



Mosques as Community-Based Vertical Evacuation Shelters in Tsunami-Prone Coastal Padang, Indonesia

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Abstract Indonesia is among the most tsunami-prone countries in the world due to its location along active subduction zones. In coastal cities such as Padang, extremely short tsunami arrival times, high population exposure, and the limited distribution of purpose-built vertical evacuation shelters reveal a critical gap in socially embedded evacuation planning. This study examines the potential of mosques to serve as community-based vertical tsunami evacuation shelters in coastal Padang, focusing on spatial suitability, social legitimacy, and adaptive reuse within a local disaster risk reduction context. Using a qualitative, evidence-informed conceptual design approach, the study integrates secondary spatial data, tsunami hazard information, mosque distribution data, and structured evidence synthesis of empirical studies on evacuation behaviour, social trust, place attachment, and community resilience. Spatial overlay analysis was used to identify mosques located within high-risk coastal zones, while the reviewed literature was thematically analysed to assess the social and behavioural feasibility of mosque-based evacuation. The findings indicate that many mosques are located within tsunami-prone neighbourhoods and embedded in familiar everyday community networks. Their accessibility, social legitimacy, and routine public use may support evacuation responsiveness under severe time constraints. The study proposes the “Why Not Mosque?” framework to conceptualise mosques as socially embedded evacuation infrastructure that can complement formal vertical shelter systems. Rather than claiming direct structural or behavioural validation, this study offers a policy-relevant conceptual model that requires further testing through structural assessment, evacuation simulation, community surveys, and interviews with mosque administrators and disaster agencies. This study contributes to disaster risk reduction research by reframing mosques as socially embedded evacuation infrastructure

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and by linking faith-based disaster governance, social infrastructure, adaptive reuse, and tsunami evacuation planning within a single conceptual framework.

Keywords: tsunami evacuation, community-based disaster risk reduction, religious infrastructure, vertical evacuation shelter, adaptive reuse, social trust, community resilience

1. INTRODUCTION

Indonesia ranks among the world's most tsunami-prone countries because it lies along active subduction zones where the Indo-Australian Plate converges with the Eurasian Plate. This tectonic setting has repeatedly generated large earthquakes with significant tsunami potential along the western coast of Sumatra (Sieh, 2007). Recent studies indicate that stress accumulation along the Sumatran megathrust, particularly in the Mentawai–Siberut segment, remains a major concern for coastal cities such as Padang (Jihad et al., 2023; Konca et al., 2008). Probabilistic tsunami hazard assessments further suggest that tsunami run-up heights in Padang may reach 10–15 m, with estimated arrival times of less than 30 minutes after a major earthquake. Probabilistic tsunami hazard assessments further suggest that tsunami run-up heights in Padang may reach 10–15 m, with estimated arrival times of less than 30 minutes after a major earthquake (Ramli et al., 2022). This short evacuation window makes rapid access to nearby vertical evacuation spaces essential, especially for densely populated coastal neighbourhoods.

Disaster mitigation efforts in Padang have included early warning systems, evacuation routes, and purpose-built vertical evacuation shelters. However, previous assessments show that the number, capacity, and spatial distribution of these shelters remain insufficient. Existing vertical evacuation shelters can accommodate only a small proportion of the at-risk population and are unevenly distributed across tsunami-prone coastal areas (Ashar et al., 2014). Horizontal evacuation is also constrained by limited road capacity, traffic congestion, low public awareness, and short tsunami arrival times (Adji et al., 2025). Studies on evacuation behaviour demonstrate that under severe time pressure, people tend to choose destinations based on proximity and perceived accessibility rather than optimal safety considerations (Pangesti & Hizbaron, 2026). Together, these factors reveal a critical structural weakness in Padang's evacuation system. Road network-based studies further show that in several coastal neighbourhoods, pedestrian travel times to formal shelters exceed realistic evacuation windows (Shabrina & Ahmad, 2023). These findings indicate that Padang's evacuation challenge is not only a matter of shelter shortage, but also a mismatch between formal shelter locations, settlement patterns, and everyday mobility networks.

Evacuation effectiveness depends not only on infrastructure availability but also on how people perceive, trust, and use evacuation spaces. Studies of tsunami evacuation behaviour show that people rarely act through purely rational optimisation during emergencies. Instead, evacuation decisions are shaped by time pressure, risk perception, familiarity, social influence, and trust in available destinations (Makinoshima et al., 2020; Paton, 2013). Research on social

capital and community resilience also demonstrates that social networks, trust, and collective capacity are crucial in shaping disaster response and recovery (Aldrich & Meyer, 2015). In near-field tsunami scenarios, where decisions must be made within minutes, familiar and socially trusted buildings may become more effective evacuation destinations than technically designated but unfamiliar shelters.

Within this behavioural and social context, mosques constitute a distinctive form of public infrastructure in Indonesia's coastal cities. In Padang, mosques function not only as places of worship but also as centres of daily social interaction, moral authority, local coordination, and community learning. Evidence from Banda Aceh shows that mosques may become preferred evacuation destinations because of their accessibility, symbolic meaning, and strong place attachment (Vivita et al., 2023). These findings align with broader research showing that trust and distrust of vertical evacuation buildings strongly influence evacuation choices under social pressure (McCaughey et al., 2017). In predominantly Muslim urban communities such as Padang, mosques may therefore operate as social infrastructure: everyday public spaces where trust, familiarity, and collective coordination are continuously reproduced (Klinenberg, 2019).

Despite this potential, disaster risk reduction research has not yet sufficiently integrated mosques into formal tsunami evacuation planning. Existing studies on tsunami evacuation in Padang have primarily focused on hazard exposure, shelter capacity, road-network accessibility, and evacuation modelling (Ashar et al., 2014; Shabrina & Ahmad, 2023). Mosque-related disaster studies, meanwhile, have often discussed religious buildings as spontaneous refuge spaces, post-disaster recovery sites, or culturally meaningful places rather than as pre-disaster preparedness infrastructure (Vivita et al., 2023). This separation has produced a conceptual gap between technical evacuation planning and socially embedded religious infrastructure. Previous studies have not adequately examined mosques simultaneously as spatially distributed buildings, socially trusted institutions, adaptive architectural assets, and potential components of urban evacuation governance.

This gap is also relevant to wider debates in faith-based disaster governance, adaptive reuse, urban resilience, and critical infrastructure. Studies of faith-based disaster governance in Indonesia show that religious organisations can contribute to disaster mitigation, preparedness, public awareness, and multi-stakeholder collaboration (Baidhaw, 2015). Adaptive reuse literature further suggests that existing buildings can be reconfigured for new functions while preserving their original social and cultural roles (Bullen, 2007). Urban resilience studies emphasise that cities should be understood as interconnected social, ecological, and technical systems that must absorb, adapt to, and recover from shocks (Meerow et al., 2016). Critical infrastructure debates similarly underline the need to address vulnerability paths and interdependencies that may intensify disaster impacts (Pescaroli & Alexander, 2016). Taken together, these debates suggest that evacuation infrastructure should not be treated as purely technical or physical. It should also be accessible, socially legitimate, institutionally governable, and embedded in everyday community life.

To avoid overgeneralising the evidence base, this study distinguishes between three types of evidence. First, Padang-specific evidence is used to establish the local tsunami risk context,

shelter deficit, mosque distribution, and evacuation accessibility challenges. Second, evidence from Banda Aceh is used comparatively to understand how mosques may become trusted and meaningful evacuation destinations in a post-tsunami Indonesian Muslim urban context. Third, broader comparative and theoretical literature on evacuation behaviour, social trust, social infrastructure, adaptive reuse, urban resilience, and disaster governance is used to support the conceptual development of the framework. This distinction is important because the study does not claim that findings from Banda Aceh or other contexts can be directly transferred to Padang without further empirical validation.

This study addresses this gap by introducing the “Why Not Mosque?” framework, which conceptualises mosques as socially embedded vertical evacuation infrastructure. The framework is theoretically distinct because it brings together four dimensions that are often treated separately in disaster risk reduction studies: spatial accessibility, faith-based disaster governance, social infrastructure, and adaptive reuse of existing public buildings. Rather than viewing mosques only as cultural symbols or post-disaster gathering spaces, this study positions them as potential components of community-based evacuation systems in tsunami-prone urban areas. This approach is consistent with the Sendai Framework’s emphasis on strengthening disaster risk governance, investing in resilience, enhancing preparedness, and promoting whole-of-society engagement (United Nations Office for Disaster Risk Reduction, 2015).

Accordingly, this study aims to examine the potential of mosques as community-based vertical tsunami evacuation shelters in Padang City’s coastal areas. Specifically, it seeks to (1) analyse the spatial distribution and accessibility of mosques within tsunami risk zones; (2) examine how social trust, familiarity, and place attachment shape evacuation preferences; (3) assess how adaptive reuse principles can support mosque-based vertical evacuation; and (4) develop a conceptual framework for integrating mosques into community-based disaster preparedness and urban evacuation planning.

2. RESEARCH METHOD AND DESIGN

2.1 Research Approach and Study Area

This study adopts a qualitative, evidence-informed conceptual design approach to develop a framework for integrating mosques as community-based vertical tsunami evacuation shelters in coastal urban settings. Rather than testing a single intervention or conducting primary field experiments, the study synthesises spatial, social-behavioural, architectural, and disaster governance evidence to formulate an applied disaster risk reduction model. This approach is appropriate because the study aims to clarify the feasibility and policy relevance of mosque-based evacuation planning before direct structural testing, evacuation simulation, or community-based empirical validation is conducted.

The study focuses on the coastal areas of Padang City, West Sumatra, Indonesia. Padang is a critical case because it is exposed to potential tsunamis generated by the Mentawai–Siberut megathrust, has densely populated coastal neighbourhoods, and faces a limited distribution of purpose-built vertical evacuation shelters. Under these conditions, rapid access to nearby vertical evacuation spaces is central to local disaster risk reduction planning.

This study should be understood as a conceptual and evidence-informed study rather than as a direct empirical validation of mosque-based evacuation shelters. Its findings are based on secondary spatial data, prior empirical studies, and conceptual synthesis. The study does not include field surveys, structural engineering assessments, evacuation simulations, or interviews with mosque administrators, residents, or disaster management agencies. Therefore, the findings are presented as preliminary feasibility arguments and planning considerations that require further empirical and technical validation before implementation.

2.2 Data Sources and Evidence Selection

This study relied on secondary data from three main sources. First, spatial data were derived from tsunami hazard maps, mosque distribution data, and relevant spatial information on coastal exposure, elevation, and settlement patterns. Tsunami hazard information was obtained from national disaster and meteorological sources, while mosque distribution data were obtained from the Padang branch of the Indonesian Mosque Council (Dewan Masjid Indonesia). Second, social and behavioural evidence was drawn from peer-reviewed studies on tsunami evacuation behaviour, social trust, place attachment, community resilience, and faith-based disaster response in Indonesia and comparable contexts. Third, conceptual and policy-oriented evidence was drawn from literature on social infrastructure, adaptive reuse, urban resilience, critical infrastructure, and disaster risk governance.

The evidence synthesis followed a structured purposive selection strategy. Sources were included when they met at least one of the following criteria: (1) peer-reviewed articles or recognised institutional reports on tsunami hazards, evacuation shelters, evacuation behaviour, or community preparedness in Padang or comparable coastal contexts; (2) studies addressing social trust, place attachment, social capital, religious institutions, or faith-based disaster governance; (3) studies discussing adaptive reuse, vertical evacuation, multifunctional buildings, urban resilience, or critical infrastructure; and (4) international disaster risk reduction frameworks relevant to community-based preparedness and whole-of-society resilience. Sources were excluded when they were opinion pieces without methodological transparency, duplicated materials, studies unrelated to disaster risk reduction, or studies whose geographical and socio-cultural contexts were too distant to inform the Padang case.

2.3 Spatial Analysis and Accessibility Verification

Spatial analysis was conducted using a Geographic Information System (GIS). Tsunami hazard zones were overlaid with mosque distribution data to identify mosques located in high-risk coastal areas. High-risk areas were defined as zones with low elevation, close proximity

to the coastline, and significant exposure to potential tsunami inundation. Mosque locations were then assessed in relation to surrounding residential clusters, existing evacuation infrastructure, and pedestrian accessibility.

To strengthen the spatial feasibility assessment, this study applies an accessibility-screening procedure based on estimated walking time. Walking time was calculated using the formula: $\text{travel time} = \text{network distance} / \text{walking speed}$. An average walking speed of 1.2 m/s was used as a pedestrian evacuation assumption. Based on this assumption, a 30-minute evacuation window corresponds to a maximum walking distance of approximately 2.16 km, while a 25-minute window corresponds to approximately 1.8 km. This threshold was used to assess whether mosques located in relatively sparse distribution areas, particularly mosque IDs 18, 84, and 145 in Figure 2, could realistically serve the farthest nearby residential clusters within the available evacuation window.

This accessibility screening was intended to avoid overgeneralising the feasibility of mosque-based evacuation shelters. Mosques located within the 30-minute walking-time threshold may be considered spatially feasible as potential evacuation nodes, subject to further structural, capacity, and institutional assessment. Conversely, mosques located beyond the threshold should not be treated as stand-alone evacuation options. In such areas, mosque-based shelters need to be complemented by additional vertical evacuation structures, such as purpose-built shelters, retrofitted schools, elevated public buildings, evacuation towers, or improved pedestrian evacuation routes.

2.4 Evidence Synthesis, Coding, and Analytical Validation

Qualitative and behavioural evidence was analysed through structured evidence synthesis. The selected studies were coded using a combined deductive and inductive procedure. Deductive codes were derived from the research objectives and included spatial accessibility, shelter proximity, social trust, familiarity, place attachment, religious legitimacy, adaptive reuse, and community-based governance. Inductive codes were added when recurring themes emerged from the literature, such as everyday use of mosques, nonverbal risk communication, underutilised purpose-built shelters, and the role of religious institutions in community mobilisation.

The coded findings were then grouped into three analytical domains: spatial feasibility, social-behavioural feasibility, and architectural-governance feasibility. Spatial feasibility refers to mosque location, proximity, accessibility, and potential integration with existing evacuation networks. Social-behavioural feasibility refers to trust, familiarity, place attachment, and likely evacuation preferences under time pressure. Architectural-governance feasibility refers to adaptive reuse potential, building function, institutional management, volunteer coordination, and community-based preparedness. These three domains informed the development of the “Why Not Mosque?” framework.

Several strategies were used to strengthen analytical validity and minimise interpretive bias. First, the study applied source triangulation by comparing spatial evidence, behavioural

research, architectural considerations, and disaster governance literature. Second, it distinguished between evidence directly derived from Padang and evidence inferred from comparable contexts such as Banda Aceh. Third, claims based on secondary literature were framed cautiously and were not treated as direct empirical validation of mosque-based shelters in Padang. Fourth, each design and policy recommendation was checked against the three analytical domains to ensure coherence between evidence, interpretation, and proposed application.

2.5 Conceptual Model Development

The “Why Not Mosque?” framework was developed through an iterative conceptual modelling process. The first step identified the core problem: the mismatch between tsunami evacuation needs, formal shelter distribution, and community mobility patterns in coastal Padang. The second step integrated spatial analysis with evidence on evacuation behaviour, social trust, and place attachment. The third step translated these findings into adaptive reuse principles for mosque-based vertical evacuation shelters. The fourth step positioned mosque management committees, volunteer teams, and local residents as key actors in a community-based disaster preparedness system.

The resulting framework conceptualises mosques not merely as religious buildings or spontaneous refuge spaces, but as socially embedded evacuation infrastructure. It links physical accessibility, social legitimacy, adaptive architectural use, and local governance capacity within one preparedness model. Because this study is conceptual and evidence-informed, the framework should be understood as a basis for further empirical testing rather than as a final operational shelter plan. Future validation should include structural engineering assessment, evacuation simulation, community perception surveys, and interviews with mosque administrators, residents, and disaster management agencies.

3. RESULT

3.1 Tsunami Risk Context and Shelter Needs in Padang City

Padang City faces exceptionally high tsunami risk due to the active Mentawai–Siberut megathrust. Probabilistic tsunami hazard assessments indicate a substantial likelihood of tsunami run-up heights of approximately 10–15 m along the western coastline, with estimated arrival times of less than 25 minutes following a major earthquake (Ramli et al., 2022). This short arrival time creates severe constraints for horizontal evacuation, especially in densely populated coastal neighbourhoods where road capacity, distance to higher ground, and traffic congestion may delay evacuation. The spatial distribution of population density across Padang City is shown in Figure 1.

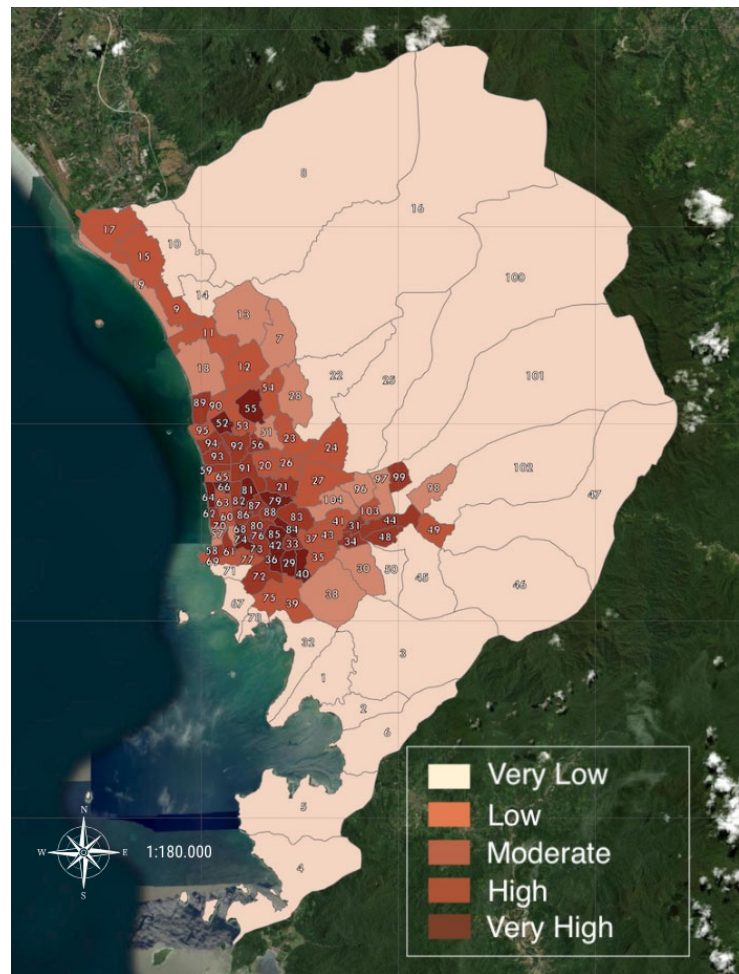


Figure 1. Population density spatial map

Previous assessments show that existing purpose-built vertical evacuation shelters remain insufficient in number, capacity, and spatial distribution (Algamar, 2022; Ashar et al., 2014). The shelter deficit is particularly critical in coastal districts where high population density overlaps with limited access to formal evacuation buildings. Road network-based analysis further indicates that in several coastal neighbourhoods, the shortest pedestrian routes to designated shelters may exceed realistic evacuation timeframes (Shabrina & Ahmad, 2023). These conditions confirm the need for additional, locally accessible evacuation nodes that are closer to residential clusters and embedded within everyday mobility networks.

3.2 Spatial Distribution and Structural Potential of Mosques in High-Risk Zones

The spatial overlay analysis identified 190 mosques across Padang City. Of these, approximately 58 mosques are located within high-risk coastal zones, particularly in areas with low elevation and substantial exposure to potential tsunami inundation. The concentration of mosques in coastal districts such as Padang Barat and Padang Utara suggests that mosques are spatially embedded within areas where rapid access to vertical evacuation is most urgently needed.



Figure 2. Spatial distribution of mosques and tsunami-prone areas

Among the mosques located in high-risk zones, approximately 23 buildings have reinforced concrete structures with two or more floors. These buildings represent an initial pool of potential mosque-based vertical evacuation sites, although their suitability cannot be confirmed without detailed structural engineering assessment. Their spatial characteristics indicate three preliminary advantages for evacuation planning: proximity to residential areas, continuous everyday public use, and distribution within neighbourhood-scale pedestrian networks (Algamar, 2022).

Accessibility analysis indicates that many mosques in Padang Utara and Padang Barat are reachable by nearby residents within a short walking time. However, this finding should not be generalised to all mosques or all coastal neighbourhoods. Mosque-based evacuation feasibility depends on site-specific accessibility, structural safety, vertical capacity, and institutional readiness. For this reason, additional screening was conducted for mosques located in relatively sparse distribution areas.

3.3 Accessibility Screening for Sparsely Distributed Mosques

Additional accessibility screening was introduced for mosque IDs 18, 84, and 145 in Figure 2 because these mosques are located in areas where mosque distribution appears relatively sparse. The purpose of this screening was to avoid assuming that all mosques in high-risk zones can serve nearby residents within the available tsunami evacuation window. Using an average walking speed of 1.2 m/s, a 30-minute evacuation window corresponds to a maximum walking distance of approximately 2.16 km, while a 25-minute window corresponds to approximately 1.8 km.

The mosque coordinate dataset identifies the selected mosques as follows. Mosque ID 18 is Masjid Al-Manar, located in Dadok Tunggul Hitam, Koto Tangah. Mosque ID 84 is Masjid Darul Ishlal, located in Lubuk Buaya, Koto Tangah. Mosque ID 145 is Masjid Nurul Yaqin Komplek Denai Pamulang, located in Padang Sarai, Koto Tangah. These three locations provide a basis for further road-network verification from the farthest nearby residential clusters.

This screening clarifies that mosque-based vertical evacuation planning cannot be applied uniformly across all coastal areas. Where the road-network distance from the farthest residential cluster to a mosque is within the 30-minute threshold, the mosque may be considered spatially feasible as a potential evacuation node, subject to structural and institutional assessment. Where the distance exceeds this threshold, the mosque should not be treated as a stand-alone evacuation option. Instead, additional vertical evacuation structures, such as purpose-built shelters, retrofitted schools, elevated public buildings, evacuation towers, or improved pedestrian evacuation routes, are required.

This finding strengthens rather than weakens the “Why Not Mosque?” framework. It shows that mosque-based shelters should complement, not replace, formal vertical evacuation infrastructure. The framework should therefore be applied selectively through spatial screening, structural assessment, and local evacuation-network planning.

3.4 Social and Behavioural Feasibility of Mosque-Based Evacuation

The evidence synthesis indicates that evacuation behaviour is strongly influenced by trust, familiarity, perceived accessibility, and place attachment. Studies on tsunami evacuation show that people under severe time pressure often move toward destinations they know, trust, and perceive as socially legitimate (Makinoshima et al., 2020; McCaughey et al., 2017; Paton, 2013). This behavioural pattern is especially relevant in near-field tsunami contexts, where residents have limited time to evaluate alternative destinations.

Evidence from Banda Aceh shows that mosques may become preferred evacuation destinations because they are familiar, accessible, and symbolically meaningful to local communities (Vivita et al., 2023). In Padang, where mosques are part of everyday religious and social life, these buildings may function as trusted social infrastructure that supports rapid collective movement during emergencies. The social feasibility of mosque-based evacuation

therefore lies not only in physical proximity, but also in the ability of mosques to mobilise trust, routine familiarity, and community coordination.

3.5 Conceptual Design Features of Mosque-Based Vertical Evacuation Shelters

Based on the spatial and social-behavioural findings, this study proposes an adaptive reuse approach for mosque-based vertical evacuation shelters. The proposed model preserves the primary religious function of the mosque while adding emergency evacuation capacity through modest architectural and operational adjustments.

The design incorporates several key features. Upper floors or roof decks function as temporary evacuation spaces with an estimated capacity of 300–600 people, depending on building size. The ground floor remains dedicated to religious activities under normal conditions, while external staircases or ramps facilitate rapid vertical circulation during emergencies. To communicate the shelter function intuitively, the design integrates visual markers such as porous façade elements, reducing reliance on textual signage. Ideally, mosque-based shelters also incorporate an early warning system (EWS), including LiDAR sensors and CCTV cameras installed along the coastline. These systems transmit real-time shoreline imagery via cloud-based platforms to monitors within mosques and activate tsunami early warning alarms. The proposed use of multipurpose spaces across mosque floors and rooftop areas is illustrated in Figure 6.

The implementation of mosque-based vertical evacuation shelters can follow two main approaches, depending on site-specific physical conditions and land availability (see Figure 3). First, shelters can be developed by incrementally adding new structures above existing mosque buildings, an approach well-suited to areas with limited horizontal space. This strategy builds on existing social and spatial foundations while increasing vertical capacity without requiring relocation (see Figure 4). Second, shelters can be constructed as new, separate structures that connect directly to mosque buildings through bridges or corridors. This model is more appropriate for mosques with available horizontal space, as it allows for greater evacuation capacity without disrupting the mosque's primary religious functions (see Figure 5).

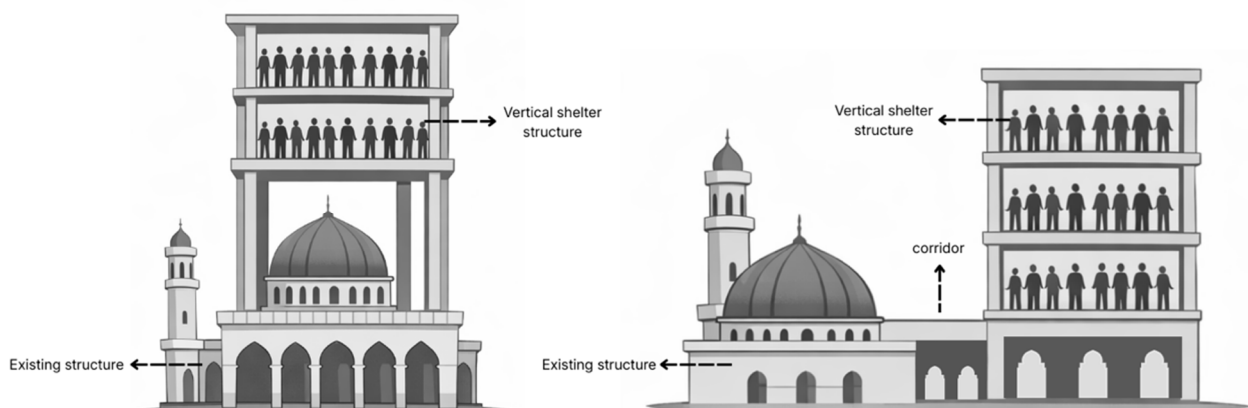


Figure 3. Two approaches to developing mosque-based vertical evacuation shelter

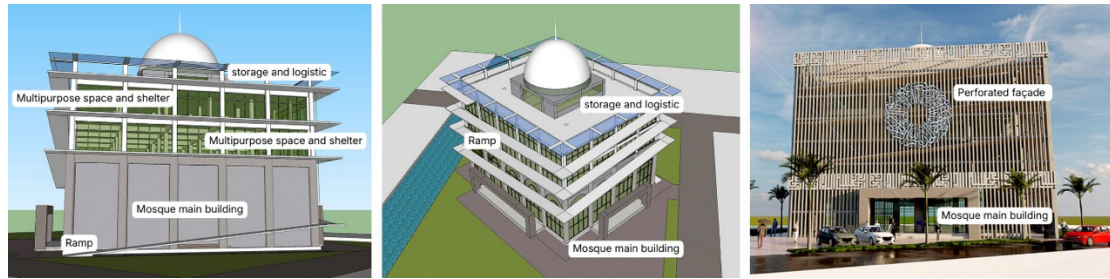


Figure 4. Building a shelter concept on the existing structure



Figure 5. The concept of a shelter building on a separate structure



Figure 6. The concept of utilising multipurpose space in a mosque-based vertical shelter

Two design approaches are proposed depending on site conditions. The first involves strengthening and extending existing mosque structures to support vertical evacuation functions. This approach is suitable for dense areas with limited land availability. The second involves constructing a separate evacuation structure connected to the mosque through a bridge or corridor. This option is more suitable where additional land is available and where separation between worship functions and evacuation capacity is required. Both approaches require detailed technical assessment before implementation, including structural integrity, load-bearing capacity, staircase width, rooftop safety, accessibility for vulnerable groups, and compliance with evacuation building standards.

3.6 The "Why Not Mosque?" Framework

The "Why Not Mosque?" framework conceptualises mosques as socially embedded vertical evacuation infrastructure. The framework integrates three feasibility dimensions: spatial feasibility, social-behavioural feasibility, and architectural-governance feasibility. Spatial feasibility refers to the location of mosques within high-risk coastal neighbourhoods and their potential accessibility from nearby residential clusters. Social-behavioural feasibility refers to trust, familiarity, place attachment, and the role of mosques in shaping evacuation preferences. Architectural-governance feasibility refers to adaptive reuse potential, institutional management, volunteer coordination, and community-based preparedness. The resulting community-based preparedness coordination model is presented in Figure 7.

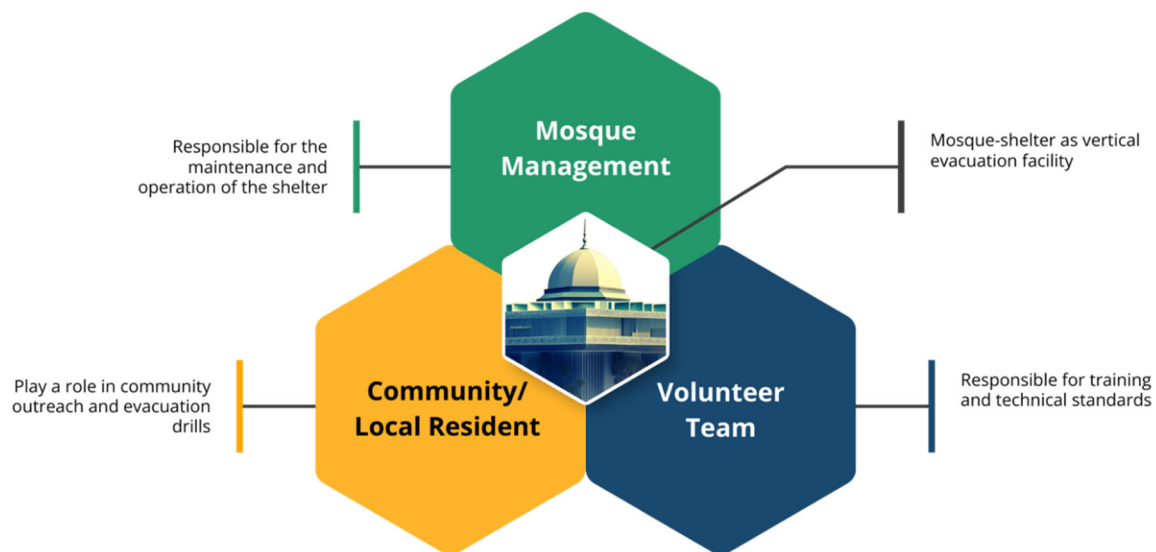


Figure 7. The "Why Not Mosque?" community-based preparedness coordination model

Within this framework, mosque management committees, volunteer teams, local residents, and disaster management agencies form the core actors of mosque-based evacuation planning. Mosque committees can support day-to-day management and legitimacy, volunteer teams can coordinate drills and operational procedures, residents can participate in preparedness activities, and disaster agencies can provide technical guidance and institutional recognition. The framework therefore positions mosques not as informal or ad hoc shelters, but as potential community-based evacuation nodes that require formal planning, technical assessment, and governance integration.

4. DISCUSSION

4.1 Interpreting the Key Findings

This study shows that mosques have potential to complement vertical tsunami evacuation planning in coastal Padang, but only under specific spatial, structural, and institutional conditions. The findings indicate that many mosques are located in tsunami-prone coastal

neighbourhoods, embedded in everyday community mobility networks, and supported by high levels of social familiarity and trust. These characteristics are relevant to near-field tsunami evacuation, where residents have limited time to identify and reach safe destinations (Makinoshima et al., 2020; McCaughey et al., 2017; Paton, 2013).

However, the findings also show that mosque-based evacuation planning should not be generalised across all coastal areas. Mosques located in sparse distribution areas or beyond realistic walking-time thresholds cannot function as stand-alone evacuation shelters. In such locations, mosque-based shelters must be complemented by other vertical evacuation structures, including purpose-built shelters, retrofitted schools, elevated public buildings, evacuation towers, and improved pedestrian routes. This qualification is consistent with previous findings that evacuation effectiveness depends not only on shelter availability but also on travel distance, road-network accessibility, and realistic pedestrian movement under time pressure (Ashar et al., 2014; Shabrina & Ahmad, 2023). Therefore, the “Why Not Mosque?” framework should be understood as a selective and complementary evacuation strategy rather than a universal shelter solution.

4.2 Theoretical Contribution: Faith-Based Governance, Social Infrastructure, and Adaptive Reuse

This study advances mosque-related disaster risk reduction research by shifting the analytical focus from mosques as spontaneous refuge spaces, cultural symbols, or post-disaster recovery sites to mosques as potential pre-disaster preparedness infrastructure. Previous studies have shown that mosques may become trusted places during disaster events, particularly because of accessibility, symbolic meaning, and place attachment (Vivita et al., 2023). However, these studies have rarely translated this social trust into a conceptual model for formal evacuation planning. The “Why Not Mosque?” framework addresses this gap by linking mosque location, social legitimacy, adaptive architectural potential, and community-based governance capacity within one evacuation model.

From the perspective of faith-based disaster governance, mosques should not be understood only as religious institutions that provide moral support after disasters. They may also function as preparedness institutions that support risk communication, collective mobilisation, evacuation drills, volunteer coordination, and community-based disaster education. This expands the role of faith-based institutions from informal humanitarian actors to potential partners in formal disaster governance, provided that their roles are clearly regulated and technically supported (Baidhaw, 2015; United Nations Office for Disaster Risk Reduction, 2015).

From the perspective of social infrastructure theory, the value of mosques lies not only in their physical availability but also in their everyday social function. Mosques are routine gathering spaces where trust, familiarity, shared norms, and collective coordination are reproduced. These qualities are crucial in tsunami evacuation because people under severe time pressure are more likely to move toward places they already know and trust (Klinenberg, 2019;

Makinoshima et al., 2020; McCaughey et al., 2017). This argument also aligns with disaster resilience research showing that social capital, trust, and community networks shape disaster preparedness, response, and recovery (Aldrich & Meyer, 2015; Paton, 2013).

From the perspective of adaptive reuse, the proposed framework demonstrates how existing religious buildings can be reconfigured for emergency functions while preserving their primary religious role. This approach is particularly relevant in dense coastal cities where land scarcity, funding limitations, and the underuse of single-purpose evacuation buildings can constrain disaster risk reduction planning. Adaptive reuse allows selected mosques to maintain everyday religious and social functions while adding emergency capacity through structural strengthening, external access routes, rooftop or upper-floor evacuation spaces, visible wayfinding, and operational preparedness (Bullen, 2007). This possibility is also supported by recent evidence that some mosque structures may have potential as alternative tsunami evacuation buildings, although detailed structural assessment remains necessary before formal designation (Ibrahim et al., 2024).

4.3 Urban Resilience and Critical Infrastructure Implications

The “Why Not Mosque?” framework also contributes to urban resilience and critical infrastructure debates by proposing a decentralised evacuation model. In near-field tsunami contexts, evacuation infrastructure cannot depend solely on a small number of large, purpose-built shelters. Such an approach may create accessibility gaps, congestion, and unequal protection for communities located far from formal shelters. A decentralised network that combines formal shelters, mosque-based nodes, schools, public buildings, and evacuation towers can increase redundancy and reduce dependence on single infrastructure types. This logic is consistent with urban resilience thinking, which understands cities as interconnected social, ecological, and technical systems that must absorb, adapt to, and recover from shocks (Meerow et al., 2016).

This framework therefore reframes evacuation infrastructure as a socio-technical system. Its effectiveness depends not only on building height, capacity, or engineering performance, but also on accessibility, social trust, institutional coordination, route connectivity, and public recognition. This point is relevant to critical infrastructure debates, which emphasise that disaster impacts often emerge through vulnerability pathways, interdependencies, and cascading failures across infrastructure systems (Pescaroli & Alexander, 2016). For local governments and disaster management agencies, the practical implication is that mosques should be mapped, screened, and classified according to their feasibility. Only mosques that meet minimum requirements of accessibility, structural safety, vertical capacity, access circulation, institutional readiness, and community acceptance should be considered for integration into formal evacuation networks.

This approach is consistent with resilience-oriented disaster governance, which emphasises preparedness, local capacity, whole-of-society participation, and investment in existing community assets (United Nations Office for Disaster Risk Reduction, 2015). It also supports

a more realistic evacuation strategy for Padang by combining technical planning with socially embedded infrastructure already present in coastal neighbourhoods.

4.4 Limitations and Future Research

The findings of this study should be interpreted cautiously. The evidence supports the conceptual and planning relevance of mosque-based vertical evacuation shelters, but it does not provide final operational validation. The study relies primarily on secondary spatial data, prior empirical studies, and conceptual synthesis rather than field surveys, direct structural assessments, evacuation simulations, or interviews with mosque administrators, residents, and disaster management agencies. Evidence from Banda Aceh is used as a comparative reference, not as a direct substitute for empirical data from Padang. Therefore, the “Why Not Mosque?” framework should be treated as a preliminary evidence-informed conceptual model, not as a final operational shelter plan.

Future research should conduct structural engineering assessments of selected mosques, including load-bearing capacity, foundation strength, staircase width, rooftop safety, access for vulnerable groups, and compliance with vertical evacuation standards. Evacuation simulations should also be conducted to test walking time, congestion, route capacity, and shelter demand under different tsunami arrival scenarios. Further research should include community surveys and interviews with mosque administrators, local residents, disaster management agencies, and urban planners to assess institutional readiness and community acceptance.

5. CONCLUSION

This study examined the potential of mosques to function as community-based vertical tsunami evacuation shelters in the coastal areas of Padang City, Indonesia. The findings suggest that selected mosques may complement formal vertical evacuation infrastructure because they are spatially embedded in coastal neighbourhoods, socially trusted by local communities, and adaptable for emergency functions through carefully planned reuse. In near-field tsunami contexts, where evacuation time is extremely limited, such everyday and familiar public buildings may help improve evacuation responsiveness.

However, mosque-based evacuation planning should not be generalised to all mosques or all coastal areas. Its feasibility depends on site-specific conditions, including walking-time accessibility, structural safety, vertical capacity, access circulation, institutional readiness, and community acceptance. Mosques located beyond realistic walking-time thresholds should not be treated as stand-alone shelters; instead, they should be complemented by purpose-built shelters, retrofitted schools, elevated public buildings, evacuation towers, or improved pedestrian routes.

The “Why Not Mosque?” framework therefore reframes mosques as socially embedded evacuation infrastructure rather than as informal or symbolic disaster spaces. Its main

contribution lies in linking spatial accessibility, social legitimacy, adaptive reuse, and community-based governance within a single disaster risk reduction model. Future implementation requires structural engineering assessment, evacuation simulation, community surveys, and formal coordination between mosque committees, local residents, volunteer teams, and disaster management agencies.

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COMPETING INTERESTS

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

AUTHORS’ CONTRIBUTIONS

Febrin Anas Ismail: Conceptualisation and Methodology. Rully Yusuf and Eka Pebriansyah: Funding acquisition. Yenny Narny: Project administration and Resources. Fauzan: Supervision. Ahmad Muhajir: Writing and Visualisation. Muhammad Alfarisi Farhan: Data curation and Software. All authors reviewed the article, contributed to the discussion of results, approved the final version for submission and publication, and take responsibility for the integrity of its findings.

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DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author, Yenny Narny, upon reasonable request.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES

During the preparation of this manuscript, the authors used ChatGPT by OpenAI and Grammarly to refine the English translation, academic tone, grammar, and readability. These tools were not used to generate research data, conduct spatial analysis, or replace the authors’ interpretation. All content was critically reviewed, edited, and approved by the authors, who take full responsibility for the accuracy, integrity, and final content of the manuscript.

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