

Evaluation of the thermal behavior of a prefabricated triangular-structure ecotourism module

Evaluación del comportamiento térmico en un módulo ecoturístico prefabricado de estructura triangular

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ABSTRACT

Ecotourism housing solutions face limitations in thermal comfort and energy efficiency due to the use of industrial materials and the lack of passive systems, which generates daytime overheating and nighttime heat loss. In view of this issue, the objective of the research was to evaluate the thermal efficiency of a prefabricated triangular-structure ecotourism module, that integrates a foldable system and reed-based biopanel bonded with prickly pear cactus mucilage. A descriptive methodology design was applied to evaluate a full-scale material test specimen exposed to outdoor conditions in Huánuco during two seasonal periods (dry and wet). Through direct quantitative observation, indoor and outdoor temperatures were recorded during periods of maximum solar radiation (10:00 a.m.) and cooling (4:00 p.m.). The results evidenced high thermal stability; in dry season, the indoor temperature variation was 9.2 °C, faced to 12.5 °C outdoors, and in wet season was only 3.5 °C, despite an outdoor fluctuation of 10.3 °C, maintaining a temperature between 7 and 15 °C higher than the outside temperature during critical hours. It is concluded that this comprehensive bioclimatic design constitutes a highly efficient passive climate control system that reduces dependence on artificial systems and ensures sustainability in natural environments.

Keywords: ecotourism module; sustainable architecture; prefabrication; thermal insulation; solar control; solar energy; bioclimatics.

RESUMEN

Las soluciones de vivienda ecoturística enfrentan limitaciones en el confort térmico y la eficiencia energética debido al uso de materiales industriales y a la falta de sistemas pasivos, lo que genera sobrecalentamiento diurno y pérdida de calor nocturna. Ante esta problemática, el objetivo de la investigación fue evaluar la eficiencia térmica de un módulo ecoturístico prefabricado de estructura triangular, que integra un sistema rebatible y biopaneles de carrizo aglutinados con mucílago de tuna. Se aplicó una metodología de diseño descriptivo para evaluar un espécimen de ensayo de materiales a escala real, expuesto a la intemperie en Huánuco durante dos periodos estacionales (seco y húmedo). Mediante observación cuantitativa directa, se registraron las temperaturas interiores y exteriores en los momentos de máxima radiación (10:00 a. m.) y de enfriamiento (4:00 p. m.). Los resultados evidenciaron una alta estabilidad térmica; en clima seco, la variación interna fue de 9.2 °C, frente a los 12.5 °C del exterior, y en clima húmedo fue de apenas 3.5 °C ante una fluctuación externa de 10.3 °C, reteniendo entre 7 y 15 °C por encima del exterior en horas críticas. Se concluye que este diseño bioclimático integral constituye un sistema de climatización pasiva altamente eficiente, que reduce la dependencia de sistemas artificiales y garantiza la sostenibilidad en entornos naturales.

Palabras clave: módulo ecoturístico; arquitectura sostenible; prefabricación; aislamiento térmico; control solar; energía solar; bioclimática.

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Introduction

In the field of ecotourism, architecture faces the challenge of integrating into the natural landscape and minimizing its ecological footprint. However, the current problematic situation shows that existing ecotourism housing solutions present serious limitations in terms of thermal comfort and energy efficiency. These deficiencies are mainly due to the use of industrial materials with low insulating performance and the absence of passive systems adaptable to local climatic conditions. As a consequence, buildings experience overheating during the day and heat loss at night, which increases dependence on artificial climate control systems and negatively affects environmental sustainability (Honey, 2008). To address this problem, bioclimatic architecture is presented as a key general concept, since it seeks to make optimal use of environmental conditions, such as solar radiation, natural ventilation, and orientation, to reduce energy consumption (Givoni, 1998; Olgyay, 2015). Likewise, the use of modular prefabrication is fundamental, a technique that reduces construction waste and construction times, which is particularly convenient in natural environments (Smith, 2010).

Previous studies have evidenced the existence of structures and transformable modules for similar purposes. There are precedents such as the Pempén module, developed for the Peruvian jungle (Hiromoto, 2016), and international models such as the “Camping House in Consonance with Oil and Gas Development,” aimed at mobile housing in desert areas. However, when analyzing these proposals, a research gap or void is identified: these solutions do not include a retractable thermal membrane system capable of dynamically regulating the entry of light and heat through vernacular materials. This deficiency limits their efficiency under conditions of high thermal variability. Therefore, there is a need to overcome these limitations through a sustainable and low-cost architectural proposal. To this end, it is based on the use of the truncated pyramidal form, recognizing that the triangle constitutes the elementary structural system that is non-deformable under external loads (Gere & Timoshenko, 1997), and is the figure in which a structure achieves true stability (Torroja, 1957; González Meza, 2016). The feasibility of proposing a module of this type, temporary and movable, has been conceptually supported for use in natural environments (World Intellectual Property Organization [WIPO], 2024).

Based on the foregoing, the objective of this research is to evaluate the thermal behavior of a prefabricated ecotourism module, based on a triangular structure composed of wood and metal elements, which incorporates a retractable system and biopanel made of carrizo and prickly pear mucilage. Accordingly, the aim is to optimize interior thermal insulation, regulate incident solar radiation, and reduce environmental impact, ensuring adequate integration of the dwelling into the natural environment.

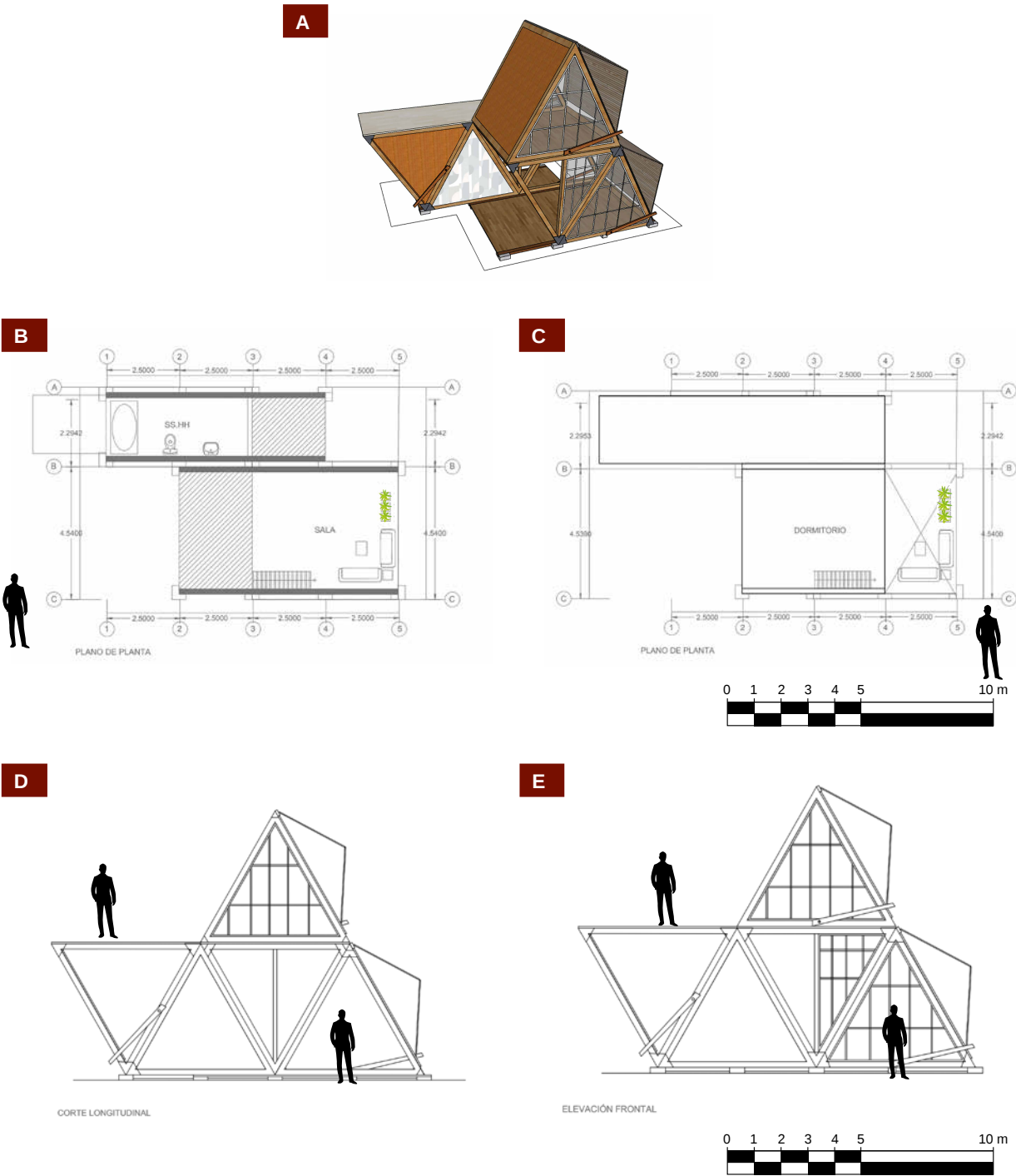
Materials and methods

Prefabricated ecotourism module with triangular structure

The present research was developed with a quantitative approach and a descriptive design, aimed at evaluating the thermal behavior of a prototype made with natural biomaterials, exposed to real environmental conditions. The temperature of the passive thermal system consisting of biopanel made of carrizo and prickly pear mucilage was measured, as well as the thermal behavior of the experimental prototype.

The ecotourism module corresponded to a prefabricated structure with a triangular configuration and truncated pyramidal shape, composed of wooden elements, metal joints, and retractable panels intended to control solar radiation and provide natural ventilation. For its development, a 20 cm × 20 cm airtight cubic prototype was constructed for thermal testing. Natural materials such as carrizo, plywood, and prickly pear mucilage were used to develop the thermal insulation system. The construction process began with the extraction and preparation of the prickly pear mucilage, which was mixed with water, glycerin, and gelatin until an adhesive biogel was obtained. Subsequently, the carrizo stems were cut and adhered to plywood sheets to form the biopanel. Finally, the panels were assembled to form the experimental prototype (see more details in Figure 1).

Figure 1
General views of the triangular-structure module: (A) perspective or detail view of the module, (B) first-floor plan view, (C) second-floor plan view, (D) longitudinal section view, and (E) front elevation view.



It should be noted that the module has been validated by WIPO (2024). In this regard, it is described that the present invention refers to a modular triangular structure comprising a plurality of triangular support elements, with intermediate connections, a base to keep the structure above the ground and protect it from moisture, as well as a thermal membrane to provide insulation. Likewise, it is conceived as a temporary, prefabricated, and assemblable camping module, whose assembly and disassembly require approximately seven days, allowing it to be transported between different natural environments. The architectural design of the module is versatile,

as it can be arranged in different ways according to the needs of users and its occupancy capacity. This is related to the concept of flexible architecture, understood as mobile, foldable, and deployable structures that allow adaptation to climatic, use, and mobility changes, according to Kronenburg (2007).

The sample consisted of a 20 cm × 20 cm cubic prototype. From the perspective of materials testing, this size is justified as a real-scale specimen or test specimen that reproduces the exact stratigraphy of the construction assembly, consisting of plywood panels, a uniformly cut carrizo covering, and an ecological binder based on prickly pear mucilage. This experimental design at scale made it possible to verify the insulating capacity of the assembly before its application in the macroecotourism module. Preparation of the specimen began with the extraction of prickly pear mucilage, which was mixed with water and ground. In parallel, a solution of water, glycerin, and gelatin was heated until a viscous and homogeneous gel was obtained, which was subsequently combined with the extracted mucilage. This biogel was applied to the surface of the plywood sheets to fix the carrizo strips together, which required a drying period of four to five hours in a cold environment. Finally, the dry panels were assembled using an ecological adhesive and minimal mechanical fastening, ensuring an airtight assembly suitable for thermal analysis.

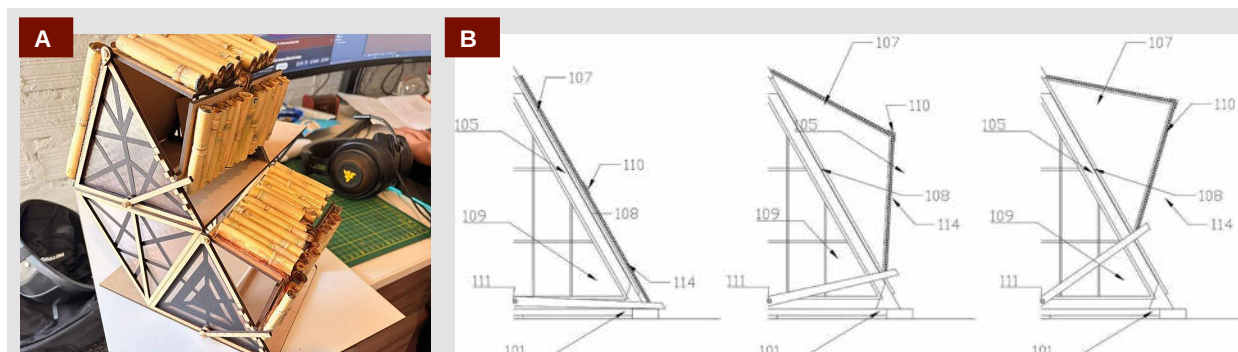
Technical advantage of the module: thermal window

Taking thermal window systems as a reference, defined as glazing solutions designed to reduce heat losses and gains through the use of double or triple glazing, it was proposed to incorporate three layers: at the ends, cane and plywood; and, on the inside, instead of the conventional air cavity, prickly pear mucilage as an insulating material. This proposal is consistent with what Neila González (2004) and Givoni (1994) state, indicating that thermal windows are transparent enclosures whose double- or triple-glazing system, with intermediate cavities and insulating frames, significantly reduces heat flow between the interior and exterior, improving the energy efficiency of the building.

The construction of the physical model made it possible to verify the volumetric, structural, and mechanical operation of the retractable system. Through scaled materials, the modulation, inclination of the planes, and opening sequence of the thermal window were reproduced, validating the performance of the hinges and side panels, as well as the stability of the assembled module. Thus, the triangular design falls within the framework of bioclimatic architecture and stands out for its efficiency in ecotourism environments, owing to its low environmental impact, its capacity to adapt to the climate, the responsible use of natural materials, and the incorporation of a retractable system that improves interior thermal comfort. In this context, bioclimatic architecture is understood as a design system based on the regulation of heat exchanges through façades, windows, materials, shading, and radiation control (Neila González, 2004; Givoni, 1994). Likewise, specialized literature demonstrates that modular and retractable systems allow active management of ventilation, solar radiation, and interior thermal comfort according to environmental conditions (Kronenburg, 2007).

Figure 2

(A) Scale model. (B) Details of the retractable element



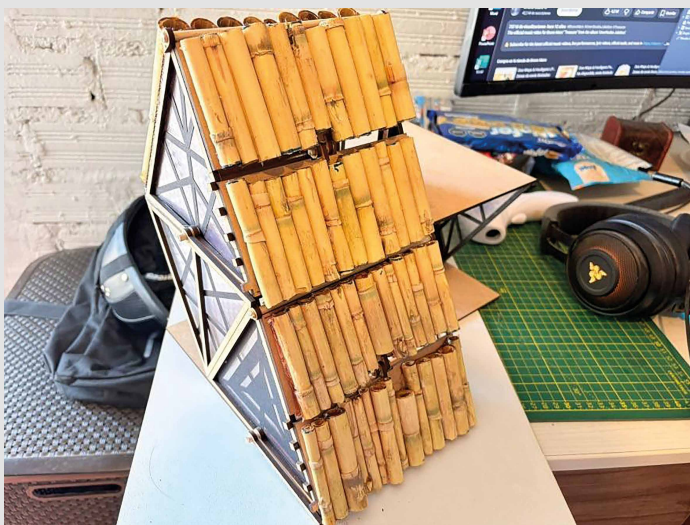
Elements of the retractable system

Carrizo

Carrizo was used as the enclosure of the retractable structure. At the same time, its hollow interior contributed to thermal insulation, given that *Arundo donax* is a perennial grass with tall, hollow, and segmented stems that produces large amounts of biomass and is widely used in lightweight construction due to its rapid growth and low thermal conductivity (Lewandowski et al., 2003). Due to its structural characteristics, carrizo was efficiently coupled to the retractable system. Its lignocellulosic structure provides a notable strength-to-weight ratio and flexibility, making it suitable for lightweight construction systems such as quinchá, latticework, and cladding, as well as for pressed panels and contemporary biocomposites, provided that it is treated against moisture and degradation to ensure durability. Finally, the use of carrizo contributed favorably to environmental aspects, given that materials of natural origin—such as carrizo, bamboo, and plant fibers—reduce environmental impact, improve thermal insulation, and constitute a sustainable alternative to conventional industrial materials (Pérez et al., 2011; Lewandowski et al., 2003). Finally, Pérez et al. (2011) indicate that energy demand is reduced and the microclimate is improved through shading and evapotranspiration.

Figure 3

Arrangement of the carrizo in the scale model



Adhesive and biopanel based on prickly pear mucilage

The biopanel manufacturing process consists of extracting the prickly pear mucilage, grinding it, and boiling it until a viscous mixture is obtained, which is applied to wooden sheets to fix horizontally aligned carrizo. After twenty-four hours of drying, a rigid, insulating, and biodegradable panel is obtained, avoiding the impacts of synthetic adhesives. This biomaterial, compatible with plant fibers, promotes biofabrication and the circular economy and allows the manufacture of boards, cladding, and lightweight components for passive insulation systems. In experimental tests with a 20 × 20 cm cube and square panels, the biopanel demonstrated greater thermal stability than the outdoor environment, evidencing its capacity to dampen climatic variations and provide protection against moisture and wear.

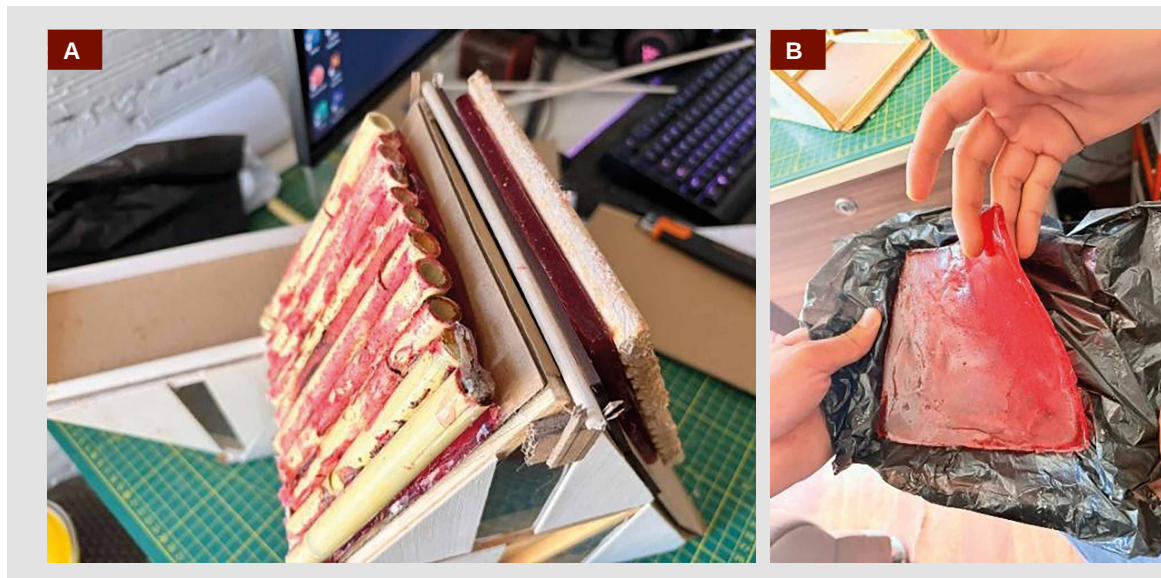
The central section of the biopanel consists of a gelatinous layer based on starch and prickly pear mucilage (*Opuntia ficus-indica*), specifically designed to optimize adhesion between cane and plywood. In this regard, Cobana and Antezana (2007) indicate that starch is composed of two structurally distinct polymers: amylose and amylopectin. A higher concentration of the latter substantially increases the adhesive capacity of the

carbohydrate, a biodegradable binding and stabilizing property that is suitable for the cohesion of the panel components. This action is complemented by the properties of prickly pear mucilage, which, as mentioned by Feugang et al. (2006), is a biopolymer extracted directly from the cladodes of the prickly pear cactus that constitutes a complex matrix of hydrophilic polysaccharides. Its molecular structure not only gives it a high moisture-retention capacity but also allows it to act as an excellent natural binder and adhesive agent.

Thanks to the synergistic properties of these natural binders, the biopanel acquires the structural solidity necessary to be integrated into the retractable ecotourism module. In this application, the panel fulfills the bioclimatic function of regulating solar radiation without resorting to artificial climate control systems, offering a sustainable, economical, and replicable solution for local communities. Thus, the use of mucilage and starch consolidates these elements as high-performance natural resources, strengthening the integration of sustainability, economic accessibility, and thermal efficiency in architecture projects oriented toward ecotourism.

Figure 4

(A) Arrangement of the mucilage in the scale model. (B) Mucilage sample



Research design

The present research adopted a non-experimental design at a descriptive level, structured as an exploratory technological case study. Since the main objective focused on the technical evaluation and characterization of the prototype in a specific scenario, the data analysis was oriented toward reporting point measurements and single values of the physical variables, dispensing with inferential statistical analyses. For methodological purposes, the components of analysis were defined as the passive thermal system (composed of the carrizo biopanel and the natural prickly pear mucilage binder) and the interior thermal behavior of the module. The study was conducted under outdoor exposure conditions, subjecting the prototype to direct solar radiation and real thermal fluctuations of the local environment, which made it possible to evaluate the response and efficiency of the material under real climatic conditions.

For the collection of empirical data, the technique of direct quantitative observation was used. The main measurement instrument was a precision infrared digital thermometer, used to simultaneously record surface and ambient temperatures, expressed in degrees Celsius. Likewise, as documentary support and to ensure traceability and rigor in field data collection, a detailed photographic record was implemented, accurately recording the date and time of each point evaluation.

Procedure

The empirical procedure consisted of exposing the prototype to real outdoor conditions in the city of Huánuco during two climatic periods representative of four consecutive days each: the dry period (June 3 to 6, 2025) and the wet period (November 20 to 23, 2025). Data collection was carried out through direct quantitative observation using an infrared digital thermometer, and the interior and exterior temperatures of the prototype were simultaneously recorded in degrees Celsius. Measurements were taken daily at two critical times: at 10:00 a.m., corresponding to the period of highest direct solar radiation, and at 4:00 p.m., characterized by a decrease in ambient temperature. In total, sixteen synchronous records were consolidated, supported by a photographic record to ensure measurement traceability. The data obtained were tabulated for descriptive analysis, and thermal variations were calculated as the difference between the temperatures recorded at both measurement times.

Data analysis

The quantitative data obtained from the thermal measurements were systematically tabulated for subsequent processing. Basic descriptive statistics were used, calculating the temperature difference as the difference between the exterior and interior temperatures of the prototype at each measurement time. These statistical criteria, together with the calculation of the daily thermal variation observed in the mornings and afternoons of both periods, made it possible to quantify the material's damping capacity and thermal stability.

Results

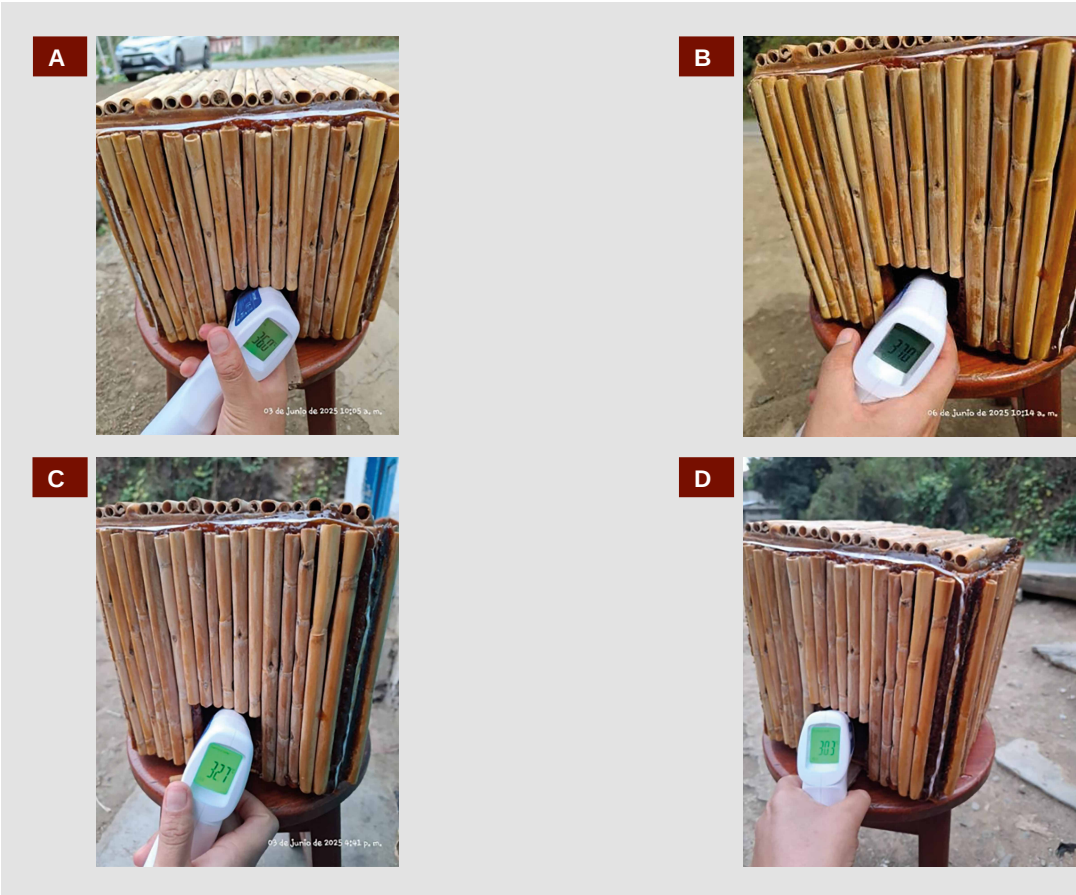
The evaluation of the prototype's thermal behavior revealed significant differences between the interior space and the outdoor environment in both climatic periods analyzed, demonstrating the insulating capacity of the system composed of carrizo biopanel and prickly pear mucilage. The records obtained during the dry period (Table 1) show that, during the time of highest solar incidence (10:00 a.m.), the interior temperatures remained within a higher and more stable range, from 36 to 37 °C, compared with the exterior temperatures, from 32 to 33 °C. In contrast, during the afternoon thermal decline (4:00 p.m.), the outdoor ambient temperature decreased markedly to values between 19.5 and 20.5 °C, while the interior space of the prototype experienced more gradual cooling, with temperatures ranging from 32.7 to 30.4 °C. This dynamic demonstrates that the prototype mitigates the impact of abrupt environmental fluctuations during the dry season.

Table 1
Thermal records for the dry period (June 2025)

Date	Time	Exterior temperature (°C)	Interior temperature (°C)	Temperature difference
June 3	10:00 a. m.	32°	36°	4°
	4:00 p. m.	19.5°	32.7°	13.2°
June 4	10:00 a. m.	33°	36.2°	3.2°
	4:00 p. m.	19.9°	27.8°	7.9°
June 5	10:00 a. m.	32.3°	36.9°	4.6°
	4:00 p. m.	20.5°	30.4°	9.9°
6 de June 6	10:00 a. m.	32°	37°	5°
	4:00 p. m.	20.4°	30.3°	9.9°

For the wet period (Table 2), morning monitoring (10:00 a.m.) showed interior temperatures fluctuating between 33.4 and 34.8 °C, compared with a lower exterior range of 28 to 29.2 °C. In the afternoon (4:00 p.m.), while the outdoor environment recorded a notable decrease, reaching minimum values of 18.9 to 19.6 °C, the interior of the specimen maintained high thermal stability, with values ranging from 31.3 to 34.7 °C. These data confirm that the configuration of the construction assembly provides greater thermal inertia and damping under high-humidity conditions.

Figure 5
Times and dates of the internal temperature tests. (A) June 3, 2025 / 10:05 a.m. (B) June 6, 2025 / 10:14 a.m. (C) June 3, 2025 / 4:41 p.m. (D) June 6, 2025 / 5:01 p.m.



Comparative analysis of thermal oscillation

The analysis of the net thermal variations between the two control times reveals differential insulating behavior of the biopanel according to seasonality. During the dry period, the thermal oscillation of the outdoor environment reached 12.5 °C, while inside the prototype it was reduced to 9.2 °C. This damping phenomenon was even more evident during the wet period, where the exterior fluctuation of 10.3 °C was drastically reduced to only 3.5 °C inside. In summary, the interseasonal comparison demonstrates that the experimental prototype effectively dampens thermal oscillations in the real environment during both periods of the year, achieving its highest performance and interior thermal stability during the wet period.

Table 2
Thermal records for the wet period (November 2025)

Date	Time	Exterior temperature (°C)	Interior temperature (°C)	Temperature difference
November 20	10:00 a. m.	28°	33.4°	5.4°
	4:00 p. m.	18.9°	34.7°	15.8°
November 21	10:00 a. m.	29.2°	34.8°	5.6°
	4:00 p. m.	19.6°	32.8°	13.2°
November 22	10:00 a. m.	28.9°	33.7°	4.8°
	4:00 p. m.	19.2°	34.4°	15.2°
November 23	10:00 a. m.	29°19.4°	34.5°	5.5°
	4:00 p m.		31.3°	11.9°

Figure 6

Results of the tests conducted during different evaluation periods. (A) Test conducted on November 20, 2025 (10:37 a.m.). (B) Test conducted on November 23, 2025 (10:28 a.m.). (C) Test conducted on November 20, 2025 (4:10 p.m.). (D) Test conducted on November 23, 2025 (4:19 p.m.)

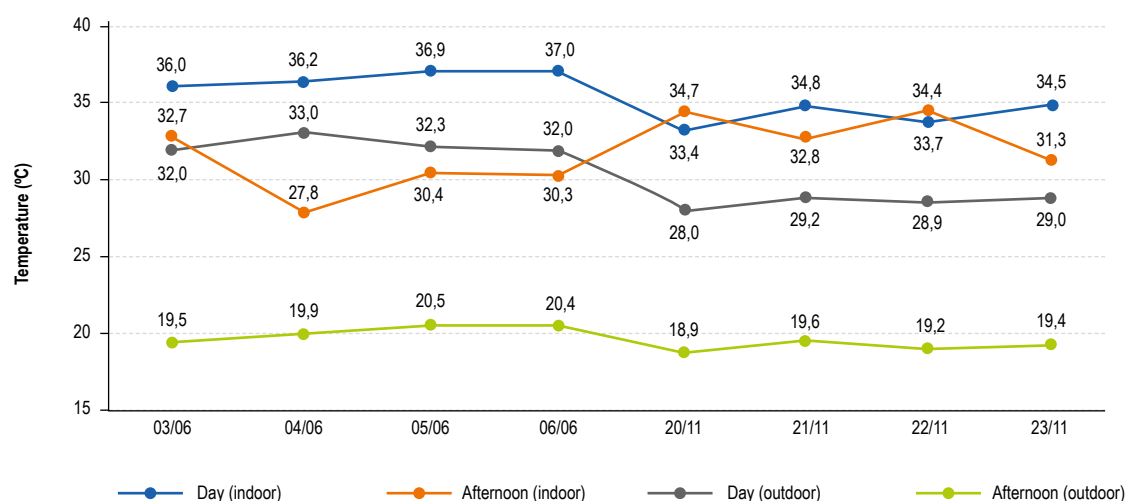


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During the dry period, morning monitoring (10:00 a.m.) showed that the interior temperatures of the experimental prototype fluctuated between 28 and 35 °C, compared with an average outdoor ambient temperature of 34 °C, marking the initial seasonal thermal differences. However, the most notable behavior was recorded in the afternoon (4:00 p.m.), when the exterior temperature dropped sharply to values close to 18 °C, while the interior of the cube retained heat between 31.3 and 34.7 °C, demonstrating the capacity of the construction assembly to slow energy loss and act as a thermal buffer. This interior thermal stabilization effect was analytically confirmed by evaluating the net variations between both control times, where the exterior fluctuation in June (dry period) reached 12.5 °C, compared with an interior variation of only 9.2 °C, a damping phenomenon that was even more pronounced in November (wet period), where the exterior oscillation of 10.3 °C was reduced to an interior variation of only 3.5 °C. These figures consolidate the material's performance by ensuring high internal thermal inertia, particularly during critical hours of environmental cooling.

Figure 7

Comparison of the interior and exterior temperatures recorded during the dry and wet periods



Discussion

The results obtained in the two measurement stages—June (dry climate) and November (wet climate)—show significantly more stable thermal behavior in the prototype than in the outdoor environment. This stability confirms the effectiveness of the system composed of carrizo, prickly pear mucilage, and a retractable membrane as a passive strategy. When comparing these findings with similar studies, the behavior of the prototype is consistent with that reported by Pérez et al. (2011) and Lewandowski et al. (2003), who demonstrate that the use of plant fibers and natural passive systems reduces energy demand and improves thermal insulation compared with conventional industrial materials. Likewise, the comfort achieved is structurally consistent with the principles of bioclimatic architecture described by Givoni (1998) and Olgyay (2015).

When analyzing the specific data, it can be observed that during the hours of highest radiation (10:00 a.m.), the interior reaches temperatures slightly higher than those outdoors, with differences of 3 to 5.6 °C. This controlled thermal gain phenomenon is due to the physical structure of carrizo (*Arundo donax*). As indicated by Lewandowski et al. (2003), this grass has hollow stems that generate continuous air chambers with low thermal conductivity. This gives it low thermal conductivity, allowing it to accumulate heat moderately without causing abrupt overheating of the interior. On the other hand, the most critical and important behavior is observed during the cooling hours (4:00 p.m.). While the exterior temperature drops drastically to 18–20 °C, the interior of the module remains between 27 and 34 °C, reducing thermal loss by 7–15 °C. Why does this level of thermal retention occur? The answer lies in the use of the prickly pear-based biopanel. As Feugang et al. (2006) and Cobana and Antezana (2007) point out, mucilage and amylopectin act as stabilizers with a strong binding capacity. In the construction system evaluated, this biomaterial acts as an organic sealant that fills the microspaces between the plywood and carrizo, preventing the infiltration of cold outdoor air and efficiently retaining the heat captured during the morning.

Finally, the stability demonstrated by the data validates the operational relevance of the retractable system. The fact that the interior temperature is maintained during the afternoons demonstrates that the membrane acts as an effective insulating barrier when closed. This result is consistent with the approach proposed by Kronenburg (2007), who maintains that modular and retractable systems allow radiation and ventilation to be actively managed according to environmental conditions. In summary, the proposed module meets the efficiency parameters of thermal enclosures (Neila González, 2004), empirically demonstrating that the combination of triangular design and vernacular materials generates a stable and self-sufficient interior microclimate.

Despite the positive results regarding the module's thermal stability, the research presents methodological and technical limitations that should be specified in future replications. First, the collection of empirical data was limited to a descriptive design based on an exploratory technological case study, which entailed dispensing with more complex inferential statistical analyses or computational predictive fluid dynamics (CFD) modeling. Likewise, the evaluated sample consisted of an experimental cubic prototype, at a reduced scale of 20 × 20 cm, temporarily exposed to outdoor conditions. Although this prototype rigorously reproduced the stratigraphy of the construction assembly of carrizo and prickly pear mucilage, it does not reflect the actual spatial dynamics of ventilation and occupancy or the internal thermal loads inherent to a complete macroecotourism habitable module. Finally, the field monitoring procedure was limited to specific climatic periods of four consecutive days in each season (dry and wet) in the city of Huánuco, restricting the readings to two critical times per day. Therefore, continuous twenty-four-hour thermal behavior, as well as the degradation, durability, and biological vulnerability of organic binders in the long term, were not evaluated.

Conclusion

The research demonstrates that the prefabricated ecotourism module, with its retractable triangular structure, is a technical and sustainable solution that ensures non-deformable stability and lightness for rapid assembly in natural environments. It was confirmed that the comprehensive bioclimatic design (orientation, ventilation, and separation from the ground) enables passive thermal comfort without artificial climate control, supported by a retractable thermal membrane arranged over a retractable system supported by the triangular frame of the structure, which regulates radiation and retains heat. The results validated the high efficiency of the carrizo and prickly pear mucilage biopanel, highlighting that in June the interior thermal variation was only 9.2 °C, compared with 12.5 °C outdoors, while in November stability was even greater, with only a 3.5 °C interior change in response to an external fluctuation of 10.3 °C. The system maintained the interior between 27 and 35 °C when the exterior dropped to 18–20 °C, achieving constant differences of between 7 and 15 °C above the outdoor environment during critical hours, owing to the low conductivity of carrizo and the organic sealing provided by the mucilage.

The importance of this study lies in the functional synergy of its components: carrizo, as a tubular insulator; mucilage, as a sealant against infiltration; and the retractable window, as a dynamic regulator, significantly reducing the energy footprint. The implications of these findings suggest that the integration of biofabrication and bioclimatic architecture can transform tourism infrastructure into self-sufficient and culturally adapted microclimates. As a recommendation, given that the results correspond to a preliminary validation at an experimental scale, it is imperative to conduct additional studies in full-scale habitable modules. It is suggested that priority be given to evaluating the long-term durability of biomaterials, a detailed analysis of implementation costs, and a critical examination of their social and economic replicability, which would pave the way for an effective transition toward sustainable construction solutions.

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Author contributions

PRRV: investigador principal, supervisión general del proyecto, conceptualización y desarrollo del estudio.
 JSHZ: coinvestigador, redacción de resultados y discusión.
 ECG: redacción de resultados.
 JAPSM: redacción de resultados.
 LDAO: coinvestigador conceptualización y desarrollo del estudio.
 HRZV: metodología y estadística del estudio.

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