

MUD HOUSES IN NEPAL: BALANCING TRADITION, SUSTAINABILITY AND MODERN NEEDS

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ABSTRACT

Mud houses are a resilient alternative housing option, offering natural cooling, cost-effectiveness, longevity, and earthquake resilient. The increasing prevalence of concrete buildings spurred by urbanization and disasters exacerbates environmental concerns, fueling the resurgence of sustainable technologies such as traditional mud construction. This article employs a systematic literature review methodology to conduct a comprehensive search of scholarly articles, books, reports, and other relevant sources related to mud houses in Nepal and around the world. This paper delves into the challenges and opportunities associated with balancing tradition, sustainability, and modern needs concerning mud buildings in Nepal, emphasizing the importance of cultural perspectives and theoretical frameworks in preserving Nepal's architectural heritage. The findings emphasize community involvement in mud house construction, with traditional skills passed down through generations, extending to knowledge transfer initiatives, advocating for educational programs and workshops empowering communities to sustain traditional construction methods while embracing modern advancements when appropriate.

Keywords: *Mud Houses, Tradition and Modernity, Sustainability Challenges, Seismic Resilience*

Introduction

During my tenure in Pakistan, a Pakistani colleague from Balochistan province shared a fascinating account of constructing a mud house in his village. Intriguingly, he documented the entire process, along with the associated costs, on social media. This endeavor unexpectedly drew the attention of policymakers who recognized the cost efficiency of such construction. They approached him with an interest in replicating this model in rural areas. This anecdote reflects the potential impact of mud houses not only as traditional dwellings but also as innovative solutions with broader societal implications. In this context, my colleague expressed his curiosity about Nepal, citing the country's reputed history and expertise in constructing seismic-resilient mud houses. Eager to validate this information, he sought insights into Nepal's traditional building practices. This narrative prompted a personal reflection on my childhood in Nepal, where most

neighboring houses in Bhaktapur Municipality were constructed from mud, each with a distinctive and practical structure.

Typically, these mud houses utilized a load-bearing structure. The ground floor, fortified with at least two rows of thick walls, served a dual purpose – functioning as a cow shed and providing storage for firewood and straw, thereby creating a cohesive and multifunctional space. Transitioning to the first floor, the same robust wall structure persisted with wooden window, featuring rooms within half of a row. Moving upward, the second floor introduced a structural shift with a wooden beam replacing the central wall. This adaptation increased open space, fostering a conducive environment for social gatherings. Finally, the top floor, designed for the kitchen and terrace, incorporated wooden beams and mud walls. The architectural logic behind this structure was meticulous. The foundation comprised a high plinth made of mud, strategically constructed to prevent water seepage, and establish a sturdy base for the entire house. This unique blend of functionality and sustainability embodied the essence of traditional Nepalese mud house construction.

In recent years, Nepal has seen a significant shift from traditional mud houses to modern concrete houses. This transition has been driven by factors such as urbanization, population growth, and the aftermath of natural disasters. While the shift is driven by factors such as accessibility to modern materials and perceptions of durability, initiatives promoting eco-friendly technologies, including traditional mud-stone construction, are emerging. The surge in urbanization and population growth in Nepal, notably in the Kathmandu valley, has resulted in the construction of numerous concrete houses, with the Department of Urban Development and Building Construction reporting 69 completed and under-construction apartments in the valley, contributing to an overcapacity issue, as exemplified by the construction of 70,090 houses in the Kathmandu metropolitan city, seven times beyond its recommended limit, predominantly utilizing modern building materials like cement and concrete (Khadka, 2023). The shift from traditional mud houses to concrete houses in Nepal is influenced by several factors, including the availability of materials, changing preferences, and the impact of modernity. The accessibility of contemporary construction materials like cement and concrete has facilitated the construction of resilient and enduring structures, resulting in a gradual transition from traditional mud houses to concrete ones ("Timber replaced by concrete in home construction," 2023). The perception of greater durability and resilience to natural disasters, such as earthquakes and floods, has fueled a rising preference for concrete houses over traditional mud structures, particularly in urban areas (Khadka, 2023). The transition to concrete houses in Nepal has been driven by the impact of modernity and evolving lifestyles, with urbanization and industrialization fostering a preference for modern building materials and

techniques, resulting in a diminishing practice of traditional mud house construction (Dhungana, 2019). While the shift to concrete houses has been significant, there is also a growing awareness of the environmental impact of modern construction materials. As a result, some initiatives are promoting the use of sustainable and eco-friendly building technologies, including the revival of traditional mud-stone construction techniques (Budhathoki, 2021).

In the diverse architectural landscape of the Kathmandu Valley, encompassing stone, brick, cement-bonded stone, and reinforced concrete structures, a comprehensive study on earthquake disaster mitigation revealed varying degrees of damage among these building types, classifying them into seven categories—Stone structures, Brick structures, Cement-bonded stone structures and Reinforced concrete, with findings indicating that traditional construction methods like stone and masonry exhibited greater resilience to earthquake damage compared to cement-bonded stone and brick structures (Ohsumi et al., 2016). During these seismic challenges, the cultural fabric of Nepal remains intricately interwoven with traditional dwellings, prominently featuring mud houses. Rooted in history and passed down through generations, mud houses have been the sanctuaries of Nepalese communities, embodying a harmonious balance between cultural heritage and environmental sustainability (Shrestha, 2009). However, as globalization and urbanization cast transformative shadows, these venerable structures face the risk of neglect and obsolescence. Traditional Newari houses have proven to be stronger than modern construction methods in resisting earthquake damage due to their vertical use and construction materials (Chakradhar, 2015). The seismic vulnerability of Nepal has been starkly evident in the seismic events that have punctuated its history, leaving indelible imprints on the landscape and the lives of its inhabitants. The earthquake of 2045 B.S., etched in the memory of communities like Bhaktapur, not only claimed lives but also rendered thousands of houses uninhabitable, showcasing the critical need for resilient and sustainable housing solutions ("403 forbidden," n.d.).

Mud houses in Nepal have long been a significant form of construction, despite the weak strength of mud mortar and the brittle nature of unreinforced stone and brick masonry structures (Khadka, 2020). These houses hold cultural and historical importance in the country, reflecting Nepal's rich heritage and traditions. However, the devastating 2015 Gorkha earthquake exposed the vulnerabilities of these traditional structures, leading to a need for reconstruction efforts (Khadka, 2020). The aftermath of the earthquake revealed regional variations in reconstruction rates and delays, with many earthquake victims opting to repair their cracked houses or construct new ones without considering seismic safety and the current housing designs also fail to meet the space requirements of the local population (Khadka, 2020).

Mud houses in Nepal go beyond mere shelters; they serve as symbols of the country's cultural identity, embodying the ingenuity of Nepalese craftsmanship and their harmony with nature. Providing both comfort and protection against the region's unpredictable climate, these structures reflect the nation's rich history and deep-rooted traditions. This article delves into the challenges and opportunities associated with balancing tradition, sustainability, and modern needs concerning mud houses in Nepal. It focuses on aspects like their cooling effect, affordability, sustainability, and seismic resilient, integrating modernism and postmodernism theories into the discourse for a nuanced understanding of their place in the contemporary architectural paradigm. The exploration seeks to unravel the implications of cultural perspectives intertwined with theoretical frameworks, illuminating the delicate balance between preserving tradition and meeting the demands of the modern age. Despite vulnerabilities exposed by the 2015 Gorkha earthquake and the 2023 Jajarkot earthquake, mud houses in Nepal continue to symbolize cultural identity, craftsmanship, and harmony with nature. This prompts a critical exploration of challenges and opportunities in balancing tradition, sustainability, and modern needs, emphasizing the importance of cultural perspectives and theoretical frameworks in preserving Nepal's architectural heritage.

The mud houses in Nepal navigates a nuanced equilibrium between traditional, sustainable, and contemporary requirements. Rooted in cultural heritage, traditional mud houses boast a flexible design and environmentally friendly advantages. Despite their susceptibility to earthquakes, these structures persist as emblematic of Nepali identity. The rising prevalence of concrete constructions spurred by urbanization and disasters intensifies environmental apprehensions, prompting a renewed interest in sustainable technologies like traditional mud construction. Mud buildings continue to serve as a resilient alternative, offering natural cooling, cost-effectiveness, longevity, and earthquake resilient.

This article aims to explore the significance of mud houses in Nepal as a resilient housing option amidst urbanization and environmental concerns. Specifically, it addresses the following research questions: What are the benefits and challenges of mud houses compared to modern construction? How can traditional skills and community involvement enhance the sustainability of mud houses? What role does modern technology play in preserving these traditional structures?

This study employs a systematic literature review methodology, focusing on scholarly articles, books, and reports related to mud houses in Nepal and globally. The selection criteria included relevance to the topic, publication within the last two decades, and geographical focus on regions with similar climatic and seismic conditions. The review encompasses literature published from 2000 to 2023,

ensuring a comprehensive understanding of the current discourse surrounding mud houses.

Using modernism and postmodernism theory as analytical lenses, this paper analyzed the issue of mud houses. Modernism, a movement that emerged in the late 19th and early 20th centuries, sought new forms of art, philosophy, and social organization in response to the rapidly changing industrial world. It emphasized experimentation, innovation, and the rejection of traditional forms across various fields. Modernism is a philosophical, religious, and art movement that emerged in the late 19th and early 20th centuries, reflecting the desire for new forms of art, philosophy, and social organization in response to the rapidly changing industrial world ("Modernism," 2023). It encompassed various fields, including literature, art, and philosophy, and was characterized by a rejection of traditional forms and a focus on experimentation and innovation (Kuiper, 2009). Modernism represented a break from traditional forms of art and literature, which were considered outdated or obsolete and fostered a period of experimentation in the arts, particularly in the years following World War (Kuiper, 2009). Modernism encouraged impressionism, subjectivity, and a focus on how perception takes place, rather than on what is being perceived and saw the rise of self-consciousness and a commitment to principled self-scrutiny which This can be observed in various forms of art where the attention is on the process of creating or reshaping the environment through technology and knowledge ("Modernism," 2018).

Postmodernism, which emerged in the mid-20th century as a response to modernism, rejected universal truths and blurred the boundaries between high and popular culture. It embraced complexity, diversity, and multiple layers of meaning in artistic approaches. In anthropology, postmodernism emphasized the role of the anthropologist's own culture in understanding other cultures. Postmodernism is a movement that emerged in the mid-20th century as a response to modernism. Postmodernism is defined by its rejection of universal truths, blurring the lines between high and popular culture, embracing complex layers of meaning, and encompassing diverse art-making approaches such as pop art, neo-expressionism, feminist art, and the Young British Artists of the 1990s ("Postmodernism," n.d.). In anthropology, postmodernism insists that anthropologists must consider the role of their own culture in the explanation of the "other" cultures being studied (Salberg et al., n.d.).

Traditional mud houses in Nepal embody elements of both modernism and postmodernism. Modernism is evident in the incorporation of modern techniques and materials into these structures. Postmodernism is reflected in the preservation and celebration of local culture and history, showcasing a unique expression of identity through traditional architecture. Traditional mud houses have been

improved and updated with modern materials and techniques, such as the use of concrete and bricks in addition to mud (Onyejegbu et al., 2023). This combination of traditional and modern materials and methods demonstrates the willingness to experiment and innovate within the context of traditional architecture. Traditional mud houses in Nepal can be seen as a prime example of postmodernism in architecture, as they represent a unique expression of local culture, history, and environment. These houses are built using traditional techniques and materials, such as mud and straw, which are locally sourced and have been used for generations (Onyejegbu et al., 2023). The use of traditional materials and techniques in these houses reflects a commitment to preserving and celebrating local culture and history, rather than adhering to a universal standard of modernity.

Integrating both modernist and postmodernist perspectives, this paper offers a comprehensive understanding of mud houses in Nepal. The synthesis recognizes the significance of functional efficiency and safety (modernism) while embracing the cultural richness, diversity, and historical continuity embodied in mud houses (postmodernism). In this harmonious coexistence of tradition and modernity, efficiency is balanced with the preservation of cultural values. Employing modernism and postmodernism as theoretical frameworks, this exploration transcends simplistic dichotomies, delving into a nuanced analysis of mud houses. The aim is to unravel the complexities surrounding these structures and cultivate a deeper appreciation for their role in bridging tradition with the evolving needs of modern society. These theoretical frameworks act as guiding threads, weaving together various themes and perspectives embedded in Nepal's architectural heritage.

Findings and Discussions

Mud houses offer numerous benefits, including natural cooling, affordability due to readily available materials and lack of need for advanced technology, environmental friendliness from the use of natural materials and absence of fossil fuels (Khadka, 2020), seismic resistance achievable through proper design (Khadka, 2020; Adhikari & D'Ayala, 2020), and a low carbon footprint due to reduced transportation and energy efficiency, making them an eco-friendly and practical choice for construction (Times, 2022). However, mud houses exhibit challenges such as lower durability and fragility, requiring frequent maintenance, and their small size, potentially limiting community livelihoods (extraordinary benefits of a house made of mud, 2023; Adhikari & D'Ayala, 2020).

Harnessing Natural Coolness: The Sustainable Cooling Effect of Mud Houses

In my community, elderly residents often reminisce about how, in the past, mud houses provided warmth during winter and kept them cool in the hot season.

However, in recent times, the prevalence of concrete structures has led to a reversal of these effects. Nowadays, they find that concrete structures make the interiors feel excessively hot during the summer and uncomfortably cold in the winter. Researchers have explored the inherent qualities of mud as a building material, shedding light on its capacity to contribute significantly to energy efficiency and sustainable living. This literature review delves into key studies that have systematically investigated the cooling effect of mud houses, offering valuable insights into their environmental and thermal advantages. Research on mud houses and their cooling effect has shown promising results. Chel and Tiwari (2009) found that a mud house in India had significant energy and carbon savings, with an annual cooling energy saving potential of 1813 kW h/year. Guenot & Maury (1995) and Zhao et al. (2010) both highlighted the practical advantages of mud cooling systems, including improved borehole stability and safety in drilling operations. Gupta et al. (2017) further supported the cooling effect of mud houses, particularly those with courtyards, in a comparative study of thermal performances in different types of mud huts. These studies collectively suggest that mud houses can have a significant cooling effect, making them a sustainable and energy-efficient housing option. Mud houses have excellent thermal mass, allowing them to store and release heat slowly, maintaining a stable interior temperature throughout the day which means mud houses are warm in winter and cool in summer, providing natural insulation and concrete has a high thermal mass, which can make it less effective in areas with short cooling periods (Marsh, 2023).

Affordability

The utilization of inexpensive, locally accessible materials, labor-intensive construction, energy-efficient qualities, versatility in design, and general sustainability are the reasons why mud houses are less expensive. These elements make mud homes an environmentally benign and economically feasible dwelling alternative, especially in situations where resource efficiency and cost-effectiveness are critical. Mud houses are an affordable and eco-friendly option for housing, especially in regions where land and labor are abundant and inexpensive. Mud houses are also sustainable and environmentally friendly, as they use natural materials like mud, which is easily available and has excellent insulation properties. Mud houses, constructed with locally available materials like clay, sand, and straw, leverage abundant and easily trainable manual labor in rural areas, offering an eco-friendly and sustainable housing solution with a low environmental impact and high thermal mass for temperature regulation, minimizing energy consumption (Henderson, 2023). Affordable walling materials, including mud and burnt brick, are widely used in low-income areas (Kiptum et al., 2020). Mud bricks, in particular, are cost-effective and can be enhanced with additives to improve their properties (Bahobail, 2012). Mud concrete blocks have been found to be the most suitable and

sustainable walling material for affordable housing in the tropics (Udawattha & Halwatura, 2017). In sub-Saharan Africa, earthbag wall systems have been shown to be more cost-effective and thermally efficient than burnt brick walls (Wesonga et al., 2023). Mud houses are cost-effective due to the abundance of mud as a locally sourced material, which can reduce transportation costs. They also offer good insulation and soundproofing, further contributing to their cost-effectiveness (Chauhan, 2022). However, mud houses require regular maintenance, such as re-plastering and damp-proofing, to protect them from moisture damage and mud houses can be weak building materials, requiring frequent care and maintenance (Chauhan, 2022). Concrete houses are often more expensive than mud houses, as concrete and other modern materials are often imported and can be resource-intensive (Marsh, 2023).

Sustainability

Mud houses are examples of sustainability in many senses; they represent environmentally conscious building methods that take social, economic, and environmental factors into account. Mud is a natural and abundant material that does not require much energy to manufacture or transport. It is fully recyclable and biodegradable, making it a suitable choice for the environment (Marsh, 2023). Mud houses have excellent thermal mass, allowing them to store and release heat slowly, which helps maintain a stable interior temperature throughout the day. This makes mud houses warm in winter and cool in summer, reducing the need for artificial heating and cooling (Marsh, 2023). Mud houses are recyclable and biodegradable. The basic construction material, mud, is reusable, and when dismantled, the raw materials can be recycled and reused. This contributes to a circular economy and reduces waste (Chauhan, 2022). The production of compressed stabilized earth blocks for mud house construction, involving soil tempering, yields reusable blocks with high heat resistance, contributing to a lower carbon footprint compared to conventional construction materials, and minimizing temperature fluctuations in the surrounding environment and mud houses are fire-resistant, offering an additional layer of safety compared to concrete houses (Chauhan, 2022).

Seismic Resilience

A range of studies have explored the use of mud houses as a seismic resilience strategy in Nepal. Khadka (2020) and Gautam et al. (2016) both highlight the resilience of vernacular mud houses in the face of earthquakes, with the latter emphasizing the need for cost-effective and culturally reflective construction. Resilient features of traditional mud houses include wooden pillars, rounded Gurung houses, and construction techniques that provide better performance during earthquakes (Gautam et al., 2016). However, Hendriks and Opdyke, (2021) found that while earthquake-resistant construction knowledge was widely adopted

in reconstructed houses, there were variations in safer construction across communities. The Nyatapola Temple in Bhaktapur, Nepal, suffered minor damages during the 2015 earthquake due to its seismic-resistant design and solid structure featuring a massive plinth foundation, reinforced wooden struts and beams, elevated location, substantial weight (Times, 2019). Macabuag (2012) proposed a retrofitting technique using polypropylene packaging straps to enhance the seismic resilience of non-engineered masonry, which could potentially be applied to mud houses. These studies collectively suggest that mud houses, with appropriate construction and retrofitting techniques, can serve as a viable seismic resilience strategy in Nepal.

A critical theme in the literature revolves around the seismic resilience of traditional construction methods, particularly in the context of Nepal's vulnerability to earthquakes. Studies such as the work by Adhikari and D'Ayala (2020) on the 2015 Nepal earthquake provide valuable insights into the seismic performance of stone in mud mortar masonry buildings. Understanding the structural dynamics and performance of mud houses during seismic events is paramount in appreciating their enduring relevance in a region prone to earthquakes. However, the impact of modernization on these traditional houses, including changes in building materials and technologies, has led to their popular rejection following earthquakes (Forbes, 2018). To improve resilience, capacity building in both traditional and modern construction technologies, the use of local materials, and a transparent construction certification system are recommended (Forbes, 2018). The incorporation of indigenous skills and practices, such as the use of wooden studs and energy-dissipating construction details, is also crucial in enhancing the seismic resilience of these traditional mud houses (Dixit et al., 2002). In conclusion, while studies underscore the seismic resilience of traditional mud houses in Nepal, emphasizing the importance of culturally reflective construction and retrofitting techniques, challenges persist, including variations in safer construction practices across communities and the impact of modernization, necessitating a holistic approach that combines indigenous skills, capacity building, and transparent certification systems to ensure the enduring viability of mud houses as a seismic resilience strategy.

Failures of Mud House in the 2015 Earthquake and the 2023 Jajarkot Earthquake

Despite their advantages, mud houses present challenges, including lower durability, fragility, and the need for frequent maintenance (extraordinary benefits of a house made of mud, 2023; Adhikari & D'Ayala, 2020). The small size of mud houses may also pose limitations on community livelihoods. These challenges underscore the importance of addressing structural and economic aspects when considering mud houses as a housing option. During the devastating earthquake in

2015 in Nepal, mud houses were found to be highly susceptible to collapse (Khadka, 2020). Similarly, in the 2023 Jajarkot earthquake, the majority of the houses damaged were old and traditional mud houses, according to officials (Shrestha, 2023). The vulnerability of mud houses during the 2015 Gorkha earthquake and the 2023 Jajarkot earthquake can be attributed to factors such as inadequate construction techniques, weak building materials, lack of building code implementation, poorly built houses, and cultural and economic factors. Mud houses are susceptible to earthquake damage due to some attributes of materials consisting of less stiffness, brittleness, and poor bonding (Awall et al. 2019). Inadequate construction techniques and lack maintenance contributed to the collapse or damage of mud houses during these earthquakes (Khadka 2020). The 2015 earthquakes have failed to implement the building code, which has fixed certain standards for houses to be built with mud-bonded bricks (Shrestha, 2023). As a result, many mud houses were damaged or collapsed during these earthquakes. The Jajarkot earthquake raised concerns about poorly built houses, as many local governments have yet to implement the building code (Shrestha, 2023). Experts say that Nepal's response to the Jajarkot earthquake has shown it has developed its search and rescue capabilities, but the country's preparation for future disasters is still inadequate (Ghimire, 2023). Mud houses are an integral part of Nepal's architectural heritage and are symbolic of local culture and history and the shift towards concrete construction has led to a decline in traditional mud house construction, potentially threatening the preservation of local building techniques and materials (Daly et al., 2023). While traditional mud houses in Nepal embody cultural heritage and sustainable practices, their susceptibility to seismic events and structural challenges necessitate careful consideration of construction techniques, building codes, and maintenance practices to enhance resilience and mitigate risks. Balancing the preservation of architectural traditions with the implementation of improved technologies and practices is crucial for ensuring the longevity and safety of mud houses in the face of natural disasters and evolving building standards.

Blending of Modern Technology

The integration of modern technology into traditional mud houses has been a topic of interest in sustainable construction. Modern mud houses offer several advantages due to the use of contemporary materials and construction techniques. Integrating modern technology into traditional mud houses can enhance their sustainability, durability, and comfort. Efforts are underway to seamlessly incorporate traditional Nepali architectural motifs into new constructions, recognizing the technologically resilient nature of vernacular construction technology in Nepal, particularly against floods and earthquakes, and fostering a growing awareness of the need to preserve the country's rich architectural heritage

by integrating modern technologies to enhance overall resilience and sustainability (Gautam et al., 2016). Modern insulation materials, such as polymers or mineral wool, can be used to improve the thermal performance of mud houses, providing better insulation than traditional methods ("Utilities one," 2023). Solar-powered ventilation systems can be installed to improve indoor air quality and reduce the need for artificial lighting, making mud houses more energy-efficient ("Mud: An eco-friendly construction materials," 2020). Rainwater harvesting systems can be integrated into mud houses to collect and store rainwater for use in daily activities and agriculture, reducing dependence on scarce water resources and energy-efficient lighting solutions, such as LED lights, can be used to reduce energy consumption in mud houses, making them more sustainable and cost-effective ("Mud: An eco-friendly construction materials," 2020).

Blending modern house construction and traditional mud house construction can involve incorporating contemporary materials and techniques while maintaining the unique characteristics of mud houses. This approach can help preserve cultural heritage, enhance sustainability, improve earthquake resistance, utilize local materials, and provide affordable housing options. Integrating modern materials like steel, concrete, and glass into traditional mud house construction can enhance the structural integrity and durability of the building, while still maintaining the eco-friendly benefits of mud houses (Home page, 2023). By combining traditional techniques with modern sustainable practices, such as rainwater harvesting, solar panels, and energy-efficient lighting, can improve the overall sustainability of mud houses (Home page, 2023). Mud houses, deeply rooted in Nepal's historical and cultural fabric, serve as tangible expressions of local identity (Shrestha, 2009). Blending modern construction techniques with traditional design elements, such as intricate woodwork and traditional architectural styles, can help preserve Nepal's cultural heritage while incorporating modern amenities (Home page, 2023). Incorporating modern earthquake-resistant techniques, such as reinforced mud construction or earthen bag construction, can enhance the seismic resilience of mud houses, while still maintaining their unique appearance (Adhikari & Johnson, 2015). Utilizing local materials, such as stone and brick, can be combined with modern construction techniques to create structures that are both culturally appropriate and sustainable (Home page, 2023). Blending modern and traditional construction methods can result in more affordable housing options, as mud houses can be built using locally available materials and labor (Marsh, 2023).

Striking a Balance Between Tradition and Innovation in Mud House Construction

The discourse on mud houses reveals a spectrum of advantages and challenges, forming the foundation for a nuanced discussion on their role in sustainable and

resilient housing. Positioned as an eco-friendly alternative with potential widespread adoption, traditional mud houses offer benefits like natural cooling, affordability, and a low carbon footprint, showcasing a return to the wisdom of building with locally sourced materials, as demonstrated in studies conducted in India and beyond.

Aligned with sustainability principles, the affordability of mud houses, rooted in readily available materials and manual labor, challenges resource-intensive concrete structures, particularly in regions abundant with land and labor. However, this narrative takes a turn when confronted with the reality of durability issues and the need for frequent maintenance, potentially limiting their application in diverse community settings.

Mud houses emerge as sustainable solutions not just for environmental friendliness but also for seismic resilience, highlighted in studies on earthquake resilience in Nepal. Yet, a dichotomy surfaces with reports of vulnerabilities during earthquakes, emphasizing the critical role of construction techniques, building codes, and cultural factors in ensuring resilience.

Contemplating the future of mud houses naturally leads to a shift in the discussion towards the incorporation of modern technology. The blend of traditional construction with contemporary innovations, from solar panels to rainwater harvesting systems, seeks to address challenges while preserving the essence of mud house living.

The findings underscore the importance of educational programs and workshops aimed at empowering communities to sustain traditional construction methods while embracing modern advancements. These initiatives could significantly impact future practices and policies in mud house construction by fostering a culture of knowledge transfer and innovation. For instance, training programs could focus on modern building techniques that complement traditional methods, ensuring the longevity and safety of mud houses in the face of changing environmental conditions.

This blending of modern and traditional approaches aims to leverage the strengths of both, enhancing sustainability, structural integrity, and comfort. Striking a balance between cultural heritage and the demands of a changing world, the discussion extends beyond technology to encompass socio-economic factors. A holistic approach, embracing indigenous skills, transparent certification systems, and capacity building, is urged to ensure the longevity and safety of mud houses.

In navigating this discourse, it becomes evident that the future of mud houses lies in a thoughtful integration rather than an outright rejection of tradition or an uncritical embrace of modernity. The challenge is not merely technological but

socio-cultural, demanding a delicate equilibrium to propel mud houses into a resilient and sustainable future. The findings emphasize community involvement in mud house construction, with traditional skills passed down through generations, extending to knowledge transfer initiatives, advocating for educational programs and workshops empowering communities to sustain traditional construction methods while embracing modern advancements when appropriate.

The literature review reveals several key findings regarding mud houses in Nepal. Firstly, while mud houses offer significant benefits such as affordability, natural cooling, and seismic resilience, they also face challenges, including durability issues and the need for frequent maintenance. Community involvement is crucial, as traditional skills passed down through generations enhance the construction process. Furthermore, the integration of modern technology, such as solar panels and rainwater harvesting systems, presents opportunities to improve the structural integrity and comfort of mud houses.

Conclusion

The discourse on mud houses in Nepal passes through a delicate balance between traditional, sustainable and modern needs. Traditional mud houses are rooted in cultural heritage, exhibiting a versatile design and environmentally friendly benefits. Despite the vulnerabilities revealed by earthquakes, these structures remain symbols of Nepali identity. The increasing trend of concrete buildings driven by cities and disasters is exacerbating environmental concerns, fueling the resurgence of sustainable technologies such as traditional mud construction. Mud buildings remain an alternative resilient through natural cooling, affordability, durability and earthquake resilience.

The incorporation of modern technology in mud houses appears as a strategic approach, addressing issues of convenience and maintenance. This mix enhances the integrity and comfort of the building while preserving the essence of mud home living. In housing development, a holistic approach, including community involvement, knowledge transfer and educational programmes, is crucial. Balancing tradition and innovation ensure longevity for mud houses that represent not only accommodation, but a reflection of Nepal's cultural identity and environmental harmony. The future depends on thoughtful inclusion, acknowledging social and cultural challenges, and acknowledging progress towards resilient and sustainable housing.

In conclusion, this article highlights the delicate balance between tradition, sustainability, and modern needs in the context of mud houses in Nepal. By addressing the challenges and opportunities identified through the literature

review, this study contributes to the ongoing discourse on sustainable housing solutions that honor cultural heritage while meeting contemporary demands.

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