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Sustainable Rural Housing Models: A Systematic Review Focused on Climate Resilience and Quality of Life

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Modelos Habitacionais Sustentáveis para Áreas Rurais: Estratégias Construtivas e Resiliência Climática

RESUMO

Objetivo – Analisar modelos habitacionais sustentáveis para áreas rurais, com foco em práticas construtivas que ampliem a resiliência climática e melhorem a qualidade de vida das populações.

Metodologia – Revisão sistemática da literatura sobre tecnologias arquitetônicas, uso de materiais locais, eficiência energética e fontes de energia renováveis aplicadas ao contexto rural.

Originalidade/Relevância – O estudo aborda lacunas relacionadas à integração entre inovação tecnológica, preservação cultural e sustentabilidade habitacional em áreas rurais, tema ainda pouco documentado, sobretudo em assentamentos e no agronegócio.

Resultados – Identificou-se o uso de arquitetura vernacular, materiais naturais, estratégias bioclimáticas e energias renováveis como soluções viáveis, capazes de elevar o conforto térmico, a eficiência energética e a adaptação às mudanças climáticas.

Contribuições Teóricas/Metodológicas – Sistematização de práticas construtivas sustentáveis e ampliação do debate sobre habitação rural resiliente, indicando caminhos para pesquisas aplicadas e avaliações comparativas.

Contribuições Sociais e Ambientais – Melhoria da qualidade habitacional, redução de impactos ambientais, fortalecimento cultural local e incentivo a soluções de baixo custo e maior sustentabilidade no meio rural.

PALAVRAS-CHAVE: Sustentabilidade. Construção ecológica. Mudanças climáticas.

Sustainable Housing Models for Rural Areas: Construction Strategies and Climate Resilience

ABSTRACT

Objective – To analyze sustainable housing models for rural areas, focusing on construction practices that enhance climate resilience and improve quality of life.

Methodology – Systematic literature review addressing architectural technologies, local materials, energy efficiency, and renewable energy sources applied to rural contexts.

Originality/Relevance – The study addresses theoretical gaps related to the integration of technological innovation, cultural preservation, and sustainable rural housing, especially in agribusiness regions and rural settlements.

Results – Findings highlight vernacular architecture, natural materials, bioclimatic design, and renewable energy as viable solutions that improve thermal comfort, housing quality, and climate adaptation.

Theoretical/Methodological Contributions – Organization of sustainable construction practices and expansion of knowledge on climate-resilient rural housing, supporting future applied research.

Social and Environmental Contributions – Improvements in living conditions, environmental impact reduction, cultural valorization, and promotion of affordable sustainable solutions in rural areas.

KEYWORDS: Sustainability. Green building. Climate change.

Modelos de Vivienda Sostenible para Zonas Rurales: Estrategias Constructivas y Resiliencia Climática

RESUMEN

Objetivo – Analizar modelos de vivienda sostenible para zonas rurales, centrándose en prácticas constructivas que aumenten la resiliencia climática y la calidad de vida.

Metodología – Revisión sistemática de la literatura sobre tecnologías arquitectónicas, uso de materiales locales, eficiencia energética y energías renovables en el contexto rural.

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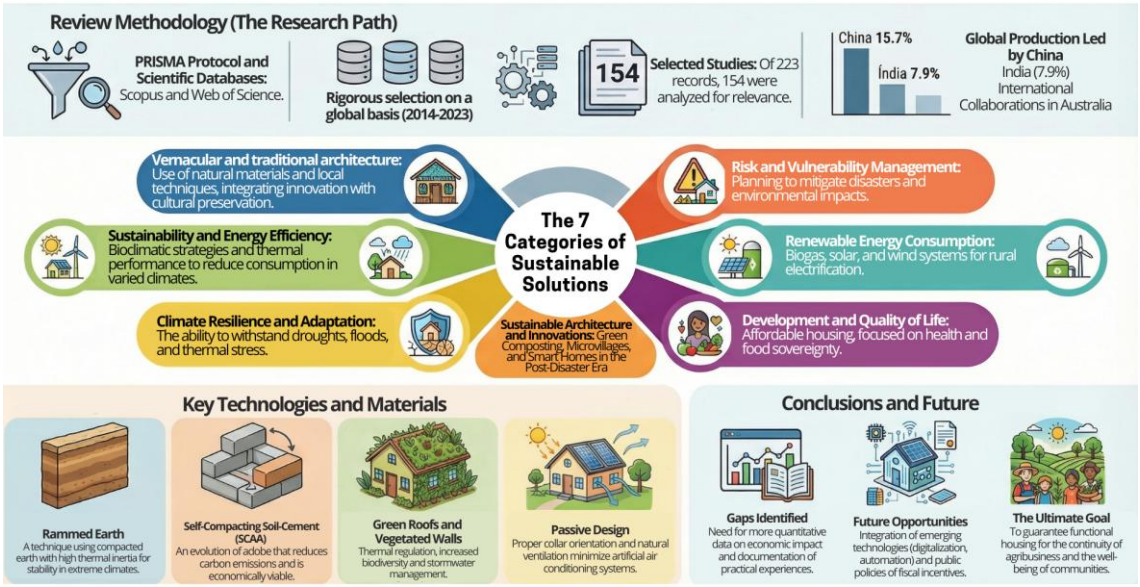
Originalidad/Relevancia – El estudio aborda vacíos teóricos relacionados con la integración entre innovación tecnológica, preservación cultural y sostenibilidad habitacional en áreas rurales y asentamientos.
Resultados – Se identificaron soluciones como arquitectura vernácula, materiales naturales, estrategias bioclimáticas y energías renovables que mejoran el confort térmico y la adaptación al cambio climático.
Contribuciones Teóricas/Metodológicas – Sistematización de prácticas constructivas sostenibles y fortalecimiento del campo de estudio sobre vivienda rural resiliente.
Contribuciones Sociales y Ambientales – Mejora de la calidad habitacional, reducción de impactos ambientales, valorización cultural y promoción de soluciones sostenibles de bajo costo.

PALABRAS CLAVE: Sostenibilidad. Construcción ecológica. Cambio climático.

GRAPHIC ABSTRACT



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1 INTRODUCTION

Sustainability in rural construction has emerged as a critical discourse within the agribusiness sector, particularly in response to accelerating global climate change (Guo; Wu; Miao, 2023; Liu et al., 2020; Zhang et al., 2021). Rural regions, where agribusiness constitutes a fundamental economic pillar, confront substantial infrastructural and housing challenges (Bansal; Chadchan; Sen, 2022; Baytelieva et al., 2023; Yi et al., 2022). Ensuring that these built environments are not merely functional but also resilient to adverse climatic conditions is paramount to safeguarding the well-being of rural communities (Kosanović et al., 2019; Munyai et al., 2021; Pitts; Gao; Le, 2020). Within this context, sustainable housing models have emerged as promising solutions, integrating green building practices with climate resilience strategies (Burford; Robertson, 2018).

The concept of climate resilience encompasses the capacity of buildings and communities to withstand, adapt to, and recover from extreme weather events such as droughts, floods, and severe storms (Jabareen, 2013). Sustainability in construction involves the utilization of eco-friendly materials, energy efficiency optimization, and the integration of renewable energy sources, with the objective of minimizing environmental impacts while promoting thermal comfort and enhancing residents' quality of life (Xueyong et al., 2016). However, the application of these principles to rural housing presents considerable challenges, particularly when balancing cost-effectiveness, resource accessibility, and technical feasibility (Cárdenas-Gómez; Bosch Gonzales; Damiani Lazo, 2021; Jebens-zirkel Imm; Zirkel Zirkel, 2022; Rezaeinia, 2020).

The central problematic addressed in this study concerns the scarcity of housing models that, beyond satisfying the functional and economic demands of agribusiness, offer climate resilience and contribute to the sustainable development of rural areas (Aguilar-Sanchez; Almodovar-Melendo; Cabeza-Lainez, 2023; Ghofrani; Sposito; Faggian, 2016; Haji Adenan et al., 2014). In vulnerable regions, the majority of rural dwellings lack adequate structural capacity to cope with the escalating impacts of climate change, thereby creating an urgent imperative to investigate and develop construction practices that harmonize sustainability with resilience (Baytelieva et al., 2023; Gonzalez, 2015; Godoy & Silva, 2025; Nemer *et al.,* 2026).

This study aims to conduct a systematic review of sustainable housing models for rural areas, with particular emphasis on construction practices that enhance climate resilience and improve population quality of life. The research seeks to identify architectural technologies, locally-sourced materials, and renewable energy systems, highlighting viable solutions for implementation within agribusiness contexts and rural settlements, including through public policy interventions.

The methodology employed consists of a systematic review of academic literature and case studies addressing sustainable rural housing. Articles, monographs, and technical reports examining climate resilience, sustainability in rural construction, and applied environmental technologies were analyzed. Based on this review, a meta-analysis was conducted to identify

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available standards and the most effective solutions, with particular attention to the specific requirements of rural areas.

This study is justified by the increasing demand for housing solutions that demonstrate resilience to climate change while promoting sustainable development and improving quality of life in rural communities. Given the central role of agribusiness in the economy and the intensification of extreme weather events, the development of appropriate infrastructure is vital to ensure the continuity of agricultural activities and social well-being in these regions.

The structure of this work is organized as follows: the subsequent section presents the detailed methodology, explicating the inclusion and exclusion criteria for analyzed studies. Following this, the results of the systematic review are presented quantitatively. The discussion section then highlights the principal solutions identified. Finally, concluding remarks and recommendations for future research and practical implementations are provided.

2 METHODOLOGY

The methodology of this study is grounded in a systematic literature review utilizing the Scopus and Web of Science databases. These platforms were selected for their academic credibility, comprehensive scope, and quality of peer-reviewed publications, encompassing fields such as architecture, sustainability, and agribusiness. Access to rigorously peer-reviewed publications ensures data robustness, enabling global coverage of research on rural housing and climate resilience.

The temporal scope of this study covers the period from 2014 to 2023, focusing on recent innovations and scholarly discourse concerning climate change and sustainable technologies in rural contexts. Since 2016, with the adoption of the UN 2030 Agenda, the imperative to align rural construction practices with the Sustainable Development Goals (SDGs)—particularly SDG 7 (Affordable and Clean Energy) and SDG 11 (Sustainable Cities and Communities)—has become increasingly evident. Global agreements such as the Paris Agreement and deliberations in international forums underscore the urgency of innovative solutions to climate challenges. The analysis of publications during this period ensures that the proposed solutions reflect contemporary realities affecting rural communities.

The research adopted a global approach without geographical or linguistic restrictions, aimed at mapping sustainable architectural solutions and construction practices across diverse regions worldwide. This international scope, justified by the heterogeneity of climatic and socioeconomic conditions, enriches the analysis by incorporating experiences adapted to varied rural contexts. Consequently, this approach facilitates the identification of solutions applicable across different regions, contributing to a holistic understanding of the subject matter.

Data processing was conducted using RStudio software with the biblioshiny package, selected for its capacity to perform detailed and interactive bibliometric analyses. This tool facilitates data exploration and visualization, enabling the identification of patterns in scientific literature and temporal analysis of publications (Moral-Muñoz et al., 2020).

The study adhered to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol, which ensures transparency and methodological rigor in

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systematic reviews. The adoption of PRISMA is justified by its widespread international acceptance, offering a standardized framework for reporting results (Page et al., 2021). Its application ensures that all stages of article selection and exclusion are documented, providing reproducibility and clarity throughout the research process.

The following Boolean search string was employed to identify relevant records: "housing" AND "rural" AND "climate" AND "sustainab*". Following the initial search, duplicate entries were removed. Subsequently, records were screened through systematic examination of titles, abstracts, and keywords to assess direct relevance to the study topic or identify inappropriate focus, with exclusion of those failing to meet the criteria of sustainability, climate resilience, or rural contextual appropriateness.

At this stage, to assess eligibility, records were required to satisfy the criteria delineated in Table 1.

Table 1 – Eligibility criteria

Critério	Descrição	Justificativa
Period	Publications between 2014 and 2023	The time frame aims to capture the most recent innovations and discussions on sustainability and resilience in rural housing.
Type of Publication	Peer-reviewed articles, books, book chapters, technical reports.	The choice of peer-reviewed publications and technical reports ensures the robustness and reliability of the data.
Geographic Context	Studies without geographic restrictions, if they are related to the rural context.	The global scope allows for the analysis of solutions in different climatic and socioeconomic conditions.
Central Theme	Studies addressing sustainability, climate resilience, or rural construction with an emphasis on housing.	The focus on sustainability and climate resilience is essential to understanding how rural construction can be more adaptable to climate change.
Relevance to Research	Studies that specifically address architectural technologies, local materials, renewable energy, or construction strategies applicable to the rural context.	The research seeks to identify technologies and practices that can be applied to rural housing, especially in the context of agribusiness.
Language	Studies without language restrictions.	The study considers all languages, ensuring a significant volume of data.
Exclusion	Studies that deal with urban housing, without a focus on rural areas, or that do not directly address sustainability and climate resilience.	The objective is to focus on solutions geared toward the rural context, excluding urban or generic analyses.

Source: Prepared by the authors.

Data visualization employed diagrams, graphs, and word clouds to represent the frequency of key terms within the analyzed articles. These visual representations facilitate the

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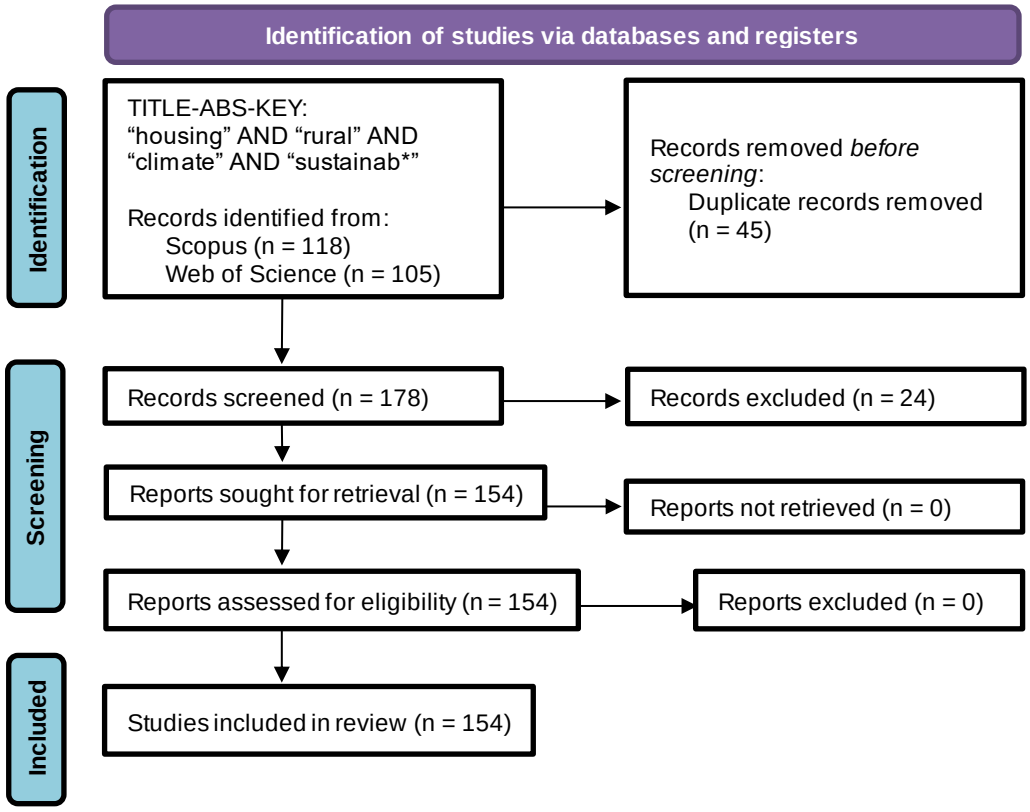
identification of recurrent concepts in the literature, offering a synoptic overview of trends in rural housing and sustainability research, thereby assisting in data interpretation.

These methodological tools, utilized in an integrated manner, ensure that the study was conducted with rigor, transparency, and efficiency, providing a robust foundation for the analysis and discussion of results.

3 RESULTS

The results of this systematic review were derived from an analysis of publications indexed in the Scopus and Web of Science databases, covering the period from 2014 to 2023. Initially, 223 studies satisfied the search criteria; however, following application of the PRISMA protocol (as illustrated in Figure 1), 154 studies meeting the inclusion criteria were selected. These studies provide a substantive foundation for examining sustainable housing models in rural contexts with emphasis on climate resilience.

Figure 1 – Flow diagram for the systematic review of included studies



Source: Prepared by the authors, adapted from the PRISMA flowchart.

The bibliometric analysis revealed a negative annual growth rate of -11.77%, with a mean document age of 4.01 years and 18.3 citations per document. A total of 688 keywords were employed by 633 authors, with an average of 3.8 co-authors per document and 20.22% of

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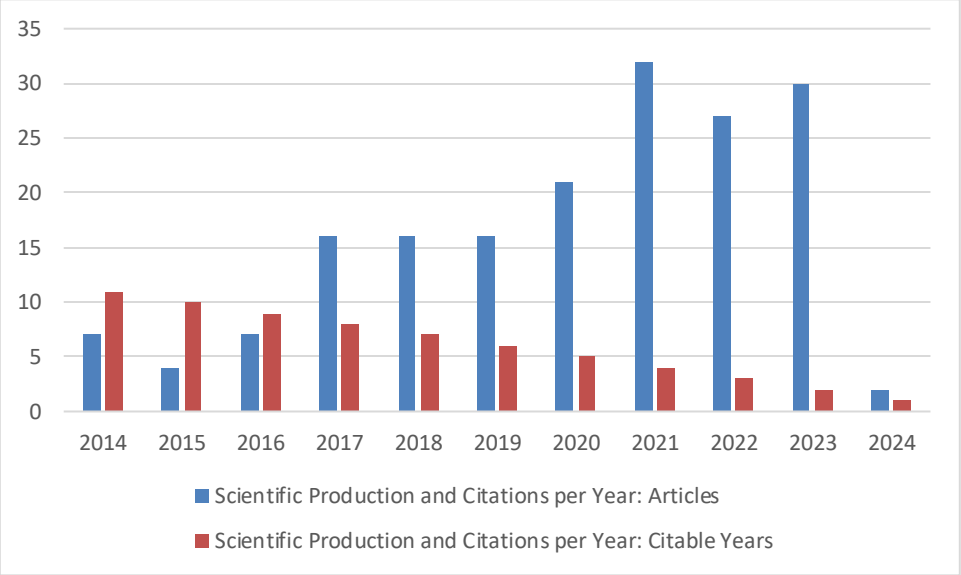
publications resulting from international collaborations. Nevertheless, 28 documents were single-authored, representing 24 individual authors. The majority of documents comprised research articles (117), followed by conference proceedings (21), book chapters (9), and review articles (7), indicating substantial diversity in knowledge dissemination modalities within the field.

Graph 1 illustrates scientific production and annual citations from 2014 to 2023, with some publications anticipated for 2024. In 2014, seven articles were published, accumulating an average of 116.86 citations per article and totaling 10.62 citations per year, reflecting high academic relevance. However, in 2015, production declined to four articles, with the average citation count decreasing precipitously to 22.50.

In subsequent years, although the number of publications increased, citations per article declined correspondingly. In 2021, production peaked at 32 articles; however, the average citation count was merely 9.66, indicating an increase in quantity but a concomitant decrease in impact. By 2023, the average had further declined to 3.43 citations per article, suggesting challenges in maintaining research relevance. This analysis indicates that despite growth in scientific production volume, the quality and scholarly impact of research may not have maintained pace with this expansion, raising questions regarding the sustainability of academic impact within this domain.

Graph 1 - Scientific Production and Citations per Year



Source: Prepared by the authors.

The Sankey diagram presented in Figure 2 illustrates the relationships among sources (SO), authors (AU), and subject descriptors (DE) of identified records. A concentration of topics related to sustainability, energy, construction, and environmental concerns is evident, indicating the multidisciplinary nature of the research domain. Furthermore, collaborative patterns among authors on highlighted topics suggest an evolution in research trajectories.

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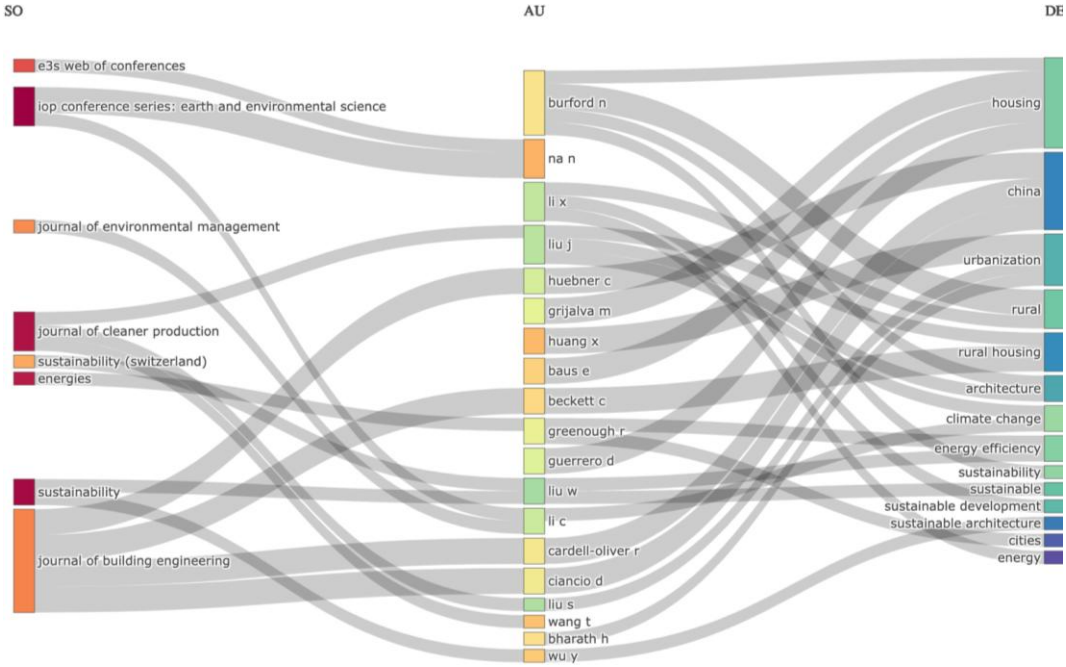
Figure 2 – Relationships between sources, authors, and topics



Source: Prepared by the authors.

Figure 3 demonstrates that the most prominent journals are IOP Conference Series: Earth and Environmental Science and Sustainability, each contributing 9 articles, followed by the Journal of Cleaner Production (4), Energies (3), Energy and Buildings (3), and Water (3). Bradford's Law confirms the centrality of these sources, with the six principal journals comprising Zone 1 of relevance, while remaining sources demonstrate production levels of two or fewer published articles.

Regarding local impact, Sustainability exhibits an h-index of 6, followed by the Journal of Cleaner Production with 4 and Energy and Buildings with 3. Total citation counts vary considerably, with the Journal of Cleaner Production receiving 247 citations, while Water and Building and Environment accumulated 36 and 105 citations, respectively. Publication output from these sources demonstrates a consistent upward trend, particularly highlighting the growth trajectory of IOP Conference Series and Sustainability between 2020 and 2023.

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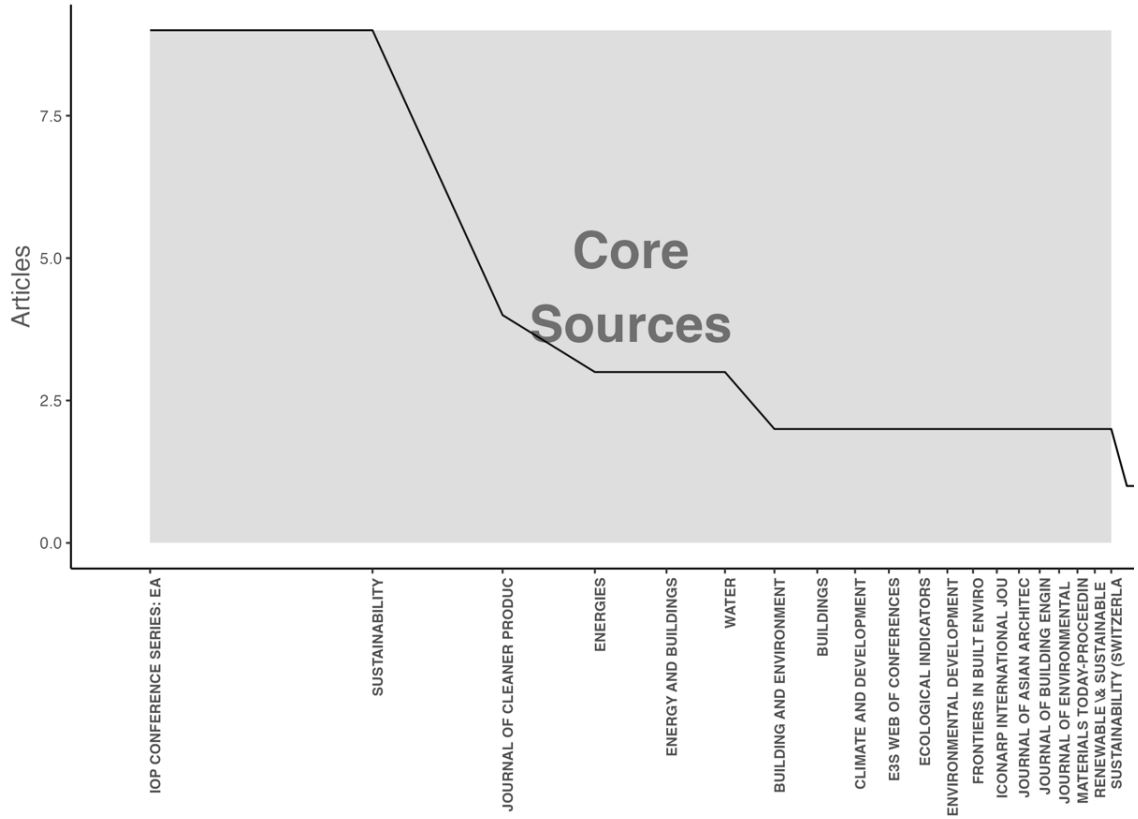
Figure 3 – Main sources according to Bradford's Law



Source: Prepared by the authors.

Data concerning the most prolific authors, as presented in Figure 4, indicate that N.A. N is the most productive researcher, with 5 published articles, followed by Huang X, Wang T, and Wu Y, each contributing 3 articles. Remaining authors demonstrate productivity levels of 2 articles or fewer. In terms of local impact, Huang X demonstrates the highest h-index of 3, having accumulated 160 citations since 2017, followed by Wang T with 76 citations since 2019. Lotka's Law indicates that the majority of authors (94.2%) contributed a single article, while a minimal proportion (0.2%) produced five articles. Temporally, authors such as Wu Y and Baus E have maintained consistent publication records with elevated annual citation rates, distinguishing themselves within their respective fields.

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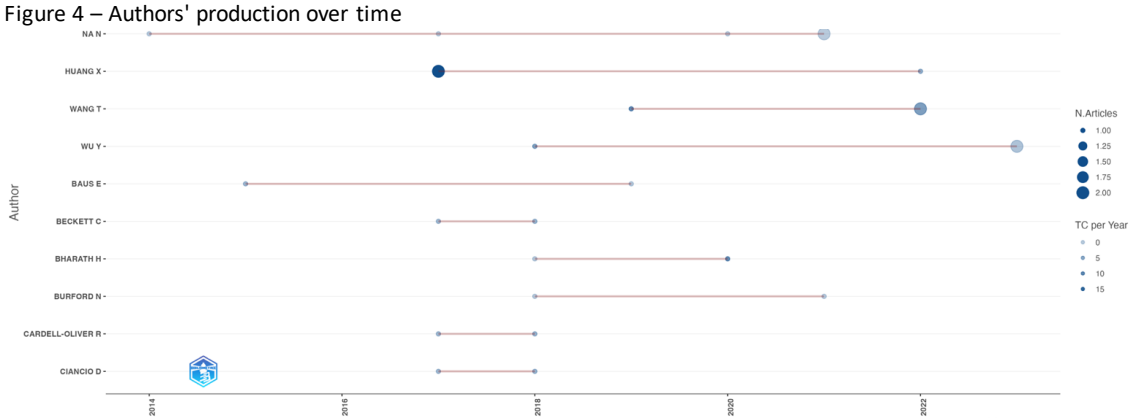
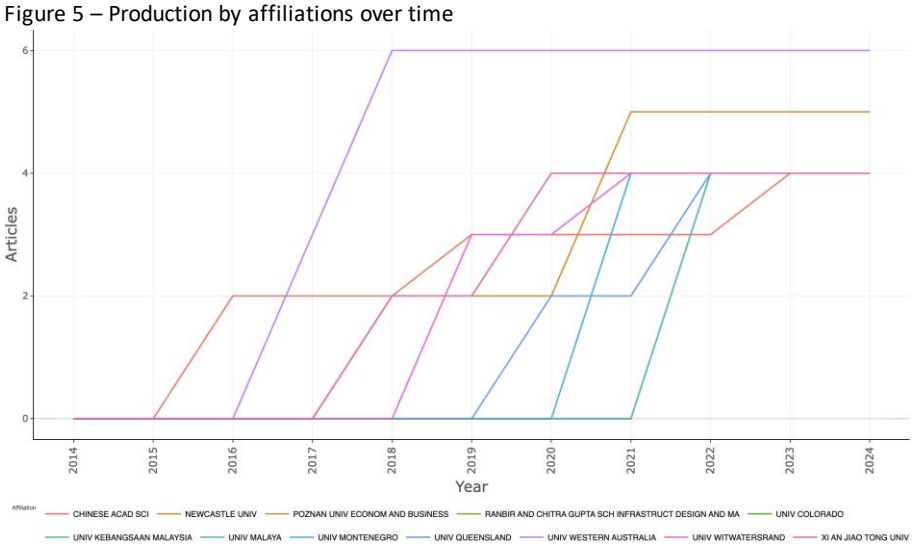
Figure 4 – Authors' production over time



Source: Prepared by the authors.

Data presented in Figure 5 demonstrate that the University of Western Australia leads with 6 published articles, followed by Newcastle University with 5. Additional institutions, including the Chinese Academy of Sciences and the University of Queensland, contributed 4 articles each. These institutions assume significant roles in scientific production within the studied domain.

Figure 5 – Production by affiliations over time



Source: Prepared by the authors.

The data reveal that China leads with 28 articles (15.7% of total production), of which 25% represent international collaborative efforts. India follows with 14 articles (7.9%), although only 7.1% involve international collaborations. Australia, the United States, and the United Kingdom also demonstrate notable contributions with 8 and 7 articles respectively, with Australia exhibiting the highest proportion of international collaboration (37.5%).

China leads in aggregate scientific production with 75 articles, followed by India with 47 and the United Kingdom with 30. Regarding scholarly impact, China has accumulated 661 citations, yielding an average of 23.6 citations per article. Countries such as Italy and Cyprus,

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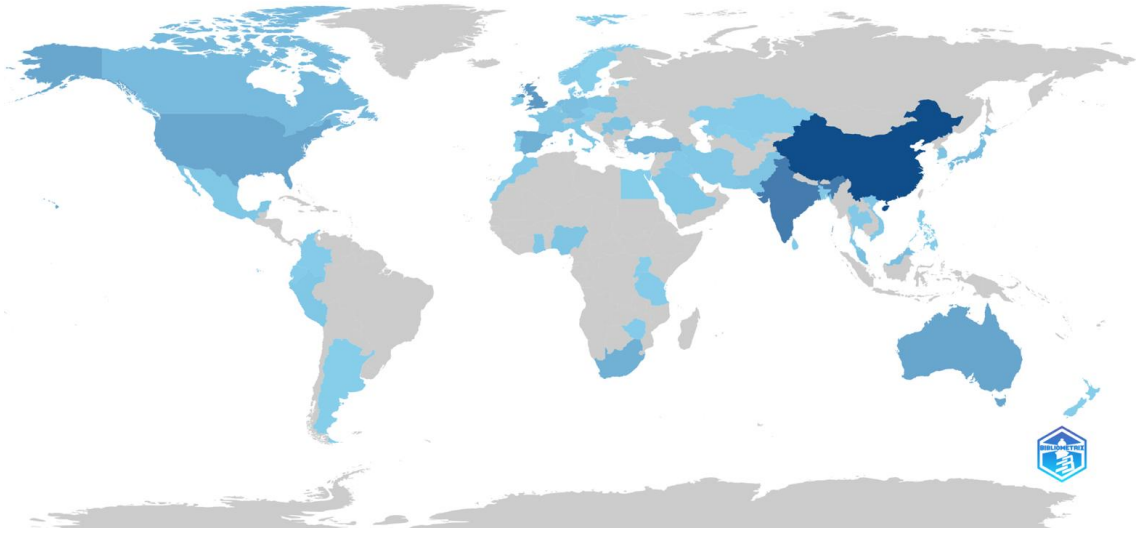
despite lower publication volumes, demonstrate elevated citation averages at 44.7 and 54.5 citations per article respectively. Remaining countries exhibit fewer than 50 citations per article.

Figure 6 – Scientific production by country



Source: Prepared by the authors.

The most highly cited documents globally are predominantly published in high-impact scientific journals. Moritz's (2014) study, published in Nature, leads with 756 total citations and an average of 68.73 citations per year. Another noteworthy article is Khatoun (2016), published in Communications of the ACM, with 272 citations and an annual impact of 30.22. More recent studies, such as those by Liu (2019) in Acta Geographica Sinica and Zhang (2020) in the Journal of Environmental Management, also demonstrate significant annual citation rates.

Publications in the Journal of Cleaner Production and Renewable & Sustainable Energy Reviews frequently rank among the most cited, reflecting the relevance of topics such as clean production and renewable energy systems. Average article impact varies considerably, with recent studies, such as Pandey (2022), achieving an average of 16.67 citations per year and a normalized total citation (TC) of 8.77, highlighting their growing scholarly influence. Remaining works accumulated fewer than 50 total citations during the study period.

Figure 7 presents the most frequent terms in scientific publications over time. The term "housing" emerges as the most recurrent, with 40 occurrences, followed by "sustainable development" (25) and "climate change" (24). Since 2014, terms associated with sustainable development and climate change have demonstrated increased frequency, reflecting their growing significance in scholarly discourse. From 2018 onwards, a pronounced upward trend is observable in the utilization of terms such as "China," "rural areas," "human," and "economics," indicating a growing research focus on environmental and social dimensions within global sustainability frameworks.

Emerging topics including "climate change" and "adaptation" have gained prominence in recent years, reflecting the urgency of scholarly discourse concerning climate change impacts and the pursuit of solutions in vulnerable regions. Trends in "sustainable development" and "energy efficiency" underscore the intersection between sustainability principles and energy

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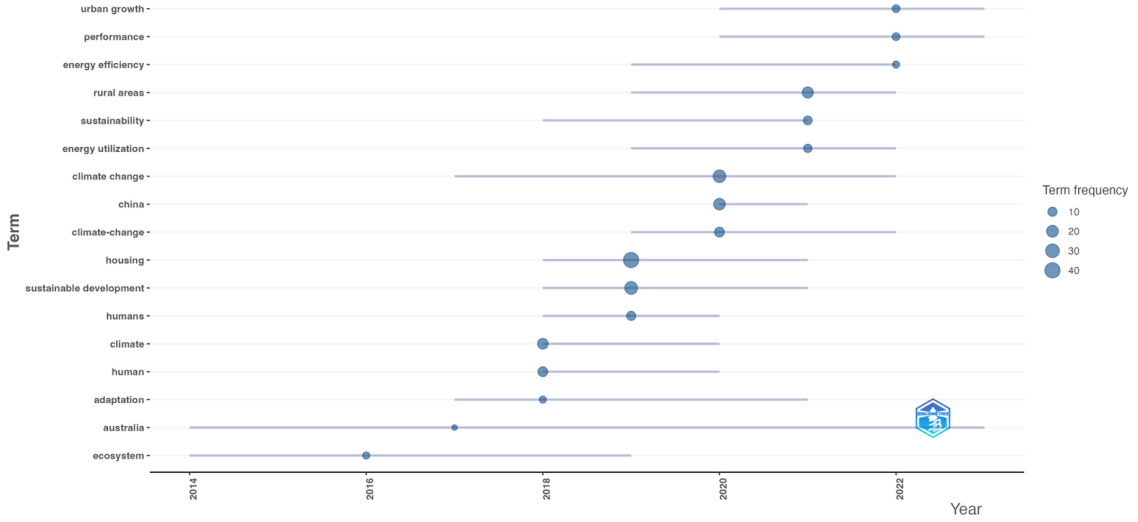
performance optimization—critical considerations in contemporary sustainable development paradigms.

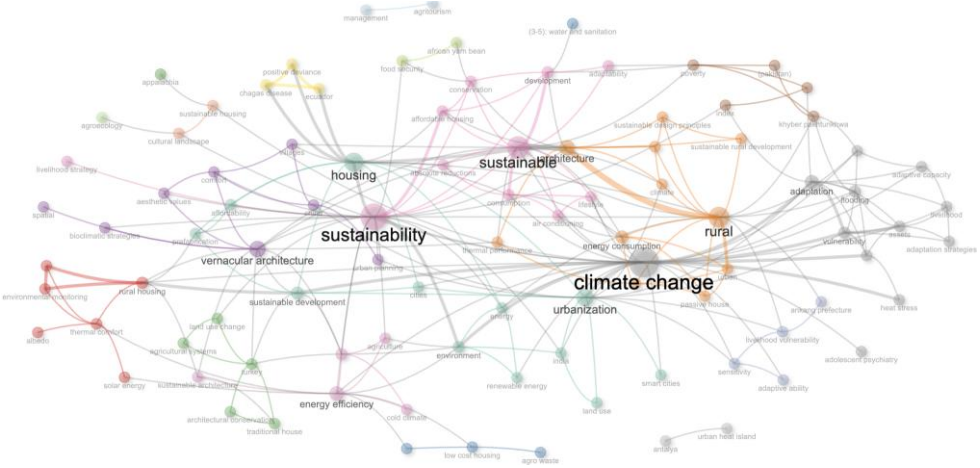
Figure 7 – Topic trends over time



Source: Prepared by the authors.

Figure 8 presents a thematic network highlighting the centrality and density of terms in research addressing sustainability and housing. "Climate change" and "housing" constitute primary nodes, demonstrating high betweenness centrality, while "sustainability" exhibits prominence across multiple metrics. "Energy efficiency" and "rural housing" are similarly relevant, particularly within thematic clusters addressing energy performance and sustainable development in rural contexts.

Figure 8 – Thematic map network



Source: Prepared by the authors.

Vernacular architecture and rural development emerge as prominent themes, reflecting the integration of cultural and environmental considerations. These data indicate that scholarly discourse on climate change, housing, and sustainability is intrinsically intertwined

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with concerns regarding energy efficiency and sustainable architecture, particularly within rural contexts.

4 DISCUSSION

This discussion presents the thematic categories and research clusters encompassing works included in the discourse on sustainable housing models for rural areas, highlighting their specific contributions and classifications, while excluding topics demonstrating limited relevance to the principal research focus.

1. Vernacular and Traditional Architecture: This category encompasses 22 studies analyzing how indigenous architectural practices contribute to sustainability objectives. Notable contributions include adaptations of vernacular architecture to climatic conditions (Karahan; Davardoust, 2020) and cultural contexts (Gençer; Yüksek, 2022), employing natural materials and local construction techniques, exemplified by self-built shelters in the Mediterranean region (Barreca; Tirella, 2017) and biopolymer applications in Bangladesh (Ghosh et al., 2023). Studies additionally address sustainability in tropical African regions (Margani, 2020) and rural areas of India (Panda; Ray, 2023), demonstrating the integration of technological innovation with cultural preservation. Examples such as Casa Nautilus Solar (Jebens-zirkel Imm; Zirkel Zirkel, 2022) and adobe reconstructions in Andean seismic zones (Cárdenas-Gómez et al., 2021) illustrate the resilience inherent in these practices. In traditional communities such as Kampong Ayer in Brunei (Haji Adenan et al., 2014), these studies suggest that preserving vernacular architectural traditions is essential to promoting resilient and ecologically sustainable construction in vulnerable areas.

2. Sustainability and Energy Efficiency: This category comprises 37 studies analyzing thermal performance and energy efficiency in rural and low-cost housing globally. Investigations include comparative assessments of performance in earthen brick buildings in sub-Saharan Africa (Wesonga et al., 2023) and solar heating systems in cold climates of Central Asia (Mehta, 2020). Bioclimatic strategies are particularly prominent, exemplified by the rehabilitation of agricultural estates in Spain (Peres, 2023) and thermal bridge optimization in China (Guo; Wu; Miao, 2023). Energy efficiency in low-cost African housing is addressed through solutions such as compressed earth blocks (Hanafi, 2021). Additional studies examine retrofitting interventions in East African housing (Kebir et al., 2022) and solar system implementations in rural China (Shao; Chen; Zhu, 2016). Although less central to the thematic focus, investigations into the impact of energy improvements on public health in the United Kingdom (Sharpe et al., 2019) are also referenced. These studies collectively promote sustainable, climate-adapted solutions that enhance energy efficiency and well-being in vulnerable communities.

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3. Climate Resilience and Adaptation: This category encompasses 22 studies examining strategies to enhance the adaptive capacity of rural communities to climate change. Notable contributions include vulnerability assessments of agricultural communities in China (Huang et al., 2017) and the Eastern Himalayas (Das et al., 2021), as well as resilience evaluations of communities displaced by dam construction and analyses of climate variability impacts on nomadic herders in Kazakhstan (Baytelieva et al., 2023). Several studies analyze heat exposure risks for agricultural workers in Ghana (Frimpong et al., 2017) and heat stress in poultry farming systems in low-income countries (Nyoni; Grab; Archer, 2019). Particular emphasis is placed on resilient housing design, featuring low-cost construction techniques in India (Varun Raj et al., 2021) and innovative housing models in rural contexts (Burford; Robertson, 2018). Additionally, adaptations to flood risk in South Africa (Munyai et al., 2021) and environmental risk management frameworks in Pakistan (Shah et al., 2019) are examined, alongside decontamination strategies in affected areas of Japan (Itonaga, 2019) and water governance systems in South Korea (Choi et al., 2017). These studies collectively reflect the diversity of challenges confronting rural communities in climate change adaptation.

4. Sustainable Architecture and Technological Solutions: This category presents 15 studies focused on sustainable practices and technological innovations in housing and urban planning. Noteworthy investigations include responsible energy decision-making in Turkey (Üstündağlı Erten et al., 2023) and green composting as a solution for low-income communities (Al Mamun et al., 2020). Additional works address environmental justice within the global food system (Gonzalez, 2015) and social vulnerability to climate change in urban and rural settlements (Ge; Dou; Liu, 2017). The integration of traditional and advanced solutions for sustainable rural housing is explored (Tran, 2018), alongside the impact of environmentally conscious building design (Xueyong et al., 2016). Projects such as sustainable micro-villages in Australia (Barnett, 2018) and intelligent housing reconstruction in post-tsunami Sri Lanka (Dissanayake; Bartsch, 2018) illustrate resilience and sustainability principles in practice. Furthermore, threats to sustainable wetland utilization in Zimbabwe (Musasa; Marambanyika, 2020) and ecological practices in Karst preservation in Colombia (Gelvez-Chaparro et al., 2020) are analyzed.

5. Rural Development and Quality of Life: This category encompasses 10 studies exploring sustainable solutions to improve living conditions in rural areas. Particularly notable is a project for affordable, healthy housing in Tanzania (von Seidlein et al., 2017). Additional studies analyze environmental management practices in rural settlements in China (Liu et al., 2020) and gardening practices promoting food sovereignty in the Wapekeka First Nation (Thompson; Mason; Robidoux, 2018). Nature-based solutions are examined in Poland for climate change mitigation (Małecka-Ziembińska; Janicka, 2022), while tax reform proposals aim to promote local financial sustainability (Cohen, 2019). These studies collectively emphasize the importance of affordable and sustainable solutions in enhancing quality of life within rural communities.

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6. Energy Consumption and Behavior in Rural Areas: This category comprises 20 studies exploring sustainable energy solutions for rural areas, with emphasis on climate resilience and carbon emission reduction. Studies analyze the adoption of biomass heating systems (García-Maroto et al., 2021) and residential electrification utilizing renewable energy sources including biogas, solar, and wind power (Shah; Jha, 2024). Research additionally addresses thermal comfort in Chinese villages (Pitts; Gao; Le, 2020), electricity consumption patterns in Thailand, and challenges of energy access in Central America (Yoshida et al., 2020). Particularly noteworthy are hybrid renewable energy systems in India (Shah; Jha, 2024) and clean energy transitions in Nepal (Ram; Bahadur; Shukuya, 2019) and China (Ravindra; Kaur-Sidhu; Mor, 2021), as well as assessments of carbon emission policy impacts in rural China (Zhang; Zhang, 2020).

7. Climate Risks and Vulnerabilities: This category encompasses 24 studies analyzing the vulnerability of rural communities to natural disasters, including floods and severe storms, and their implications for housing security and quality of life. Studies focus on methodologies for flood vulnerability assessment in Ghana (Afriyie; Ganle; Santos, 2018) and Pakistan (Khan et al., 2023), alongside adaptation strategies to mitigate impacts (Ao et al., 2022). Research on pastoral community resilience in northern China (Ding et al., 2014) and the influence of green infrastructure on rural planning (Ghofrani; Sposito; Faggian, 2016) is also examined. Additional studies investigate the relationships among land use patterns (Sharma et al., 2023), environmental degradation (Schulze; Malek; Verburg, 2021), and pollutant emissions (De Lotto et al., 2022), emphasizing the necessity of sustainable planning frameworks to mitigate climate risks and promote adaptation in countries including China (Zhang et al., 2019), India (Bansal; Chadchan; Sen, 2022), Japan (Wang; Ochiai, 2022), and Australia (Wang et al., 2022).

8. Works with Low Adherence to the Theme of Sustainable Housing Models for Rural Areas: Certain thematic areas, including Sustainable Agriculture and Food Security, while related to broader sustainability concerns, demonstrate limited direct connection to rural housing or climate resilience, focusing predominantly on agricultural production systems. Similarly, research addressing Sustainability and Environmental Justice and Sustainable Architecture demonstrates greater emphasis on urban contexts and social justice issues, with limited applicability to rural environments. Smart Cities and Technologies for Sustainability, although relevant to urban contexts, lack direct application to rural areas characterized by limited infrastructure. While these works contribute to broader sustainability discourse, they offer limited practical contribution to sustainable rural housing solutions.

In summary, the categories discussed demonstrate relevance to the development of sustainable housing models in rural areas, while areas exhibiting low thematic adherence were excluded due to their focus on urban or technological issues distant from rural realities.

5 FINAL CONSIDERATIONS

The objective of this study was to conduct a systematic review of sustainable housing models for rural areas, with particular emphasis on construction practices that enhance climate resilience and improve population quality of life. Through rigorous analysis of scientific literature

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and case studies, it was possible to identify a diverse portfolio of architectural technologies, locally-sourced materials, and renewable energy systems that offer viable solutions for rural contexts, particularly within agribusiness and rural settlement frameworks.

The results demonstrate that the most effective housing models are those integrating locally-sourced, cost-effective materials, renewable energy systems, and adaptation to regional climatic specificities. These solutions not only enhance structural resilience to climate change but also promote sustainable development, improving thermal comfort and quality of life for rural populations.

However, certain limitations of this study warrant acknowledgment. First, the systematic review focused on academic sources and case studies, which may have excluded relevant local experiences or practical initiatives not yet adequately documented in scholarly literature. Additionally, the research did not comprehensively address the economic and political challenges inherent in large-scale implementation of these technologies, particularly in less developed regions or those with limited access to technological and financial resources.

Another aspect meriting attention is the absence of detailed quantitative economic impact assessment of the proposed solutions. Although the study highlighted effective construction practices, comparative cost-benefit data across different rural contexts remain lacking, which would be essential to ensure practical viability.

Consequently, significant opportunities exist for future research. More detailed investigations into the cost-effectiveness of these housing solutions, alongside studies directly involving local communities, would be fundamental to enriching the field. Furthermore, exploring the integration of emerging technologies, such as digitization in rural construction and automation for energy efficiency optimization, could open new avenues for making these practices more accessible and adaptable.

Looking forward, opportunities also exist to expand scholarly discourse on the role of public policies and financing mechanisms that incentivize the adoption of these technologies in rural areas. Tax incentive policies, subsidies, and training programs could constitute topics for future investigation, ensuring that sustainable housing models can be widely implemented, particularly in more vulnerable communities.

In conclusion, this work fulfills its objective of identifying sustainable and resilient housing solutions for rural areas while simultaneously paving the way for new approaches and complementary research that deepen understanding and facilitate implementation of these practices in the field. The continuity of this research agenda is paramount to ensuring that rural areas can effectively address the challenges of climate change in a sustainable manner.

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DECLARAÇÕES

CONTRIBUIÇÃO DE CADA AUTOR

Ao descrever a participação de cada autor no manuscrito, utilize os seguintes critérios:

- **Concepção e Design do Estudo**: Willian dos Santos Flores.
- **Curadoria de Dados**: Willian dos Santos Flores e Camila Amaro de Souza.
- **Análise Formal**: Willian dos Santos Flores em Análise Bibliométrica; Camila Amaro de Souza Análise Técnica.
- **Aquisição de Financiamento**: Não houve financiamento para o estudo, porém Willian dos Santos Flores é bolsista CAPES em nível de doutorado por demanda social.
- **Investigação**: Willian dos Santos Flores.
- **Metodologia**: Willian dos Santos Flores desenvolveu, Camila Amaro de Souza fez revisão crítica.
- **Redação - Rascunho Inicial**: Willian dos Santos Flores.
- **Redação - Revisão Crítica**: Camila Amaro de Souza.
- **Revisão e Edição Final**: Willian dos Santos Flores e Camila Amaro de Souza.
- **Supervisão**: Camila Amaro de Souza.

DECLARAÇÃO DE CONFLITOS DE INTERESSE

Nós, **Willian dos Santos Flores** e **Camila Amaro de Souza**, declaramos que o manuscrito intitulado "**Modelos Habitacionais Sustentáveis para Áreas Rurais: Estratégias Construtivas e Resiliência Climática**":

1. **Vínculos Financeiros**: Não possui vínculos financeiros que possam influenciar os resultados ou interpretação do trabalho. O presente trabalho foi realizado com apoio da Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Código de Financiamento 001.
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