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RECONSTRUCTION OF ETHNOSCIENCE KNOWLEDGE FOR DISASTER PREPAREDNESS

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ABSTRACT

Indonesia's high exposure to earthquakes and tsunamis demands preparedness that is both scientifically grounded and culturally embedded. Aceh's experience in 2004 showed that technological warning systems alone cannot protect communities, whereas the oral tradition of smong on Simeulue Island helped residents evacuate within minutes. However, indigenous knowledge does not automatically become preparedness: it may fade across generations, remain weakly integrated into schools, and lack explicit scientific explanation. This conceptual article aims to formulate how ethnoscience knowledge can be reconstructed to strengthen disaster preparedness. Using a literature-based qualitative analysis of national and international studies published mainly between 2016 and 2026, the article synthesises three strands of work: ethnoscience reconstruction in science education, local and indigenous knowledge in disaster risk reduction, and the smong tradition. The analysis proposes a five-stage reconstruction model, namely identifying original knowledge, verifying it against scientific evidence, reconstructing it as ethnoscience, transforming it into learning and community practices, and evaluating and revitalising it. The article argues that reconstruction converts tacit, orally transmitted warnings into explicit, testable, and transferable knowledge, while also exposing the limits of local knowledge, such as hazard-specific signs that are not universally valid. Implications are offered for school curricula, community institutions, and local policy in Aceh. The article concludes that ethnoscience reconstruction should be treated as a two-way dialogue between community knowledge and earth science, and that testing its effect on preparedness empirically remains an agenda for future research.

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INTRODUCTION

Indonesia sits at the convergence of several active tectonic plates and therefore faces recurrent earthquake and tsunami threats. Aceh was among the regions that felt the consequences most strongly when the earthquake and tsunami of 26 December 2004 devastated the province's coast. The event showed that preparedness cannot be built solely through infrastructure and early warning technology, because at that time most Acehnese

residents did not yet recognise tsunamis as a real threat (Suciani et al., 2018). Law Number 24 of 2007 defines preparedness as a series of activities to anticipate disasters through organisation and appropriate, effective steps (Republik Indonesia, 2007). Preparedness thus rests on the knowledge, attitudes, and actions of residents that can be carried out independently within minutes.

The contrast most often cited comes from Simeulue Island. The 2004 earthquake and tsunami caused only seven deaths among about 86,735 residents, and mass evacuation along the coast took place within minutes of the earthquake (Suciani et al., 2018). This safety has been attributed to *smong*, a word in the Devayan language referring to a giant wave after a major earthquake, which has been passed down through songs, short verses, lullabies, and stories since the 1907 tsunami (Rahman et al., 2018; Suciani et al., 2018). This experience shows that communities possess indigenous science, namely empirical knowledge of natural phenomena that grows from cross-generational observation and has not yet been formalised in the language of science (Risamasu et al., 2023).

However, Simeulue's success cannot be replicated automatically. A review of tsunami early warning systems in Indonesia concluded that preparedness for earthquakes and tsunamis remains low, so that residents are not yet able to save themselves independently when disaster strikes (Kurniasih et al., 2020). In Aceh Besar, the preparedness of students at an elementary school studied by Yuliawan and Desfandi (2023) was only in the "almost ready" category, with an index of 58.35. In Simeulue itself, the application of smong material at junior and senior high school levels is considered not to be going well because it only involves integrating content and has not yet become part of school culture (Abdi et al., 2022), while changing interests among young people threaten the sustainability of the tradition (Kamaly et al., 2025). Sutton et al. (2020) also question how risk communication and risk-reduction behaviour can be sustained as the evocative power of disaster memory fades.

The core problem, therefore, lies not in whether local knowledge exists, but in how that knowledge is processed so that it endures, can be tested, and can be learned by generations who have not experienced disasters. In science education, a similar effort is known as ethnoscience reconstruction, the process of exploring communities' indigenous science and then interpreting it into scientific knowledge (Sudarmin, 2015; Sumarni et al., 2016). Reconstruction has been carried out on various cultural practices, including palm sugar production, the lives of communities on the shores of Lake Sentani, and the Belaq Tangkel ritual of the Sasak people (Mukti et al., 2022; Risamasu et al., 2023; Sumarni et al., 2016). In the literature search for this study, such applications were generally directed at

science learning, whereas their use for disaster preparedness has rarely been formulated conceptually.

At the global policy level, the Sendai Framework for Disaster Risk Reduction 2015–2030 places the use of traditional, indigenous, and local knowledge to complement scientific knowledge within its first priority, namely understanding disaster risk (UNISDR, 2015). A recent review affirms that integrating local and scientific knowledge still requires critical assessment of its approaches, challenges, and enabling factors (Hermans et al., 2022). A review of local wisdom in disaster management in Indonesia likewise notes the need for research on how to integrate it into planning and on its effectiveness (Syuryansyah & Habibi, 2023). This study is situated in that gap.

Based on this background, the objectives of this study are to explain the position of ethnoscience within the disaster preparedness framework, to analyse the smong tradition as an example of indigenous disaster science, to formulate a model for reconstructing ethnoscience knowledge for preparedness, and to identify its implications for education and local policy. This study is conceptual and literature-based, so the model formulated has not been tested empirically. The scope of examples is limited to earthquake and tsunami threats in Aceh, particularly the smong tradition; generalisation to other types of disaster such as floods, landslides, and land fires requires caution.

RESEARCH METHODOLOGY

This article is a conceptual article using a qualitative literature review approach. Sources were selected purposively from national and international journal articles, proceedings, books, and official documents addressing three groups of topics, namely ethnoscience reconstruction and indigenous science, local and indigenous knowledge in disaster risk reduction, and the smong tradition and tsunami preparedness in Aceh. Most references were published between 2016 and 2026, and one older source was retained because it contains the foundational formulation of ethnoscience.

The search was conducted through online journal portals and open databases using the keywords ethnoscience, reconstruction of indigenous science, local wisdom, disaster preparedness, smong, and *local and indigenous knowledge*. Inclusion criteria covered relevance to one of these topics, clarity of source identity, and connection to the Indonesian or Aceh context. Documents that merely mentioned local wisdom without any link to disasters or learning were not used.

The analysis was carried out thematically in three steps. First, the findings of each source were read and coded. Second, the codes were grouped into themes, namely

ethnoscience concepts, characteristics of indigenous disaster science, transmission mechanisms, and barriers to integration. Third, the themes were synthesised into a conceptual model. The validity of the synthesis was maintained through source triangulation: a conclusion was used as a basis for the model only if it was supported by more than one study or was consistent with standard earth science explanations. Because it is conceptual, this study did not collect primary data and does not report effect sizes.

RESULT AND DISCUSSION

Ethnoscience within the Disaster Preparedness Framework

Ethnoscience is understood as a knowledge system that grows from the culture and local wisdom of a community concerning natural phenomena, which is then given a scientific explanation through reconstruction (Sudarmin, 2015). Indigenous science is its raw material: knowledge built by traditional communities from long experience and containing scientific concepts that have not yet been formalised. Ethnoscience is indigenous science that already has a scientific explanation (Risamasu et al., 2023). Reconstruction is therefore not intended to replace original knowledge with modern science, but to translate the two so that they can check and enrich one another.

This distinction matters for disaster studies because closely related terms are often used interchangeably. Indigenous knowledge refers to knowledge held by the indigenous people of a region, local knowledge encompasses the knowledge of communities of diverse ethnic and social backgrounds, and local practices are the concrete actions communities take in responding to their environment (Syuryansyah & Habibi, 2023). Ethnoscience adds a different dimension: it does not stop at documentation but proceeds to testing and explanation. With this dimension, local knowledge about natural signs can be treated as hypotheses examined against earth science data, rather than beliefs to be accepted or rejected wholesale.

The position of ethnoscience in preparedness can be mapped onto three phases of disaster management. In the pre-disaster phase, local knowledge helps communities recognise risks and design preventive measures suited to their environment and culture. During a disaster, it provides guidance for action and mobilises local resources. In the post-disaster phase, it supports recovery and collective learning (Syuryansyah & Habibi, 2023). The smong indigenous knowledge management model developed by Rahman et al. (2017) uses similar logic: in the pre-disaster phase, indigenous knowledge is mainstreamed into related activities, and during a disaster that knowledge enables the community to think clearly, make decisions, and protect themselves and others. Ethnoscience fills the layer

between these phases by turning implicit knowledge into knowledge that can be taught and evaluated.

Smong as Indigenous Disaster Science

Smong meets the characteristics of indigenous disaster science because it contains a concise cause-and-effect observation: a strong earthquake may be followed by a giant wave, and the right action is to immediately move to higher ground. This knowledge is stored in traditional oral channels and, after the 2004 tsunami, spread to various other cultural channels (Rahman et al., 2018). A study by Ramli et al. (2024) of 30 informants consisting of traditional leaders and residents found that Simeulue ancestors internalised smong wisdom through oral culture since 1907, with *mananga-nanga*, *manafi-nafi*, and *nandong* as educational media, and that the knowledge was known across age groups. The value of smong wisdom in tsunami mitigation in Simeulue Regency has also been examined by Gadeng et al. (2018).

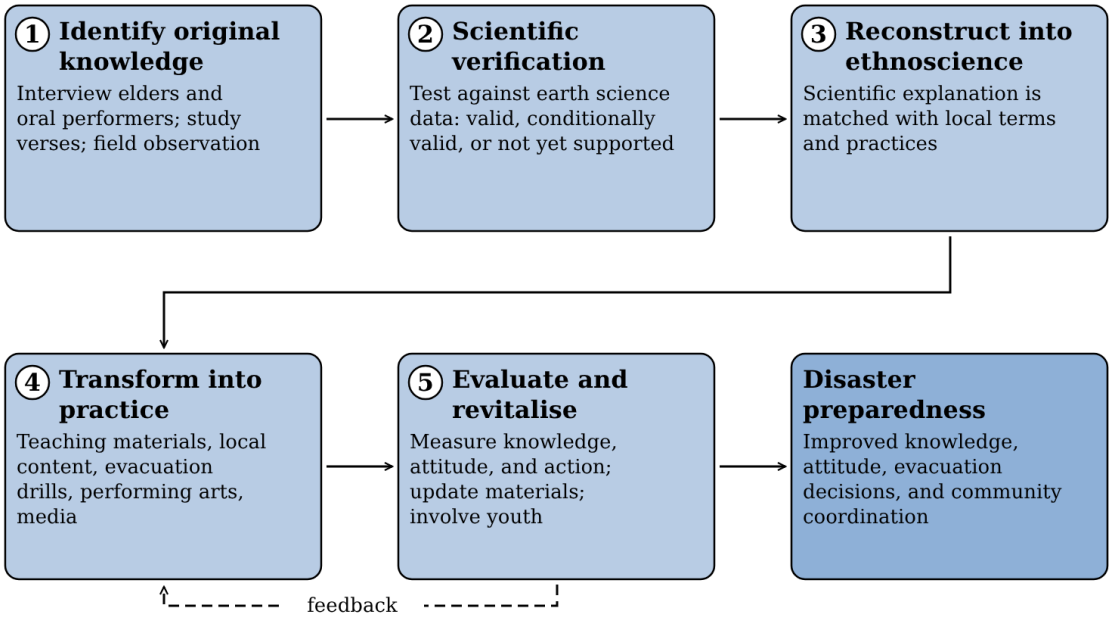
From an ethnoscience perspective, three features of smong deserve attention. First, smong is experience-based knowledge born from a real event, the 1907 tsunami, and then passed down as a lesson (Rahman et al., 2018). Second, smong is packaged in an aesthetic and emotional form of songs, verses, and stories so that it is easy to remember and repeat (Suciani et al., 2018). Third, smong is a keyword understood by all Simeulue residents to describe a giant wave after a major earthquake (Suciani et al., 2018), so it functions as a short, uniform risk communication code.

That strength also reveals its limits. Kurniasih et al. (2020) emphasise that tsunami early warning systems concern not only technology but also community preparedness as a sociocultural component, and view smong as an example that can be adapted to other hazard-prone areas. Rahman et al. (2018) found that understanding of the smong story differed depending on the source from which participants learned it, and that community resilience can be strengthened when lessons from smong are integrated into ongoing tsunami risk management efforts. This means that, without reconstruction, smong risks becoming a cultural heritage that is remembered but not practised.

Stages of Reconstructing Ethnoscience Knowledge for Preparedness

Reconstruction practice in ethnoscience studies essentially moves from exploring a community's indigenous knowledge, to interpreting it into scientific concepts, to using it as a learning resource (Risamasu et al., 2023; Sumarni et al., 2016). This study adapts that flow for disaster contexts by adding two steps that are specific needs of preparedness, namely transformation into drill practices and evaluation and revitalisation. The result is a five-

stage model summarised in Figure 1. This model is the authors' synthesis of the reviewed literature, not a validated model.



Source: Authors' synthesis

Figure 1. Model of Ethnoscience Knowledge Reconstruction for Disaster Preparedness

First stage, identification of original knowledge. Knowledge is gathered from traditional leaders, elders, and oral art performers through interviews, field observation, and study of verses, as is common in smong studies (Ramli et al., 2024). At this stage, the natural signs recognised, the recommended actions, the language and medium of delivery, and the social context of transmission are recorded. Variation among speakers is recorded and not standardised, because understanding can differ depending on the learning source (Rahman et al., 2018).

Second stage, scientific verification. Each element is compared with tested earth science knowledge, for example earthquake mechanisms in subduction zones, tsunami wave characteristics, wave arrival times, and coastal topography. Elements can be classified as valid, conditionally valid, or not yet supported by evidence. This stage protects communities from two errors at once, namely rejecting knowledge that is actually accurate and retaining beliefs that are misleading.

Third stage, reconstruction into ethnoscience. Elements that pass verification are given a scientific explanation and paired with local terms. Table 1 gives an example of reconstruction results for five elements of smong. The explanation in the second column is standard earth science knowledge, while the third column formulates the practical output for preparedness.

Table 1. Example of Reconstructing Smong Indigenous Knowledge into Disaster Ethnoscience

Element of indigenous knowledge	Scientific explanation (ethnoscience)	Output for preparedness
A strong earthquake near the coast as an initial sign	A large earthquake in a subduction zone can displace the seabed and trigger a tsunami. Strong, prolonged shaking indicates a large, nearby earthquake source.	Strong shaking becomes the trigger for immediate evacuation, without waiting for a siren or instructions.
Sudden sea withdrawal	In some tsunamis a wave trough can precede the wave crest, but this does not always occur.	Treated as an additional sign; not waited for and not approached.
Running to the hills	Higher ground reduces exposure to inundation. Wave arrival time from a nearby source is only a few minutes.	Routes and assembly points to high ground are mapped and rehearsed regularly.
The keyword smong	A single term understood by all residents simplifies the risk message and speeds up decision-making.	The local term is paired with the term tsunami in school materials and media.
Transmission through manafi-nafi, nandong, and mananga-nanga	Repetition, narrative, and emotional content strengthen long-term memory and intergenerational transmission.	Used as the basis for local content, performing arts, and youth training.

Source: Authors' synthesis from Rahman et al. (2018), Ramli et al. (2024), and Suciani et al. (2018)

Table 1 shows three patterns of reconstruction results. The first is confirmation, when original knowledge is consistent with earth science explanations, such as the link between a strong earthquake and a tsunami and the advice to move to high ground. The second is correction or limitation, when a sign known to the community applies only under certain conditions, such as the withdrawal of the sea. The third is framing, when the oral manner of transmission is explained through principles of learning and risk communication so that it can be redesigned for schools and media. These three patterns show that reconstruction is not merely validating tradition, but filtering, complementing, and preparing it so that it can be used safely.

Fourth stage, transformation into learning and community practice. Reconstructed ethnoscience is realised in teaching materials, local content curricula, evacuation drills, performing arts, and popular media. Disaster teaching materials based on local wisdom have been developed, for example for sociology subjects in Padang City (Erianjoni, 2018), and disaster mitigation education based on local wisdom in Indonesian schools has been

developed by Triastari et al. (2021). Gadeng et al. (2019) examined smong simulations in geography learning to improve disaster understanding, while Kurniasih et al. (2020) proposed television or animation programmes broadcast regularly so that preparedness content is embedded in viewers' memory.

Fifth stage, evaluation and revitalisation. The impact of transformation needs to be measured on knowledge, attitudes, and evacuation ability, for example with a preparedness index such as that used by Yuliawan and Desfandi (2023), after which materials are updated based on the measurement results. Young people are involved as actors, not merely targets, given their role in preserving smong (Kamaly et al., 2025). Syuryansyah and Habibi (2023) mark the measurement of the effectiveness of local wisdom in disaster management as a research gap, so this stage also serves as a bridge to the further research agenda.

Dimensions of Preparedness Strengthened by Ethnoscience

The reconstruction results can be read through three dimensions of preparedness. The knowledge dimension covers the ability to recognise warning signs and understand why those signs are meaningful. Here ethnoscience provides scientific reasons alongside the story, so that residents know not only what to do but also why. The attitude dimension covers trust in warning messages and willingness to act immediately. Familiarity with local language and arts becomes social capital in this dimension, because messages delivered in a community's own cultural forms are easier to trust and accept. The action dimension covers evacuation skills, route selection, and coordination with fellow residents; regular drills and simulations turn knowledge into habit.

The finding of Rahman et al. (2017) that indigenous knowledge enables communities to think clearly and act on informed decisions during a disaster is consistent with this view: knowledge embedded before a disaster becomes the basis for decisions when time is extremely limited. The division into three dimensions is the authors' analytical framework, not a standard instrument, and can be aligned with the preparedness index already used in research in Aceh (Yuliawan & Desfandi, 2023).

From Ethnoscience to Preparedness: Educational and Community Pathways

Disaster education is considered important for students in building a disaster-resilient generation (Hafida, 2019) and for the wider public (Hamid, 2020), while disaster-awareness education through outreach is carried out to increase students' knowledge of mitigation (Pahleviannur, 2019). Ethnoscience gives this effort distinctive content, because the knowledge students learn comes from their own environment and ancestors. Risamasu et

al. (2023) noted that teachers still emphasise scientific science and have not yet integrated indigenous science, and that learning that links the two is expected to help students understand concepts. For disaster studies, this means that natural science, social studies, and local content subjects can become spaces for reconstruction: students do not merely memorise smong verses but also trace the earth science basis behind their message.

An evaluation of implementation in Simeulue shows why this pathway needs to be redesigned. Abdi et al. (2022) found that the policy of integrating smong material at junior and senior high school levels had not been implemented well because it consisted only of integrating content without school cultural activities. That gap can be filled by reconstruction. Teaching materials built from ethnoscience provide a basis for practical activities, such as evacuation drills, mapping routes to high ground, and *nandong* performances accompanied by scientific explanations, so that smong becomes part of school habits and not merely a topic in a book.

The community pathway is equally important. The review by Syuryansyah and Habibi (2023) shows that the value of mutual cooperation (gotong royong), the ability to read natural signs, and community involvement play roles in the pre-disaster, during-disaster, and post-disaster phases. Local social and religious institutions, youth groups, and art studios can become venues for training that carry reconstruction results outside the classroom. Both pathways meet in risk communication: local messages familiar to residents are combined with scientific explanations and verified action instructions, so that the two reinforce rather than negate each other.

Other Local Wisdom as Candidates for Reconstruction

This model is not specific to smong. The review by Syuryansyah and Habibi (2023) compiles various examples of Indonesian local wisdom related to disasters, including the Tambo philosophy and rumah gadang of the Minangkabau people, which are linked to preparedness and earthquake-resistant buildings, farming rules of the Tolaki people and East Nusa Tenggara as a form of prevention, and the ability of the coastal community of Barru to read natural signs accompanied by taboos linked to hazards. Each example can become an object of reconstruction. The design of the rumah gadang, for instance, can be examined through earthquake engineering concepts, farming rules can be explained through concepts of land ecology and hydrology, and the ability to read natural signs can be compared with local meteorological and earth science data.

These examples also show that reconstruction is not only a task for science education. Reconstruction can involve geology, engineering, ecology, and the social sciences, so

collaborative interdisciplinary work with communities is a prerequisite. This is in line with the review's finding that studies of local wisdom in disaster contexts are spread across environmental studies, earth sciences, social sciences, and engineering (Syuryansyah & Habibi, 2023).

Challenges and Epistemic Caution

The first challenge is that not all local knowledge has a scientific basis, and not all valid signs are universal. The withdrawal of the sea, for example, does not precede every tsunami, and at a nearby earthquake source the wave can arrive only a few minutes after the shaking. Reconstruction therefore needs to position strong shaking as the main evacuation trigger and the withdrawal of water as an additional sign that must not be waited for or approached. A message that makes a single sign a condition for evacuation can in fact be dangerous.

The second challenge is that local knowledge is specific to threats and places. Smong was formulated for tsunamis on Aceh's west coast, so copying it for flash floods or landslides without new reconstruction would be misleading. The diversity of values, norms, and natural signs among communities in Indonesia (Syuryansyah & Habibi, 2023) requires that reconstruction be carried out community by community and hazard by hazard, not copied from one place to another.

The third challenge is social. Syuryansyah and Habibi (2023) cite resistance to change, lack of understanding, and structural constraints as barriers that must be overcome in integrating local wisdom into disaster management. Hermans et al. (2022) emphasise the need for critical assessment of the process of integrating local and scientific knowledge. Reconstruction also carries a risk of ownership: if carried out unilaterally by researchers or government, communities may feel they have lost control over their knowledge. Reconstruction therefore needs to be participatory, with traditional leaders and oral performers positioned as validating partners and co-authors of materials, not merely informants.

The fourth challenge concerns evidence. The model in this study was constructed from a literature synthesis, so it cannot yet be claimed to improve preparedness. Further research needs to test it through quasi-experimental designs or action research in schools and villages, with indicators of knowledge, attitudes, and evacuation ability measured before and after the intervention.

Implications for Education and Policy in Aceh

The first implication concerns the curriculum. Disaster-related local content in disaster-prone schools should not stop at reciting verses, but should include a reconstruction map that links original knowledge with earth science explanations and evacuation procedures, and use the Simeulue experience as a case study for other regions (Kurniasih et al., 2020; Triastari et al., 2021). The second implication is that teacher training needs to include ethnoscience literacy so that teachers can verify and explain local knowledge accurately. The third is that local governments and disaster agencies can encourage the documentation of other local disaster knowledge in Aceh and incorporate it into preparedness planning in the spirit of the Sendai Framework (UNISDR, 2015). The fourth is that the involvement of young people through art studios, preparedness groups, and digital media needs to be part of the preservation strategy (Kamaly et al., 2025).

CONCLUSIONS AND SUGGESTIONS

This study concludes that the reconstruction of ethnoscience knowledge is a bridge between orally transmitted local knowledge and disaster preparedness, which demands explicit, tested, and teachable knowledge. The smong tradition in Simeulue shows that indigenous disaster science can save lives, but also that its transmission is vulnerable to fading and that its application in schools is not yet optimal. The five-stage model formulated, namely identification of original knowledge, scientific verification, reconstruction into ethnoscience, transformation into learning and community practice, and evaluation and revitalisation, offers a workflow that preserves local knowledge while maintaining its scientific accuracy. Reconstruction needs to be treated as a two-way dialogue between communities and earth science, not as the replacement of local knowledge by modern science.

Based on these conclusions, researchers are advised to test this model empirically in different communities and hazard types, especially flash floods, landslides, and inland earthquakes that also threaten Aceh. Educators and policymakers are advised to develop disaster-related local content that includes scientific explanations alongside cultural texts, train teachers in ethnoscience literacy, and involve traditional leaders and young people on an equal footing. The limitations of this study, namely its conceptual nature and limited literature coverage, leave room for systematic reviews and further field research.

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