Protecting the earth, reading the nature: The disaster mitigation tradition of the Nagari Pauh Kamang Mudik community in the crevice of the limestone hills

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Abstract. The people of Nagari Pauh Kamang Mudik, who live in a limestone hilly region, live in a space fraught with risks and potential. The karst landscape provides livelihoods through wetland and dryland agriculture and limestone mining. However, this area is also prone to ecological disasters such as landslides, drought, and environmental degradation. This research highlights the traditions of disaster mitigation based on local wisdom that have been developed through generations, such as the ability to read natural signs and organize living spaces according to safe contours. This study is urgent given the increasing ecological vulnerability due to uncontrolled limestone exploitation and the impact of climate change on the local hydrological system. The primary focus is how the community balances economic activities with environmental sustainability while maintaining traditional knowledge amidst modernization. Using qualitative methods and a participatory ethnographic approach, this research combines field observations, interviews with traditional elders, farmers, and miners, and a review of local cultural documents. Using an ecocritical framework, specifically the Ecological Knowledge System and Community-Based Disaster Risk Reduction (CBDRR), this study demonstrates that the community has a contextual and collective mitigation system. These findings recommend integrating local knowledge into mitigation policies, especially in areas with unique landscapes like limestone hills.

1 Introduction

Indonesia's limestone (karst) hilly regions, particularly those inhabited by rural communities, are ecologically and socially complex landscapes. These landscapes not only provide vital natural resources such as limestone and wet and dry agricultural lands, but also pose risks of ecological disasters such as landslides, extreme droughts, and land degradation due to overexploitation. Despite these ecological limitations, local communities have traditionally developed forms of local wisdom as survival strategies that function as community-based disaster mitigation systems.

Problems arise when economic activities particularly limestone mining without sustainable management increase environmental pressure. This ecological imbalance is exacerbated by global climate change, which alters rainfall patterns and prolongs the dry season. In this context, examining how communities maintain harmony with nature through time-tested traditions, value systems, and local knowledge is crucial.

Law Number 32 of 2009 concerning Environmental Protection and Management defines local wisdom as noble values that grow and develop within a community. These values serve to protect and sustainably manage the environment. In practice, local wisdom often emerges in response to the various global cultural influences that continue to infiltrate and impact community life.

Local wisdom typically stems from long-standing community experiences and is passed down from generation to generation. This knowledge is continually practiced until it becomes part of the collective identity and behavior. It takes various forms, including norms, ethics, customary law, or rules that have binding force within a community. One form of local wisdom is disaster mitigation, reducing the risk and impact of natural disasters [1].

Data from the National Disaster Management Agency (BNPB) shows that throughout 2023, there were approximately 4,878 natural disasters, damaging 32,809 homes. While this number is down from 2021, when 5,402 disasters damaged 158,659 homes, disaster risk remains a serious concern.

Climate change contributes to the increasing frequency of disasters, one of which is increased extreme rainfall. Heavy rainfall can trigger floods, landslides, and other natural disasters. In this context, local wisdom has proven to play a crucial role in mitigating the impact of these disasters.

For example, the Minangkabau people apply local wisdom through the architecture of their traditional house, the Rumah Gadang. This house is built using wooden pegs

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instead of nails, making it more earthquake-resistant. Its distinctive design, with its pointed roof resembling buffalo horns at the ends, also reflects cultural values integrated with local wisdom in dealing with potential disasters. One of these Minangkabau communities is part of the Nagari Pauh Kamang Mudik administrative area.

Nagari Pauh Kamang Mudik is in a limestone hilly area characterized by unique geological features and potential disaster vulnerabilities. The dominance of limestone formations makes this area prone to several natural hazards, including landslides, cliff collapses, and seasonal droughts, due to the high porosity of the rock. The community predominantly resides on flatlands surrounded by limestone hills, as illustrated in Fig. 1 and Fig. 2. This geographical condition calls for special attention in environmental management and development planning to minimize disaster risks and ensure community safety.

Fig. 1. Landscape of Nagari Pauh Kamang Mudik (Author's documentation)

This study aims to uncover the tradition-based disaster mitigation strategies practiced by the Nagari Pauh Kamang Mudik community, who live on a limestone hillside, and to examine their relevance in community-based disaster risk reduction. By understanding local approaches, we hope there will be room for integration between formal policies and traditional wisdom in building community resilience to ecological disasters.

Fig. 2. Limestone excavation site and landslide site in Nagari Pauh Kamang Mudik (Author's documentation)

2 Methodology

This research employed a qualitative method with a participatory ethnographic approach, as the knowledge studied is contextual, embedded in everyday practices, and passed down orally. The research location is in a village in the limestone hills, Nagari Pauh Kamang Mudik in Agam Regency, where agricultural and mining activities coexist.

Data collection techniques include the following: Participatory observation of community activities in farming, mining, and rituals or traditions related to environmental management, as well as in-depth interviews with traditional leaders, miners, farmers, and village women as guardians of cultural values. Documentary studies include artisanal mines, local inscriptions, village records, or oral narratives about disasters and adaptation.

This research uses an ecocritical paradigm encompassing two main theoretical frameworks: *First*, the Ecological Knowledge System (EKS), to examine how communities understand, interpret, and respond to ecological phenomena through their unique perspectives. *Second*, Community-Based Disaster Risk Reduction (CBDRR) examines how communities build mitigation systems based on solidarity, social structures, and historical experience.

Data were analyzed thematically using open coding, theme grouping, and narrative interpretation to capture local meanings embedded in community mitigation practices. The results of this method illustrate concrete practices that we can recommend as part of a locally based disaster mitigation strategy.

3 Literature review

3.1 Community-based disaster mitigation

Community-Based Disaster Risk Reduction (CBDRR) was developed in response to the limitations of top-down approaches to disaster risk reduction. Successful disaster mitigation depends heavily on the active participation of local communities in recognizing, planning for, and responding to risks in their environment [2]. The CBDRR approach emphasizes the role of communities in recognizing potential hazards, leveraging local capacities, and building social resilience based on values and internal relationships.

3.2 Local wisdom and ecological knowledge systems

Local wisdom is often considered a system of ecological knowledge accumulated through long experience interacting with nature. Various studies show that traditional communities have highly contextual disaster adaptation mechanisms based on ecological observations, belief systems, and sociocultural structures [3, 4]. In the context of rural communities in karst areas, this local wisdom can take the form of prohibitions on mining during certain months, reading changes in sky color or water flow, and traditional rituals as a form of symbolic communication with nature.

3.3 Ecological vulnerability in karst areas

Local wisdom is often considered a system of ecological knowledge accumulated through long experience interacting with nature. Various studies show that traditional communities have highly contextual disaster adaptation mechanisms based on ecological observations, belief systems, and sociocultural structures [3, 4]. In rural communities in karst areas, this local wisdom can take the form of prohibitions on mining during certain months,

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Karst areas are known for their fragile and unstable geological characteristics. A study by Day & Urich highlighted that mining activities in karst areas increase the risk of environmental damage, water quality degradation, and disasters such as cave collapses and landslides [5]. Therefore, integrating modern geological knowledge with local community strategies is crucial for maintaining the sustainability of living spaces. Research by Adi in Gunung Sewu showed that farming communities and limestone miners employ adaptive strategies to maintain spatial security through house layout, mining rotation, and spring management [6].

3.4 The role of ritual and culture in mitigation systems

Culture is crucial in shaping early warning systems and disaster risk management. According to Nas in Javanese and Nusantara culture, belief systems and rituals often serve as social bonds and control mechanisms against natural exploitation [7]. Examples include the Earth Alms ceremony or prohibitions on working in specific locations on sacred days, which people believed would minimize adverse events. These symbolisms and rituals should be interpreted as spiritual expressions and ecological and social mitigation strategies.

4 Findings and discussion

4.1 Natural sign-based mitigation system

Observations and interviews show that the people of Nagari Pauh Kamang Mudik have a disaster mitigation system based on natural signs that has been passed down through generations. This system is not simply a spontaneous response to natural phenomena, but rather a structured part of local knowledge that people practice daily. The community is highly sensitive to environmental changes, which they use as a basis for decision-making to avoid disaster risks.

Some natural indicators used as references include a change in the color of spring water, turning yellow, which we believed to indicate cracks in the upstream soil layer. Furthermore, small cracks in the walls of houses facing the hill are considered an early sign of a possible landslide. Beyond physical symptoms, livestock behavior, such as chickens and goats, which suddenly descend to the lowlands for no apparent reason, is also an early warning of potential disasters. This knowledge demonstrates how communities connect various natural phenomena as a unified system of ecological signals [2-6].

This locally-based mitigation system runs parallel to the oral traditions that live within the community, such as folktales, advice from traditional elders, and religious rituals imbued with ecological significance. This knowledge is passed down verbally and through social practices such as mutual cooperation, village deliberations, and traditional activities that shape collective awareness. The role of elders and parents is crucial in ensuring that the younger generation understands and respects this knowledge as part of their cultural identity and as an instrument of safety.

Thus, the Pauh Kamang Mudik community not only passively observes natural phenomena but also interprets and internalizes them as part of their survival strategy. Environmental sensitivity serves as a disaster mitigation tool and a spiritual and moral connection between humans and nature. This system demonstrates that local wisdom can significantly reduce disaster risk, particularly in geologically vulnerable areas with minimal access to modern technology.

4.2 Traditional spatial planning and safe zones

The placement of houses in Nagari Pauh Kamang Mudik is not done haphazardly. Instead, it follows the Minangkabau philosophy of life known as *Alam Takambang Jadi Guru* (Nature Takes Its Lead as Teacher) and *Di Ma Bumi Dipijak, Di Sinan Langik Dijunjung* (Where the earth is stepped on, there the sky is upheld). This principle emphasizes the importance of living in harmony with nature, where all decisions including residential construction are guided by an understanding of environmental conditions. Local communities choose to avoid steep slopes prone to landslides and prefer to build homes on gentle slopes, supported by large rocks or stable geological formations as natural supports.

Locating houses near large rocks is based on local beliefs and reflects a deep understanding of geological risks. These large rocks are seen as natural safeguards against potential ground shifts and provide a more stable foundation for the building. This prevents the structure from sliding or collapsing during heavy rain or minor earthquakes. This aligns with landslide and landslide risk mitigation principles from a modern disaster science perspective.

In addition to settlement strategies, communities are actively conserving land in hilly areas by planting trees with strong roots, such as bamboo and hibiscus. This planting is done collectively, especially in vulnerable areas, as a form of shared responsibility for preserving nature. The roots of these trees function as soil binders and water absorbers, which can prevent erosion and strengthen slope structures. This practice is scientifically recognized as effective in reducing landslide risk, as Day & Urich noted in their study of tropical ecology [5].

By combining local wisdom and practical ecological knowledge, the people of Nagari Pauh Kamang Mudik demonstrate that disaster mitigation does not always rely on modern technology. They have developed an adaptive and sustainable way of life, using nature as both a teacher and a partner. The cultural values internalized in their daily lives strengthen community-based mitigation efforts, transforming them not only as potential disaster victims but also as active participants in building environmental resilience.

4.3 Ritual tradition as a social system for risk control

Traditional ceremonies like Balek Padang, as shown Fig. 3, held annually in Nagari Pauh Kamang Mudik, have a meaning that extends beyond mere spiritual celebration. This ritual is believed to "cool" nature and maintain a harmonious relationship with the guardian spirits of the hills, or the rulers of nature, believed in by the local community. According to local beliefs, if nature feels disturbed or "angry" due to human activity, disasters such as landslides or droughts can occur as a warning or punishment. Therefore, Balek Padang is not only a form of respect for the forces of nature but also a means of controlling human activity.

Fig. 3. The Balek Padang Ceremony in Nagari Pauh Kamang Mudik (Author's documentation)

Although rooted in spiritual traditions, the primary function of this ritual is ecological and social. This ceremony serves as a crucial moment to remind the community of the importance of maintaining the balance of nature and avoiding overexploitation of the environment. During the ceremony, traditional elders and community leaders convey moral and ecological messages that govern how humans should behave towards nature. The community absorbs these messages as part of a shared value system and guides daily activities, including decision-making regarding land use.

Besides being a tool for collective awareness, Balek Padang also serves as an effective social control mechanism. Through this ritual, the community sets specific boundaries for environmentally hazardous activities, such as tree felling, clearing new land, or limestone mining. Individuals or groups who violate these values can face social sanctions, such as ostracism or customary reprimands. This creates intense social pressure for all community members to adhere to the unwritten rules preserved through tradition.

One form of prohibition from this practice was restricting mining activities during certain months considered spiritually "hot" and prone to disasters. This prohibition functionally resembles the modern concept of an environmental moratorium: a temporary halt to activities that risk damaging the ecosystem [4-7]. Although not formulated in scientific language or formal policy, this local wisdom demonstrates that the Pauh Kamang Mudik community has long applied the principles of conservation and disaster mitigation collectively and sustainably through their own culture.

4.4 Integration of local wisdom in formal policies

To date, very few policies at the regional level explicitly integrate local knowledge systems into formal disaster mitigation strategies. Local knowledge, which has been passed down through generations, is often viewed as separate from modern scientific approaches. This results in the vast potential of local wisdom being underutilized in disaster management policies and practices. Yet, this knowledge is crucial, especially in areas with limited access to technology or resources. In fact, various studies have shown that local wisdom can significantly contribute to disaster risk reduction in a cost-effective, effective, and sustainable manner. Wisner emphasized that local communities often possess time-tested coping strategies and can respond to disasters in ecologically and socially relevant ways [2]. A concrete example can be found in Nagari Pauh Kamang Mudik, where the community practices various forms of traditional mitigation that have proven effective in facing disaster threats, particularly hydrometeorological disasters. This demonstrates that local wisdom is a cultural heritage and a strategic resource for community resilience.

Unfortunately, the separation between local knowledge and formal policies often hinders the realization of a genuinely inclusive mitigation approach. Initiatives by governments and scientific institutions are top-down and do not involve communities as subjects of knowledge. However, ignoring local experiences and understanding risks produces policies that are out of context and difficult for communities to accept. Therefore, a paradigm shift is needed in the policy formulation process, one that recognizes the central role of local communities in the disaster management system.

This research emphasizes the importance of a collaborative approach between scientists, governments, and local communities to create a hybrid and contextual disaster mitigation system. This approach combines scientific and technological excellence and values, and utilizes the wealth of local knowledge that has proven adaptive to the surrounding environment. With equal and participatory collaboration, the mitigation system developed will be more rooted in the social and cultural realities of the community, making it more effective and sustainable in the long term. This hybridization of knowledge is expected to form the foundation for disaster mitigation policies that are more inclusive and responsive to local needs.

5 Discussion

The results of this study reinforce previous findings on the importance of local wisdom in community-based disaster mitigation systems. Berkes in Sacred Ecology states that traditional knowledge about the environment is a form of ecological adaptation and reflects the ethical and spiritual relationship between humans and nature [3]. In the

context of the rural communities living in the limestone hills studied, practices such as reading natural signs and seasonal prohibitions on mining are concrete manifestations of this knowledge system.

The spatial planning based on the Kampuang Aman principle found in this study also aligns with Adi's findings in the Gunung Sewu karst area, where communities use local spatial patterns adapted to land contours and water flow directions to reduce the risk of landslides and drought [6]. This demonstrates consistency across different karst areas in developing landscape-based mitigation systems.

Furthermore, research by Nas and Lansing highlights that cultural rituals have symbolic meaning and concrete socio-ecological functions [4-7]. In the communities studied, the Balek Padang ceremony serves as a collective reminder of maintaining harmony with nature. This ritual creates time and space for social reflection and serves as a control mechanism against the overexploitation of resources.

However, unlike other customary areas that have received formal legal recognition for their traditional systems (for example, indigenous communities in Bali or the Baduy), rural communities in this karst area have not yet achieved institutional legitimacy. This indicates a gap between practice on the ground and recognition in formal policy systems.

From a methodological perspective, the participatory ethnographic approach used in this study also emphasizes the importance of direct researcher involvement in community life. As Chambers argued within the Participatory Rural Appraisal (PRA) framework, we can deeply understand local realities through closeness and trust, not mere remote observation [8]. Then, oral stories about the myth of natural conservation and sustainable management of forest are very essential as a part natural disaster mitigation [9, 10].

Thus, the findings of this study not only strengthen existing literature but also provide a new contribution by documenting the unique mitigation practices of limestone hill communities, which have previously been underrepresented in locally-based disaster studies.

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6 Conclusion

This research shows that the Nagari Pauh Kamang Mudik community, who live on a limestone hillside, has a disaster mitigation system built on local wisdom, historical experience, and direct interaction with their landscape. This system encompasses ecological observations, such as natural signs and animal behavior, and manifests itself in traditional spatial planning and cultural practices, such as rituals and customary prohibitions.

This tradition functions as an ecological, social, and spiritual adaptation system. Communities have proven capable of recognizing risks and responding contextually in sustainable and low-cost ways. These practices demonstrate that disaster mitigation does not always have to begin with modern technological interventions but can be strengthened through respect for local knowledge systems.

However, this wisdom faces serious challenges from mining expansion, environmental degradation, and the pressures of modernization that erode traditional values. Therefore, efforts to strengthen, document, and recognize local knowledge systems are needed as part of more inclusive and contextual disaster risk reduction policies.

This research also has some recommendations related to disaster mitigation. Among the recommendations are the following.

1. Formal Recognition: Local governments must recognize and incorporate local knowledge systems into disaster policy documents, such as Contingency Plans or Regional Spatial Plans (RTRW).
2. Contextual Education: Disaster education materials in Nagari Pauh Kamang Mudik schools should be adapted to the local knowledge students already have from their environment.
3. Scientific and Traditional Collaboration: There needs to be a space for dialogue between scientists, the government, and the people of Nagari Pauh Kamang Mudik to integrate modern science with local traditions in disaster mitigation.
4. Documenting Traditions: The Pauh Kamang Mudik Village Government and cultural and academic institutions are advised to document local mitigation practices through digital archives, videos, or publications, so they are not lost to time.
5. Mining Moratorium in Hazardous Zones: The government needs to establish no-mining zones based on the results of participatory mapping with residents to maintain ecological stability and the safety of residents.

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