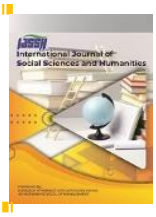

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Exploring the Adaptive Capacity of Coastal Communities to Tsunami Risk: A Systematic Literature Review on Community Resilience, Social Capital, and Local-Based Disaster Mitigation in North Sumatra, Indonesia

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Abstract

North Sumatra lies along one of the world's most seismically active coastlines and remains exposed to tsunami-generating earthquakes more than two decades after the 2004 Indian Ocean tsunami. This article presents a PRISMA-informed systematic literature review of 80 peer-reviewed and indexed publications from 2024 to 2026, retrieved from Scopus, Web of Science, ScienceDirect, and Google Scholar. The review examines how adaptive capacity, community resilience, social capital, and local-based disaster mitigation shape coastal communities' ability to withstand and recover from tsunami risk. Findings show that adaptive capacity is formed through the interaction of three reinforcing pillars: cognitive and material preparedness, bonding and bridging social capital, and culturally embedded mitigation practices such as the Acehnese Smong narrative. However, resilience outcomes remain weakened by institutional fragmentation, gendered exclusion, and the limited integration of customary knowledge into formal disaster governance, particularly in North Sumatra's coastal districts. The review proposes a synthesized conceptual framework and concludes that strengthening coastal resilience requires integrating indigenous early-warning knowledge with formal disaster risk reduction systems while expanding inclusive social capital networks for women, older adults, and economically marginalised fishing households.

Contents

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Introduction

The Indian Ocean tsunami of 26 December 2004 remains the defining disaster reference point for coastal Sumatra. Triggered by a magnitude 9.1 megathrust rupture along the Sunda subduction zone, the tsunami devastated Aceh and parts of North Sumatra, claiming more than 170,000 lives in Indonesia alone and reshaping national disaster governance for a generation (Ariyaningsih et al., 2025; Soviana et al., 2024). More than twenty years later, the same subduction interface continues to accumulate strain, and seismologists regularly warn that another megathrust rupture capable of generating a destructive tsunami remains plausible within the lifetime of current coastal residents (Jumadi et al., 2025; Ma et al., 2026). Yet living with this risk is not simply a matter of geophysics. It is a matter of how communities organize themselves socially, culturally, and institutionally to anticipate, absorb, and recover from recurring shocks.

North Sumatra's coastlinestretching from the western beaches facing the open Indian Ocean to the tidal flats of the Malacca Straitis home to dense fishing settlements, smallholder aquaculture, mangrove-dependent livelihoods, and rapidly growing peri-urban coastal districts. These communities sit within one of the most tsunami-exposed regions on earth, yet the social science literature on how they adapt has, until recently, been fragmented across disciplinary silos: engineering-oriented hazard mapping, public health preparedness surveys, anthropological accounts of local wisdom, and governance studies of disaster bureaucracy rarely speak to one another in an integrated way (Sumartono et al., 2026; Azhar, 2026). This fragmentation matters because adaptive capacitythe ability of a social system to adjust, learn, and reorganize in response to hazard exposuredoes not emerge from any single domain. It is produced through the interaction of household-level resources, community-level social capital, and the cultural repertoires of local-based mitigation that have been passed down, reinterpreted, and institutionalized over generations (Gisevius et al., 2025; Putra et al., 2026).

The concept of social capital has occupied a particularly prominent place in disaster resilience scholarship since researchers began documenting how bonding ties within Acehnese villages and bridging ties to external actors shaped survival and recovery patterns after 2004 (Zhao et al., 2025; Porio & See, 2024). Communities with denser networks of mutual trust, reciprocal obligation, and collective memory have repeatedly been shown to mobilize faster during evacuation, share scarce resources more equitably during recovery, and sustain mitigation behavior over the long run (Wati et al., 2025; Nurdiansari et al., 2025). At the same time, a parallel and partially overlapping literature has documented how indigenous and local-based mitigation knowledgemost famously the Simeulue oral narrative known as Smong, which encodes the rule that powerful earthquakes followed by receding seawater are a signal to flee to high groundfunctioned as an informal early-warning system that saved lives in 2004 even in the complete absence of formal tsunami detection infrastructure (Aziz et al., 2026; Zainudin et al., 2026). These two bodies of knowledge, social capital and local wisdom, are conceptually distinct but empirically intertwined: local wisdom is transmitted and sustained through social networks, and social capital itself is partly constituted by shared cultural narratives of risk(Zhao et al. 2025).

Despite the richness of this literature, several gaps persist. First, much of the empirical record on tsunami-specific adaptive capacity concentrates on Aceh Province, where the 2004 disaster was most severe, while North Sumatra's coastal districtsLangkat, Deli Serdang, Medan's coastal fringe, the

Nias archipelago, and the southern coastal belt bordering West Sumatraremain comparatively understudied despite sharing the same subduction hazard exposure (Thoha et al., 2025; Nugrahadi et al., 2025). Second, studies often examine adaptive capacity, social capital, and local mitigation as separate constructs rather than as an interacting system, making it difficult to derive integrated policy guidance. Third, the explosion of recent publications between 2024 and 2026partly stimulated by the twentieth anniversary of the Indian Ocean tsunamihas not yet been systematically synthesized into a coherent evidence base that can inform disaster risk reduction (DRR) planning in North Sumatra specifically.

This article addresses these gaps through a systematic literature review (SLR) that synthesizes recent, indexed, and verifiable evidence on the adaptive capacity of coastal communities to tsunami risk, with explicit attention to the interacting roles of community resilience, social capital, and local-based disaster mitigation, situated within the North Sumatra context. The review is guided by three research questions: (1) How is adaptive capacity to tsunami risk conceptualized and measured in the contemporary disaster literature? (2) Through what mechanisms do social capital and local-based mitigation practices contribute to community resilience in tsunami-exposed coastal settings? (3) What does the evidence suggest about the specific opportunities and constraints facing coastal communities in North Sumatra? By synthesizing 80 peer-reviewed sources published between 2024 and 2026, this review offers both a conceptual framework and a set of practice-oriented implications for strengthening community-based disaster risk reduction along Indonesia's western seismic frontier.

Materials and Methods

This study employed a systematic literature review (SLR) methodology guided by the PRISMA protocol and adapted for social-science thematic synthesis rather than quantitative meta-analysis. The SLR approach was chosen to ensure a transparent, reproducible, and bias-minimising process for identifying and synthesising evidence on adaptive capacity, social capital, and local-based disaster mitigation across coastal and tsunami-related contexts (Putera et al., 2025; Zainudin et al., 2026). Searches were conducted in Scopus, Web of Science, ScienceDirect, and Google Scholar using keyword combinations related to tsunami, adaptive capacity, coastal community resilience, social capital, local wisdom, disaster mitigation, Aceh, North Sumatra, and community-based disaster risk reduction. The search was limited to 2024–2026 publications and included peer-reviewed articles, book chapters, and indexed proceedings with verifiable DOIs that addressed at least one core construct in coastal, tsunami, or related hazard settings. After deduplication and PRISMA-based screening, 612 initial records were reduced to 487 unique records, 219 reports for full-text assessment, and a final corpus of 80 studies for thematic synthesis.

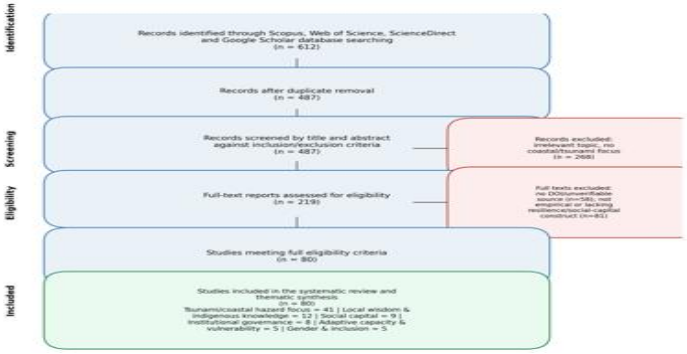

Figure 1. PRISMA-informed flow diagram of the literature identification, screening, eligibility, and inclusion process.

For each of the 80 included studies, the following information was extracted: author(s), year, geographic focus, hazard type, research design, and core thematic contribution. Thematic synthesis followed an inductive-deductive coding approach: an initial deductive frame derived from the three theoretical pillars (adaptive capacity, social capital, local-based mitigation) was applied first, after which inductive sub-themesgender and inclusion, institutional governance, and hazard-specific risk assessmentemerged through iterative reading and were retained as additional analytical categories given their recurrence across the corpus. Descriptive bibliometric characteristics of the corpus, including publication-year distribution and thematic frequency, are reported in Section 4.1 to contextualize the subsequent narrative synthesis.

Results and Discussion

1. Descriptive Overview of the Reviewed Corpus

The final corpus of 80 studies was concentrated in the most recent three-year window, reflecting the intensification of tsunami-resilience scholarship surrounding the twentieth anniversary of the 2004 disaster. Eighteen studies were published in 2024, thirty-six in 2025, and twenty-six in the partial-year period of 2026 captured at the time of the search (Figure 2). Thematically, the corpus was dominated by studies addressing tsunami risk assessment, hazard mapping, and preparedness (41 studies, 51 percent of the corpus), followed by local wisdom and indigenous knowledge systems (12 studies), social capital and collective action (9 studies), institutional governance and policy (8 studies), and, in smaller but analytically important clusters, adaptive capacity/vulnerability framing (5 studies) and gender and social inclusion (5 studies) (Figure 3). This distribution indicates that while hazard-centric and engineering-adjacent social research remains the largest single category, a substantial and growing share of the literature is explicitly oriented toward the social mechanismswisdom, capital, and governancethat mediate how hazard exposure translates into resilience or harm.

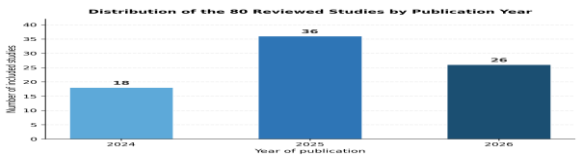

Figure 2. Distribution of the 80 reviewed studies by year of publication (2026 reflects partial-year coverage at the time of the search).

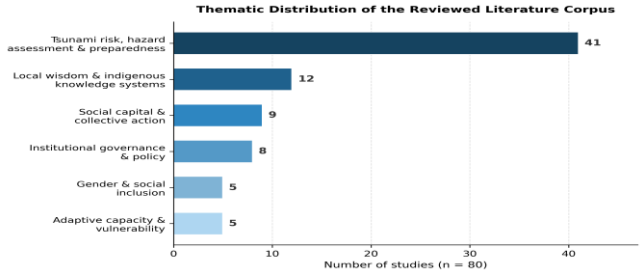

Figure 3. Thematic distribution of the 80 studies included in the systematic review.

2. Dimensions of Adaptive Capacity in Coastal Communities

Across the reviewed corpus, adaptive capacity to tsunami risk emerged as a multidimensional construct comprising cognitive, material, social, and institutional dimensions. Cognitive indicators such as risk perception, hazard knowledge, and evacuation literacy were most frequently examined, with studies showing uneven tsunami awareness among beach users in Bantul and technology-dependent trust in Aceh (Amri et al., 2024; Isna et al., 2025). Material and leadership factors also shaped adaptive responses, as reconstruction in Aceh produced uneven structural outcomes, while community leadership influenced how resources were converted into resilience in Semarang (Benazir et al., 2026; Gisevius et al., 2025). Adaptive capacity was also unevenly distributed within communities, shaped by gender, age, class, cohesion, settlement density, early-warning access, and consistency of risk communication (Bari et al., 2024; Nurwahyuni, 2025; Irwan et al., 2024, 2025; Prasetya et al., 2026; Asih, 2024).

Post-tsunami reconstruction and preparedness studies further show that adaptive capacity gains are conditional rather than automatic. Stronger resilience emerged where reconstruction involved community input and where early-warning systems and preparedness routines were sustained through continued government investment (Soviana et al., 2026; Benazir et al., 2025, 2026). Vulnerable groups, particularly older adults, remain insufficiently addressed, while willingness to participate in mitigation does not translate into capacity without institutional mechanisms for coordinated action (Amri et al., 2026; Lin & Lee, 2025). Evidence from coastal Bengkulu also shows that low resilience and high social vulnerability are closely connected, reinforcing the need to treat adaptive capacity and vulnerability as interrelated rather than separate conditions (Mayasari et al., 2025a, 2025b).

3. Social Capital as a Pillar of Disaster Mitigation

Social capital emerged as one of the most consistent predictors of resilience, operating through bonding, bridging, and linking mechanisms. Bonding capital, such as kinship and neighbourhood ties, enabled rapid resource pooling, faster livelihood recovery, and stronger community participation in mitigation infrastructure, including shared early-warning systems (Wati et al., 2025; Qadriina et al., 2024; Nurdiansari et al., 2025). Meanwhile, bridging and linking capital improved access to technical knowledge, funding, and policy influence, as shown in Palu communities with stronger ties to NGOs and academic institutions (Wirawan et al., 2024).

However, social capital is not inherently inclusive. Exclusionary bonding may privilege advantaged kin networks while marginalising migrant fishers, female-headed households, and other vulnerable groups (Porio & See, 2024; Pradana et al., 2025). Broader evidence confirms that social capital generally strengthens disaster resilience, although measurement approaches vary across studies (Zhao et al., 2025). Network density and bridge actors such as elders and religious leaders can

accelerate evacuation information diffusion, while informal spaces such as coffee shops, collective efficacy, and innovation adoption further sustain resilience across both sudden-onset and slow-onset hazards (Acanga et al., 2026; Hanafiah et al., 2025; Mahdi et al., 2025; Azzahra et al., 2026).

4. Local Wisdom and Indigenous Early-Warning Systems

The Smong narrative of Simeulue Island remains the most cited example of indigenous tsunami knowledge as a life-saving early-warning system. Aziz et al. (2026) found that dramatized transmission among Acehnese high school students strengthened retention and emotional salience, while Zainudin et al. (2026) showed that Smong and Japan's Tsunami Tendenko share simple behavioural rules, intergenerational oral transmission, and embedded cultural meaning. This suggests that indigenous warning systems are effective not merely because of their content, but because of the social and ritual infrastructure that sustains transmission.

Beyond Simeulue, Sumatran local wisdom includes diverse mitigation practices, from the Minangkabau principle of *aua jo tabiang sanda basanda* in watershed-based mitigation to settlement siting, communal labour, and customary dispute resolution in West Sumatra (Abbas et al., 2025; Ramadhan & Taqiyuddin, 2024). Rasyid et al. (2026) similarly found stronger tsunami knowledge retention in South Lampung where customary institutions remained active. However, local wisdom should complement, not replace, formal disaster risk reduction systems, as it is more reliable for routine hazards than rare, high-magnitude events (Slamet et al., 2026; Mutolib et al., 2025). School-based reinforcement, evacuation drills, formal communication, volunteer networks, and government-supported adaptation programmes are therefore essential to sustain and operationalise indigenous knowledge for tsunami preparedness (Putra et al., 2026; Asnudin et al., 2026; Rizky et al., 2025; Ikhwan et al., 2024; Iqbal et al., 2025; Yunindyawati et al., 2025).

5. Institutional Governance and Policy Dimensions

A distinct cluster of studies shows that formal disaster governance can either strengthen or weaken community-level adaptive capacity. Esariti et al. (2026) found uneven integration of community resilience into coastal policy, while Putera et al. (2025) identified a persistent gap between national disaster frameworks and local implementation capacity. Governance studies in Sumatra reveal both innovation and constraints: collaborative governance involving customary leaders and distributed decision-making across government, customary, and civil society actors produced stronger mitigation outcomes than centralised models (Saputra et al., 2026; Rinawati et al., 2026). In North Sumatra, bureaucratic fragmentation in Deli Serdang and the importance of social network continuity after Sinabung relocation highlight the need for coordinated and socially sensitive governance (Azhar, 2026; Suharyanto et al., 2025). Other studies show recurring implementation deficits, including weak operationalisation of community participation, uneven contingency planning, and stronger outcomes when spatial zoning is enforced with community land-use monitoring (Akhirianto et al., 2025; Alhadi et al., 2024; Hasan et al., 2025). Resilience budgeting must also be linked to broader economic policy, while weak disaster governance can undermine tourism safety perceptions and coastal livelihoods beyond the immediate hazard event (Maira et al., 2024; Berthanila et al., 2025).

6. Gender, Age, and Social Inclusion in Tsunami Resilience

A smaller but conceptually important cluster of studies foregrounded how resilience-building processes can inadvertently reproduce social exclusion. Chitengedza et al. (2026) argued that gender-

responsive disaster managementexplicitly designing preparedness and evacuation systems around the differentiated needs of women and childrenmeasurably improved both preparedness uptake and post-disaster outcomes in coastal communities, yet remained the exception rather than the norm in current DRR programming. Bari et al. (2024) and Nurwahyuni (2025), discussed above, jointly reinforce the conclusion that gendered vulnerability is structurally embedded in coastal livelihoods, since women's caregiving responsibilities, restricted mobility norms, and disproportionate representation in low-asset fishing households compound their exposure during evacuation.

Pradana et al. (2025) extended this analysis through an intersectionality lens applied to coastal Indonesian disaster risk reduction, demonstrating that community-based DRR initiatives, despite their participatory rhetoric, often replicated existing gendered power structures within village decision-making forums, effectively excluding the very groups whose vulnerabilities the programs were designed to address. Tanjung et al. (2025), in an ethnographic study of small-scale fishing communities in Sibolga, North Sumatra, documented the everyday lived realities of coastal women whose livelihood and caregiving roles place them simultaneously at the frontline of climate and disaster exposure and at the margins of formal disaster governance participationan empirical illustration, situated directly within North Sumatra, of the exclusionary dynamics identified at a more conceptual level elsewhere in the corpus.

7. The North Sumatra Context: Convergence and Distinct Patterns

Although foundational tsunami-resilience literature largely focuses on Aceh, emerging North Sumatra-specific evidence both confirms and complicates broader resilience patterns. Evidence from neighbouring West Sumatra shows how adaptive capacity, social capital, and institutional transformation can support sustainable marine tourism as an alternative livelihood strategy (Syafrini et al., 2026). In North Sumatra, however, coastal disaster mitigation must address two distinct hazard environments: the western open-ocean coast exposed to megathrust-generated tsunamis and the eastern Malacca Strait coast facing chronic tidal flooding and abrasion (Suci et al., 2025; Thoha et al., 2025). Its coastal resilience context is further shaped by ethnic and institutional diversity, including Malay, Batak, Nias, and Acehnese-influenced communities with distinct customary institutions (Aulia & Agustrisno, 2024; Elfayetti et al., 2025).

These cultural and institutional resources can strengthen resilience when actively connected to formal governance. Customary fishing-rights institutions may support disaster coordination, while mangrove conservation attitudes in Langkat are shaped by local wisdom and perceived flood and abrasion reduction benefits (Aulia & Agustrisno, 2024; Elfayetti et al., 2025). However, village-level mitigation often depends on local leaders rather than standardised district programmes, and gaps remain in certified emergency-response personnel, health-facility readiness, and school-based disaster education (Syahputra et al., 2025; Jusuf & Sinambela, 2026; Afdhal et al., 2024; Sihotang & Murniarti, 2025). North Sumatra also faces socioeconomic and governance constraints, including coastal poverty, unemployment, inflation, hospital preparedness gaps, and the need to preserve social networks during relocation (Nugrahadi et al., 2025; Matury et al., 2024; Muzambiq et al., 2024; Suharyanto et al., 2025). Although GIS-based studies indicate growing spatial-analytical capacity, fine-grained tsunami inundation modelling for the western coast remains less developed than in Aceh, Padang, or Bali (Putri & Mansor, 2025; Anggraini et al., 2026; Suci et al., 2025). Overall, North Sumatra possesses important resilience resources, but their activation remains uneven and constrained by economic precarity, institutional fragmentation, and limited technical capacity.

8. Methodological Characteristics of the Reviewed Studies

Beyond thematic content, the corpus also shows clear methodological patterns. Most studies used qualitative or mixed-methods case studies focused on a single village, district, or island, which are useful for capturing local specificity but limited in producing generalisable causal claims (Nurdiansari et al., 2025; Mariati et al., 2024). A smaller group used household surveys and composite indices to measure vulnerability or preparedness at scale, while newer studies applied social network analysis and GIS-based modelling to examine information flows and hazard exposure alongside social variables (Bari et al., 2024; Amri et al., 2024; Acanga et al., 2026; Tarihoran et al., 2025). Systematic and narrative reviews also provided second-order evidence that supports the thematic synthesis of this review (Ma et al., 2026; Zhao et al., 2025; Zainudin et al., 2026). However, longitudinal panel studies remain largely absent, limiting the field's ability to test how adaptive capacity, social capital, and local wisdom evolve across multiple hazard cycles, particularly in unpredictable high-risk settings such as North Sumatra.

9. Synthesis Matrix of Key Constructs

To consolidate the narrative synthesis presented above, Table 1 summarizes representative exemplar studies for each of the three core constructs, drawing primarily on Indonesian and North Sumatra-relevant cases, alongside their principal empirical contribution to the integrated framework developed in Section 5. The matrix is not exhaustive of the full 80-study corpus but is intended to illustrate the type of evidence underpinning each construct and to make explicit the chain of reasoning connecting individual studies to the broader synthesis.

Table 1. Synthesis matrix linking the three core constructs to exemplar studies from the reviewed corpus.

Construct	Exemplar Study (Setting)	Principal Empirical Contribution
Adaptive capacity	Gisevius et al. (2025) – Semarang, Indonesia	Community leadership quality moderates how material resources are converted into adaptive responses to recurring coastal flooding.
Adaptive capacity	Bari et al. (2024) – Coastal Bangladesh	Gender, age, and class intersect to determine differential access to early-warning information and evacuation capacity.
Social capital	Wati et al. (2025) – Coastal Riau, Indonesia	Dense bonding ties function as informal insurance, enabling rapid resource pooling during flood events.
Social capital	Acanga et al. (2026) – Coastal communities (multi-site)	Network density and well-connected bridge individuals predict speed and reach of tsunami evacuation information diffusion.
Local-based mitigation	Aziz et al. (2026) – Simeulue, Aceh	Dramatized transmission of the Smong narrative strengthens retention and

		emotional salience of the evacuation rule among youth.
Local-based mitigation	Rasyid et al. (2026) – South Lampung, Indonesia	Knowledge retention is strongest where customary adat institutions remain active and capable of enforcing collective norms.
Institutional governance	Saputra et al. (2026) – West Sumatra, Indonesia	Collaborative governance incorporating customary leaders produces more durable mitigation outcomes than top-down arrangements.
North Sumatra context	Aulia & Agustrisno (2024) – North Sumatra coast	Customary fishing-rights institutions provide an organizational scaffold for disaster coordination where still intact.

10. Discussion: Toward an Integrated Framework

The synthesis presented in Section 4 supports an integrated conceptual model in which community resilience to tsunami risk emerges from the dynamic interaction of three pillarsadaptive capacity, social capital, and local-based mitigationoperating under conditions of persistent hazard exposure (Figure 4). This model departs from earlier, more linear conceptions of disaster preparedness as a simple function of hazard knowledge plus material resources. Instead, the reviewed evidence suggests a recursive system: social capital determines how effectively local wisdom is transmitted and how equitably material adaptive capacity is distributed (Wati et al., 2025; Qadriina et al., 2024); local wisdom, in turn, shapes the content and credibility of risk perception that underlies cognitive adaptive capacity (Aziz et al., 2026; Zainudin et al., 2026); and adaptive capacity outcomes feed back into the social capital available for the next hazard cycle, since successful collective mitigation experiences tend to reinforce community trust and cooperative norms, while failed or inequitable responses can erode them (Pradana et al., 2025; Porio & See, 2024).

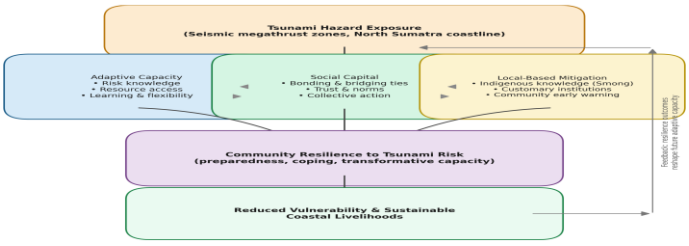

Figure 4. Integrated conceptual framework linking tsunami hazard exposure, adaptive capacity, social capital, and local-based mitigation to community resilience and reduced vulnerability outcomes.

This integrated framework reconciles the tension between studies that view local wisdom as a life-saving resource and those that caution against treating it as sufficient on its own. Local wisdom systems such as Smong are effective because they trigger immediate behavioural responses through dense social transmission networks, but their effectiveness depends on continued social vitality and institutional reinforcement as generational distance from the 2004 tsunami increases (Aziz et al., 2026;

Zainudin et al., 2026; Putra et al., 2026). Where social capital weakens due to migration, urbanisation, or declining customary institutions, local wisdom retention also erodes, showing that social capital sustains local-based mitigation across generations (Rasyid et al., 2026; Aulia & Agustrisno, 2024). Comparative evidence from Japan and Chile further shows that preparedness and recovery are shaped by pre-disaster community resilience, resident status, and the embedding of warning knowledge in routine cultural practices (Shiozaki et al., 2026; Cisternas et al., 2024; Zainudin et al., 2026).

For North Sumatra, this means that transferring local wisdom requires more than disseminating factual information; it must be embedded through schools, customary institutions, and village networks. However, institutional fragmentation can prevent adaptive capacity, social capital, and local wisdom from being scaled effectively, so the three-pillar model must be supported by multi-level governance (Azhar, 2026; Akhirianto et al., 2025; Saputra et al., 2026; Rinawati et al., 2026; Esariti et al., 2026; Putera et al., 2025). Because social capital and local wisdom are shaped by intra-community power relations, resilience strategies must also address exclusion risks affecting women, older adults, and economically precarious households (Bari et al., 2024; Pradana et al., 2025; Tanjung et al., 2025). Thus, North Sumatra requires a differentiated strategy that strengthens customary fishing and resource institutions, invests in school-based intergenerational knowledge transmission, and addresses economic precarity as a foundation for social and cultural resilience-building (Aulia & Agustrisno, 2024; Sihotang & Murniarti, 2025; Nugrahadi et al., 2025; Maira et al., 2024).

11.Practical and Policy Implications

Several practice-oriented implications follow from this synthesis. Disaster risk reduction in North Sumatra should formally engage customary institutions, including *adat* councils, fishing-rights bodies, and religious leaders, as co-implementers of mitigation programmes because collaborative governance involving customary actors produces more durable outcomes (Saputra et al., 2026; Rinawati et al., 2026). School curricula should also integrate formal hazard science and local wisdom narratives to reach younger generations who are increasingly distant from the 2004 tsunami memory (Sihotang & Murniarti, 2025; Aziz et al., 2026). At the same time, gender-responsive evacuation, shelter, and relocation planning must be treated as a core design criterion to avoid reproducing exclusion (Chitengedza et al., 2026; Pradana et al., 2025). Because coastal poverty constrains adaptive capacity, disaster mitigation should be linked with regional economic development and livelihood diversification (Nugrahadi et al., 2025; Maira et al., 2024). Agencies should also actively reinforce indigenous knowledge systems such as Smong through community events, performance-based education, and emergency-response curricula rather than assuming their automatic persistence (Zainudin et al., 2026; Slamet et al., 2026). Finally, North Sumatra's dual coastal hazard profile requires geographically differentiated investment: west-coast districts need tsunami-specific early-warning infrastructure and evacuation planning, while east-coast districts require mangrove rehabilitation and tidal flood defence, supported by parallel investment in hospital and emergency medical readiness (Elfayetti et al., 2025; Thoha et al., 2025; Matury et al., 2024).

12. Limitations of the Review

This review has several limitations. Its focus on 2024–2026 publications captures recent scholarship but excludes earlier foundational post-2004 tsunami studies. The DOI-based selection improves traceability but may omit grey literature, government reports, and local Indonesian studies

without DOI registration. The thematic synthesis also involves interpretive judgment, so the bibliometric counts should be read as indicative rather than definitive. Finally, because North Sumatra-specific tsunami research remains limited, some implications draw on adjacent evidence from volcanic relocation, coastal poverty, and coastal governance studies, highlighting the need for future primary research on tsunami resilience in North Sumatra.

Conclusion

This systematic literature review synthesised 80 peer-reviewed studies published between 2024 and 2026 to examine how adaptive capacity, social capital, and local-based disaster mitigation shape coastal resilience to tsunami risk, with a focus on North Sumatra. The findings support an integrated model in which social capital sustains local wisdom, local wisdom shapes adaptive capacity, and adaptive outcomes reinforce or weaken future resilience. The Smong tradition illustrates the value of culturally embedded early-warning knowledge, but such knowledge requires institutional reinforcement through schools and customary institutions. In North Sumatra, resilience resources exist but remain unevenly activated due to institutional fragmentation, coastal poverty, and gendered exclusion. Strengthening resilience therefore requires integrating indigenous knowledge with formal disaster risk reduction, applying gender-responsive planning, linking mitigation with livelihood policy, and expanding primary research in North Sumatra's coastal districts.

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