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Original Article

Transitional Shelters for Migrants in India: A Review of Low-Cost Rapid Construction Technologies

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Abstract - *India faces an increasing need for transitional shelters due to high internal migration and frequent natural disasters. Migrant workers, especially in construction and informal sectors, often live in unsafe, temporary conditions without access to basic services. This review explores low-cost, rapid construction technologies for transitional shelters tailored to India's socio-economic and climatic needs. It evaluates modular systems, prefabricated panels, 3D printing, and traditional methods using local and recycled materials, based on criteria like Affordability, construction speed, environmental impact, and cultural suitability. Case studies from India are examined alongside global examples to highlight practical applications, challenges, and success rates. The central role of NGOs and government schemes, as well as gaps in long-term performance data and inclusive policy frameworks, are also discussed. Findings suggest that while multiple technologies are promising, their success depends on community participation, policy support, and field-level validation. This review identifies research gaps in lifecycle assessment, user adaptation, and urban and disaster planning integration. It recommends future directions involving pilot projects, digital tools, and cross-sector collaboration to develop inclusive, sustainable, and scalable shelter solutions for vulnerable migrant populations..*

Keywords - *Transitional shelters, Low-cost housing technologies, Migrant workers, Modular construction, Disaster-resilient housing.*

1. Introduction

India is home to millions of people who migrate from one place to another in search of work, especially in the construction and informal sectors. Most of this movement happens within the country, from rural areas to cities or across state borders. States like Uttar Pradesh, Bihar, Jharkhand, and West Bengal see many people moving out, while cities such as Mumbai, Delhi, Chennai, and Ahmedabad attract incoming workers [1]. These migrants usually engage with short-term or seasonal jobs since they are frequently on the move and their stay is temporary and unpredictable, making them rarely receive formal housing support [2]. Due to their poverty, many of them are forced to live in slums, rented rooms in poor condition, or on construction sites in makeshift tents, often without access to water, sanitation, or safety [3]. These conditions make an urgent need for transitional shelter homes that are affordable, movable, and quick to build.

Transitional shelters were a prime solution for people who lost their homes during severe disasters like floods, earthquakes, or conflicts and for those facing economic or job-related displacement [4]. Transitional shelters give migrants more durability, insulation, and privacy [5]. They should be designed to last months or even years until families move into permanent homes. Using local materials such as bamboo, timber, or corrugated metal sheets keeps costs low, makes repairs simple, and allows upgrades over time [6]. These shelters provide safe, stable living spaces that help people regain confidence and dignity while they rebuild. In India, they are vital because the country often faces natural disasters. Internal migration in India has a long history. It has been driven by rural distress, seasonal work, and uneven development since independence. In the 1960s and 70s, many people moved to cities such as Mumbai, Kolkata, and Delhi, leading to informal settlements that were never formalised. Housing programs like the Sites and Services Schemes (1970–1980) and Valmiki Ambedkar Awas Yojana (2001) were created for the urban poor, but often left out migrants without permanent addresses. Even newer programs like Pradhan Mantri Awas Yojana have struggled to include mobile or circular migrants because of strict eligibility rules. These gaps show an ongoing disconnect between housing policies and the realities of internal migration.

In 2023 alone, India faced migration of more than 500,000 people due to events such as floods, cyclones, and earthquakes. Since it was lower than in 2022, when

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displacements reached 2.5 million, it still reflects the country's vulnerability [7]. Human-made events such as localised violence and conflict created an unrest situation among people in Manipur and displaced over 67,000 people in the same year [8]. While internal migration has shown signs of slowing, the need for temporary housing in disaster-affected and high-risk regions remains critical. In most cases, rebuilding permanent homes for migrants can take months or even years [9]. In this condition, the transitional shelters help bridge this gap, offering a safe space during recovery. India also faces a major urban housing crisis, with over 18 million homes in short supply, primarily affecting low-income families and migrant workers [10].

Rapid urbanisation, high land costs, and slow approval processes have made it challenging to keep up with demand for affordable housing. The Indian Government introduced schemes like Pradhan Mantri Awas Yojana (PMAY) to address this. Still, migrant workers often miss out due to a lack of documents or permanent addresses [11]. During COVID-19, the government set up temporary shelters in some cities, but these efforts were short-lived and lacked consistency [12]. In today's scenario, most housing policies still focus on permanent solutions, leaving a clear policy gap regarding transitional and mobile shelter options. Several NGOs and grassroots organisations, such as SPARC, Aajeevika Bureau, and SEEDS India, have provided temporary housing, night shelters, health services, and legal aid for migrant workers and have tried to fill this gap [13]. These organisations work in partnership with local governments to run community kitchens, mobile toilets, or shelter homes. However, the scale of the problem demands greater collaboration between the government, NGOs, and private players to build scalable and sustainable transitional housing models [14].

While several studies address post-disaster housing and urban poverty, very few focus on the intersection of migrant labour and transitional shelters in the Indian context. Existing literature either emphasises disaster relief or long-term housing, leaving a gap in evaluating low-cost, rapid, and flexible shelter technologies suited to India's mobile and vulnerable populations. Additionally, there is limited synthesis of traditional and emerging construction technologies within the same framework. This review bridges that gap by comprehensively comparing modular systems, prefabrication, 3D printing, and indigenous methods to propose contextually relevant solutions.

Figure 1 depicts the conceptual framework for Transitional Shelter Solutions. India experiences high levels of internal migration driven by seasonal employment, economic distress, and climate-related disasters. Despite playing a significant role in urban development, migrant workers frequently live in informal, unsafe, and unhygienic shelters without access to basic services. These inadequate housing conditions lead to social exclusion, poor health outcomes, and increased vulnerability, especially during crises. Although some policy interventions exist, they mainly focus on permanent housing and overlook the urgent, flexible shelter needs of migrants. Transitional shelters are not only practical, but they are also aligned with global development goals. They directly support the United Nations Sustainable Development Goals (SDGs), especially SDG 11 (Sustainable Cities and Communities), SDG 1 (No Poverty), and SDG 10 (Reduced Inequalities), by offering safe and inclusive living conditions for the most vulnerable [12]. They also support SDG 3 (Good Health and Well-being) by protecting people from exposure, disease, and stress. Furthermore, when built with locally available or recycled materials, transitional shelters promote SDG 12 (Responsible Consumption) and SDG 13 (Climate Action), making them a sustainable and responsible solution for a recurring challenge. Low-cost, rapid construction technologies can be effectively used to build transitional shelters for migrant populations in India [15].

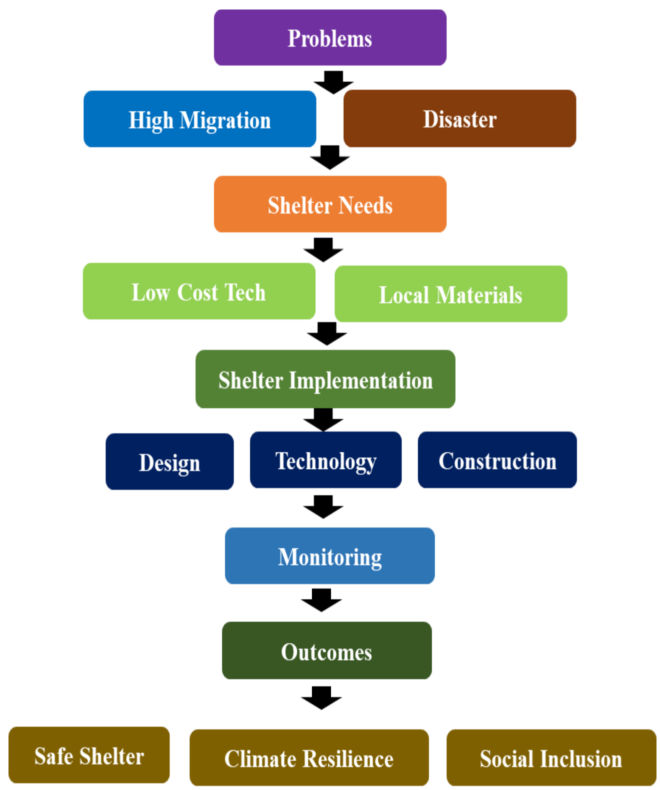

Fig. 1 Conceptual framework for transitional shelter

This article examines both modern modular units and traditional building methods to determine which approach is most effective in India. It reviews research, case studies, and practical examples to show what is possible, culturally suitable, scalable, and sustainable. It also identifies policy and knowledge gaps that affect the quality of life for migrant workers, who help build cities yet struggle to find adequate housing. While past research has often focused on disaster response, urban housing, or migrant labour, few studies have examined how low-cost and rapid construction methods can meet the transitional shelter needs of migrant workers in India. This review addresses that gap by assessing modular systems, prefabricated panels, traditional practices, and green materials for their fit with Indian conditions. Its value lies in combining technology assessment, social needs, and policy analysis to give a complete picture. The goal is to show what works, what does not, and what still needs attention to create safe, affordable, and dignified housing for India's most vulnerable mobile populations.

This review is novel in combining various low-cost, rapid construction technologies such as modular units, prefabricated panels, 3D printing, recycled materials, and traditional Indian methods into a single comparative framework that directly addresses the transitional shelter needs of migrant workers in India. Bardhan and Debnath [16] studied thermal comfort in modular housing 16, and Chippagiri et al. [17] studied energy efficiency in prefab systems. However, neither examined how these technologies could be adapted for mobile and underserved populations. This study goes further by comparing their practical use under real Indian conditions, examining policy gaps, and including case studies from NGOs and post-disaster projects. It also links traditional eco-friendly materials with modern building practices to suggest scalable and sustainable shelter solutions.

This integrated approach fills a significant gap in existing literature and provides a holistic basis for future research, planning, and implementation of transitional shelters. Over the past two decades, research on post-disaster housing, urban informal settlements, and affordable housing technologies has grown globally. Many studies emphasised temporary shelters' cost and energy performance, while others, like Faragallah [18], proposed models for semi-permanent, sustainable housing. In the Indian context, Biswas [19] and Srivastava [11] explored gaps in temporary housing policies, but these have mainly addressed disaster recovery rather than ongoing migrant housing needs. Technical research by Mahadevan et al. [20] and Barbhuiya et al. [21] has shown the potential of 3D printing and recycled materials, yet lacks focus on real-world applications for mobile populations. This review builds on these foundational studies by combining policy, technology, and local construction practices to address a clear research gap specific to India's migrant workers and their transitional housing needs.

2. Necessity of Transitional Shelters

India's large-scale internal migration has exposed millions of people to poor living conditions, especially during crises like natural disasters, pandemics, and urban evictions. Immanuel et al. [22] explained that the events, such as the floods in Assam, cyclones in Odisha, and the nationwide COVID-19 lockdown, have displaced countless families. Ghosh et al. [23] related that the migrant construction workers who make up a significant part of the urban labour force often live in overcrowded, unsafe, and unhygienic makeshift settlements. These scenarios reveal the urgent need for transitional shelters that can be a practical bridge between short-term emergency relief and long-term housing solutions. To fully understand the value of transitional shelters, it is important to distinguish them from temporary and permanent housing.

Yu et al. [24] revealed that temporary shelters are usually basic structures like tents or tarpaulin setups provided immediately after a disaster. Temporary shelters are quick to set up but lack durability and comfort. Yau et al. [25] elaborated how permanent housing offers long-term infrastructure with formal services and legal ownership, but it often takes years to plan, fund, and build.

Haque [26] analysed migrant workers in India, especially those in seasonal or project-based jobs, and found that transitional shelters can be essential [26]. Many individuals do not qualify for housing schemes like Pradhan Mantri Awas Yojana due to a lack of required documents or a permanent address.

Global research, including a bibliometric review by Lyu et al. [27], showed that unstable housing is a serious problem for migrant construction workers worldwide. Many face wage discrimination, poor health, and exploitative work conditions, all made worse by inadequate housing. Lombard [28] highlighted that these issues are heightened in India by unregulated labour practices and urban planning that often overlook temporary or mobile populations. Poor shelter harms both physical and mental health. It leads to more workplace injuries, unhygienic living conditions, and stress and limits access to clean water and healthcare. A study by Harun et al. [29] proposed semi-customised container housing for migrant workers, offering a scalable, quick-to-build option that could work in India.

To be truly effective, transitional shelters must follow certain key design principles as shown in Figure 1. These principles are informed by international best practices and the specific needs of India's migrant communities. Tortorici et al. [30] highlighted that Cost-effectiveness is essential. Materials such as ferrocement, Glass Fibre Reinforced Gypsum (GFRG), stabilised mud blocks, or recycled items like plastic bricks and fly ash blocks should be affordable and locally available.

Wagemann [31] indicated that Modular construction or prefabrication can further cut costs and allow mass production. Speed matters, especially after disasters or mass evictions. Wardeh et al. [32] studied how technologies, such as prefabricated container units and digitalised workflows, enable construction within days, reducing downtime and ensuring quick recovery for affected populations. Given the mobility of migrant labour, shelters should be easy to move or reuse.

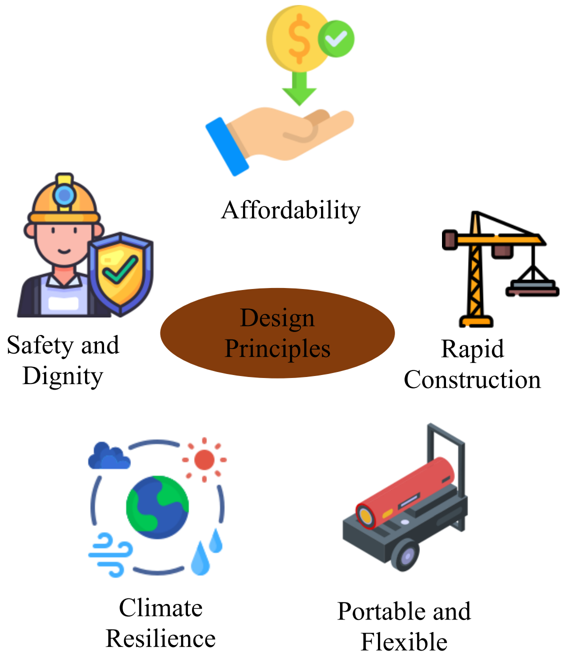

Fig. 2 Design principles of transitional shelters

Perrucci et al. [33] characterised Modular units that can be dismantled and reassembled in new locations as ideal for rural and urban settings. This is particularly useful for project-based workers who shift locations frequently. India's varied climate requires shelters that withstand extreme heat, heavy monsoon rains, and strong winds. Kuchai et al. [34] highlighted that Shelters must meet basic safety, hygiene, and privacy standards. Secure doors, fire-resistant materials, proper ventilation, and separate sanitation for men and women create safer, more dignified living spaces. Haque et al. [35] investigated the fact that better living conditions are linked to improved safety on construction sites. Transitional shelters are more than just physical structures. They can support social inclusion and economic empowerment. Yap [36] analysed facilities such as community kitchens, learning centres, and digital hubs that help residents build connections, access services, and prepare for jobs. This shift from basic housing to inclusive habitation can improve quality of life and long-term outcomes. Integrated shelter planning also strengthens national resilience. Meeting housing needs during periods of transition helps India respond to migration trends, protect public health, and move toward Sustainable Development Goal 11 for inclusive, safe, resilient, and sustainable cities.

Cultural relevance is key to the long-term success of transitional shelters. Involving local communities, especially migrants, artisans, and traditional builders, in planning and design ensures that shelters match local preferences, customs, and climate needs. This participatory approach builds a sense of ownership, which improves maintenance and reduces the risk of abandonment. NGO-led projects have shown that shelters designed with community input fit local lifestyles better and are more likely to be reused or upgraded. Including community voices is socially inclusive and an effective way to create meaningful, sustainable shelter solutions. When linked to broader development goals, transitional shelters can support social integration and economic mobility for migrant communities. Safe, stable, and hygienic living conditions make it easier for migrants to find nearby jobs, enrol children in school, and access health and legal services. Shelters with shared spaces, learning hubs, or digital access points can help residents build skills, secure steady work, and adapt to urban life. Over time, this leads to better economic outcomes and lowers the risk of social exclusion. Transitional housing should be seen as a temporary fix and a step toward long-term settlement, inclusion, and self-reliance.

3. Translational Housing Technologies

To assess the suitability of different construction methods for transitional shelters in India, this review considers six key criteria derived from international best practices and local needs such as Affordability, or cost-effectiveness for large-scale deployment, Speed of construction, crucial in post-disaster or migrant contexts, Structural performance, including strength and seismic resilience, Thermal comfort and environmental adaptability, especially for India's varied climates, Sustainability, in terms of material reuse, carbon footprint, and waste reduction and Social acceptability and cultural relevance, which influence long-term use and maintenance. Each technology is reviewed through this lens to provide a comprehensive understanding of its strengths, limitations, and applicability in the Indian context. Transitional shelters are an emerging solution that needs to be built quickly, cost-effectively, and with materials that provide comfort and protection for migrants and low-income people. In India, during disasters, some areas experience high migration rates that demand rapid housing solutions. Several construction technologies, both traditional and modern, have been explored. This section reviews key technologies suitable for low-cost, rapid shelter construction, focusing on their performance, practicality, and relevance to Indian conditions.

3.1. Modular Construction

Modular construction is a technique or process of building structures using prefabricated units or readymade modules manufactured off-site under controlled conditions and quickly assembled on location. Figure 2 depicts the efficiency of modular construction in low-cost, affordable housing. This method has gained attention in various housing contexts due to its potential for Affordability, flexibility, and sustainability. Bardhan and Debnath [16] studied in India, The performance of this modular construction was evaluated for its thermal comfort of modular low-cost homes in Mumbai, simulating different combinations of wall and window using low-cost materials like cement bonded boards, GFRG panels, and gypsum boards did not meet ASHRAE-55 standards, highlighting the greater influence of wall materials over windows on indoor comfort, and stressing the need for climate-appropriate alternatives [16]. Kim et al. [37] state that, looking at student housing, a habitability, sustainability, and affordability framework was applied to assess modular dormitories. While these units showed flexibility and reusability, thermal comfort and ventilation remained significant concerns. This study suggested that government support and the use of underutilised land could improve the feasibility of modular housing for students. Similarly, Lee et al. [38] have explored modular construction for small-scale public rental housing projects in Seoul and found it feasible despite higher costs. The study highlighted environmental benefits achieved through repetition, including reduced material waste and increased productivity. It introduced a novel scheduling method that centres on on-site installation timing, improving risk and time management. Figure 3 depicts the efficiency of modular construction for translational housing.

Dara et al. [39] compared a standard model to an improved version with passive solar strategies in container-based housing. The enhanced design reduced energy consumption by up to 79% and life cycle costs by 10%, showing that even shipping containers can be turned into sustainable, energy-efficient homes. Supporting this, Romero et al. [40] analysed the WikiHouse Skylark 250 system, which uses wheat straw insulation and clay plaster to achieve Net Zero energy performance (55 kWh/m²/year). It also reduced construction time by 44% and cost by 29%, proving the benefits of modular design paired with renewable energy.

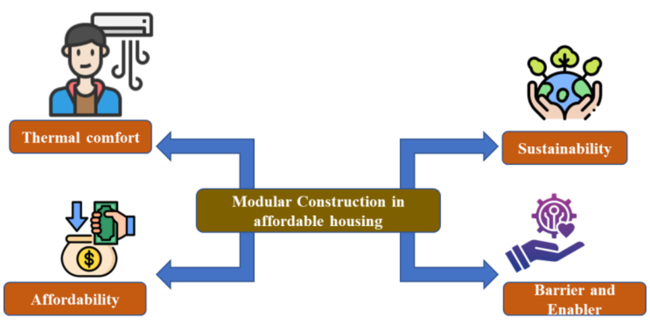

Fig. 3 Efficiency of modular construction

In another study, Khan et al. [41] identified 111 Modular integrated Construction (MiC) drivers in affordable sustainable housing, with social acceptance and user satisfaction ranking highest, followed by productivity and supportive policies, underscoring the need for institutional and community-level backing. Technical innovations continue to strengthen modular housing's relevance. Zukowski [42] demonstrated how a small modular house designed for cold climates could achieve zero-energy balance through energy simulations. Key strategies, including using a ground source heat pump, optimisation of solar angles, and installing PV panels, resulted in a 35% reduction in primary energy use. Lastly, Rockwood et al. [43] presented a modular, climate-responsive housing system using Fibre Reinforced Cementitious Composite (FRCC) for Pacific island nations. These precast components were easy to assemble, structurally robust, and adaptable to cultural needs, with safety factors exceeding 12 and 24 for standard and reinforced panels, respectively. It was inferred that modular construction offers a practical and adaptable path to sustainable housing when supported by thoughtful design, suitable materials, and strong institutional backing.

3.2. Prefabricated Panels

Prefabricated panels are readymade components for walls, roofs, or floors manufactured in factories and quickly assembled on-site. These systems benefit transitional and low-cost housing in India, where fast and affordable construction is crucial, particularly for migrants and people displaced by disasters. Lightweight materials like GI sheets, bamboo composites, and cement boards are commonly used, making these panels easy to transport and suitable for remote or high-mobility areas. Several innovations have emerged in the Indian context. Puri et al. [44] study also showed that prefabrication becomes economically viable for housing projects with more than 100 units of 25 m² each. They have proposed bamboo-reinforced wall panels that are 56% lighter and 40% cheaper than traditional brick walls while offering similar strength, and these panels also contribute to reducing greenhouse gas emissions by lowering the use of cement and bricks.

During environmental performance, Berizzi et al. [45] have demonstrated the possibility of using prefab mobile homes with 92% natural, 35% recycled, and 100% recyclable materials without any increase in production costs. Such designs show that prefab systems can be sustainable and visually integrated with natural surroundings. Sah et al. [46] also comprehensively reviewed five prefabricated wall systems, focusing on Precast Concrete Sandwich Panels (PCSPs). These offer high structural performance and thermal efficiency, but face challenges like better shear connectors and more sustainable materials. A modular housing prototype has been introduced to address flexibility and structural resilience in urban settings, combining prefabricated panels with a frame of pillars and beams. Djukanovic et al. [47] approach allows diverse housing designs, better cost control, and strong earthquake resistance.

In structural performance, Boafo et al. [48] have assessed modular prefabricated buildings for thermal comfort, acoustics, energy use, and seismic behaviour and found that prefab systems improve construction quality, reduce waste, and offer meaningful environmental benefits. Meanwhile, Riggs et al. [49] have conducted studies on prefab micro-units in the U.S., demonstrating that combining compact design with modular methods can increase the supply of affordable housing. However, they identified key adoption barriers, including zoning restrictions and limited financing options. Finally, Linger [50] has explored the cultural appeal of prefabricated homes in France, noting that they suit mobile workers and retirees, with many buyers treating them as flexible investments rather than permanent family homes. To summarise, prefabricated panel systems are an innovative solution for India's housing needs, offering Affordability, faster construction, environmental benefits, and design adaptability. However, challenges such as material performance, regulatory support, and access to financing must be addressed to scale adoption in wide construction applications.

3.3. 3D Printing

3D printing, a recent emerging technology using additive manufacturing, provides a promising method for building low-cost transitional housing, especially for migrants and displaced populations. This technology allows automated layering of materials like concrete to create entire homes within days, using minimal labour and reducing material waste. Studies have highlighted the potential of 3D printing in affordable housing, especially in South Africa, and emphasise the need for awareness, training, government support, and cost reduction of printers to drive wider adoption. In India and similar developing regions, 3D printing is gaining traction for quickly delivering customised, eco-friendly homes. Similarly, technology has demonstrated efficiency in addressing Nigeria's housing deficit by enabling rapid construction, reducing errors, and enhancing safety, particularly for internally displaced individuals affected by urban pressures and conflicts.

Towards sustainability, Moghavedi et al. [51] showed that using 3D printing in the construction of houses in Africa helps to reduce carbon emissions by 48% and labor use by 72%, their life cycle costs are still 381% higher due to proprietary materials, stressing the need for locally available, affordable alternatives with less labor and economic implications. Md. Hossain et al. [52] noted that 3D printing reduces construction time, material waste, and workforce needs, and that the impact on labor markets varies based on local workforce structures, especially in countries relying heavily on immigrant labor. Further, a study by Allouzi et al. [53] stated that a 65% reduction in concrete costs for a public building project in Jordan underscored the financial advantages of this approach in developing regions, which helped demonstrate cost savings [53].

From a technological perspective, Singh et al. [54] explored the use of 3D printing combined with Cloud Manufacturing (CM) and the Internet of Things (IoT), which helps to enhance construction sustainability and efficiency. Similarly, a review by Wu et al. [55] showed that the synergy between 3D printing and Building Information Modelling (BIM) has been reviewed, noting its potential for mass customisation and better project control. However, both studies were thoughtful about challenges in scalability, material limitations, and life cycle uncertainties. In brief, 3D printing offers an innovative path for rapid, customizable, and low-labor housing solutions for migrants. Yet, to scale effectively in India, it must overcome high material costs, energy inefficiency, and the need for localized manufacturing strategies that align with the country's economic and environmental conditions.

3.4. Traditional Indian Methods

Traditional Indian construction techniques offer time-tested, low-cost, and eco-friendly solutions that are particularly valuable for transitional shelters in rural and disaster-prone areas. These methods rely on locally available materials such as mud, bamboo, cane, rice husk, fly ash, and recycled components, which are naturally insulating, easy to build, and culturally familiar to many communities. For example, Madhumathi et al. [56] explained that the mud houses in Meenakshipuram, Tamil Nadu, have shown excellent thermal performance, maintaining cooler indoor temperatures during hot weather, thanks to thick mud walls and thatched roofing. Similar benefits were observed by Ashraf et al. [57] in traditional homes in rural Lucknow, where indoor temperatures stayed 4–6°C cooler than outdoors, reinforcing the value of mud's insulating properties.

Bain [58] and Dash et al. [59] highlighted that the Bamboo construction is another widespread and sustainable practice, especially in the northeastern states of Assam, Mizoram, and among the Lepcha community in Sikkim. These communities use bamboo for walls, roofing, flooring, and livestock shelters, with different species selected for specific roles. Singh et al. [60] described northeast India's diverse climates, bamboo, cane, mud, and wood, which are adapted into designs with passive solar features that naturally improve thermal comfort and energy efficiency. Traditional building methods face both social and material challenges. Kulshreshtha et al. [61] noted that earthen construction is affordable and sustainable, but often rejected because it is seen as outdated or inferior. Studies show these designs also need adjustments for current climate conditions. For example, Gupta et al. [62] found that conventional mud huts in Ranchi now trap more heat at night due to changing temperatures. They recommend thinner walls, better ventilation, and improved insulation to maintain comfort.

Deb [63] analysed the recent innovations that have promoted materials such as stabilised mud blocks, fly ash bricks, calcium silicate, and lightweight concrete panels as alternatives to conventional bricks and cement. These options are beneficial where traditional construction needs reinforcement or adaptation for better durability and scalability. Cherian et al. [64] have further supported this by demonstrating that GFRG (Glass Fibre Reinforced Gypsum) construction uses 16% less embodied energy, 25–44% less raw material, and significantly cuts down on time and labour, showing how traditional ideas and modern innovations can come together. In a broader context, Hu [65] reviewed eight low-carbon, bio-based materials commonly found in vernacular architecture, like adobe, bamboo, straw bales, cob, and rammed earth and links them to sustainable construction practices.

The study emphasises design for disassembly and modularity, concepts found in traditional buildings, which help reduce construction waste and promote a circular economy in the building industry. To put it briefly, traditional Indian methods offer valuable, adaptable solutions for transitional housing, especially when updated to meet modern needs. Combining local materials, passive design strategies, and community engagement can lead to cost-effective, climate-resilient, and culturally sensitive shelters for migrant populations.

3.5. Recycled Waste Materials

Recycled waste materials have emerged as a practical and eco-friendly solution for building transitional shelters in India, especially for displaced and low-income populations. Using these materials leads to cost reduction and also helps to address pressing environmental issues such as plastic waste and industrial byproducts. It is necessary to conduct a wide range of studies to explore the effectiveness of recycled components like Expanded Polystyrene (EPS), fly ash, plastic waste, and earth-based materials in low-cost construction.

In particular, EPS panels are gaining attention for their lightweight, insulating, and durable properties. Lee et al. [66] evaluated several EPS-based panels made using fibre-reinforced and wire mesh varieties. They found they met essential safety, cost, and fire resistance standards for housing in developing nations.

Fernando et al. [67] have demonstrated the effectiveness of recycled EPS panels for walls and roof insulation, showing improvements in operational energy use and life cycle costs. Surendra and Ravindra [68] highlighted the cost-efficiency and strength of ferrocement roof slabs in structural roofing by incorporating up to 20% fly ash. Innovation of Affordable Roofing System (ARS), combining ferrocement with bamboo-cement panels, has also proven to reduce construction costs by over 36% while maintaining safety and ease of installation. In addition, Bedoya Ruiz et al. [69] have assessed the seismic suitability of ferrocement housing in vulnerable regions, based on full-scale modelling and simulations.

Exploring the broader use of plastic waste, Gulhane [70] demonstrated the viability of Recycled Plastic Lumber (RPL) in housing, which showed strong structural performance and earthquake resilience. In Nigeria, Solaja et al. [71] assessed Recycled Plastic Bottle (RPB) construction and found it promising but underutilised due to limited public awareness and technical know-how. Moreno Sierra et al. [72] proposed modular shelters made from recycled plastic blocks performed better thermally than traditional materials in post-disaster scenarios. Akinwumi et al. [73] described that for soil-based construction, adding 1% shredded plastic to Compressed Earth Bricks (CEB) increased compressive strength by 244%, though higher plastic content reduced durability, necessitating protective finishes. Of et al. [74] explored the complete replacement of cement with melted waste plastic in bricks and blocks, observing improved insulation and bending strength, showcasing plastic waste's dual role in housing and environmental cleanup.

Fly ash remains one of the most studied materials for sustainable construction. Jena et al. [75] introduced fly-ash-enriched earthen unburnt bricks, which showed greater strength than traditional mud bricks and required no burning. Rivera et al. [76] developed alkali-activated soil blocks using high-carbon fly ash and achieved strengths up to 17 MPa while reducing global warming potential by 75%. Kumar [77] assessed FaL-G hollow blocks, confirming their durability, lightweight nature, and resistance in sulfate environments.

Likewise, Islam et al. [78] demonstrated that fly ash can effectively reduce cement usage in Compressed Stabilised Earth Blocks (CSEBs) without compromising their quality, making them more cost-effective than fired clay bricks. Recycled waste materials such as plastic, EPS, fly ash, and ferrocement can provide affordable, durable, and eco-friendly options for transitional shelters. They combine local availability, good structural performance, and waste reduction. These materials meet urgent housing needs while supporting long-term sustainability in construction. Further supporting its viability, D'Orazio et al. [79] tested the special HOMEDONE reinforced EPS system and confirmed its excellent weather resistance and structural performance under severe freeze-thaw and UV conditions.

New innovative materials can improve the sustainability and performance of transitional shelters. Phase change materials store and release heat to regulate indoor temperatures, reducing the need for active cooling. Aerogels and vacuum insulation panels offer high thermal resistance in thin layers, making them useful for compact shelters. Other options include self-healing concrete, cool roof coatings, and biodegradable composites made from algae or agricultural waste. These can increase durability and lower environmental impact. While still new in India, such materials could be integrated into modular and prefabricated systems, especially with renewable energy or passive design features. Future research and pilot projects can test their suitability for low-cost, large-scale use in transitional housing.

3.6. Comparison of Materials for Transitional Shelters

Table 1 offers a clear and practical comparison of different building materials that can be used to construct transitional shelters for migrants in India. It shows how various low-cost and sustainable materials - like recycled plastics, Expanded Polystyrene (EPS), fly ash bricks, ferrocement, bamboo panels, and compressed earth blocks perform in terms of strength, insulation, durability, environmental impact, and cost. Studies in this review by Moghavedi et al. (2024) and Allouzi et al. (2020) provide cost, Speed, and performance data. 3D-printed shelters have cut construction time by up to 70% and costs by 30–65%, depending on materials and design [51, 53]. Romero et al. (2023) described Modular housing prototypes, such as WikiHouse, that reduced construction time by 44% and cost by 29% while keeping good energy efficiency [40]. Puri et al. (2017) analysed the Prefabricated bamboo-reinforced panels, which cost 40% less and weighed 56% less than traditional brick walls, making them easier to transport and assemble [44]. Surendra and Ravindra [68] stated that Ferrocement roofing systems using fly ash cut roofing costs by 36%. M D Orazio et al. [79] highlighted that EPS-based panels reduced operational energy use and enabled rapid site assembly within days. These quantitative findings reinforce the viability of these technologies for scalable deployment in transitional housing projects across India.

Table 1. Comparison of different materials for translational shelters

Material Type	Composition	Applications	Strength	Thermal Insulation	Durability	Environmental Impact	Cost	Authors
Compressed Stabilised Earth Blocks	Soil + Cement/Lime	Walls, Foundations	Moderate to High	Good	Moderate	Low to Moderate	Low	[21]
Fly Ash Bricks	Fly ash + Sand + Lime	Walls, Partitions	High	Moderate	High	Moderate	Moderate	Barbhuiya et al. (2025)
Recycled Plastic Lumber	Recycled plastic	Structural Components	Moderate	Good	High	Low (uses plastic waste)	Moderate	Gulhane & Gulhane (2017)
Expanded Polystyrene (EPS) Panels	Cement-coated EPS with reinforcements	Walls, Roofs	Moderate	High	Low (cracking issue)	Moderate to Low	Low	Lee et al. (2006), D'Orazio et al. (2020)
Ferrocement Panels	Cement mortar + Mesh (steel or textile)	Roofs, Walls, Slabs	High	Moderate	High	Moderate (with fly ash)	Low	Ahmad et al. (2014), Surendra & Ravindra (2021)
Agro-Waste Materials (Rice husk, Coir)	Rice husk ash, Coconut fibre, etc.	Walls, Roofing, Insulation	Low to Moderate	High	Moderate	Low	Low	Barbhuiya et al. (2025)
EPS Foam Concrete Panels	Cement, sand, fly ash, 50% recycled EPS, cement fibre boards	Walling for single-storey and partitioning for multi-storey buildings	Comparable to conventional concrete panels	Good due to EPS; lower conductivity	Good durability under tropical conditions	Low due to EPS reuse and fly ash use	Moderate, lower than traditional concrete over time	Dissanayake, Jayasinghe, M.T.R. Jayasinghe
EPS Sandwich Wall Panels	Foam concrete with 50% recycled EPS, cement fibre boards	Load-bearing walls for single-storey and partitions for multi-storey	Sufficient for load-bearing (flexural & compressive strength tested)	Low density enhances insulation	Good weathering resistance and mechanical performance	Reuses non-biodegradable EPS waste	Low cost for mass production, factory-assembled	Fernando, M.T.R. Jayasinghe, C. Jayasinghe
GFRG Wall Panels	Glass fibre reinforced gypsum panels	Precast walls, fast construction housing units	High strength, suitable for seismic areas	Moderate to high, depending on core fill	Durable, long service life	Saves cement and reduces carbon footprint	Lower due to precast and fast setup	Cherian et al.

Recycled Plastic Brick	Shredded or melted plastic waste, sand/cement alternatives	Blocks and panels for low-cost transitional shelters	Varies; enhanced with fibre/plastic content	Improved insulation with higher plastic content	Variable, dependent on the mix and plastic type	Reduces plastic waste, lower CO2 than cement	Low-cost use of waste materials	Multiple sources (Akinwumi et al., Solaja et al.)
Modular Bamboo Panels	Bamboo, lime/cement binder, locally available fillers	Wall panels for rural or eco-friendly housing	Moderate, adequate for non-load-bearing use	Naturally insulating due to the bamboo structure	Good with appropriate treatment	Eco-friendly and renewable material use	Low; cheaper than brick-and-mortar	Puri et al.
Phase Change Material Concrete	Cellular concrete with caprylic acid in basalt powder	Thermal energy storage in buildings	Slight reduction due to PCM, but structurally acceptable	High (solar thermoregulation)	Good after multiple melting/solidification cycles	Reduced energy demand and carbon emissions	Moderate	Kocyigit et al.
Insulation with PCM	Phase Change Materials (e.g., RT-35HC) integrated into building walls	Wall insulation	N/A	Very high (optimised thermal performance)	Satisfactory for long-term use	Reduces cooling energy load	Varies with PCM type	Anter et al.
Leather Waste Polymer Composite	Expanded polymeric matrix with chromium-tanned leather waste	Thermal and acoustic insulation	Durable and stable	Excellent	High, with chromium offering resistance	Risk from chromium; recycling waste reduces the impact	Low (uses industrial waste)	Ribeiro et al.

Each material has been evaluated based on real-life applications, such as walling, roofing, or insulation, and studies from trusted researchers and institutions back the findings. Also, it helps identify affordable, quick to build, safe and environmentally friendly materials.

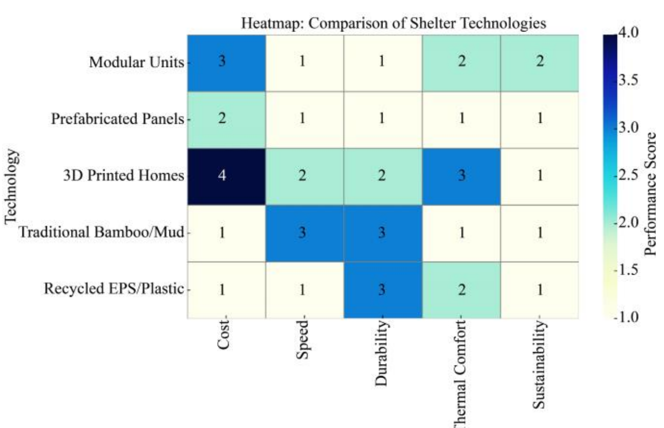

Fig. 4 Comparison matrix of shelter technologies

4. Case Study of Transitional Shelter in India

Transitional shelter programs worldwide offer lessons for India. In Japan, post-earthquake modular shelters focused on thermal comfort, privacy, and long-term use, which helped shape disaster policy reforms. In Turkey, container housing after the 1999 İzmit earthquake provided Speed and mobility but struggled with social cohesion. After the 2010 Haiti earthquake, many NGOs built bamboo and timber shelters, but low community involvement led to cultural mismatches and poor use. In contrast, Kenya's Kalobeyei Integrated Settlement for refugees combines housing with economic activities and public services, showing how shelter can support long-term integration. These examples show that while speed and cost matter, social relevance, durability, and ongoing community engagement are just as crucial for scaling transitional housing in India.

India has faced many natural disasters and humanitarian crises that displaced large numbers of people and created urgent shelter needs. Over the past 20 years, government agencies, international organisations, and NGOs have worked together to provide transitional shelters. After the 1999 Odisha Super Cyclone, which killed thousands and displaced hundreds of thousands, the government's first response was to build large numbers of temporary thatch shelters. However, these structures were highly vulnerable to monsoons and heat. Subsequently, the Odisha State Disaster Management Authority (OSDMA) has implemented semi-permanent shelter programs involving NGOs like CARE India and ActionAid. These shelters used disaster-resilient materials such as ferrocement and CGI sheets, supported by mason training and community involvement. During 2018, the Kerala floods led to the displacement of over a million people. The state government has established relief camps in public buildings such as schools, community halls, and religious institutions. Shelter Technical Cell (STC) of Government of Kerala, in coordination with NGOs like Habitat for Humanity and the United Nations Development Programme (UNDP), developed transitional shelters using locally available materials such as bamboo, ferrocement, and prefabricated steel frames to emphasise “build back better” with sustainable design, sanitation integration, and gender-sensitive space.

During the COVID-19 pandemic in 2020, millions of migrant workers in urban India faced homelessness in states like Maharashtra, Delhi, and Tamil Nadu, which established temporary quarantine shelters and food camps in stadiums, schools, and under-construction buildings. In Maharashtra, organisations like YUVA and ACfS provided rapid assessments and collaborated with the municipal authorities to provide food, sanitation, and temporary accommodation for stranded migrants. The Society for the Promotion of Area Resource Centres (SPARC), in collaboration with the National Urban Livelihood Mission (NULM), has founded night shelters for the urban homeless across cities like Delhi and Mumbai. These shelters use prefabricated panels or reinforced steel frames with basic amenities such as bedding, toilets, and drinking water. In Delhi, the Delhi Urban Shelter Improvement Board (DUSIB) built permanent night shelters, some designed for women, families, and older people. Many use modular construction so they can be moved or expanded when needed.

Sustainable Environment and Ecological Development Society (SEEDS) has been active in post-disaster shelter work, especially in Uttarakhand in 2013 and Bihar in 2008 during the Kosi floods. In Uttarakhand, SEEDS built transitional shelters from local stone, bamboo, and GI roofing, reinforced with welded wire mesh bands for seismic resistance and climate suitability. The program also trained masons and encouraged community ownership, helping people later rebuild permanent homes with the same techniques. In Bihar, SEEDS collaborated with UNDP and the Government of India to construct elevated platforms and raised huts made from bamboo and mud plaster, thereby reducing flood risk. Shelters were often built by affected families with technical guidance, supported by local NGOs, using cash-for-work models and local labour.

GIZ India (Deutsche Gesellschaft für Internationale Zusammenarbeit) partnered with the Tamil Nadu Slum Clearance Board (TNSCB) and some NGOs like IGSSS, planned to construct green housing and temporary shelter projects in the tsunami-affected regions of Nagapattinam and Kanyakumari districts. These shelters use stabilised earth blocks, natural ventilation, and solar lighting. GIZ promoted community-led planning and provided technical training on sustainable materials. In Tamil Nadu, the Auroville Earth Institute (AEI) has developed cost-effective, climate-resilient methods using compressed stabilised earth blocks, arches, vaults, and domes. AEI’s transitional shelters are known for low embodied energy, earthquake resistance, and good thermal comfort. After the 2004 tsunami, hundreds of such shelters in Tamil Nadu and Puducherry served as both transitional and long-term homes. This approach focuses on self-help construction, training local artisans, and using soil from the site. Conversely, the UNDP has been instrumental in supporting shelter response after major floods in Bihar during 2008, including bamboo and ferrocement walls on elevated plinths, often doubling as community centers for shelter construction. In Assam in 2017, high-stilted bamboo structures were constructed on a flood-prone river island. These interventions also included WASH facilities and solar lighting, offering comprehensive support to disaster-hit populations.

In Mumbai, some popular NGO’s such as Saathi and Aajeevika Bureau have joined with municipal corporations to establish night shelters for migrant workers using repurposed containers or prefabricated units and provided safe sleeping spaces with lockers, water, and sanitation facilities. In Delhi, over 200 night shelters were created under the DUSIB initiative, responding to seasonal needs, particularly during winters. Mobile shelters mounted on trucks were also used to reach homeless populations in transient locations. India’s post-disaster experience, particularly in Gujarat (2001), Kashmir (2005), and Uttarakhand (2013), has increasingly favored owner-driven reconstruction. This model includes technical training, material depots, cash support, and policy facilitation. The National Disaster Management Authority (NDMA) guidelines encourage using intermediate shelters with disaster-resilient features such as welded wire mesh reinforcements, GI roofing, and local materials. This participatory approach has shown improved satisfaction and faster transition to permanent housing.

Although large-scale statistical evaluation of transitional shelters remains limited, available case reports and evaluations studied by Cherian et al. (2020) offer valuable insights. In post-tsunami Tamil Nadu, AEI’s CSEB shelters recorded over 85% long-term occupancy, indicating sustained user satisfaction [64]. SEEDS India’s projects in Uttarakhand and Bihar reported structural durability of over 5 years, with more than 70% of beneficiaries reusing techniques for permanent housing. In Delhi, shelters constructed under the DUSIB initiative maintained over 90% seasonal occupancy, with gender-sensitive units receiving positive feedback from women's groups (SPARC reports). Shelter prototypes built after Kerala floods, integrating sanitation and solar lighting, achieved 60–80% higher user approval ratings compared to earlier thatch-based models. These statistics reflect the importance of construction speed and cultural appropriateness, safety, and integration with services in determining long-term shelter success.

Table 2. Key transitional shelter case studies in india

Event/ Location	Implementing Body	Materials/ Methods Used	Notable Features/ Outcomes
Odisha Super Cyclone (1999)	OSDMA, CARE India, ActionAid	CGI sheets, ferrocement	Semi-permanent shelters; local mason training
Kerala Floods (2018)	STC Kerala, UNDP, Habitat for Humanity	Bamboo, steel frames, ferrocement	Gender-sensitive design; integration of sanitation
COVID-19 Crisis (2020)	State Govts., YUVA, SPARC, ACfS	Repurposed buildings, prefab panels	Emergency shelters with food, sanitation, and city-level coordination
Uttarakhand Floods (2013)	SEEDS India	Bamboo, stone, GI roofing	Seismic-resistant shelters with community involvement
Bihar Kosi Floods (2008)	SEEDS India, UNDP	Raised bamboo-mud huts	Cash-for-work model; flood-resilient platforms
Tamil Nadu Tsunami (2004)	Auroville Earth Institute (AEI)	CSEB blocks, vaults, domes	Self-help construction; earthquake-resistant and energy efficient
Delhi Night Shelters	DUSIB, SPARC	Modular and prefab units	90% occupancy; gender-focused shelters with basic amenities

5. Challenges and Limitations of the Study

While comprehensive in reviewing low-cost and rapid construction technologies for transitional shelters in India, this study faces several challenges and limitations. Firstly, much of the available data is fragmented and context-specific, making it difficult to generalise findings across India's diverse geographic and socio-economic settings. Many case studies focus on isolated regions or disaster events, limiting their broader applicability to nationwide policy or scalable design frameworks. Secondly, although the review covers a range of modern and traditional construction methods, there is a lack of comparative field data to evaluate these shelters' long-term performance, maintenance, or user satisfaction under real-life conditions. This restricts the ability to assess materials' durability, thermal comfort, and adaptability over time. Thirdly, the study relies heavily on secondary sources such as research articles, technical papers, and NGO reports. Primary fieldwork, such as interviews with beneficiaries, builders, or policymakers, was not conducted, which may have added practical insights or revealed hidden implementation barriers.

Furthermore, the effectiveness of transitional shelters also depends on institutional coordination, regulatory approvals, and funding availability, which vary widely across states and were outside the scope of this study. Some promising technologies, such as 3D printing and modular units, are still in early adoption in India and face high costs, limited workforce training, and logistical hurdles. Also, though culturally appropriate and eco-friendly, traditional methods suffer from low public acceptance and often need technical upgrades to meet modern safety and climate standards. A significant policy gap limits the impact of transitional shelters. Most national housing schemes focus on permanent housing and overlook temporary or mobile groups such as migrants. Without targeted government support, these technologies may remain underused.

Future studies should include field trials, stakeholder input, and policy analysis to develop practical, scalable, and inclusive solutions. Several national policies have indirect implications for transitional shelters, though few address them explicitly. The Pradhan Mantri Awas Yojana (PMAY-Urban and PMAY-G) primarily focuses on permanent affordable housing but lacks provisions for temporary or mobile populations. The National Urban Housing and Habitat Policy (NUHHP, 2007) emphasises inclusive housing, yet does not outline transitional shelter strategies for migrant workers or disaster-affected groups. Similarly, NDMA Guidelines on Temporary Shelters (2008) recommend transitional shelter deployment post-disaster, but these are rarely institutionalised across states. In the Smart Cities Mission and State Slum Redevelopment Policies, flexible shelter models have yet to be incorporated into urban planning frameworks. These policy gaps underscore the urgent need for a dedicated national framework or sub-policy focused on transitional housing that accounts for migrant mobility, disaster resilience, and inter-agency collaboration.

This review combines insights from peer-reviewed literature with selected NGO reports and case-based documents to reflect both academic rigour and ground-level realities. Peer-reviewed studies provide validated data on material performance, thermal comfort, and structural feasibility, while NGO reports offer valuable evidence on community engagement, policy gaps, and post-disaster implementation strategies. Reports from organisations like

SEEDS, SPARC, Habitat for Humanity, and GIZ India have contributed practical knowledge of transitional shelter delivery, which is often unavailable in academic publications. Future studies should expand this integration by systematically reviewing grey literature, government policy documents, and real-time impact assessments to create a more holistic knowledge base.

While the review draws connections between construction technologies and observed improvements in cost, Speed, and user satisfaction, it is essential to clarify that many of these findings represent correlations rather than proven causal relationships. For instance, shelters built with prefab materials or bamboo composites may show better occupancy rates or resilience. Still, these outcomes can also be influenced by contextual factors such as community engagement, local governance, or access to services. Few studies employ experimental or longitudinal designs to isolate the effect of specific materials or methods. While trends and associations can be seen from reported outcomes, they should not be taken as proof of cause and effect without further evidence.

Despite the potential of different shelter technologies, many challenges limit their use. Local areas often lack the technical skills needed for modular or 3D-printed construction. Prefabricated components face supply chain delays, and non-traditional materials like GFRG or EPS panels require skilled labour that is not always available. Land access and legal issues can slow deployment, especially in urban slums or disaster zones. Communities may resist shelters if they do not match cultural preferences or use unfamiliar materials. At the institutional level, fragmented governance, irregular funding, and weak coordination between agencies can leave projects stalled or poorly maintained. Solving these issues will require training, flexible rules, community involvement, and long-term policy support.

6. Research Gaps and Future Directions

Despite growing interest in transitional shelter solutions for migrants in India, several research gaps remain unaddressed. Most studies are based on laboratory results or simulations. There is limited real-world testing of transitional shelters to assess durability, climate response, and user satisfaction over time.

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To move from theory to practice, future work should include pilot projects that test transitional shelter technologies in real-life Indian conditions. These pilots can be developed with local governments, NGOs, and affected communities to assess construction speed, climate resilience, cost, and user satisfaction over time. Areas with frequent disasters or high seasonal migration, such as Assam, Odisha, and Maharashtra, can serve as test sites. Results from these trials can validate lab-scale innovations, guide design changes, and support policy adoption. Pilot shelters can also act as living laboratories, collecting long-term data on housing performance and socio-economic impacts for migrant populations.

Global examples offer valuable lessons. Review by Yau et al. [25] stated that modular shelters were adapted to local culture in post-tsunami Indonesia and included sanitation. In South Africa, studies by Aghimien et al. (2021) explored 3D-printed housing for urban poor settlements [80]. Atmaca et al. [2] discussed that in Turkey, container housing after the 1999 earthquake worked for short-term relief but failed to support long-term social integration. Romero et al. [40] elaborated on Kenya's Kalobeyei Settlement, which combined durable housing with social services, showing the value of integrating shelter and livelihoods. These cases stress the importance of user-centred design, lifecycle analysis, and policy alignment principles relevant for India's transitional housing. Also, the lack of long-term performance data is a significant barrier to informed decisions. Without real-world information on durability, maintenance, climate adaptability, and user retention, it is hard to know which technologies provide the best long-term value.

Studies that track shelter performance for 2–5 years, especially in extreme climates or shifting population areas, are essential. They can guide upgrades, reduce waste, and prevent early abandonment. Tracking social and economic outcomes such as health, job access, and education can help shape more inclusive and adaptable shelter policies. Stakeholder insights are critical for developing effective solutions. NGOs like SEEDS, SPARC, and the Auroville Earth Institute have hands-on experience with transitional housing in varied settings. Their input can improve design, training, and post-occupancy support. Feedback from migrant workers can guide location choices, layouts, and cultural fit. Urban planners and construction agencies can flag implementation challenges, while government officials can outline regulatory and funding constraints. Involving these groups through workshops, surveys, and field pilots can turn research into practical, scalable, and policy-aligned shelter models.

7. Conclusion

This review highlights the pressing need for transitional shelters in India to support migrant populations and disaster-affected communities. Drawing insights from various technologies and case studies, this section summarises the following key conclusions from the research and proposes practical policy recommendations.

- India faces an urgent and recurring need for transitional shelters due to internal migration, natural disasters, and urban housing shortages.

- Migrant workers are often excluded from formal housing policies due to a lack of documentation, permanent address, or a policy focus on permanent housing.
- Transitional shelters serve as a critical bridge between emergency relief and permanent housing, offering temporary yet safe and stable living conditions.
- Various technologies offer promising solutions, such as modular construction, prefabricated panels, 3D printing, traditional materials, and recycled components.
- However, the real-world application of these technologies varies in cost, durability, user acceptance, and climate suitability.
- Traditional methods using bamboo, mud, and local materials remain relevant, especially when updated with modern reinforcements and community participation.
- The key criteria for effective transitional shelter models are Sustainability, Speed, Affordability, and scalability.

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