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SYSTEMATIC REVIEW OF THE THERMAL PERFORMANCE OF SOLAR CAPTURE STRATEGIES IN HIGH ANDEAN DWELLINGS

REVISIÓN SISTEMÁTICA DEL DESEMPEÑO TÉRMICO DE ESTRATEGIAS DE CAPTACIÓN SOLAR EN VIVIENDAS ALTOANDINAS

REVISÃO SISTEMÁTICA DO DESEMPENHO TÉRMICO DE ESTRATÉGIAS DE CAPTAÇÃO SOLAR EM HABITAÇÕES DA REGIÃO ALTOANDINA

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ABSTRACT

High-Andean dwellings in Peru, located between 3,000 and 5,000 meters above sea level, face critical thermal comfort conditions due to winter temperatures ranging from –3 °C to –20 °C and limited construction capacity to retain heat. Although there are studies on passive systems, there is no systematic comparison that evaluates the efficiency of these strategies, considering the region's typical thermal and environmental conditions. This study addresses this gap by using the PRISMA methodology to identify and compare passive solar gain strategies aimed at improving thermal comfort, based on 15 investigations published between 2013 and 2024. The results show that semidirect strategies, such as Trombe walls and attached greenhouses, achieve the highest temperature increases, while direct gain and storage systems contribute to indoor thermal stability. Together, these systems establish a technical basis for the bioclimatic design of high Andean dwellings adapted to cold climates.

Keywords
solar capture, passive solar heating, thermal comfort, solar architecture

RESUMEN

Las viviendas altoandinas del Perú ubicadas entre los 3,000 a 5,000 m.s.n.m., enfrentan condiciones críticas de confort térmico por temperaturas invernales de –3 °C a –20 °C y limitada capacidad constructiva para conservar el calor. Aunque existen investigaciones sobre sistemas pasivos, no se cuenta con una comparación sistemática que evalúe la eficiencia de las estrategias según las condiciones térmicas y ambientales características de la región. Ante este vacío, el presente estudio aplica la metodología PRISMA para identificar y comparar estrategias pasivas de captación solar orientadas a mejorar el confort térmico, a partir de 15 investigaciones publicadas entre los años 2013 y 2024, cuyos resultados muestran que las estrategias semidirectas, como muros Trombe e invernaderos adosados, alcanzan los mayores incrementos térmicos, mientras que las de captación directa y almacenamiento complementan la estabilidad interior. En conjunto, estos sistemas establecen una base técnica para el diseño bioclimático de viviendas altoandinas adaptadas a climas fríos.

Palabras clave
captación solar, calentamiento solar pasivo, confort térmico, arquitectura solar

RESUMO

As residências nas altas montanhas do Peru, localizadas entre 3.000 e 5.000 metros acima do nível do mar, enfrentam condições críticas de conforto térmico devido às temperaturas invernais de –3 °C a –20 °C e à capacidade limitada das construções para conservar o calor. Embora existam pesquisas sobre sistemas passivos, não há uma comparação sistemática que avalie a eficiência das estratégias de acordo com as condições térmicas e ambientais características da região. Diante dessa lacuna, o presente estudo aplica a metodologia PRISMA para identificar e comparar estratégias passivas de captação solar destinadas a melhorar o conforto térmico, a partir de 15 investigações publicadas entre os anos de 2013 e 2024, cujos resultados mostram que as estratégias semidiretas, como paredes Trombe e estufas anexas, alcançam os maiores aumentos térmicos, enquanto as de captação direta e armazenamento complementam a estabilidade interior. Em conjunto, estes sistemas estabelecem uma base técnica para o projeto bioclimático de habitações andinas adaptadas a climas frios.

Palavras-chave
captação solar, aquecimento solar passivo, conforto térmico, arquitetura solar

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INTRODUCTION

The high Andean regions of Peru, located between 3,000 and 5,000 m.a.s.l., present extreme climatic conditions characterized by low temperatures, marked thermal oscillations, and frequent episodes of frost (National Meteorology and Hydrology Service of Peru [SENAMHI], 2020). During the winter, the temperature can drop to -20 °C, creating indoor nighttime conditions close to or even below 0 °C, which has a profound impact on the health, well-being, and quality of life of the rural population, especially that of children and older people. This problem is intensified by energy poverty, limited access to efficient technologies, and the precariousness of traditional building systems, which use materials with low thermal inertia and little use of solar radiation, resulting in homes with poor living conditions (Wieser et al., 2021).

Faced with this problem, passive solar collection strategies have emerged as a technically viable and economically accessible solution to improve thermal conditions in high Andean dwellings. In this context, some studies have addressed the issue through scientific literature reviews. Cerrón Contreras (2022) reviewed articles on passive heating systems applied to high-Andean homes, concluding that the most efficient strategies increased indoor temperature by ΔT = 9.5 K, with peak values of ΔT = 22 K relative to outdoor conditions near -7 °C. Complementarily, Molina Fuentes et al. (2020) conducted a systematic evaluation of the thermal performance of an experimental module of high-Andean housing in San Francisco de Raymina, Ayacucho (3,700 m.a.s.l.). The study considered twelve configurations that incorporated passive architectural techniques (insulated floors, double doors, double-glazed windows), active solar systems (radiant wall and radiant tube), and internal loads (gas stoves and staying overnight). The results reported increases in ΔT of 9.5 K and peaks of up to 16.6 K during the critical early morning hours, relative to outdoor temperatures of -7.1 °C.

Despite the advances described, the methodological limitations identified in previous studies underscore the need for a systematic comparison that allows identifying the passive strategies that are more efficient, depending on the system type and the specific local conditions of the high Andean regions. Thus, understanding how building materials, solar radiation, and climate influence the thermal behavior of homes is key to evaluating the potential and limitations of each strategy using rigorous methodological quality criteria and structured typological classifications.

In this framework, this study aims to comparatively analyze through a systematic review of scientific literature published between 2013 and 2024, the thermal performance of different passive solar collection strategies in high-Andean dwellings. These are classified into three groups: direct capture, semi-direct capture, and conservation and storage. The purpose is to identify which measures are more effective for improving indoor temperature and thermal comfort, rather than to generate technical guidelines to support public policies and state programs aimed at promoting thermally adequate social housing in high-Andean areas.

METHODOLOGY

This research was carried out in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, which are recognized for their methodological usefulness in systematic reviews by ensuring the transparency and

Table 1. Study selection criteria. Source: Prepared by the authors.

Criterion	Inclusion	Exclusion
Language	Spanish or English	Other languages
Access	Open access (full text available)	Without full access
Year of publication	Between (2013-2024)	Before 2013
Type of study	Original studies, systematic reviews, research articles	Editorials, letters to the editor, Theses, and Books.
Subject	Thermal performance and/or sustainability in homes in high Andean areas or cold climates.	Studies on hot, urban, coastal, or unrelated climates.
Strategies analyzed	Passive solar collection strategies (Trombe walls, attached greenhouses, etc.)	Active or mechanical air conditioning systems.
Data presented	Presents quantitative or qualitative results on thermal comfort, energy demand, or energy efficiency	Studies without relevant or quantifiable data - "only theoretical."

Note. These criteria guarantee the relevance and timeliness of the analyzed literature.

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Table 2. Search string used in databases. Source: Prepared by the authors.

Main term	Related terms	Boolean operator	Consultation structure
Passive strategies	"passive design", "bioclimatic strategies"	OR	"passive strategies" OR "passive design"
Thermal performance	"thermal efficiency", "thermal behavior"	OR	"thermal performance" OR "thermal efficiency"
High Andean areas	"altiplano", "cold climates", "Andean regions"	OR	"high Andean areas" OR "cold climates" OR "Andean regions"
Solar capture	"solar gain", "passive solar exploitation"	OR	"solar capture" OR "solar gain"
		AND (general combiner)	("passive strategies" AND "thermal performance" AND ("high Andean zones" OR "cold climates")

Note. The keywords were combined by using Boolean operators (AND, OR) to link the strategies.

Table 3. Search string used in databases. Source: Prepared by the authors.

Main term	Search structure	Results obtained
Passive strategies	"passive strategies" OR "passive design" OR "bioclimatic strategies"	24
Thermal performance	"thermal performance" OR "thermal efficiency" OR "thermal behavior"	18
High Andean areas	"high Andean areas" OR "cold climates" OR "altiplano" OR "Andean regions"	20
Solar capture	"solar capture" OR "solar gain" OR "passive solar harvesting"	15
	Total	77

Note. The searches were carried out between March and April 2025, applied to open-access articles since 2013.

reproducibility of the research process (Page et al., 2021). Therefore, the search was limited to open-access studies in Spanish and English published in recent years that address thermal performance and sustainability in homes in high-Andean areas or cold climates, with an emphasis on passive solar collection strategies. In this sense, the methodology is structured into four stages following the PRISMA guidelines: Eligibility criteria, information sources, evaluation studies, and synthesis of results.

STAGE 1: ELIGIBILITY CRITERIA

To ensure the quality and relevance of the studies, clear inclusion and exclusion criteria were defined (Table 1), focusing on the thermal performance and sustainability of high-Andean dwellings with passive solar collection strategies.

STAGE 2: SOURCES OF INFORMATION

Search strategy

Specialized scientific databases were used to collect the studies: Scopus for its broad, multidisciplinary coverage of scientific research, SciELO for its focus on open-access publications in Latin America, and the Google Academic search engine, between March and May 2025. To do this, search strings were developed (Table 2) using Spanish and English keywords, with Boolean operators (AND, OR) to optimize accuracy and scope.

STAGE 3: EVALUATION OF ARTICLES

Identification of studies

After defining the query structure, systematic searches were performed in the databases using combinations of key terms related to passive strategies, thermal performance, high Andean areas, and solar capture, connected by Boolean operators (Table 3).

Removal of duplicates

To guarantee accuracy in the review process, duplicate studies were removed to avoid redundancy and ensure each publication was considered only once in the analysis. This refinement was carried out using the Mendeley reference manager, which allowed the selected articles to be organized, classified, and consolidated efficiently. Of the 77 studies initially retrieved from the databases,

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Table 4. Initial screening of studies. Source: Prepared by the authors.

No.	Title of the study	Relevance	Reason for the decision
1	Systematic evaluation of the thermal performance of an experimental high Andean housing module to achieve thermal comfort with solar energy	Yes	It uses passive heating strategies and energy simulation software, such as EnergyPlus.
2	A bioclimatic approach to develop spatial zoning maps for passive comfort, heating, and cooling strategies within a composite zone of India	No	Urban context, not high Andean

Note. The selection and discarding are recorded after screening by title and abstract, ensuring transparency in the review.

Table 5. Representative studies according to inclusion and exclusion criteria. Source: Prepared by the authors.

Title (Year/Author)	Selection	Reason for exclusion or inclusion
Iruri Ramos et al. (2023) Colca Valley, Peru	Included	It analyzes passive strategies for solar capture, insulation, and airtightness in high-Andean housing, with experimental results on thermal performance and interior comfort.
Zwalnan et al. (2021).	Excluded	It evaluates active solar water-heating systems in Nigeria; the focus is on active systems, and the geographical/climatic context does not align with the Andean highlands of Peru.

Note. This table only includes two studies, selected to exemplify the review filtering process.

17 duplicates were identified and removed, leaving 60 for the next phase.

Screening by title and abstract

To ensure the transparency of the selection process, a screening table (Table 4) was prepared, listing two representative studies, and they were evaluated based on the title and abstract. This is presented below as methodological evidence of the preliminary review stage.

During the initial screening stage, 33 of the 60 preliminary studies were excluded because they focused on active systems or were conducted in non-Andean contexts. As a result, 27 potentially relevant investigations were identified for analysis of thermal performance in homes in high-Andean areas.

STAGE 4: SYNTHESIS AND RESULTS

After applying the inclusion and exclusion criteria established in Table 1, the full texts of the 27 pre-selected investigations were evaluated for their thematic and methodological relevance. At this stage, two representative studies are presented to clearly and transparently illustrate the evaluation and classification process, thereby avoiding overloading the document (Table 5).

The selection of included and excluded studies adheres to the PRISMA 2020 guidelines and the methodological recommendations proposed by Gisbert & Bonfill (2004) for systematic reviews, prioritizing the presentation of paradigmatic examples that reflect rigorous compliance with the established criteria. For example, the study by Iruri Ramos et al. (2023) was included, as it analyzes passive strategies in the Colca Valley (Arequipa), supported by quantitative data that show a 23% reduction in energy demand and a thermal increase of +5.9 °C by insulating roofs with local materials, using dynamic simulations and specific thermal transmittance values for the envelope.

Of the 27 pre-selected studies, 15 were finally selected that provide evidence on the thermal performance of passive solar collection strategies in high Andean buildings. This process is summarized in the PRISMA flowchart (Figure 1), which details the steps from initial identification to final selection. These investigations form the basis for the results and discussion section of this study.

RESULTS AND DISCUSSION

For the analysis of the results from the 15 selected investigations, the results were organized by the type of passive solar capture strategy used and synthesized into three thermal gain systems. This classification allowed

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the studies to be grouped into three comparative tables, which facilitated both the analysis of the reported thermal increases (ΔT in K), understanding that ΔT is always the temperature difference between indoor and outdoor environment, and the evaluation of the effectiveness of each system in relation to the geographical context, the volume of the air-conditioned space and the available capture area.

GAINS BY DIRECT CAPTURE SYSTEM

Table 6 summarizes the main findings of research that implemented direct solar capture strategies in high-Andean homes, prioritizing orientation, the type of collector element (skylights, windows, or collectors), and their thermal impact.

The direct capture systems demonstrated that the skylights implemented by Molina et al. (2021) in San Francisco de Raymina, Ayacucho, constitute the most successful strategy by achieving a thermal increase of ΔT = 16.6 K during the Andean winter. The most important finding reveals that skylights of only 2.4 m^2 can contribute significantly to the total solar gains of a house, which evidences a cost-benefit ratio of (6.9 K/m^2) that takes advantage of the high zenith solar radiation available in high Andean areas.

GAINS BY SEMI-DIRECT CAPTURE SYSTEM

Table 7 summarizes three representative studies that applied semi-direct solar capture strategies in high-Andean homes and evaluated their impact on winter thermal gain. The research includes systems such as Trombe walls and attached greenhouses, detailing their configurations, site altitudes, and achieved thermal results. This information allows comparison of the relative effectiveness of each intervention in cold, high-altitude climatic contexts.

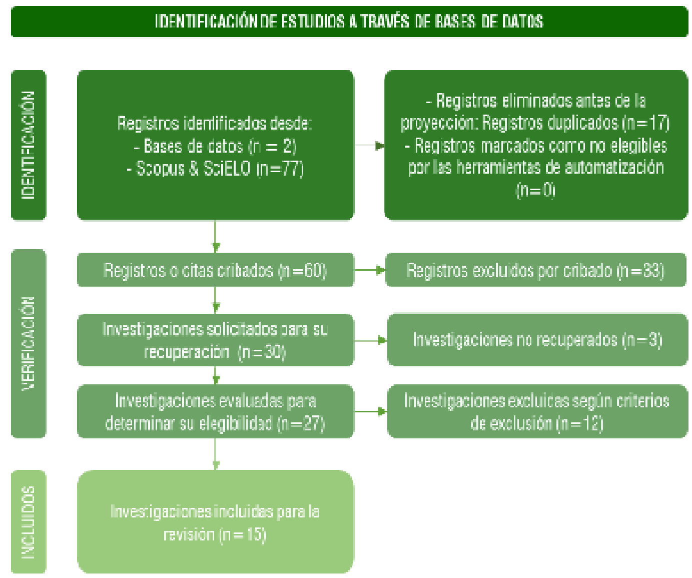

Figure 1. PRISMA flow diagram. Source: Prepared by the authors.

The semi-direct systems showed the highest thermal performance, highlighting a modified Trombe wall with

Table 6. Investigations that used direct capture systems. Source: Prepared by the authors.

Author (Year) - Location, Altitude	Strategy	Capture area (m²)	Climatized volume (m³)	Thickness/ Material	Conductivity (W/m·K)	ΔT (K)	Rel. ΔT/m²	Type of study
Molina et al. (2021). - San Francisco de Raymina, Ayacucho, 3,700 m.a.s.l.	Overhead polycarbonate skylight	2.4	65	0.006 m honeycomb polycarbonate	0.19	16.6	6.9	Experimental
Cerrón Conteras (2024). - Sabaino, Apurímac, 4,000 m.a.s.l.	Zenith skylights	3.0	60	Typical adobe, sheet metal	0.85/50.0	10.0	3.33	Experimental
Resano et al. (2021). Cusco, 3,399 m.a.s.l.	North windows + overhead skylights	2.5	55	Adobe 0.25 m, fiber cement	0.72/0.35	3.0	1.2	Experimental
Soto Holgado & Salcedo Guillén (2024). - Cusco, 3,214 m.a.s.l.	Collector oriented N 20°E	14.0	62	Adobe 0.40 m, double-glazed	1.40/0.80	16.0	1.14	Simulated

Note: Four of the fifteen investigations used direct solar capture in high-Andean homes.

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Table 7. Investigations that used semi-direct capture systems. Source: Prepared by the authors.

Author (Year) - Location, Altitude	Strategy	Capture area (m²)	Climatized volume (m³)	Thickness/ Material	Conductivity (W/m·K)	ΔT (K)	Rel. ΔT/m²	Type of study
Facelli Sanchez & Mercado Hancco (2024). - Cusco, 3,365 m.a.s.l.	Trombe wall + acrylic pellets	12.0	132	Brick 0.25 m, glass 0.008 m, pellets 0.025 m	0.65/5.60/0.20	28.6	2.38	Simulated
Ponce Gonzales et al. (2021). - Imata, Arequipa, 4,519 m.a.s.l.	Polycarbonate attached greenhouse	18.84	27.6	Adobe 0.015 m plaster, polycarbonate 0.006m	0.349/0.19	14.6	0.77	Experimental + Simulated
Silva Lindo et al. (2016). Huaraz, Áncash, 3,080 ma.s.l.	Attached greenhouse + glazed windows	6.0	45	Adobe, single glass 0.004m	0.80/0.80	3.7	0.62	Experimental

Note: Three of the fifteen investigations used semi-direct solar capture in high-Andean homes.

Table 8. Thermal gain by strategies based on conservation and storage. Source: Prepared by the authors.

Author (Year) - Location, Altitude	Strategy	Envelope area (m2)	Climatized volume (m3)	Thickness/ Material	Conductivity (W/m·K)	ΔT (K)	Rel. ΔT/ m²	Type of study
Molina Fuentes et al. (2020). San Francisco de Raymina, Ayacucho, 3,700 m.a.s.l.	Combined passive strategies	8.0	90	Combined system	0.35	9.5	1.19	Simulated
Wieser et al. (2021). - Orduña, Puno, 4,200 m.a.s.l.	Natural materials + insulation	8.0	72	Natural material 0.20m	0.15	8.0	1.0	Experimental
Parí Quispe et al. (2021). - Puno, 3,800 m.a.s.l.	Lake Titicaca bulrush walls/ roofs	15.0	78	Bulrush 0.15m	0.09	7.6	0.51	Experimental
Flores Condori (2014). - Colloco, Ilave, Puno, 3,500 m.a.s.l.	Adobe + porous stone + cypress wood	10.0	110	Adobe 0.40m porous stone	0.72/0.55	7.5	0.75	Experimental
Espinoza Montes (2013). - Junín, 3,800 m.a.s.l.	Solar collector + storage chamber	6.84	5.76	Optimized collector	0.30	6.0	0.88	Experimental
Iruri Ramos et al. (2023). - Colca Valley, Arequipa, 3,600 m.a.s.l.	Roof insulation + compacted earth walls	8.5	85	Compacted earth, insulation	0.45/0.04	5.9	0.69	Experimental
Molina-Fuertes et al. (2024). - Imata, Arequipa, 4,500 m.a.s.l.	Thermally resistant cavity wall	9.0	55	Wall with cavities	0.25	5.9	0.66	Experimental
Jiménez et al. (2017). - Peruvian High Andean region, >4,000 m.a.s.l.	Native envelope insulators	12.0	50	Local materials 0.18m	0.11	5.0	0.42	Experimental

Note: Studies show that natural materials and simple techniques improve thermal comfort in high Andean homes.

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acrylic pellets developed in Cusco by Facelli Sanchez & Mercado Hancco (2024), which achieved an increase of up to ΔT = 28.6 K in winter, with the room temperature at -0.4 °C. The incorporation of porous media significantly improved thermal circulation and heat storage, maintaining indoor comfort during the coldest hours.

THERMAL GAIN BY CONSERVATION AND STORAGE

Table 8 brings together eight studies on passive strategies applied in high-Andean dwellings located above 3,000 m.a.s.l., which focus on two complementary mechanisms: heat conservation through materials with high thermal resistance (insulation) and solar energy storage through walls and elements with high thermal inertia. These solutions, based on traditional construction techniques and the use of local resources, seek to slow heat loss to the outside and reduce indoor temperature oscillations during the Andean winter season.

The conservation and storage systems identified that the insulation with native materials implemented by Wieser et al. (2021) in Orduña, Puno, constitutes a successful strategy, achieving a ΔT of 8.0 K under extreme conditions of up to -20°C. The most important finding establishes that the bulrush of Lake Titicaca presents an exceptional thermal conductivity of 0.09 W/m·K, comparable with modern industrial insulators, but with the advantage of being a local, renewable, and low-cost resource.

DISCUSSION

ANALYSIS BY ALTITUDINAL FLOOR

Middle Floor (3,000-3,500 m.a.s.l.): Direct capture systems showed better performance, especially overhead skylights with ΔT = 16.6 K (Molina et al., 2021) and terraced greenhouses with ΔT = 3.7 K (Silva Lindo et al., 2016). At these altitudes, the solar radiation is intense, but the night temperatures are not extreme, which favors direct collection strategies.

High Floor (3,500-4,000 m.a.s.l.): Semi-direct and thermal storage systems demonstrated greater efficiency. The modified Trombe walls with ΔT = 28.6 K (Facelli Sanchez & Mercado Hancco, 2024) and the combined strategies with ΔT = 9.5 K (Molina Fuente et al., 2020) maintained better thermal stability during the critical night hours.

Very High Floor (>4,000 m.a.s.l.): In extreme conditions, the combined strategies showed better results. The attached greenhouse by Ponce Gonzales et al. (2021) in Imata (4,519 m.a.s.l.) achieved a ΔT of 14.6 K, while insulation systems with natural materials obtained a ΔT of 8.0 K (Wieser et al., 2021), providing nocturnal thermal stability essential for habitability.

RELATIVE EFFICIENCY BY STRATEGY

The results show that the relative efficiency (ΔT/m^2) varies significantly:

- Maximum efficiency: Overhead skylights (light and ventilation) (6.9 K/m^2)
- High efficiency: Modified Trombe walls (2.38 K/m^2)
- Moderate efficiency: Overhead skylights (3.33 K/m^2)
- Variable efficiency: Semi-detached greenhouses (0.62-0.77 K/m^2)

LIMITATIONS AND CONSIDERATIONS

Among the identified limitations, reliance on simulations in some studies, limited long-term onsite validation, and low representation of the diversity of high-Andean microclimates stand out. However, studies such as Ponce Gonzales et al. (2021) demonstrate the feasibility of experimental-numerical validation with differences less than 1.1°C.

IMPLICATIONS FOR PUBLIC POLICY

The results show that no single strategy guarantees comfort under critical high-Andean conditions, requiring the integration of multiple passive solutions. For the design of social housing policies in the Andean high plains, it is recommended:

- Middle floor: Prioritize overhead skylights and direct capture
- High floor: Implement modified Trombe walls and combined strategies
- Very high floor: Developing terraced greenhouse systems with natural insulation

The adoption of these passive strategies adapted to the local context can significantly improve habitability and reduce energy poverty in high-Andean homes, with thermal increases ranging from ΔT = 3.0 K to ΔT = 28.6 K, depending on the altitude and strategy implemented.

CONCLUSION

Passive solar collection strategies in high-Andean dwellings transcend conventional thermal improvements to become vectors of sustainable habitat transformation, capable of redefining livability conditions in contexts of extreme climatic vulnerability. The documented thermal increases (ΔT = 3.0 K to 28.6 K) represent the difference between habitability and uninhabitability at altitudes where night temperatures reach -23°C, while the differentiation by altitudinal floor direct capture for medium zones (3,000-3,500 m.a.s.l.), semi-direct systems for high floors (3,500 to 4,000 m.a.s.l.) and combined strategies for extreme conditions (>4,000 m.a.s.l.) establishes a new mapping of thermal comfort that can guide differentiated public policies. The validation of native materials such as totora (bulrush) (conductivity 0.09 W/m·K) that exceed the performance of industrial insulators, along with thermal efficiency of up to 6.9 K/m^2 in overhead skylights, shows that the Andean built space can achieve thermal comfort levels comparable to conventional buildings through low-cost and high replicability interventions.

The results obtained indicate the potential of passive solar collection strategies to reduce heating energy demand and improve thermal comfort in high-Andean homes. In addition, these findings allow identifying opportunities to optimize the use of local materials and promote low-cost interventions adapted to the climatic particularities of each altitudinal floor. However, the scarcity of applied research at altitudes above 4,500 m.a.s.l. is recognized as a limitation that limits the validity of results under extreme altitude conditions. Therefore, it is recommended that experimental and simulation studies be conducted to evaluate the replicability, thermal efficiency, and economic viability of these strategies in real-world contexts, as well as their implications for reducing energy poverty and rural communities' sustainability.

CONTRIBUTION OF AUTHORS CRediT

Conceptualization, F.S.A and F.S.H; Data Curation, F.S.A and F.S.H; Formal analysis, F.S.A and F.S.H; Acquisition of financing, F.S.A and F.S.H; Research, F.S.A and F.S.H; Methodology, F.S.A and F.S.H; Project Management, F.S.A and F.S.H; Resources, F.S.A and F.S.H; Software, F.S.A. S.A and F.S.H; Supervision, F.S.A and F.S.H; Validation, F.S.A and F.S.H; Visualization, F.S.A and F.S.H; Writing – Original draft, F.S.A and F.S.H; Writing – revision and editing, F.S.A and F.S.H.

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