

IMPLEMENTATION OF THE DUAL FUNCTION CONCEPT IN DISASTER SALTERS IN MAGELANG REGENCY

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Abstrak

Keywords:

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Spatial flexibility;
Disaster shelter;
Modular interior

The Gunungpring Village area, Muntilan District, Magelang Regency is classified as Disaster-Prone Area (KRB) I of Mount Merapi, facing threats of volcanic earthquakes and volcanic ash. The distribution of the existing 17 Final Evacuation Sites (TEA) in this regency is uneven and prone to neglect due to minimal utilization under normal conditions (BPBD Magelang Regency, 2018). This research aims to design a permanent shelter with a Dual-function concept that integrates the functions of daily public facilities with emergency evacuation functions. The dual-function strategy in this study aligns with the evolutionary direction of contemporary architectural resilience research toward adaptive reuse (Mouhcine, 2025). The research results show that the dual-function concept can be applied as a planned transformation system, rather than merely alternating use of space. The transformation is supported by open floor plans, demountable partitions, folding furniture, and clear zoning. The dual-function shelter is capable of functioning as a daily public facility as well as an adaptive, safe, and easily operable evacuation shelter, while supporting the improvement of community preparedness and the effectiveness of disaster management in the Mount Merapi eruption-prone area.

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INTRODUCTION

Magelang Regency is one of the regions with a high risk of Mount Merapi eruptions. The experience of the 2010 eruption demonstrated that the evacuation process requires not only safe evacuation locations but also spaces capable of systematically accommodating the basic activities of refugees, ranging from temporary housing, logistics distribution, and health services to refugee coordination. The readiness of Final Evacuation Sites (TEA) is crucial because the effectiveness of evacuation is strongly influenced by the capacity, location, and readiness of the facilities used during emergency periods.



The problems associated with TEA are related not only to the number and capacity of buildings but also to their patterns of use. Shelters designed specifically for disaster conditions have low intensity of use during normal periods, while public buildings that are spontaneously converted into refugee shelters often lack spatial configurations suited to emergency needs. Such conditions can lead to disorganized spatial arrangements, functional conflicts, limited privacy, and difficulties in dividing service and residential zones. Therefore, an approach is needed that allows a single building to remain active under normal conditions while being ready for use as an evacuation facility when a disaster occurs.

The dual-function concept is relevant because it integrates everyday public functions with emergency shelter functions within a single building system. In its application, dual-function cannot be realized merely through a change in name or use of space; it requires the ability of the space to transform quickly and in a planned manner. Tosun and Maden (2023) show that conventional shelters have limitations in spatial flexibility and the ability to adapt to changing needs. Therefore, spatial flexibility becomes an important aspect in providing shelters that are capable of responding to different usage conditions.

Such transformation can be supported through the application of modular systems to interior elements and furniture. Movable partitions, modular furniture, integrated storage systems, and pre-planned zoning enable public spaces under normal conditions to be converted into residential areas, service areas, emergency education spaces, or other supporting facilities. The modular approach not only enhances flexibility but also helps accelerate the process of functional change and reduces the need for spontaneous rearrangement when a disaster occurs. This principle aligns with the concept of resilience, which emphasizes the ability of a system to maintain functions, utilize available resources, and accelerate recovery after a disruption (Bruneau et al., 2003).

Based on these problems, this research aims to examine the application of the dual-function concept to disaster shelters in Magelang Regency, with an emphasis on the mechanisms of functional change between normal and emergency conditions through spatial flexibility and the use of modular furniture and interior elements. The results of the research are expected to produce a shelter design framework that remains productive in everyday use yet can transform quickly, orderly, and effectively when needed as an evacuation facility.

LITERATURE REVIEW

The Dual-Function Concept in Disaster Shelters

In this research, the dual-function concept is understood as the ability of a building to operate under two planned conditions of use from the outset: as a public facility under normal conditions and as an evacuation facility under emergency conditions. In the literature, similar ideas are often discussed through terms such as dual use, adaptive reuse, multifunctional emergency shelter, and adaptability of public buildings. Although the terminology differs, the main principle remains the same: utilizing buildings that are actively used on a daily basis so that they remain ready to perform emergency functions.

Xin et al. (2025) show that public facilities such as university campuses can be developed as dual-use emergency shelters. This approach is considered more efficient because it utilizes already available space, access, and infrastructure. However, dual functionality is not achieved merely by providing additional space. Readiness is also

determined by accessibility, spatial structure, capacity, and the building's ability to adapt to emergency needs.

In the context of shelters, dual function differs from merely multifunctional buildings. Multifunctional buildings can accommodate various activities under the same conditions of use, whereas dual function involves two operational modes. Under normal conditions, spaces can be used for social, educational, sports, or community activities. During a disaster, priorities shift to refugee areas, health services, logistics, kitchens, sanitation, and coordination centers.

Public Buildings as Emergency Shelters

The use of public buildings as shelters has been widely applied. Tsioulou et al. (2021) show that schools can function as evacuation sites, temporary housing, and aid distribution hubs simultaneously. The advantages lie in familiar locations, good accessibility, and the availability of basic facilities. However, such use can also create conflicts with the primary function if not planned from the beginning.

Cho and Baek (2025) also emphasize that public buildings can become important resources for post-disaster temporary housing. However, not all buildings are automatically suitable for use as shelters. Suitability is still determined by capacity, access, facility conditions, and the ability to support temporary living needs.

Doğan et al. (2026) reinforce this idea through a study on the adaptation of sports facilities into shelters. Transformation is carried out through principles such as flexibility, modularity, portability, reuse, and dismantability. These findings indicate that functional change does not always mean replacing the entire function of a space, but can take the form of capacity adjustment, priority shifts, or the reuse of space with minimal intervention.

Flexibility and Modularity as Transformation Mechanisms

Dual function requires spaces that are flexible and easily adaptable. Flexibility does not mean that a space can be changed without limits, but that it is capable of accepting different configurations quickly without compromising safety, accessibility, and the basic functions of the building.

Tosun and Maden (2023) show that the limitations of conventional shelters lie in their low ability to adapt to changing user needs. Therefore, transformation should be part of the design system rather than an improvisation once emergency conditions have already occurred.

In this regard, modular interiors serve as the primary transformation device. Demountable partitions, folding furniture, integrated storage systems, and movable elements enable spaces to be reconfigured without permanent renovation. Csikvari and Azadian (2025) show that a modular approach can also improve efficiency, component reuse, and the ability of spaces to adjust to needs.

However, modularity is not dual function in itself. Modularity is only a tool. Dual function is only established when normal functions, emergency functions, spatial configurations, capacity, storage, and activation procedures have been planned as a single system.

Concept Synthesis

Based on the literature, dual function in shelters can be formulated as a building design strategy that integrates everyday public functions and emergency functions through two planned operational modes, supported by spatial flexibility, adaptability, modularity, and a clear activation system.

Previous literature has extensively discussed public buildings as shelters, spatial adaptability, and modular systems. However, research space remains in the integration of all three within permanent shelters that continue to be actively used by the community under normal conditions and can transform rapidly during a disaster. This position is relevant to the shelter design in Magelang Regency, which positions dual function not merely as a change of function, but as a spatial transformation system prepared from the outset.

RESEARCH METHOD

This research employs a qualitative-descriptive approach within the framework of architectural design research. The focus of the research is not to measure the performance of the shelter after use in an actual disaster, but rather to conceptually structure and design the relationships between daily functions, emergency functions, interior components, and operational procedures. The research results are positioned as an evidence-based design synthesis that still requires technical validation, field simulation, and post-occupancy evaluation.

The research was conducted at Gunungpring Field, Muntilan District, Magelang Regency, Central Java, at coordinates 7°35'28.6"S 110°16'37.8"E, with a total site area of 19,419 m². This location lies within a radius of 15–20 km from the summit of Mount Merapi and is classified as Disaster-Prone Area (KRB) I, placing it outside the primary hazard radius of pyroclastic flows while remaining proximal to shelter-deficit districts such as Dukun and Srumbung, which fall under KRB II and III (Iswardianto et al., 2025). The site selection is based on its spatial planning status as Public Green Open Space and Village Treasury Land, which under regulations can be utilized for public service facilities, including disaster-related facilities (Magelang Regency Regional Regulation Number 7 of 2024).

This research utilizes two types of materials: secondary data and primary data. Secondary data include regulatory documents (Magelang Regency Spatial Plan 2024–2044; Building Regulation Number 3 of 2023), population data (BPS Magelang Regency, 2024), disaster data (BPBD Magelang Regency, 2018; BPPTKG), humanitarian standards (Sphere Handbook/UNHCR, 2018), technical building standards (SNI 1726:2019; SNI 6197:2011), as well as scientific literature related to dual-function (Hosseini, Barker, & Ramirez-Marquez, 2016; Tosun & Maden, 2023; Mouhcine, 2025). Primary data were obtained through direct observation of site conditions at Gunungpring Field, Muntilan District. The tools used consist of design software (AutoCAD and SketchUp for technical drawings), site environmental analysis tools (Autodesk Forma for solar, thermal, and wind simulations), and field survey equipment (camera, distance measuring tools, and GPS coordinate mapping devices).

Data collection was carried out in three ways. First, field observation was conducted to obtain primary data in the form of physical site conditions, community activity patterns, and area accessibility, through direct visits to Gunungpring Field. Second, literature study was conducted to obtain secondary data in the form of the dual-function building concept (Tosun & Maden, 2023), humanitarian space standards (Sphere Handbook/UNHCR, 2018) and (BNPB, 2018), as well as disaster data and spatial planning regulations from related agencies (BNPB, BPBD, BPS, and Magelang Regency Spatial Plan).

RESULT AND DISCUSSION

Context of the Need for Active and Ready-to-Use Shelters

The synthesis results indicate that the need for shelters in Magelang Regency cannot be separated from the village-based evacuation system. The importance of refugee data, inter-village agreements, toilet facilities, communal kitchens, and representative final evacuation sites demonstrates that shelters must be capable of connecting spatial aspects with organizational aspects (Arifina et al., 2021). Capacity calculations use a minimum space standard of 3.5 m² per person. This standard refers to the Sphere Handbook/UNHCR (2018), which establishes 3.5 m² of covered area per person for tropical climates and 4.5–5.5 m² for urban conditions/cold climates. The standard for enclosed space requirements in shelters is 3.5 m² per person for warm climate regions and 4.5–5.5 m² per person for cold climate regions.

Table 1. Calculation of Refugee/Visitor Capacity

Building	Capacity (Persons)	Building Area (m ²)	Effective Area (m ²)	m ² /person
Building 1 (A)	±301	±1,965.06	±1,433.91	± 4.76
Building 2 (B)	±97	±646.10	±457.17	± 4.71
Shelter 26 units (C)	104	±658.58	±422.24	± 4.06
Total	502	±3,269.74	±2,313.32	± 4.61



Figure 1. Shelter Situation

These conditions indicate that the shelter capacity is not designed with spatial densification up to the minimum limit, but still provides spatial tolerance that can be used for circulation, bed arrangement, occupant movement, and basic activities during the evacuation period. Thus, achieving an average of 4.61 m² per person can support more

decent and humane living conditions compared to configurations that only meet the minimum threshold. However, space quality cannot be determined solely from the area-per-person ratio. Aspects of ventilation, privacy, sanitation, accessibility, safety, and the needs of vulnerable groups remain important components in assessing the suitability of the shelter.

In this context, interior modularity and furniture become one of the keys to maintaining the effective area when the building transitions from normal function to emergency function. Furniture used on a daily basis needs to be designed so that it can be folded, stacked, moved, or stored in predetermined locations so as not to reduce the effective space when the shelter is activated. Conversely, elements such as modular partitions can be used to form family units, lactation rooms, examination rooms, counseling areas, or other private zones without requiring permanent changes to the building structure. Thus, modularity functions not only as a furniture efficiency strategy but also as a spatial transformation mechanism that ensures the area ratio of 4.06 to 4.76 m² per person can still be utilized optimally.

Buildings that are actively used on a daily basis have advantages because they facilitate facility maintenance, increase community familiarity with access and spatial layout, and support continuous disaster education and evacuation drills. However, routine use also has the potential to hinder emergency functions if inventories accumulate, storage spaces change function, or daily activities impede the activation process. Therefore, the dual-function concept requires a clear operational system, including the paired functions of each space, furniture storage locations, transformation procedures, modular configurations, and the parties responsible for each activation process.

With this approach, spaces used under normal conditions can be quickly converted into emergency residential spaces without losing most of their effective area. The excess area above the minimum standard is then understood not only as a result of capacity calculations but as a spatial reserve that supports flexibility, circulation, privacy, and the ability of the space to adapt to changing needs. The dual-function concept supported by modular interiors ultimately enables the building to remain productive under normal conditions while being ready to transform into a more resilient, effective, and human-needs-oriented shelter when a disaster occurs.

Transformation of Normal and Emergency Functions

Function mapping produces five main complementary groups. The sports hall serves as a large-capacity space, the multipurpose hall as a space for groups requiring higher support, the library pods as small-scale private spaces, the supporting buildings as basic service centers, and the management office as the command center. This division avoids concentrating all refugee activities into a single large space.

Table 2. Space Function Transformation Matrix

Space	Normal Mode	Emergency Mode	Main Transformation Strategy
Shelter Units	Community space, workspace, discussion, community activities	Refugee sleeping area	Folding and modular furniture folded against the wall; floor area cleared for mattresses

Multipurpose Hall	Meetings, seminars, exhibitions, social activities	Additional refugee area/communal space	Movable furniture relocated; open-plan space divided into refugee units using modular partition shelters
Exhibition Hall	Exhibitions and public activities	Refugee area	The interior uses shelter partitions. Exhibition panels/displays replaced with curtains as partitions for greater privacy
Food Court	Canteen and community culinary activities	Communal kitchen and partial refugee area	The food production area was retained as a communal kitchen. Tables and chairs moved to storage; dining area cleared and partially divided into refugee units with modular partition shelters
Library / Working Space 1	Library, working space, and learning activities	Refugee area	Modular partition furniture used as space dividers serving as sleeping area partitions
Library / Working Space 2	Library, working space, and learning activities	Refugee area + emergency school	Space divided into two zones. Part uses modular partitions for refugees; the other uses tables as emergency classrooms
Management Office	Management office and administration	Command post, registration, refugee data, BPBD communication	Flexible workspace; data system; communication radio; access for official vehicles and ambulances

The table shows that functional duality is not symmetrical. Some normal functions can be completely suspended during emergencies, while other functions remain necessary in different forms. The prayer room continues to serve as a place of worship. The canteen is not closed but is converted into a communal kitchen. The village office continues to handle administration, but its priority shifts to registration and command. This means that effective transformation does not always involve a total replacement of functions, but can take the form of capacity enhancement, priority shifts, or access restrictions.

Modular Interior as a Transformation Device

Modular interiors serve as the most tangible link between normal mode and emergency mode. Modules do not merely mean movable furniture, but configuration units that have specific dimensions, connections, storage locations, and installation procedures. In the context of shelters, modules need to be lightweight, cleanable, free of hazardous corners, reusable, and installable by officers or volunteers using simple tools.

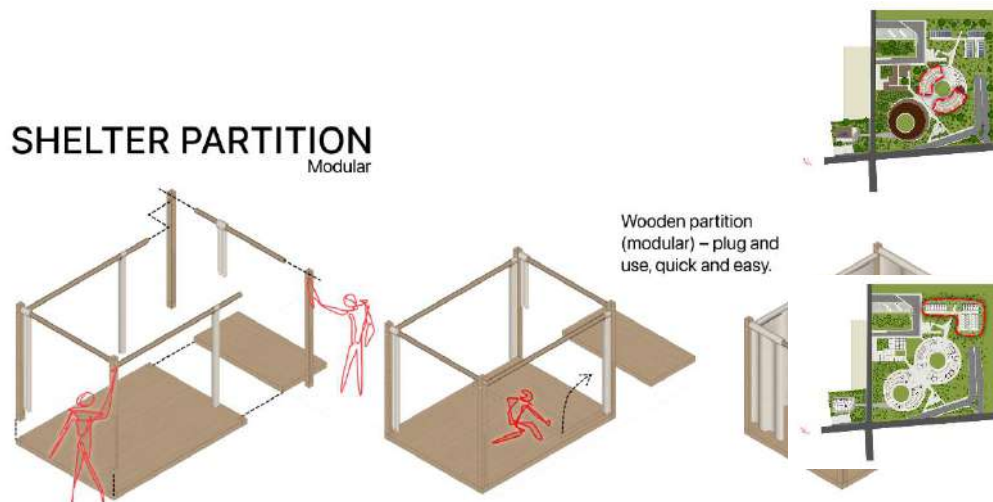


Figure 2. Shelter Partition

Figure 1 shows a modular demountable partition system composed of a wooden frame, horizontal connecting bars, and curtain elements as visual barriers. The system is designed through simple assembly stages so that the modules can be installed, dismantled, moved, and reconfigured according to needs. In emergency conditions, the partitions form temporary private spaces for family units or special activities, while when not in use, their components can be dismantled and stored compactly so as not to reduce the flexibility of the main space.

The main components consist of demountable partitions, folding furniture, and mattresses or cot beds. Partitions are used to form family units, lactation rooms, examination rooms, and counseling areas. Folding furniture allows normal spaces to be cleared without moving the entire inventory out of the building.

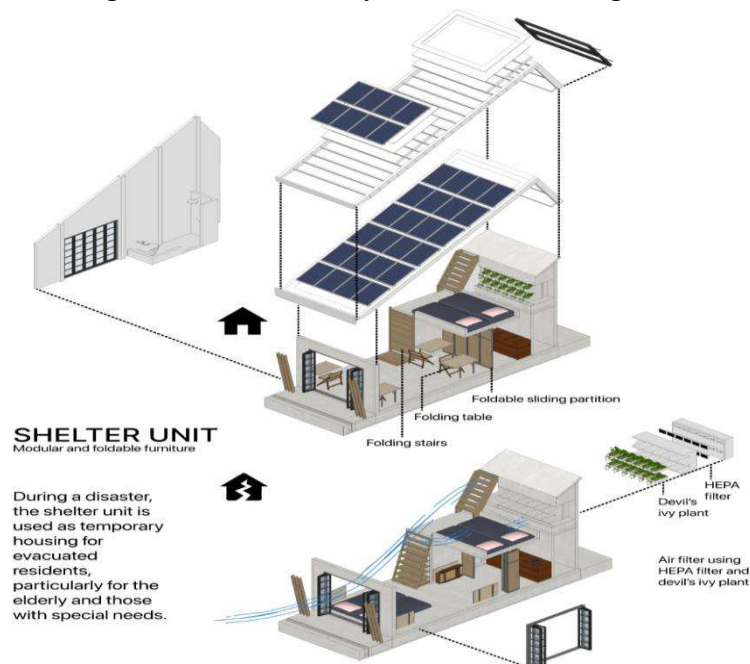


Figure 3. Application of Dual-Function in the Shelter Unit

Figure 2 illustrates the application of the dual-function principle through the integration of interior elements that can change function within a single shelter unit. Components such as folding beds, tables and chairs, stairs, shelves, and storage elements are designed to transform according to two conditions of use. Under normal conditions, the space can be utilized for daily or communal activities, while under emergency conditions these elements are reconfigured to provide sleeping areas, a kitchen, and basic needs for occupants. This integration allows functional changes to occur without permanent renovation, thereby accelerating the space adaptation process and increasing the efficiency of building utilization.

Table 3. Criteria for Modular and Flexible Interior Design

Component	Design Criteria	Risks to be Prevented
Shelter partitions	Lightweight, stable, easy to clean, with position codes, able to provide visual privacy, arrangeable for individuals or families	Blocking exits, ventilation, sprinklers, and supervision
Folding furniture	Foldable or lockable, resistant to intensive use, stored near the space	Increasing clearance time and becoming falling or tripping hazards
On-site storage	Inventoried, moisture-resistant, easily accessible by officers, not mixed with general items	Inventory lost, expired, or inaccessible during activation
Signage and wayfinding	Color codes, simple symbols, multisensory information, and easily updatable	Disorientation, cross-queues, and user misplacement

Flexibility must be limited by safety regulations. Partitions must not interrupt evacuation routes, cover sprinklers, obstruct ventilation, or create hidden spaces that are difficult to supervise. Therefore, the emergency layout must have several pre-approved configurations rather than allowing unlimited freedom. This principle aligns with Ardiansyah and Nugraheni (2025, p. 253), who position flexibility as the ability to modify in order to meet user needs, while remaining within the requirements of safety, health, and access.

CONCLUSION

The application of the dual-function concept to disaster shelters in Magelang Regency must be understood as a programmed spatial transformation system between normal conditions and emergency conditions. Under normal conditions, the building functions as a communal, social, educational, worship, service, and administrative facility. Under emergency conditions, these functions change into sleeping areas, services for vulnerable groups, health services, logistics, kitchens, sanitation, and a command center. The relationships between functions must be established before a disaster through space matrices, emergency layouts, storage points, signage, and task division.

Modular interiors and flexibility are the primary devices for transformation. Demountable partitions, folding furniture, and ready-to-use shelter partitions enable spaces to change without major construction work. Governance, inventory, maintenance

financing, periodic drills, capacity validation, and activation time testing are requirements that cannot be replaced by design. An effective dual-function shelter is not a building that can be used for too many events, but rather community infrastructure that can change quickly, safely, measurably, inclusively, and while maintaining the dignity of refugees.

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