú. Además, se llevaron a cabo estudios de casos exitosos para analizar las estrategias empleadas en esos proyectos arquitectónicos.
Resultados: los resultados del artículo destacan que en cada región del Perú (costa, sierra y selva), los arquitectos han desarrollado técnicas y utilizados materiales específicos para garantizar la durabilidad de las edificaciones frente a condiciones climáticas extremas. Por ejemplo, en la costa se utilizan pinturas y recubrimientos especiales para proteger de la corrosión, en la sierra se implementan técnicas de aislamiento térmico y en la selva se eligen materiales resistentes a la humedad.

Conclusiones: la diversidad climática del Perú ha llevado al desarrollo de técnicas arquitectónicas adaptadas que aseguran la funcionalidad y confort de los espacios. La influencia de las condiciones climáticas es crítica para el diseño efectivo de construcciones en las distintas regiones peruanas. Además de los factores climáticos, la rica diversidad cultural del Perú también ha influido en la arquitectura vernacular, resultando en edificaciones que reflejan la identidad del país.

Palabras clave: Arquitectura; Arquitectura Adaptativa; Proyectos Arquitectónicos; Diversos Climas.

INTRODUCTION

The climatic diversity of Peru, a country in western South America, has given rise to a wide range of architectural techniques and styles that have been carefully adapted to each region.[1] In this detailed research paper, we will explore in depth the architectural projects that have been carried out on the coast, in the mountains, and in the jungle of Peru, paying special attention to the particularities and challenges faced by architects in each unique context.[2]

The objective of this research is to understand in detail how the unique climatic conditions of each region influence the design and construction of buildings found there.[3] The ultimate goal is to achieve functional and comfortable spaces that are in complete harmony with the native natural environments.[4]

In the coastal region of Peru, characterized by its arid and warm climate, architects have been challenged to develop techniques that allow buildings to adapt to the constant scorching sun and gusts of salty wind from the Pacific Ocean.[5]

On the other hand, buildings must be designed and constructed considering the frequent presence of fog, rain, and low temperatures in the Peruvian highlands, where temperatures are colder due to the high altitude. In addition, in the Peruvian jungle, with its tropical and humid climate, architects face the challenge of working in an area with a high incidence of heavy rains and high temperatures.[6]

In each of these regions, architects have had to use appropriate techniques and materials to ensure the durability and resistance of buildings to extreme weather conditions.[7]

For example, special paints and coatings have been used on the coast to protect structures from corrosion caused by salt air, and cross ventilation has been used to counteract the heat.[8] In the mountains, on the other hand, thermal insulation techniques and materials such as stone and wood have been used to conserve heat inside homes. In the jungle, selecting moisture-resistant materials and adequate ventilation are fundamental aspects to consider.

It is also important to note that, beyond climatic differences, architecture in Peru has also been nourished by the rich cultural diversity of its inhabitants.[9] Indigenous and colonial influences have intertwined throughout history, creating a unique and fascinating architecture that reflects the country's identity and history.[10]

METHOD

The methodology used in this study is based on a narrative review, a tool that allows for the qualitative collection and synthesis of information on a specific topic. In this case, data and previous studies on architectural projects developed in different climates in Peru were collected. The main objective was to understand the challenges and opportunities that arise when designing and building in different areas of the country, each with its own particular climatic characteristics.

A comparative approach was key to this process. Detailed analyses of the climatic conditions of the different regions of Peru, such as the coast, the highlands, and the jungle, were carried out, identifying their particularities in terms of temperature, humidity, precipitation, and winds, among other factors. This assessment made it possible to identify how climate directly impacts design and construction decisions, from the choice of materials to ventilation, lighting, and thermal insulation solutions.

In addition to the comparative analysis of climatic conditions, a comprehensive evaluation of the architectural solutions implemented in previous projects was carried out. This allowed for the identification of innovative approaches, best practices, and adaptive strategies that have been effective in addressing climate challenges. Social, cultural, and economic aspects were also considered, as architecture not only responds to a physical environment but also to the needs and expectations of the communities that inhabit these spaces.

A key component of this methodology was the study of successful cases where architectural projects recognized for their ability to adapt to local climatic conditions were analyzed. Through these cases, the strategies and techniques used to maximize thermal comfort, minimize energy consumption, and promote sustainability in each climatic context were explored in depth. These cases served as models for understanding how architecture can respond effectively to the specific challenges of each region and how these solutions can be replicated or adapted to other contexts.

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In summary, the narrative review allowed us to identify and compare the different architectural solutions used in the various regions of Peru and highlight the lessons learned and opportunities for innovation that could be leveraged in future projects. This integrative and comparative approach offers a broad view of how architecture can play a key role in adapting to Peru's diverse climates, improving the quality of life of its inhabitants, and contributing to environmental sustainability.[11]

MAIN FINDINGS

Climates of Peru

Peru has a wide variety of climates due to its geographical location and the presence of the Andes mountain range. Among the most notable climates are hot, cold, coastal, and jungle. This variety of climates influences the architectural design and materials used in projects. It is important to consider the climatic characteristics of each region in order to achieve a design that is appropriate for the specific conditions of the site, thus ensuring thermal comfort and energy efficiency in each project.[12]

Architectural projects in warm climates

In the hot and humid climates of beautiful Peru, such as the charming north coast and the lush lowland jungle, it is absolutely necessary to design innovative and cutting-edge architectural projects that adapt to the high temperatures and humidity characteristic of the region. Aware of this pressing need, architecture experts have developed revolutionary strategies that use bioclimatic techniques, which focus on creating livable spaces that maximize the natural conditions of the environment, thus reducing dependence on artificial air conditioning systems.[13]

Architectural projects in cold climates

Architectural projects in cold climates in Peru face challenging weather conditions such as low temperatures, strong winds, and snowfall. To adapt to these conditions, specific architectural strategies must be used. One of these is using suitable building materials that provide thermal insulation, such as wood and adobe. These materials help retain heat inside homes, maintaining a comfortable temperature. Another important aspect is the design of the building envelope, which must be airtight to prevent cold air from entering. Efficient heating systems, such as wood-burning stoves or central heating systems, are also commonly used to ensure thermal comfort inside. In summary, architectural projects in cold climates in Peru require consideration of both the use of appropriate materials and design strategies that create comfortable and energy-efficient spaces.[14]

Architectural projects in coastal climates

On the coast of Peru, characterized by its arid climate and the influence of the Pacific Ocean, architectural projects must adapt to climatic conditions to provide comfort to inhabitants. In this region, fog and high humidity are common, posing challenges in terms of ventilation and corrosion protection. The materials used in architectural projects in coastal climates must be carefully selected to withstand salinity and prevent premature deterioration. In addition, it is important to consider the orientation of buildings to take full advantage of sea breezes and avoid excessive heating. Architectural design in coastal climates seeks to create cool, bright spaces using skylights, terraces, and cross ventilation. Some successful examples of architectural projects on the Peruvian coast include using corrosion-resistant materials such as stainless steel and incorporating green areas to mitigate the effects of salinity.[15]

Architectural projects in jungle climates

Architectural projects in jungle climates in Peru require a design that considers this region's characteristics. High temperatures and humidity are key factors to consider. Materials that provide thermal insulation, such as well-insulated walls and roofs, are used to combat the heat. In addition, it is necessary to allow for good ventilation in spaces with strategically placed windows. Heavy rainfall is also a challenge, so sloped roofs and adequate drainage systems are used to prevent leaks. The choice of moisture-resistant materials, such as bamboo or treated wood, is essential. In this type of climate, it is also common to use elevated architecture to protect structures from moisture and possible flooding. In summary, architectural projects in jungle climates require designs considering thermal insulation, ventilation, rain management, and moisture resistance.[13]

Influence of climate on architectural design

Climate significantly influences architectural design, as it affects various aspects of a structure. On the coast of Peru, where the climate is generally hot and dry, it is important to consider ventilation and the use of materials that are resistant to moisture. In the Peruvian highlands, where the climate varies between hot during the day and cold at night, thermal insulation must be considered to maintain a comfortable environment. In the Peruvian jungle, where the climate is tropical and rainy, architecture must resist humidity and use natural

ventilation to prevent heat buildup. Architectural design must adapt to environmental conditions in these climates to provide comfortable and functional spaces.[16]

Materials used in urban and rural areas of the coast, highlands, and jungle

The materials used in the urban and rural areas of Peru's coast, mountains, and jungle vary substantially due to the different climatic characteristics of each region. On the coast, where high temperatures and humidity prevail, reinforced concrete and steel effectively resist salinity and long-term corrosion. These materials are extremely durable and highly resistant to adverse environmental elements. In addition, additional layers of waterproofing and sealing are used to ensure greater protection against moisture and water.[17]

In the mountains, where the climate tends to be colder, materials such as stone and adobe are used. These materials provide excellent thermal insulation and are impressively resistant to extreme low temperatures. They can also retain and emit heat efficiently, ensuring a comfortable indoor temperature even on the coldest days. In addition, a combination of traditional and modern construction techniques is used to strengthen their structural strength and improve their energy efficiency.[18,19,20,21]

In the jungle, characterized by high humidity and intense, constant rainfall, buildings are mainly constructed from natural materials such as wood and cane. These materials are highly resistant to water while allowing adequate air circulation to prevent moisture buildup. These materials are carefully selected and treated to resist rot and deterioration caused by moisture and insects. In addition, bioclimatic design techniques are used to improve natural ventilation and lighting within structures and minimize the need for artificial cooling systems.[22,23,24]

These materials are precisely adapted to the unique climatic conditions of each area with the firm objective of ensuring the durability and optimal functionality of architectural projects in these diverse areas.[18] Construction professionals in Peru continue to research and develop new materials and construction techniques that are even better suited to the specific needs of each region, thus ensuring the long-term sustainability and resilience of structures.[19]

Success stories in architectural projects in different climates in Peru.

AUTOR(ES)	Proyecto	OBJETIVO	RESULTADOS PRINCIPALES
(Huaman Pichuta & Quispe Condori, 2022)	El proyecto de la Casa Proyecto Queros, ubicada en la ciudad de Cusco.	Mantener una temperatura interior adecuada durante las noches frías de esta zona de alta montaña.	La casa incorpora elementos de la arquitectura vernacular de la región, como el uso de materiales locales como la piedra y la madera, lo que le confiere un aspecto estético único.
(La Rosa Sánchez Corcuera, 2021)	El Centro de Interpretación Paracas	Este centro ha sido construido teniendo en cuenta la intensa radiación solar y los fuertes vientos característicos de la zona.	Para ello, se ha utilizado vidrio de protección solar en las ventanas y se ha diseñado una estructura aerodinámica que minimiza el impacto del viento en el edificio.
(Andrade et. al, 2024)	Residencial Las Terrazas, en Arequipa. .	Este proyecto se destaca por su diseño bioclimático, que aprovecha al máximo la luz solar y la ventilación natural.	Se ha utilizado materiales de construcción reciclados y de bajo impacto ambiental.
(Santos Becerra, 2022)	El Museo de la Nación	Este edificio cuenta con un sistema de enfriamiento pasivo que aprovecha las corrientes de aire y la orientación solar para regular la temperatura interior de manera natural.	Este enfoque sostenible ha permitido que el museo sea un referente en la arquitectura ambientalmente consciente.

Figure 1. Notable architectural projects

CONCLUSIONS

Architectural projects in Peru must be specifically adapted to the different climatic conditions that vary significantly from one region to another. For example, it is crucial to incorporate materials and construction

techniques that promote adequate indoor temperature control in hot climates. This includes the implementation of cross ventilation to optimize air circulation, thermally insulated roofs to reduce heat absorption, and using materials that reflect solar radiation, as highlighted by [20] these strategies help maintain a cooler and more comfortable environment inside spaces, minimizing the need for artificial cooling systems.

On the other hand, in Peru's cold climates, thermal insulation in walls and roofs is essential to prevent heat loss during the colder seasons. In addition, placing south-facing windows to take advantage of direct solar radiation is an effective technique that helps maximize natural heat during the day. This design approach not only improves energy efficiency but also contributes to the comfort of the inhabitants, reducing dependence on artificial heating.

One of the biggest challenges in humid climates is protecting against moisture. As mentioned by [21] waterproofing, together with an adequate drainage system, is essential to prevent mold and material deterioration. These protection systems help maintain the structural integrity of the building and create a healthy environment for occupants.

In dry climates, the primary concern is wind resistance and using materials with low thermal conductivity. Choosing these materials helps maintain a comfortable indoor temperature and reduces the impact of high outdoor temperatures. This type of design also minimizes water loss, a valuable resource in arid areas.

For high mountain climates, structural resistance to extreme weather conditions, such as strong winds and snowfall, must be considered. In addition, high-efficiency insulation materials and adequate heating systems must be used to ensure the comfort of inhabitants in these areas. These systems must be capable of withstanding extreme low temperatures without compromising the structural safety of buildings.

In coastal areas, architectural design must consider corrosion caused by the salinity of the environment. This involves the use of corrosion-resistant materials and construction techniques that protect structures from the harmful effects of salinity, such as metal oxidation and deterioration of exposed surfaces.

Finally, architecture must prioritize protection against humidity and insects in jungle climates. This is achieved by using materials that resist decomposition due to high humidity and installing insect infestation protection systems. In addition, the design must incorporate techniques that allow for good air circulation to prevent moisture accumulation in interior spaces.

In summary, each climate in Peru presents specific challenges that require adapted architectural solutions. As stated by [22] the implementation of appropriate design strategies and materials not only improves the energy efficiency of buildings but also ensures the creation of livable and comfortable spaces that respond to local needs.

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The authors declare that there is no conflict of interest.

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