JASP
Journal of Architecture and Spatial Planning

Journal of Architecture and Spatial Planning:
https://jurnal.unimed.ac.id/JASP

Growable Shelter Framework for Post-Flood Disaster Reconstruction in Medan City

Putri Sofia Lestari[1], Syafina Ramadhani Pulungan[2], Sabriyani Putri [3], Andina Zalsabila Dharma Putri [4], Mifthahul rizky[5] , Edel Atania[6], Harry Wibowo[7]
Universitas Negeri Medan, Indonesia
*Corresponding author email: **sofia.lstri09@gmail.com**

ABSTRACT

Flooding is a frequent disaster in the city of Medan and causes damage to residential areas, particularly in riverbank areas that are highly vulnerable. One of the affected areas is Kampung Aur, which is characterized by high population density, limited land availability, and inadequate infrastructure. These conditions highlight the need for a housing reconstruction strategy that not only addresses post-disaster conditions but can also evolve to meet the community's evolving needs. This study aims to develop a "growable shelter" framework as an alternative for post-flood housing reconstruction in the city of Medan. The research hypothesis posits that implementing the growable shelter concept can enhance housing resilience against flood risks while simultaneously supporting the community's social and economic needs. The method used is descriptive qualitative research with a case study approach in the Kampung Aur area. Analysis was conducted through an assessment of the area's existing conditions, the community's housing needs, and the application of resilient housing principles and modular systems. The research results indicate that the growable shelter framework, which integrates stilted house structures, mini-pile foundations, lightweight modular materials, and the concept of a "growing house," can enhance building resilience against floods and provide flexibility for gradual housing development. Thus, the growable shelter has the potential to serve as an adaptive, sustainable post-disaster reconstruction solution that aligns with the characteristics of flood-prone settlements in the city of Medan.
***Keywords**: growable shelter, post-disaster reconstruction, flooding, resilient housing, Medan City.*

ABSTRAK

Banjir merupakan bencana yang sering terjadi di Kota Medan dan menyebabkan kerusakan pada kawasan permukiman, terutama di daerah bantaran sungai yang memiliki tingkat kerentanan tinggi. Salah satu kawasan yang terdampak adalah Kampung Aur, yang ditandai oleh kepadatan penduduk yang tinggi, keterbatasan lahan, serta infrastruktur yang kurang memadai. Kondisi tersebut menunjukkan perlunya strategi rekonstruksi hunian yang tidak hanya mampu merespons kondisi pascabencana, tetapi juga mampu berkembang sesuai kebutuhan masyarakat. Penelitian ini bertujuan untuk menyusun *framework growable shelter* sebagai alternatif rekonstruksi hunian pascabencana banjir di Kota Medan. Hipotesis penelitian menyatakan bahwa penerapan konsep *growable shelter* dapat meningkatkan kemampuan adaptasi hunian terhadap risiko banjir sekaligus mendukung kebutuhan sosial dan ekonomi masyarakat. Metode yang digunakan adalah penelitian kualitatif deskriptif dengan pendekatan studi kasus pada kawasan Kampung Aur. Analisis dilakukan melalui kajian kondisi eksisting kawasan, kebutuhan hunian masyarakat, serta penerapan prinsip hunian yang resilien dan sistem modular. Hasil penelitian menunjukkan bahwa *framework growable shelter* yang mengintegrasikan struktur rumah panggung, pondasi *mini pile*, material modular ringan, dan konsep rumah tumbuh mampu meningkatkan ketahanan bangunan terhadap banjir serta memberikan fleksibilitas pengembangan hunian secara bertahap. Dengan demikian, *growable*

shelter berpotensi menjadi solusi rekonstruksi pascabencana yang adaptif, berkelanjutan, dan sesuai dengan karakteristik permukiman yang rawan banjir di Kota Medan.

Kata kunci: *growable shelter, rekonstruksi pascabencana, banjir, hunian resilien, Kota Medan.*

Introduction

Indonesia ranked fourth in the world in 2022 in terms of population density, with a total population of 278 million (census.gov, 2022). Population density in Indonesia is influenced, in part, by high birth rates and low mortality rates, making the country's massive population a serious issue, particularly in urban areas (Rahmadani et al., 2025). Medan is one of the largest cities in Indonesia, characterized by high population growth and density. The continuous increase in population has led to a decreasing availability of land for water absorption. The reduction in absorption areas, combined with the numerous river flows passing through Medan, results in waterlogging or flooding (Silitonga, 2019). Flooding is the overflow of water exceeding the river's cross-sectional capacity or planned elevation limits due to extremely heavy rainfall. Issues arise when human activities occur in flood-prone areas alongside other commercial interests (Filantropi et al., 2022). Flooding issues in the city of Medan are influenced by various factors, starting with the region's gentle slope from north to south, climatic conditions, high rainfall intensity, land-use changes, river sedimentation, and drainage capacity that cannot optimally accommodate water flow. Additionally, uncontrolled residential development has further exacerbated urban conditions and increased the risk of flooding in densely populated areas (Silitonga, 2019).

One area in the city of Medan with a high vulnerability to flooding is the Deli River floodplain. This area has organically grown into a settlement with limited infrastructure and poor environmental conditions. Sudden growth and a rising population have made the area densely built up, with minimal absorption areas. One such settlement in the Deli River area experiencing these issues is Kampung Aur, located in Medan Maimun District. Kampung Aur is a densely populated settlement characterized by organic growth, a high population density, high building density, poor drainage conditions, and vulnerability to flooding (Batubara & Rambe, 2024). The recurring floods in the city of Medan, particularly in areas along the Deli River such as Kampung Aur, highlight the high vulnerability of densely populated settlements to hydrometeorological disasters. In 2025, heavy rainfall over several days caused numerous rivers in the city of Medan to overflow, submerging thousands of residents' homes across various districts, including the Medan Maimun District where Kampung Aur is located. According to data from the Medan City Disaster Management Agency (BPBD), the October 2025 floods affected at least 3,181 homes and impacted more than 10,391 people across seven districts in Medan City. These conditions demonstrate that communities living in riverbank areas continue to face the threat of losing their homes, property damage, and disruptions to social and economic activities due to floods that recur annually.

As of 2026, the impact of the floods in the city of Medan is still being felt by the community, with a significant level of damage to homes. The City of Medan government

recorded that 242 homes sustained damage due to the major flood that occurred at the end of 2025, with damage ranging from minor to moderate to severe. This issue indicates that post-disaster management requires not only evacuation processes but also temporary housing solutions that can be quickly constructed, are safe, and are adaptable to flood-prone environmental conditions. Based on these conditions, the Growable Shelter Framework was designed as a modular temporary housing concept intended to support the post-flood reconstruction process in the city of Medan. This shelter utilizes a lightweight construction system that is easy to assemble and can be expanded by adding modules between units, thereby meeting the needs of flood-affected communities during the recovery period until permanent housing is available.

Previous studies have proposed approaches to the settlement planning of Kampung Aur through the concept of vertical villages, the development of sustainable designs, such as integrated drainage systems, rainwater harvesting, and the expansion of Green Open Spaces (GOS), particularly in riverbank areas, as well as the development of the area using an environmental behavioral approach. These approaches emphasize the importance of maintaining community social ties while improving the quality of the residential environment (Muhammad & Maulana, 2025). However, post-disaster reconstruction efforts in flood-prone areas such as Kampung Aur still require housing strategies that are more flexible and adaptable to the changing needs of the community. In this regard, the “growable shelter” concept emerges as an alternative and relevant solution when applied to flood-prone areas like Kampung Aur. This concept allows housing to evolve according to needs and spatial capacity, adapting to post-disaster environmental conditions. This approach can provide more resilient housing through a modular system, spatial flexibility, flood-adaptive structures, and phased development aligned with the community’s social conditions. Thus, it is hoped that this “growable shelter” framework can serve as a post-disaster reconstruction strategy that not only focuses on physical construction but also supports the social sustainability of the community in Kampung Aur, Medan City.

Modular Housing

In the context of architecture and construction, modular design refers to a construction system that uses building modules that can be mass-produced in a factory and then assembled on-site (A Donny 2023).

Modular design not only offers solutions for efficiency but also supports the principle of sustainability in architecture. According to (Lawson et al. 2012), modular systems generate significantly less construction waste than conventional methods and enable the use of more energy-efficient materials. Modules that can be disassembled and reassembled also support a more flexible and longer building life cycle. This is particularly beneficial in the context of “growable shelters” or adaptable housing within post-disaster reconstruction strategies that focus not only on physical construction but also on supporting the social sustainability of the community in Kampung Aur, Medan.

JASP
Journal of Architecture and Spatial Planning
Journal of Architecture and Spatial Planning:
https://jurnal.unimed.ac.id/JASP

Research Method

This study employs a descriptive qualitative method using a case study approach to examine the implementation of the "growable shelter" framework as a housing reconstruction strategy following the flood disaster in Kampung Aur, Medan Maimun District, Medan City. The descriptive qualitative method was chosen because this study aims to understand the existing conditions of the area, the characteristics of the settlement, and the community's need for housing that is resilient to flood disasters. The study site is located in Kampung Aur, a densely populated residential area along the banks of the Deli River that is highly vulnerable to flooding. The site was selected based on its characteristics as an area frequently affected by flooding, its high population density, and the limitations of its environmental infrastructure, which necessitate sustainable housing reconstruction solutions. (Batubara & Rambe, 2024).

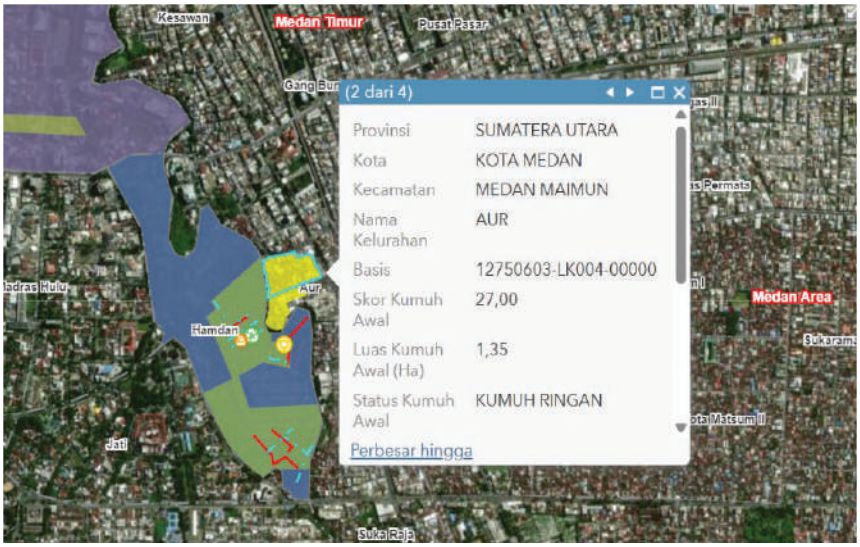


Figure 1. Map of the Slum Area in Aur Village

SIKPK/Dinas Perumahan dan Kawasan Permukiman, 2022

Data collection was conducted through field observations, documentation, and literature reviews. Observations were used to identify site conditions, settlement patterns, drainage systems, and the characteristics of existing buildings, while documentation was carried out through photographs and mapping of the study site. The literature review involved examining various references related to growable shelters, resilient housing, incremental housing, modular construction, and post-flood reconstruction. The data obtained was then analyzed using qualitative descriptive methods to identify the area's challenges and develop a growable shelter framework tailored to the conditions of Kampung Aur as a post-flood housing reconstruction strategy.

JASP
Journal of Architecture and Spatial Planning
Journal of Architecture and Spatial Planning:
https://jurnal.unimed.ac.id/JASP

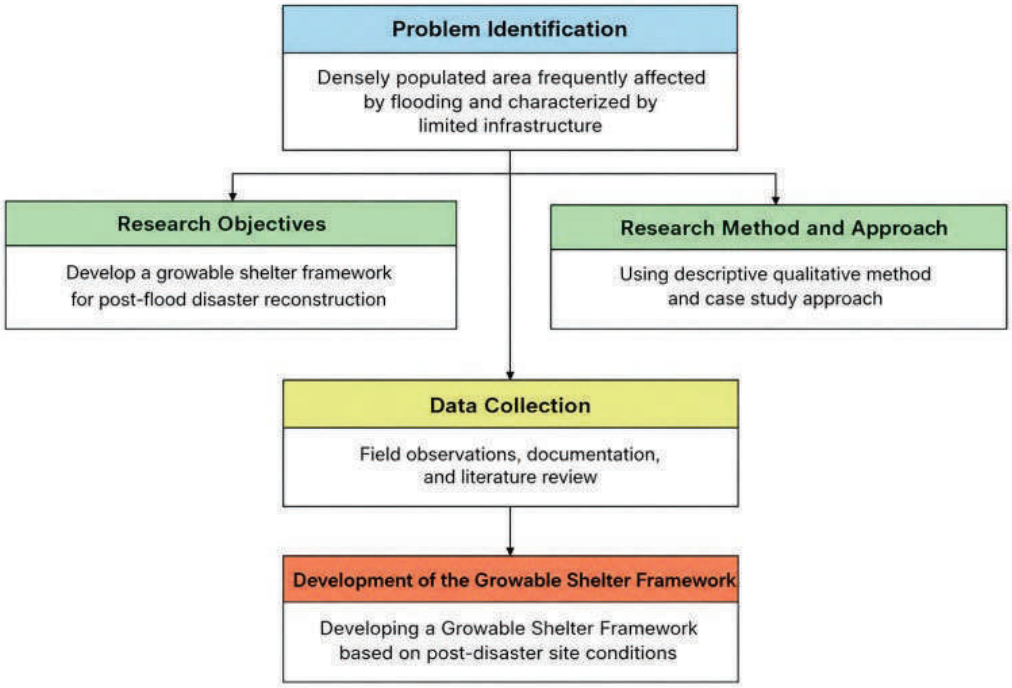


Figure 2. Research Methodology Diagram
Primary Data Analysis, 2026

Result and Discussion

This study aims to develop a framework for “growable shelters” as a strategy for post-flood housing reconstruction in the city of Medan, using Kampung Aur in the Medan Maimun subdistrict as a case study. Based on field observations and an analysis of the area’s conditions, it was found that Kampung Aur has a high level of vulnerability to flooding due to its location along the banks of the Deli River, high building density, and limited drainage systems and open spaces. These conditions expose the community to a significant risk of housing damage during river overflows or heavy rainfall. To address these issues, this study developed a “growable shelter” framework that integrates the concepts of resilient housing, modular construction systems, and incremental housing. This framework is designed to provide housing solutions that are adaptable to flooding while allowing for the gradual expansion of buildings according to the community’s needs and economic capabilities. Analysis results indicate that the use of elevated house structures, mini-pile foundations, and lightweight modular materials such as galvanized hollow sections and sandwich panels can enhance a building’s resilience against floodwater inundation and support a more sustainable reconstruction process.

Current Conditions in the Kampung Aur Area

Kampung Aur is a densely populated residential area located along the banks of the Deli River in Medan Maimun District, Medan City. The area has developed organically, with a linear settlement pattern following the river's course and clustered patterns in some parts of the area. High population density has resulted in limited open space, poor sanitation, and a lack of environmental support infrastructure. Additionally, some buildings are situated very close to the riverbed, thereby increasing the area's vulnerability to flooding (Muhammad Ridha Syafi Damanik et al., 2025).

Based on previous research findings, Kampung Aur is classified as an urban slum area facing environmental challenges such as high building density, limited access to open spaces, and flood risks due to its proximity to the Deli River. Nevertheless, this area possesses strong community social bonds, making it a potential candidate for development through planning and reconstruction approaches that preserve the local community's social character (Muhammad & Maulana, 2025). These conditions indicate that Kampung Aur requires a housing reconstruction strategy that not only reduces flood risks but also sustainably accommodates community needs. Therefore, the implementation of the "growable shelter" framework was selected as an alternative solution through the concepts of resilient, modular housing and "growing homes" that can expand to meet residents' needs post-disaster.

Figure 3. Housing Conditions in the Kampung Aur Area
Research Analysis, 2026

Analysis of the Growable Shelter Framework

The growable shelter framework is a post-disaster housing reconstruction strategy that adopts the concept of incremental housing, namely the gradual construction of housing through a core house that can be expanded according to the residents' spatial needs and economic capacity (Kristi et al., 2014). In this study, the framework integrates resilient

housing, modular systems, and growable houses. Flood resilience is achieved through elevated house structures and mini-pile foundations, while housing flexibility is supported by modular components that are easy to assemble and expand (Mehdizade & Ayoobi, 2026). Given the high density and limited land availability in Kampung Aur, this concept is considered capable of serving as a solution for adaptive, sustainable housing reconstruction that aligns with the characteristics of the communities along the Deli River.

Table 1. Framework Growable Shelter

Components	Implementation in Aur Village
Resilient Housing	Flood-resistant stage structure
Modular Construction	Modular panel system
Incremental Housing	Phased development
Community-Based Development	Meeting the needs of the community

Primary Data Analysis, 2026

Foundation Systems and Flood Adaptation

The conditions in Kampung Aur, located along the banks of the Deli River, necessitate the implementation of flood-adaptive housing designs. One strategy employed is the concept of stilt houses, with floor levels elevated above floodwater levels to reduce the risk of structural damage caused by flooding (Jia & Wang, 2022). Additionally, mini-pile foundations were selected because they are suitable for soft soil conditions and enhance the structural stability of the buildings. The combination of stilt houses and mini-pile foundations supports the concept of resilient housing within the “growable shelter” framework by enhancing flood resilience, resident safety, and the flexibility for phased housing development. Therefore, this system is deemed suitable for implementation in the Kampung Aur area, which has a high level of flood vulnerability.

Table 2. Materials Used in Growable Shelters

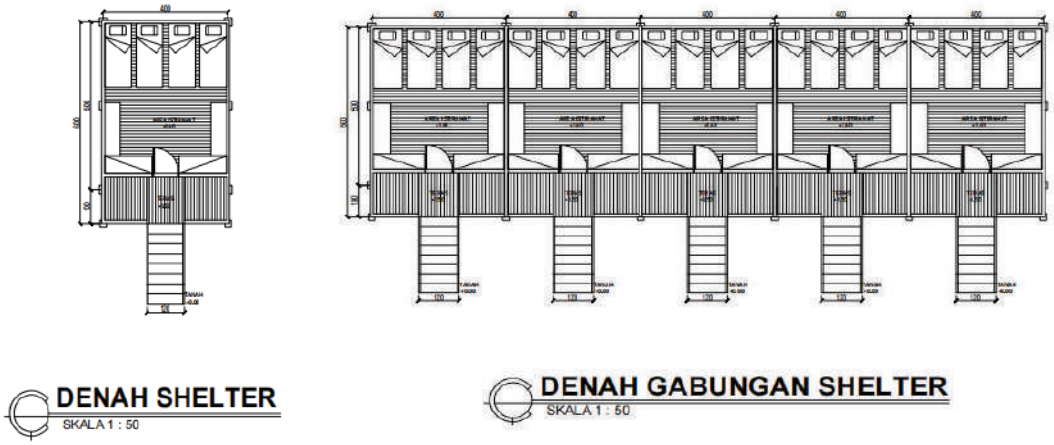
Material	Function	Dimensions	Advantages
Hollow Galvanis	Main structures (columns, beams, frames)	40×40 mm, 50×50 mm, 75×75 mm; thickness 1.6–3 mm	Lightweight, corrosion-resistant, easy to install, low maintenance costs, suitable for modular systems
Sandwich Panel	Modular wall	Thickness: 50–100 mm; panel width: ±1,000 mm; length: as required	Lightweight, quick to install, provides good thermal and acoustic insulation, and is easy to install and remove
sSpandek Insulasi	Roofing material	Thickness: 0.30–0.50 mm; effective width: ±750–1,000 mm	Weather-resistant, lightweight, reduces heat through an insulating layer, long service life
Raised Decking	A floor raised above ground level	Board thickness: 20–30 mm; floor height: approximately 1–2 m above ground level	Reducing the impact of flooding, improving air circulation, and making maintenance and repairs easier
Mini Pile	Building foundation	Cross-section 20×20 cm or 25×25 cm; length 3–12 m	Suitable for soft soil, improves structural stability, and the construction process is relatively quick
Baja Ringan C-Truss	Roof framing structure	C75, C80, or C100 profile; 0.75–1 mm thick	Lightweight, termite-resistant, corrosion-resistant, quick to install

Primary Data Analysis, 2026

In the design of the expandable shelter, the flooring system uses decking boards installed on a raised decking structure or platform. This system is designed with an elevation of approximately 1–2 meters above ground level to mitigate the risk of flooding, which frequently occurs in Kampung Aur. Wood Plastic Composite (WPC) decking was selected for its excellent resistance to moisture, durability against rot, and low maintenance requirements. In addition to enhancing the building's flood resistance, the raised decking system also improves air circulation beneath the structure, thereby supporting thermal comfort within the dwelling. The combination of the raised floor system with mini-pile foundations makes the building more adaptable to the soft, flood-prone soil conditions along the banks of the Deli River.

Layout Concept for the Growable Shelter

The Growable Shelter concept is used in this design to offer an approach to temporary post-flood housing that can be adapted to residents' needs and is designed to be modular and easily expandable. This shelter is intended to serve as temporary housing for flood-affected residents in the city of Medan for approximately six months—the estimated time required for the repair and rehabilitation of permanent housing. The shelter has an area of approximately 24 square meters and is designed to meet the basic needs of a small family, such as a resting area, a gathering space, simple storage, and good ventilation. With a simple A-frame design, the structure is effective in coping with a tropical climate characterized by heavy rainfall. Rainwater can drain more quickly, reducing the likelihood of pooling on the roof.



During the emergency response period, the floor plan was designed with space constraints and the occupants' needs in mind. The main room was designed to serve as both a sleeping area and a living room. The entry area is made more open to facilitate circulation and natural lighting. On the other hand, the floor is raised approximately 1 to 2 meters above ground level using an elevated decking system to prevent water accumulation and ensure residents' comfort during floods. The building can stand securely on soil that is damp or soft due to flooding because its structural system utilizes mini-pile foundations.

Result of the *Framework Growable Shelter*

The "growable" concept in this shelter is implemented through an interconnected modular system. The shelter is designed to be expanded by adding new triangular elements alongside the main structure using a modular connection system. With this approach, the living space can grow to accommodate an increasing number of family members or the need for additional space following a disaster. The modular system also allows for phased construction, offering greater flexibility and cost-effectiveness. Additionally, the uniform

shape of the modules facilitates production, distribution, and installation in disaster-affected areas.

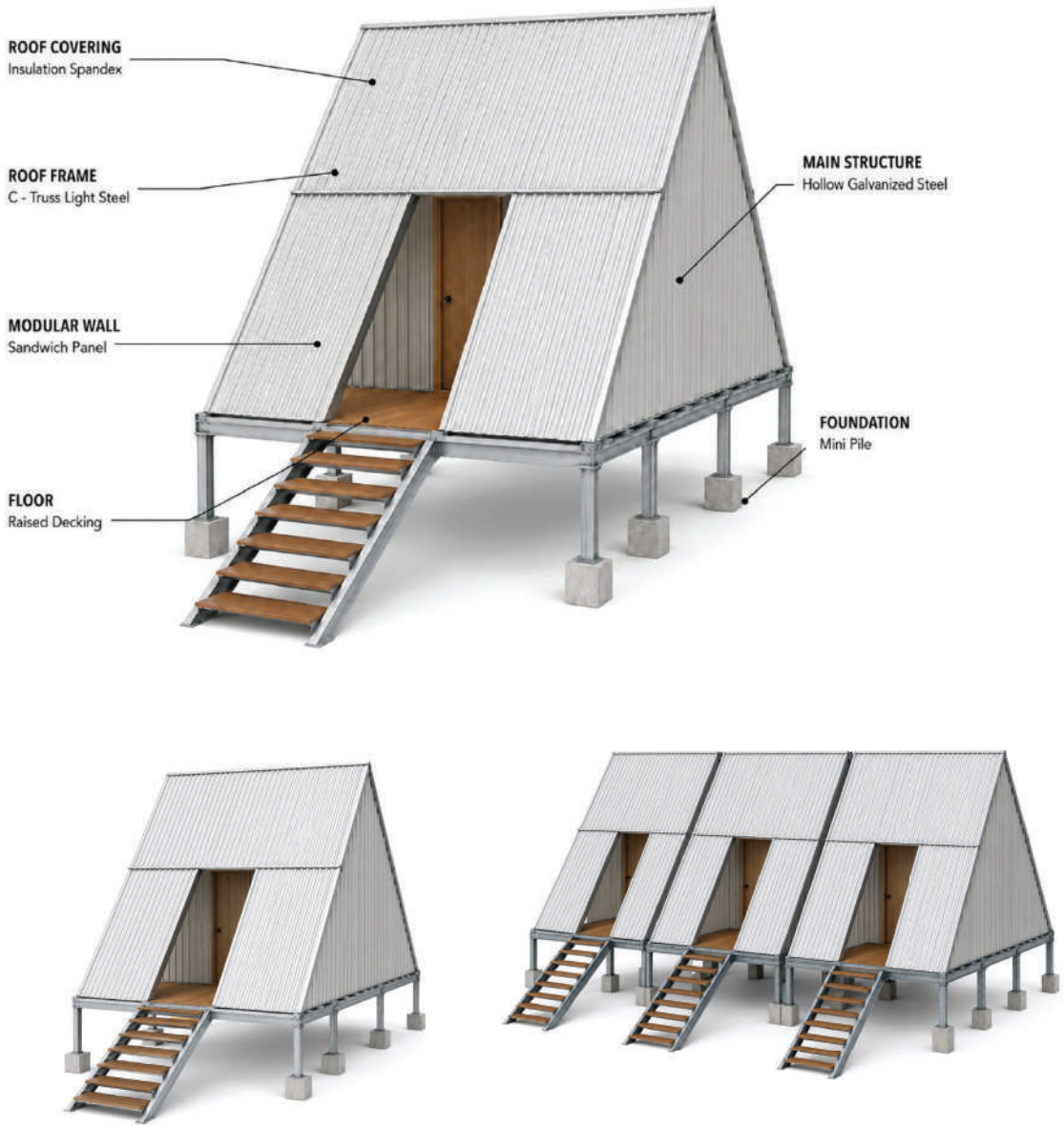


Figure 4. Growable Shelter Design

The key advantages of this design lie in its rapid construction, the flexibility of its expandable spaces, efficient use of materials, and its ability to adapt to flood conditions in the city of Medan. This shelter serves not only as temporary housing but also as a disaster-responsive architectural approach that prioritizes comfort, safety, and sustainability. With a modular

system that can be easily assembled and disassembled, along with lightweight and durable prefabricated materials, the Framework Growable Shelter concept is expected to be an effective and relevant emergency housing option to support reconstruction efforts following flood disasters in the city of Medan.

Conclusion

Based on the analysis and design conducted, the Growable Shelter Framework concept could serve as a relevant alternative in disaster-responsive architecture to support the reconstruction process following the floods in Medan, particularly in flood-prone areas such as Kampung Aur. This temporary housing design demonstrates that housing does not merely serve as emergency shelter but can also be designed in an adaptive, livable manner capable of meeting community needs during post-disaster recovery. With a modular approach and a “growable” building system, this shelter offers spatial flexibility that can be tailored to residents’ needs without compromising construction efficiency or ease of assembly. The implementation of modular concepts in the shelter results in a building system that is faster to construct, easier to assemble, and can be rapidly deployed in emergency situations. The use of lightweight structures incorporating galvanized hollow sections, modular panels, and a raised floor system reflects an effort to integrate flood resilience, efficient material utilization, and the comfort of temporary housing. Additionally, the implementation of inter-module connection systems allows for gradual spatial expansion, ensuring the shelter is not static but capable of adapting to changing resident needs during rehabilitation. This research also contributes to the development of a modular architectural concept based on disaster situations that is more contextually appropriate for urban environmental conditions in Indonesia, particularly in flood-prone areas. This shelter approach can evolve into a new concept in the design of temporary housing because it focuses not only on accelerating construction but also on aspects of sustainability, flexibility, and the long-term usability of the space. Thus, this concept is expected to serve as a more effective and humane alternative solution in post-disaster shelter design, while also serving as a reference for the development of emergency housing designs in future studies of disaster architecture and settlement planning.

Reference

Batubara, Y. Z., & Rambe, Y. S. (2024). Pola Permukiman Kumuh Pinggiran Sungai Deli Di Kampung Aur Medan Maimun. *Jaur (Journal Of Architecture And Urbanism Research)*, *8*(1), 182–193. https://doi.org/10.31289/jaur.v8i1.13000

Filantropi, H., Halawa, V., Endayanti, M., & Gultom, A. (2022). Evaluasi Banjir Pada Sungai Deli Di Wilayah Kota Medan. *Jurnal Ilmiah Teknik Sipil*, *11*(2), 317. https://doi.org/10.46930/tekniksipil.v11i2.2771

Jia, J., & Wang, Y. (2022). Interactive Effects of Admixtures on the Compressive Strength Development of Portland Cement Mortars. *Buildings*, *12*(4). https://doi.org/10.3390/buildings12040422

Kristi, J. E., Widadya, M. B., & Sigit, A. L. (2014). TRANSITIONAL SHELTER FOR DISASTER VICTIMS: BAMBOO CORE AND INCREMENTAL HOUSES. *DIMENSI (Journal of Architecture and Built Environment)*, *41*(1). https://doi.org/10.9744/dimensi.41.1.29-36

Mehdizade, A., & Ayoobi, A. W. (2026). A Holistic Design Framework for Post-Disaster Housing Using Interlinked Modules for Diverse Architectural Applications. *Sustainability*, *18*(2), 778. https://doi.org/10.3390/su18020778

Muhammad, F., & Maulana, S. (2025). *JAUR (Journal of Architecture and Urbanism Research) Transforming Slum Settlements through Vertical Kampung Concept Based on Social and Environmental Potentials in Kampung Aur*. https://doi.org/10.31289/jaur.v9i1.14706

Muhammad Ridha Syafi Damanik, Claudia Grace Simarmata, Serli Sabela, & Ermas Simaremare. (2025). *Analisis Penyebab Banjir dan Upaya Penanggulangannya: Studi Kasus di Kecamatan Medan Maimun, Kota Medan*. 699–707.

Muhammad, F., & Maulana, S. (2025). *JAUR (Journal of Architecture and Urbanism Research) Transforming Slum Settlements through Vertical Kampung Concept Based on Social and Environmental Potentials in Kampung Aur*. https://doi.org/10.31289/jaur.v9i1.14706

Rahmadani, N., Hazzah Nur, S. R., Dinas Perumahan, S., & Permukiman Dan Penataan Ruang Melalui Program Kota Tanpa Kumuh Di Kecamatan Medan Belawan, K. (2025). *Strategi Dinas Perumahan, Kawasan Permukiman dan Penataan Ruang (PKPPR) Melalui Program Kota Tanpa Kumuh (Kotaku) Di Kecamatan Medan Belawan*. https://journal.salahuddinal-ayyubi.com/index.php/AFJISH

Silitonga, B. (2019). Identifikasi Sistem Drainase Untuk Penanganan Banjir Kota Medan. In *Maret* (Vol. 2, Number 1).