

# Study and planning of the optimal environmental conditions in the constructive practice of a typical office space, to be located in the tropics of Costa Rica, promoting the use of daylight


Estudio y planeamiento de las condiciones medioambientales óptimas en la práctica constructiva de un espacio de oficina tipo, a ubicarse en el trópico de Costa Rica potencializando el uso de la luz natural

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## Keywords

Sustainability; energy saving; workplaces; daylighting; materials; reuse; Costa Rica.

## Abstract

Research for recommendations and constructive solutions applied to office spaces that represent the least impact on the natural environment and that promote and encourage for the use of daylight as the primary source of lighting.

Through the descriptive methodology, the most relevant issues on sustainability in the construction of office spaces were raised from a systemic and interdisciplinary approach.

The main energy consumption patterns of the offices in Costa Rica were examined to support the importance of energy saving and variables that impact sustainability such as construction materials, recycling practices and reuse of materials and the search for passive strategies were analyzed to the use of daylight.

Hypothesis were formulated in the search for more energy-efficient and sustainable workspaces, which through the technique of data collection and bibliographic search, came to pose the most relevant on the subject of study.

This research concluded on the need to search for a model system of strategies that would allow the use of all light energy in the internal space of the offices in Costa Rica, to generate more comfortable and visually pleasing environments, encouraging energy savings and eliminating in some periods of the day, the dependence on the use of artificial lighting; likewise, it was concerned with the search for less polluting construction materials and the generation of passive strategies for these spaces.

## Palabras clave

Sostenibilidad medioambiental; ahorro energético; espacios de trabajo; luz natural; materiales; reutilización; Costa Rica.

## Resumen

Búsqueda de recomendaciones y soluciones constructivas aplicadas a espacios de oficinas que representen el menor impacto al medio ambiente natural y que promuevan e incentiven el uso de la luz natural como fuente primaria de iluminación.

Por medio de la metodología descriptiva, se planteó lo más relevante sobre el tema de la sostenibilidad en la construcción de espacios de oficinas desde un enfoque sistémico e interdisciplinario.

Se examinaron los principales patrones de consumo energético de las oficinas en Costa Rica, para sustentar la importancia del ahorro energético y se analizaron variables que impactan la sostenibilidad como los materiales de construcción, prácticas de reciclaje y reutilización de materiales y la búsqueda de estrategias pasivas entorno al aprovechamiento de la luz natural.

Se formularon hipótesis en la búsqueda de espacios de trabajo más eficientes energéticamente y sustentables, que por medio de la técnica de recolección de datos y búsqueda bibliográfica, se llegó a plantear lo más relevante sobre el tema de estudio.

Esta investigación concluyó sobre la necesidad de buscar un modelo de sistema de estrategias, que permitieran el aprovechamiento de toda la energía luminosa en el espacio interno de las oficinas en Costa Rica, para generar ambientes más confortables y visualmente más agradables, incentivando el ahorro energético y eliminando en algunos períodos del día, la dependencia al uso de la iluminación artificial; así mismo se preocupó por la búsqueda de materiales de construcción menos contaminantes y la generación de estrategias pasivas para estos espacios.

## Introduction

This research was based on the study and a selection of strategies for bioclimatic design in buildings located in the humid tropical climate of San José, Costa Rica.

Costa Rica, is a country belonging to the Central American Isthmus, located 10° North of the terrestrial Ecuador. Its climate is tropical and due to its geographical characteristics, it is very closely related to the concept of spring, with 6 months of rainy season and six months of dry season.

“Following the energy crisis of the 1970s, European countries were the pioneers in the development of plans and programs to guarantee the rational use of energy in different sectors and the evident fluctuations in climate caused by gas emissions product of the greenhouse effect, of the nineties; architects and designers have been forced to consider new constructive solutions” [4].

“Climate change and global warming of the atmosphere represent a disadvantageous situation from the point of view of energy consumption in buildings, as artificial cooling systems have to be raised to face high external temperatures. This way, the implementation of passive solutions at the level of natural cooling and natural lighting of buildings, among others, contribute globally, to reduce pollution on a large scale and to reduce energy costs for equipment operation and maintenance.

“Today, environmental problems and the ever-latent shortage of possible energy resources make the use of natural energy very important. In this context, official architecture tends to rely more and more on the use of artificial systems, sophisticated today, with computerized controls that fail to hide the basic contradiction of its design, which makes them disproportionate consumers of energy, under the pretentious simplicity of their austere skin” [13].

“Passive strategies contribute to the increasing search for a fair and equitable development model and these propose a bioclimatic architecture, with greater productivity and user satisfaction by creating much warmer, more illuminated, humanized and healthier work environments from the point of view of energy saving; which allows visualizing the passage of time during the working day.” [1].

The construction and development of buildings directly impacts the lives of people and the health of the planet in general. “In countries like the United States, energy consumption in buildings represents a third of the total energy used, two thirds are used in electricity, one eighth in water resources, and an invaluable ecological impact of the transformation of land for construction.

“In the particular case of Costa Rica, the main energy source used at the national level is hydraulic energy and other alternative sources which are exploited, but with less use, such as wind, biomass or solar energy through photovoltaic panels, due to the high costs of operation and maintenance of the equipment with which they operate” [3]. On the contrary, it exists also a clear dependence of Costa Ricans on the use of hydrocarbons such as oil, which represents the most widely used in the country, such as transportation fuel, which is highly polluting for air quality and health of the population.

The construction materials require processes for each's extraction, the fabrication of each material and commissioning in projects, which for the most part are usually highly harmful to the environment in which they are developed.

There is no awareness from the user for the management of waste in a building, nor in the personnel who handle it during the construction process. "Waste from the construction sector affects an increasingly urgent problem: a considerable proportion of the waste that affects landfills is affected by construction and demolition of buildings. This waste can be reduced through better management of the works, the use of a greater number of recycled materials, and the conservation and re-use of old buildings "[2].

During the planification stage, the stage in which it is decided where to build a building, developers put aside the importance that exists in relation to perpetuating the biodiversity existing on the site or restoring impacted land when carrying out a project, because it doesn't exist, to date, any type of state benefit or incentive, at the level of Costa Rican regulations or standards that promote its conservation or restitution.

There is in Costa Rica the legal framework for the regulation of the rational use of energy, in which it's decreed in the Law 7447 of October 25, 1994, published in Gazette No. 236 of December 13, 1994; to aim to establish the legal framework that supports energy regulation in the country. Therefore, the law obliges the public and private sectors to carry out more responsible actions in energy matters at a general level.

However, it is considered that there are still large gaps in the laws that protect the environment, especially in the responsible management of the construction process in its stages of pre-selection of the land, pre-design, design, commissioning, maintenance and operation of a architectural project, which responds mainly to the Costa Rican context and specifically to the characteristics of the tropical climate of Costa Rica. The new trends in the design and construction of buildings point to much more flexible and versatile solutions that provide answers to architecture that respects the environment.

"For green buildings to be successful, the benefits of designing them must be known to those purchasing construction services and facilities. Because sustainability addresses the broad range of economic, environmental, and social issues, the benefit of ecological or sustainable design are potentially enormous." [11].

## **Materials and methods (Methodology)**

Through the descriptive methodology, it had been proposed the most relevant topics related to sustainability in the construction of office spaces, which were raised from a systemic and interdisciplinary approach.

The methodology applied in this research is the general theory of systems that allows a scheme with a global vision to make a proposal for the selection of strategies for the architectural design of bioclimatic buildings in the humid tropical climate of San José, Costa Rica.

This holistic methodology allows evaluating user preferences regarding to:

1. Spatial dimensions.
2. Preference between natural light and ventilation or artificial light and ventilation.
3. Feelings of comfort in space.
4. Physical infrastructure requirements.
5. Building prepared for the use of technology.

6. Basic urban infrastructure services (like roads, garbage collection service, sewerage, drinking water, others).
7. Take into account the legal framework and legislation for construction.

To carry out the research, a first stage consisted of researching bibliographic references, documentaries, international standards, national laws and photographs: all this material allowed to determine the state-of-the-art, to propose the general and specific objectives, and to generally conduct the research.

The new trends in the design and construction of buildings point to much more focused on flexible and versatile solutions, where creativity and mobility of users of the building outside and inside the built space are taken into account. For this reason, the systemic approach, as a working methodology, in which all factors contribute, directly or indirectly, to optimization in the conception of the research objective is the most pertinent.

The built environment has a profound impact on our natural environment, economy, health, and productivity. Breakthroughs in building science, technology, and operations are now available to designers, builders, operators, and owners who want to build green and maximize both economic and environmental performance.” [15]

The development model of cities represents, today, the generation of centers for the exchange of knowledge, people, technology, business, others, and at the same time they are also a symbol of pollution, generation of residues and waste. Man’s life today, his life and daily activities, are far from the activities he carried out just a decade ago.

Today’s world is much more demanding, society is transforming day by day, work activities are carried out from remote points, technology has eliminated borders and has facilitated the remote exchange of knowledge, which is increasingly frequent.

Within this new current society scheme, “technological and economic efficiency has almost constantly improved, but ecological sustainability has decreased.” [6]

Vehicle traffic, the emigration of people from the countryside to the city in search of better opportunities, overcrowding in urban centers, loss of public space and green space in cities, as well as the presence of poor infrastructure at the urban level, are environmental problems that require the intervention of all the sectors involved within the city, in the search for solutions, plans, programs, and regulations that seek to restore order, balance, and harmony with nature.

From this perspective, urban environmental management represents the method to carry out the correct understanding, analysis and implementation of proposals that in the medium and long term seek to mitigate environmental problems.

The construction process is just one more activity, which is immersed within the great set of activities that take place in a city, and from which a series of actions emerge that directly affect environmental sustainability, by impacting ecosystems, make use of natural resources, and depend on the ecological awareness of the inhabitants of a locality, which is why the search to reduce the high costs of operation and maintenance of buildings has become the main concern of today.

The use of bioclimatic design strategies, such as the use of natural light and the use of natural ventilation, among others, represent design tools that contribute to reducing energy costs in a building, which represents the beginning of the search for solutions, but in turn denotes a great void in the field.

“Daylighting has become a major topic in energy conscious design. By optimizing the potential of daylight the energy for lighting our buildings can be drastically reduced, especially in buildings used mainly during the day, and use and consequent impact”. [7]

Por lo anterior, se justifica el planteamiento de estrategias bioclimáticas, estudios e investigaciones relacionadas que tengan como objetivo restablecer la relación equilibrada y en armonía con el medio ambiente natural y el respeto a la naturaleza. En los climas cálidos y húmedos, “los invariantes de la arquitectura popular se basan en dos estrategias básicas: protección de la radiación solar y la ventilación” [10].

## Results

In the search for a better quality of life for the entire population of the Planet, and especially in the tropical latitude of Costa Rica, the study area of this research, a compendium of strategies or recommendations for architectural design focused mainly on the following to the planning of cities in an environmentally sustainable way and to the establishment of guidelines that aim to contribute to improving the management of the construction process in Costa Rica:

1. Design and approach of a summary of maps that graphically summarize the main ecological elements of each area of the country, with the aim of generating an informative and guiding tool to normalize the degree of impact admitted on a given area.
2. Regulate with stricter regulations and the implementation of concrete actions, on the impact generated by the earth movements during the construction process, the disposal of solid waste, recycling policies, the points that generate contamination of air, the use and promotion of renewable energies, as well as the recycling and reuse policies for elements.
3. The use of cross ventilation in buildings not only satisfies the comfort requirements of users, but also contributes to the decrease in energy consumption of the property.
4. Design of green, shaded and ventilated public spaces within tropical cities is essential to promote the enjoyment of public space, interaction between people, as well as life in the city.
5. Maximize the use of public transport within and outside the city, as well as strengthen services on the outskirts of the city, with the aim of discouraging the use of individual transport and emigration to the city center, in search of better and more varied services.
6. Strengthen national and internal markets to generate growth within the tropical city that generates less operating costs, which in most cases become costly and polluting for the environment.
7. Conceptualize specific design projects for the tropical climate, given that the climatic conditions are far from those existing in other latitudes, where cool breezes are not enjoyed at dusk, high levels of solar radiation, and where it probably does not rain on average ten months a year, as usually happens in our tropical context.
8. Reinforce the values and customs of tropical latitudes, strengthening the joyful culture, the way of life mostly in the open air, as well as the color of its context.
9. Promote the sowing of medium and small-scale crops, as well as maintaining the green within the city, which contributes to improving air quality, increases flora and fauna, and reduces environmental pollution.
10. Carry out a stricter and more regular control over the CO<sub>2</sub> emissions that are emitted in the different locations of the study area, with the aim of facing air pollution, offsetting it with green and lush vegetation characteristic of the tropical climate, than in the medium term would help reduce the effects of air pollution.

11. Use clear glass in openings with sunscreens, which constitutes a low-cost solution, which, if protected from rain and solar radiation, represents an effective design strategy to maintain comfortable conditions inside the buildings.
12. Use solar control glass in projects where the scale, magnitude or internal function of the project requires it, specifically reflective glass that contributes to reducing internal glare as a result of the high solar radiation typical of tropical areas.
13. Due to the characteristics of the tropical climate, plan for a high-rise, wide and open spaces that guarantee the feeling of openness, freedom that contributes to reinforcing the softness of enjoying a benevolent climate throughout the year.
14. Search for architectural solutions that keep the spaces open but in the shade, that allow visual exchange between the interior and exterior of the spaces.
15. The search for protection of natural habitats, of tropical ecosystems is essential in the training of new professionals who emerge in the work of building Costa Rica of the new millennium, who must be clear about the consequences it brings for well-being or to the detriment of the Planet, the processes and management of the new constructive processes and therefore on the development of the built environment within a natural context, which must be preserved for future generations.

## Conclusions and recommendations

1. The architectural design of buildings located in the tropical climate is a product of the response to the local climate.
2. The design proposal must holistically consider all the parts that comprise it, from the built environment to the natural environment, as well as all those factors or elements that affect the well-being of the users.
3. Temperature and humidity are the main variables that affect thermal comfort in buildings located in the tropical climate of Costa Rica.
4. The urban spaces of tropical cities must be designed focused on the enjoyment of outdoor life, the beautiful landscape and a green and interesting tour of squares and parks within the city.
5. Since sustainability focuses on achieving well-being for the majority of the population, tropical cities must guarantee quality of life for users, surrounded by squares and parks that allow interaction between the inhabitants.
6. Air quality in the tropics is especially important, since it is a variable, which provides great advantages to achieve internal comfort in buildings.
7. The generation of services, the control of the growth of cities as well as their extension, are some other factors that intervene in the sustainability of cities.
8. Bioclimatic architecture has as its primary objective of studying while researching for constructive solutions that guarantee basic conditions of comfort and habitability according to the local climate, promoting the minimum environmental impact and generating a decrease in energy consumption compared to traditional buildings.
9. The most responsible way to specify the construction materials of a building is to know the provenance, extraction methods and manufacturing or processing of them until they are put on site, which implies quantifying the total accumulated energy and therefore, the impacts on the environment in a local and global way.

10. The government of Costa Rica has evaluated the importance of being a competitive, efficient country in a globalized economic context without overlooking the link to sustainability of the environment in which it lives.
11. Costa Rica in particular, exist a lack in the legislative framework, which requires prevention in the management of natural resources during construction processes, coupled with the lack of collective interest, information, leadership, among other things, to make it happen.
12. The use of renewable energies is still in Costa Rica, a very expensive technology and therefore not very accessible for the majority of Costa Ricans.
13. Design elements such as perforated facades, green roofs, the use of piles, the height and orientation of buildings are design tools that have been traditionally used in this type of climate, to decrease the contribution of heat to buildings, where the North-South orientation, to prevent sun exposure towards the most extensive facades, have proven to be the most convenient.
14. The high humidity of the tropical climate makes ventilation one of the most widely used techniques to achieve thermal well-being in the internal space of buildings.
15. The strengthening of state universities in environmental education is recommended in order to strengthen and update the educational plans and programs in force to date, with the aim of training more and better professionals with greater environmental awareness.
16. The College of Architects and Engineers of Costa Rica, in accordance with an inter-institutional commission should encourage and coordinate the actions to be carried out on sustainability in the construction processes carried out in the country.
17. It is important to give continuity and strengthen the efforts made to date by some Costa Rican professionals, who seek to “tropicalize” the well-known environmental impact assessment systems used internationally with the aim of adapting their regulations and guidelines for architectural design. in a more real way to the tropical context of our country.
18. Finally, it is concluded that sustainability as an integral part of construction process, must be concerned with the conservation and protection of the landscape and the immediate context of the building.

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