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Model and optimization of the realization of Minangkabau local wisdom: *Aua jo tabiang sanda basanda* in disaster mitigation along the watershed (DAS) of West Sumatra

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Abstract. These local wisdom refers to the condition bamboo and riverbanks lean on, support each other, complementing and reinforcing themselves against water erosion along the watersheds (DAS). It reflects seven advantages that are embodied in its disaster mitigation model: biological, ecological, social, cultural, economic, civil engineering, and spatial planning functions. Based on this model, the optimization of its realization is formulated: (1) Realization of Ecological-Based Spatial Planning refers to land-use planning that emphasizes a balance between human activity and environmental conservation (ecology-based); (2) *Cultural-Based Environmental Management* refers to how residents and community leaders utilize natural resources according to traditional cultural values and inherited social systems; (3) *Strengthening of community and local wisdom through traditions* based on Minangkabau local wisdom lies in the community and the traditions passed down for generations; (4) Development of an Integrative Model: Traditional and Modern Comparison combines traditional values, practices, and structures with modern science and technology into a unified management system with multidisciplinary and institutional approaches to build an effective, participatory, and sustainable strategy; (5) Establishing Stakeholder Synergy, is the result of aligning the visions and roles of various actor: residents around watershed, government, traditional institutions, academics, and NGOs.

1 Introduction

Research findings (Abbas, 2025 and 2024), and data from BPBD (2022) indicate that the province of West Sumatra is highly prone to flood and landslide disasters, resulting in significant material losses [1-3]. In addition to these material losses, there are also non-material losses, such as deaths, disappearances, displacement, injuries, and illnesses. When calculated more thoroughly, non-material losses may prove even more substantial, as they disrupt many aspects of life. There is a close and important relationship between flood and landslide disasters and the growth of bamboo, particularly in the context of natural disaster mitigation along watersheds (DAS) in West Sumatra as presented in the studies by Ratnaningsih (2023), Sesunan (2014), and Suprayogi (2024) [4-6]. Bamboo spreads through underground roots and rhizomes. Its reproduction is fast, with new shoots continuously emerging, which makes bamboo potentially invasive if its spread is not controlled.

Although bamboo holds great potential as a natural buffer against floods and landslides, in several locations, more emphasis is placed on the use of turab, a civil engineering structure built to retain soil and prevent landslides. Turab is commonly built along riverbanks, hillsides, cliffs, highways, and landslide-prone areas, and is made from reinforced concrete for strength and durability. However, after reviewing the literature, no references were found on turab made from bamboo such as Corri (2008), and Ilham (2023) [7, 8], as well as online media sources [9]. This is somewhat surprising—why is that the case? To date, no sufficiently satisfying academic or methodological answer has been provided. Yet, numerous studies already explain the benefits of bamboo in preventing erosion caused by floods and landslides.

Fortunately, there exists a piece of Minangkabau local wisdom: aua jo tabiang sanda basanda, which describes the mutual leaning and reinforcement between bamboo and the riverbank—symbiotically supporting one another and strengthening against flood and landslide erosion. It reflects the community's understanding of their natural, social, and cultural environment.

Therefore, this study was conducted along the watersheds of Tanah Datar and Agam Regencies as representations of areas affected by floods, flash floods, and landslides. Its terrestrial boundaries are defined by topographic divides, and its marine boundaries extend to water areas still influenced by land activities. Watersheds are biotic environmental components that play a crucial role in ecological sustainability and balance. They are defined by topographical separators such as hill ridges that capture, retain, and channel rainfall, functioning as natural protective and buffering systems.

According to the Regulation of the Minister of Forestry of the Republic of Indonesia No. P.61/Menhut-

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II/2014 on Monitoring and Evaluation of Watershed Management, watershed environmental sustainability can be assessed using three criteria: land, water regulation, and spatial utilization. Uncontrolled land use that ignores the principles of soil and water conservation can result in increased erosion and sedimentation, reduced vegetation cover, and accelerated land degradation. The ultimate outcome of these changes is not only biophysical, such as expansion of critical land areas and reduced water quantity, quality, and continuity, but also socioeconomic—leading to a diminished ability of the community to utilize their land and a decline in their welfare.

2 Implementation mechanism

The basis for determining the research location is aligned with the Regulation of the Minister of Forestry of the Republic of Indonesia No. P.61/Menhut-II/2014 on the Monitoring and Evaluation of Watershed Management. The criteria are as follows:

1. Land Criteria, measured by:(a) Percentage of Critical Land (PLK), (b) Percentage of Vegetation Cover (PPV), and (c) Erosion Index.
2. Water Regulation: Quality, Quantity, and Continuity of Water, measured by: (a) Flow Regime Coefficient (KRA), (b) Annual Flow Coefficient (KAT), (c) Sediment Load (MS), (d) Flood Event Frequency per Year, and (e) Water Use Index (IPA).
3. Socioeconomic Indicators, including: (a) Population pressure, (b) Level of community welfare (measured by the percentage of poor households within the watershed area—i.e., the ratio of poor households to the total number of households—or by average annual per capita income), and (c) Existence and enforcement of regulations (whether or not there are community norms/local wisdom related to conservation along the watershed).
4. Infrastructure Investment Value, based on: (a) Urban classification, and (b) Investment value of water infrastructure.
5. Spatial Utilization, measured by: (a) Area of Protected Zones, and (b) Area of Cultivation Zones.

From the five criteria set by the Ministry of Forestry, the following served as the basis for selecting the research locations in this study:

1. The first criterion, especially the percentage of critical land, which was determined based on the topographic features and land coverage.
2. The second criterion, particularly the frequency of flood events per year. Points 1 and 2 are based on reports from relevant institutions such as the Regional Disaster Management Agency (BPBD), particularly from DIBI (Disaster Data and Information of Indonesia) published by the West Sumatra Provincial BPBD, as well as from social media, newspapers, online media, and other relevant documents.
3. The third criterion, mainly the presence and enforcement of regulations (specifically, the existence of community norms or local wisdom related to conservation along the watershed).

Based on these criteria, functional areas along the watershed were identified and mapped to assist in disaster mitigation by assessing the physical, socioeconomic, and cultural impacts on the model and optimization of its realization based on data from the Agam Regency Statistics Office (2025) [10], the Tanah Datar Regency Statistics Office (2025) [11], and the Sumatera River Basin Authority (2025) [12], as well as Kusuma (2019) [13], and the West Sumatra Governor Regulation (2019) [14]. Prior to this, the main watersheds and their locations were summarized according to the subdistricts within the two regencies, as presented in the following summary table 1.

Table 1. Major watersheds (DAS) and subdistrict locations in agam and tanah datar regencies

No	Main Watershed (DAS) Name	Subdistrict Location	Description
		Agam Regency	
1	Batang Agam	Baso, Kamang Magek, Banuhampu	A tributary of the Batang Sinamar that flows through several regencies/cities: Agam Regency, Bukittinggi City, Payakumbuh City, and Lima Puluh Kota Regency.
2	Batang Antokan	Tanjung Mutiara, Lubuk Basung	Originates from Lake Maninjau and flows approximately 48 km westward, emptying into the west coast of Sumatra.
3	Masang Kanan	Lubuk Basung	The Antokan watershed borders Masang Kanan watershed to the north from the estuary to the upstream, and with the headwaters of Masang Kiri in the north and east. Southeast borders the Mangau watershed, and south with Naras, Gasang Gadang, and Batang Tiku watersheds from upstream to downstream. All of these surrounding watersheds are part of the West Sumatra coastal watershed group.
4	Masang Kiri	Lubuk Basung	
5	Batang Naras	Malalak	
6	Mangau	Malalak	
7	Batang Tiku	Tanjung Mutiara	

No	Main Watershed (DAS) Name	Subdistrict Location	Description
8	Batang Jabuah	Canduang	Floods/landslides are caused by cold lava flow from Mount Marapi carrying mud, wood, and rocks into the river headwaters. This flow overflows and causes severe damage, especially when river channels are blocked (e.g., under the bridge near the Bukik Batabuah Nagari office).
9	Batang Sarasah	Canduang	
		Tanah Datar Regency	
10	Batang Anai	X Koto	Flows through several regencies including Padang Pariaman. Originates from Mount Marapi, converges in Padang Panjang, passes Mount Tandikat, and ends in the Indian Ocean.
11	Batang Arau	X Koto	
12	Batang Gadis	Batipuh	
13	Batang Sumpur	Batipuh Selatan	Flows through West Sumatra and Riau Provinces. Originates in Tanang Talu, West Pasaman Regency, West Sumatra, and empties near Bagan Siapi Api in Riau. It is called Batang Sumpur only in West Sumatra; in Riau it is known as Batang Rokan.
14	Batang Bengkawas/ Bangkahan	Pariangan	Flash floods of cold lava from Mount Marapi occurred in 1979, 2009, and 2024, resulting in fatalities. Fortunately, in 2024, the flow was diverted by a dam, minimizing the danger.
15	Batang Ombilin	Rambatan	Batang Ombilin crosses the island of Sumatra, entering Sijunjung Regency after converging with Batang Palangki and Batang Sukam. In Riau Province, it becomes Batang Kuantan in Kuantan Singingi and Indragiri Regencies, finally flowing into the Malacca Strait.
16	Batang Kiambang	Lima Kaum	April 5, 2024: Cold lava flood from Mount Marapi caused by heavy rainfall brought mud, volcanic ash, and rocks from the upstream, submerging roads and cutting vehicle access.
			May 11–12, 2024: Massive flash floods and landslides triggered by extreme rain intensity struck five subdistricts including Lima Kaum, especially the Simpang Lima Manunggal area.
17	Batang Selo	Lima Kaum and Sungayang	The headwaters of Batang Selo and Batang Sinamar are in Limapuluh Kota Regency and discharge into the Ombilin River.
18	Batang Tampo	Lintau Buo	
19	Batang Sinamar	Lintau Buo and Lintau Buo Utara	Originates in Agam Regency and empties into Kuala Tungkal on the eastern coast of Sumatra Island.

Source: Processed from various secondary data, 2025.

Based on table 1, the selected research locations were determined based on two types of watersheds (DAS) with the following criteria:

1. Watersheds that remain natural, meaning they have not experienced floods or landslides causing material or non-material losses within the past five years.
2. Watersheds that have been affected by floods and landslides, resulting in material and non-material damages within at least the past five years.
3. Ease of access to data and the availability of varied data relevant to the research focus, including access to information sources such as official documents, institutional reports, field data, and direct interviews. This ensures the acquisition of accurate, up-to-date, and relevant information to support comprehensive and multidimensional analysis. This condition increases the potential for producing richer and deeper findings, while also strengthening data triangulation validity in the analysis process. It serves as a strategic foundation for guiding the research direction and implementation to yield more optimal and contextual results.
4. Actual field issues: The selection of these two locations is also based on the presence of real and current problems, which are expected to allow the research to contribute contextual solutions.
5. Academic and practical contribution: These locations offer better potential for generating valuable research findings that contribute to both the development of scientific knowledge and its practical application.

Based on the five considerations above, the selected research sites are:

1. Agam Regency: Batang Agam and Batang Sarasah/Jabuah Watersheds
2. Tanah Datar Regency: Batang Bengkawas and Batang Kiambang Watersheds

To obtain data, various stakeholders from multiple levels of local communities and related institutions were involved, as presented in table 2.

Table 2. Research informants

No	Criteria of Involved Informans	Expected Data	Background of Selected Informants	
			Initials/Age	**Position / Address**
1	*Niniak Mamak* / Minangkabau Traditional Leaders	More in-depth know ledge of local wisdom values: (a) Meaning and practice of *aua jo tabiang sanda basanda*; (b) Role of customary law in maintaining ecological balance; (c) Social structure and customary sanctions related to environmental violations; (d) Oral narratives and local stories on disaster mitigation	1. MD-MK/63 years 2. Sy. Datuak Mangguang/ 67 years 3. AK Datuak Tunaro/ 65 years 4. H Datuak Sinaro Kayo/ 63 years	1. Minangkabau traditional figure 2. *Niniak Mamak* of Payobada Clan/Taluak IV Suku, Banuhampu 3. *Niniak Mamak* of Koto Clan/Bukik Batabuah, Canduang 4. *Niniak Mamak* of Cani ago Clan/Parambahan,
2	Local residents around selected watersheds	First-hand actors disaster-affected communities: (a) Experience facing disasters (floods, landslides); (b) Local conservation practices of rivers and soil; (c) Perception of local wisdom in flood and landslide mitigation	1. HSN/ 55 years 2. YSM/ 56 years 3. BRH/60 years 4. ALN/53 years 5. RSD/45 years 6. KMR/60years 7. SML/55 years	1. 2 residents Sarasah Jabuah 3. 4 residents around Batang Agam 5. Resident Bengkawas 6. 7 residents around Kiam bang Watershed
3	Customary Council of the Nagari (KAN)	As formal institutions responsible for customary law in the *nagari*, providing: (a) Documents/customary regulations related to the environment; (b) Traditional programs on riverbank (*tabiang*) preservation	1. SMS/63 years 2. YSM/ 60 years 3. ZLK/63 years 4. KMD/56 years	1. KAN official/Sarasah, 2. KAN offcl/Btg Agam, 3. KAN offcl/Bengkawas 4. KAN offc/Kiambang
4	Regional Disaster Management Agency (BPBD) of West Sumatra, Agam/Tanah Datar	To understand how local wisdom is integrated into disaster mitigation policies. Required data includes: (a). Disaster data in watersheds; (b) Disaster vulnerability maps; (c) Local-based mitigation and adaptation strategies	1. WLN/30years 2. FAU/45 years 3. ANZ/36 years	1. BPBD Officer/West Sumatra 2. BPBD Officer/ Agam Regency 3. BPBD Officer/ Tanah Datar Regency
5	Environmental Agency, Forestry Agency, & Natu ral Resources Agency (SDA) of West Sumatra, A gam/Tanah Datar	Based on their main duties related to watershed management and conservation. Data includes: (a) Watershed conservation programs; (b) Government intervention on riverbank degradation;(c) Their collaboration programs with local communities	1. MG/55 years 2. HDR/37years	1. Forestry Agency Officer/West Sumatra 2. Environmental Agency Officer/ West Sumatra
6	Academics & Re searchers, Experts in Sociology, Civil Engineering, Ur ban & Regional Planning, Hydro logy, Biology, & Environmental	As sources of theoretical support and comparative analysis. Their contributions include: (a) Previous studies on *aua jo tabiang sanda basanda*; (b) Studies on local-based disaster mitigation	1. ALF/62 years 2. APW/60years 3. HN/62 years 4. FH/65 years 5. TM/62 years 6. RM/35 years All experts are based in Padang City	1. Sociologist 2. Civil Engineering Expert 3. Urban & Regional Planning Expert 4. Hydrology Expert 5. Biologist 6. Environmental Expert
7	Environmental NGOs	Involved due to their local-wisdom-based community empo werment programs:(a) Community empowerment programs they've conducted; (b) Best practices within the watershed areas	1. FDS/50 years 2. HM/45 years	1. NGO "Totalitas" 2. Community Empowerment Facilitator
Total Research Informants			28 people	

Source: Primary data, 2025

In addition to the seven parties mentioned above, for the purposes of obtaining secondary data, historical documentation, regional archives, and Minangkabau natural literature were also explored to trace the history and written records of this local wisdom, in the form of local manuscripts (such as *tambo*, *kaba*) as well as photographs/maps and archival documents of past watershed (DAS) areas.

3 Model of Minangkabau local wisdom

The model of Minangkabau local wisdom, in disaster mitigation along the watershed areas plays an important role because it helps researchers to understand, explain, simulate, and predict the phenomenon. The functions of the model, which are described on the following, include:

1. *Representation of Reality.* The model simplifies complex phenomena to make them more comprehensible by representing objects, processes, or mechanisms in a more structured and simplified form.
2. *Analytical Tool.* This model helps researchers analyze the relationships between variables and explain the phenomena being studied.
3. *Prediction and Simulation.* The model enables researchers to predict future conditions or simulate various scenarios based on specific assumptions.
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6. *Decision-Making Guide.* In applied research, the model is used to provide recommendations or serve as a basis for policy or decision-making considerations.
7. *Scientific Communication.* The model makes it easier for researchers to convey ideas and findings to others in a systematic and more understandable manner.

Based on these considerations, a model and optimization of the embodiment of Minangkabau local wisdom, *Aua jo Tabiang Sanda Basanda*, in disaster mitigation along the watersheds of West Sumatra has been designed, as presented on the following page.

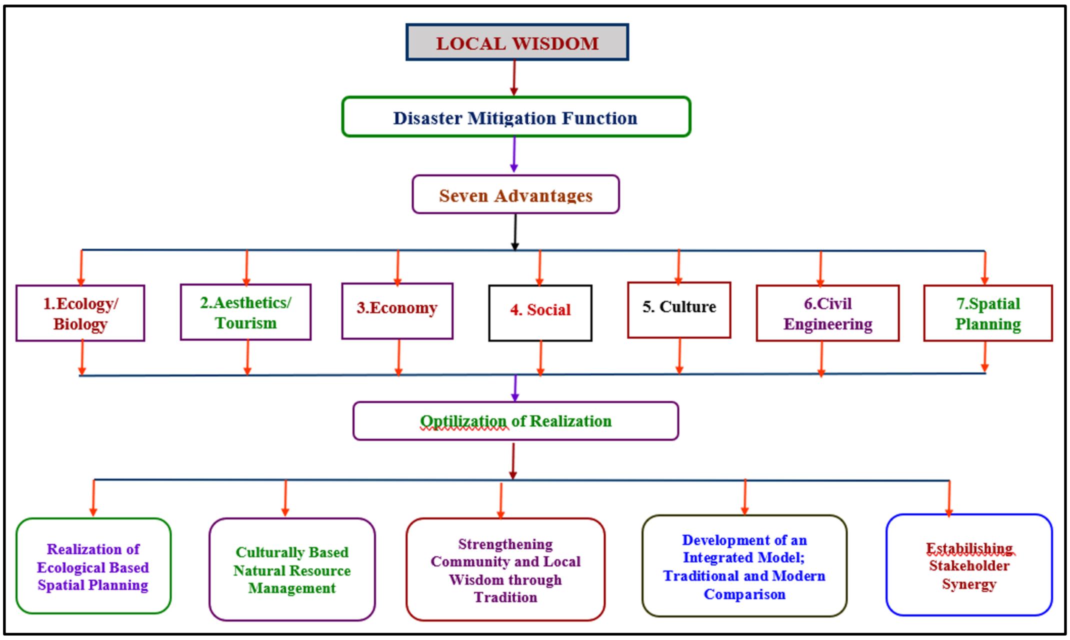

Fig. 1. Model and realization of Minangkabau local wisdom optimization.

Figure 1 illustrates not only the mapping of the model and optimization of the embodiment of Minangkabau local wisdom *Aua jo Tabiang Sanda Basanda*, but also highlights how this practice directly contributes to maintaining the ecological balance of the local community. The following section will sequentially explain the seven advantages of using bamboo as a *turab* (retaining barrier) against flood and landslide erosion along the watersheds of West Sumatra, beginning with ecological/biological, aesthetic/tourism, economic, social, cultural, civil engineering, and spatial planning aspects:

3.1 Ecological and biological aspects

1. *Ecological Advantages of Bamboo:*
   i. Soil and Water Conservation: (a) Dense and deep bamboo roots can effectively bind soil particles, preventing erosion. (b) Bamboo canopy reduces direct rainfall impact on the soil, decreasing surface runoff.
   ii. Watershed Ecosystem Restoration: (a) Bamboo creates microhabitats that support biodiversity. (b) Enhances soil moisture and stabilizes microclimate temperatures.
   iii. Reduction of Water Flow Rate: (a) Bamboo stands slow down rainwater flow, reducing flash flood potential. (b) Act as natural buffers that absorb and retain water.
2. *Biological Advantages of Bamboo:*
   i. Fast and Adaptive Growth: Bamboo grows rapidly and adapts well to various soil types, including degraded land near watersheds.
   ii. Strong and Extensive Root System: Its rhizome roots spread widely and grip the soil firmly, effectively preventing landslides and riverbank erosion.

iii. High Regeneration Ability: Bamboo can regrow quickly even after being harvested, making it suitable for long-term and sustainable reforestation.
iv. Low Maintenance Needs: Ideal for remote or hard-to-reach areas.
v. Can be Utilized for Bioenergy.
vi. Low Carbon Emissions: Bamboo absorbs more CO_2 than typical trees.

Conclusion, its ecological and biological advantages make bamboo highly effective as a conservation and protective plant in disaster-prone watershed areas in West Sumatra and elsewhere.

3.2 Aesthetic and tourism aspects

1. Aesthetic Advantages:

i. Natural and Refreshing Visual Appearance: (a) Dense bamboo stands create lush green scenery that is pleasing to the eye. (b) Tall, neatly aligned bamboo stalks give a natural artistic impression.
ii. Improved Watershed Landscape Quality: (a) Bamboo enhances riverbanks, levees, and buffer zones as part of green landscaping. (b) Reduces barren or damaged impressions in former flood or landslide zones.
iii. Support for Sustainable Landscape Architecture: (a) Bamboo aligns with eco-friendly development concepts and can be integrated into natural garden designs, bamboo bridges, or green pedestrian paths.

2. Tourism Potential:

i. Nature-Based and Educational Tourism Appeal: (a) Bamboo groves can be turned into ecotourism or conservation sites. (b) Visitors can learn about bamboo's role in the environment and disaster mitigation.
ii. Development of Instagram-able/Aesthetic Photo Spots: (a) Footpaths or bridges through bamboo forests can become attractive, viral photo locations. (b) Ideal for selfie tourism, relaxation spots, or camping areas.
iii. Opportunities for Festivals and Cultural Activities: (a) Bamboo areas can host local cultural festivals, traditional music performances, or local wisdom-based education (e.g., bamboo weaving arts, bamboo-based cuisine).

Conclusion, bamboo is not only a technical solution for flood and landslide mitigation, but also provides added value in terms of aesthetics and tourism potential. Planting bamboo along watersheds can be a dual strategy for conservation and revitalizing the local economy through tourism and culture.

3.3 Economic aspects

1. Economically Valuable Raw Material Source:

i. Bamboo stems can be utilized for: (a) Building materials (houses, fences, bridges), (b) Handicrafts (weaving, furniture, decoration), (c) Musical instruments, agricultural tools, and household items.
ii. High market value, especially when creatively and innovatively processed.

2. Promoting Creative Economy and MSMEs:

i. Bamboo planting creates opportunities for: (a) Bamboo-based home industries (souvenirs, furniture, crafts), (b) Training and community empowerment for productive enterprises, (c) Bamboo craft export potential if supported by branding and digital marketing.
ii. Long-Term Income Source: (a) Bamboo regenerates after harvest and can be harvested every 3–5 years, making it a sustainable income. (b) Selective harvesting allows continued production without damaging the entire stand.
iii. Reduces Disaster Mitigation Costs:(a) By naturally preventing floods and landslides, bamboo reduces damage to infrastructure (roads, bridges, drainage), thus lowering routine repair costs. (b) Reforestation or conservation costs can be minimized as bamboo requires relatively low maintenance.
iv. Tourism Potential Based on Local Economy: (a) Aesthetic bamboo landscapes can be developed into ecotourism destinations, (b) Additional income from entrance fees, location rentals, local guides, (c) Growth of supporting businesses: culinary, parking, souvenirs, homestays.
v. Carbon Credit Opportunities: Bamboo absorbs large amounts of carbon, making it eligible for carbon trading schemes that are now being implemented both globally and nationally.

Conclusion, bamboo along watershed areas not only protects the environment from erosion and disasters but also serves as a long-term economic asset for local communities. With proper management, bamboo can generate employment, income, and micro-enterprises based on renewable natural resources.

3.4 Social aspects

1. Community Empowerment and Participation:

i. Planting, maintaining, and utilizing bamboo can be turned into collective community activities, encouraging active participation in environmental conservation.
ii. Communities are involved at every stage: from seedling to harvesting and processing, fostering a sense of ownership over watershed environments.

2. Creation of Local Employment:

i. Job opportunities arise in sectors: (a) Bamboo farming, (b) Bamboo handicrafts and production, (c) Community-based ecotourism.
ii. Helps reduce unemployment, especially in rural areas.

3. Preservation of Local Wisdom and Culture:

i. Bamboo holds cultural value in Minangkabau society.

ii. Supports the preservation of traditions such as *rumah gadang* construction, weaving, and bamboo musical instruments.

4. Strengthening Social Solidarity and Mutual Aid:

i. Reforesting watersheds with bamboo can be a platform for *gotong royong* (mutual cooperation) and social interaction among villagers, strengthening village social cohesion.

ii. Encourages the formation of bamboo conservation groups or farming communities.

5. Raising Environmental Awareness and Education:

i. Bamboo projects in watersheds serve as environmental education for children, students, and the general public.

ii. Can be developed into learning sites for conservation for schools, university students, and nature lovers.

6. Reducing Social Conflicts Caused by Disasters: As flood and landslide risks decrease, informants stated that land disputes, displacement, or conflicts over post-disaster aid have significantly reduced.

Conclusion, bamboo as a flood and landslide buffer in watershed areas is not only an environmental solution but also a powerful social instrument connecting people with nature and with one another. These strengths make bamboo a symbol of local wisdom, solidarity, and community empowerment in building disaster resilience. Furthermore, this aspect is closely linked to community empowerment, cultural preservation, and the strengthening of social cohesion.

3.5 *Cultural aspects*

1. Preservation of Local Values and Traditions:

i. Bamboo is closely linked to local wisdom, used in various aspects of life such as architecture, ceremonies, arts, and culinary traditions (in Minangkabau: *rabuang*).

ii. Bamboo planting supports ancestral traditions that honor nature as part of human life, in line with the Minangkabau philosophy *"Alam Takambang Jadi Guru"* (Nature is the Ultimate Teacher). It is also used in building *rumah gadang*, making *saluang* (bamboo flute), and traditional household tools.

2. Symbol of Life and Local Philosophy:

i. Bamboo is culturally interpreted as a plant symbolizing resilience, flexibility, and sustainability.

ii. Bamboo planting in watersheds is not just an ecological act but reflects harmony between humans and nature, in accordance with local philosophies like *Alam Takambang Jadi Guru*.

3. Revitalization of Tangible and Intangible Cultural Heritage:

i. Allows the revival of fading bamboo crafts such as weaving, traditional musical instruments, and bamboo carving.

ii. Bamboo-rich watershed areas be used for bamboo cultural festivals, traditional art training, or music performances.

4. Strengthening Community Cultural Identity:

i. Bamboo in watersheds affirms the local identity of environmentally conscious communities with deep historical ties to the surrounding nature.

ii. Shapes a cultural narrative where river protection is not just functional but part of the customary value system.

5. Cultural Education for Younger Generations:

i. Bamboo-planted watersheds can serve as cultural learning spaces, teaching children the role of bamboo in history, art, and customs.

ii. Encourages the regeneration and interest of youth in inheriting and developing nature-based local culture.

Conclusion, bamboo is not just a plant to protect watersheds, but also a cultural symbol and a heritage of local identity. Bamboo planting becomes a concrete way to integrate environmental and cultural preservation into a unified, sustainable movement.

3.6 Civil engineering aspects

1. Effective Slope and Embankment Stabilization

i. Bamboo's deep and widespread root system is highly effective in reinforcing soil structures on slopes, riverbanks, and embankments.

ii. Bamboo roots increase soil cohesion, reducing the risk of landslides and subsidence.

2. Natural Protection Against Erosion and River Scouring

i. Bamboo acts as a natural revetment against fast-flowing water that scours riverbanks.

ii. Its dense canopy reduces the direct impact of rainfall on the soil, thus minimizing surface erosion.

3. Construction Material for Watershed Infrastructure

Bamboo culms can be used in basic civil structures: (a) Slope reinforcement (bamboo revetments), (b) Bamboo gabions, (c) Drainage channels and sediment traps, (d) Lightweight bridges or conservation access roads.

4. Economical and Eco-Friendly Engineering Solutions

i. Compared to conventional civil engineering materials like concrete or stone, bamboo is: (a) Inexpensive, easily accessible, and easy to work with, (b) Environmentally friendly and renewable.

ii. Suitable for low-budget conservation projects in rural or remote areas.

5. Design Flexibility and Adaptability

i. Bamboo can be designed to follow irregular river or slope contours.

ii. Well-suited to complex topographic conditions such as highlands, steep slopes, or hillsides.

6. Supporting Bioengineering-Based Civil Techniques

i. Bamboo is widely used in green engineering systems such as: (a) Vetiver–bamboo systems, (b) Live check dams, (c) Green barrier slope stabilization.

ii. Bamboo integrates both living (roots) and non-living (culms) structures into a stable system.

Conclusion, from a civil engineering standpoint, bamboo offers advantages as a strong, low-cost, adaptive, and sustainable natural stabilizer. It can play a vital role in watershed conservation engineering that integrates structural strength with environmental sustainability. Bamboo can be installed along riverbanks as a robust buffer against flooding and landslides, especially when using natural-based engineering (bioengineering) approaches.

3.7 Spatial planning aspects

1. Green Space Utilization
- i. Bamboo can serve as a natural greenbelt along watersheds.
- ii. This green space serves not only an aesthetic function but also protects areas prone to floods and landslides.

2. Conservation-Based Riverbank Zoning
- i. Bamboo planting supports the protective function of riparian zones in accordance with national spatial planning principles and local regulations.
- ii. Helps establish ecological buffer zones that prevent illegal or uncontrolled land conversion along riverbanks.

3. Integration of Land Use Planning and Risk Mitigation
- i. In regional spatial plans (RTRW), bamboo forests can be designated as part of: (a) Watershed conservation zones, (b) Vegetation-based disaster mitigation areas, (c) Protected Green Open Spaces (RTH-P).
- ii. Adds protective value to high-risk areas.

4. Flexible Zoning Implementation
- i. Bamboo can be planted in various spatial zones such as: (a) Riparian zones, (b) Slope/critical land zones, (c) Conservation agriculture zones.
- ii. Requires minimal changes to existing spatial structures.

5. Supporting Smart Eco Spatial Planning Principles
- i. Bamboo use aligns with smart-green planning principles: (a) Low cost, (b) Quick adaptation to land conditions, (c) Integration with local culture.
- ii. Ideal for rural areas, disaster-prone regions, or ecoregion-based development zones.

6. Minimizing Land Use Conflicts
- i. Planting bamboo in protected watershed zones can prevent land conversion to settlements or intensive agriculture that may increase disaster risks.
- ii. Helps maintain the ecological function of space over the long term.

Conclusion, from a spatial planning perspective, bamboo offers strategic solutions for sustainable, functional, and disaster-resilient watershed area management. Bamboo strengthens green space structures and protection zones without disrupting land use balance. Therefore, bamboo's advantages in spatial planning make it highly relevant to sustainable regional planning as a buffer against flood and landslide erosion.

Final note, the remarkable advantages of bamboo as a natural buffer against floods and landslides along watersheds in West Sumatra are evident. These seven benefits are derived from field data, interviews, literature reviews, and secondary sources, all explained in detail in the proposal. These seven aspects complement one another, strengthening the conclusion that bamboo is a highly effective and holistic solution for flood and landslide mitigation

4 Optimization of the realization of Minangkabau local wisdom

Based on Figure 1, several key points can be explained:

4.1 Realization of ecological-based spatial planning

Ecological-based spatial planning refers to land-use planning that emphasizes a balance between human activity and environmental conservation, especially forests, rivers, agricultural land, and settlements. This approach aims to maintain the environment's carrying and absorption capacity against human activity. Minangkabau local wisdom, rooted in the philosophy of *"Aua jo Tabiang, Sanda Basanda"*, represents unwritten customary laws that regulate traditional zoning or land use along watersheds (DAS), based on ecological characteristics and cultural values. In the context of watersheds, the realization of ecological-based spatial planning includes:

4.1.1 Natural and social zoning

- Conservation zones: maintained as water sources, rain catchment areas, and natural ecosystems.
- Protection zones: not used for settlement or intensive farming, but reinforced with bamboo.
- Utilization zones: can be used for rice fields, gardens, and settlements developed with sustainability principles.

4.1.2 Integration of customary values and ecological knowledge

- Spatial decisions are made through customary deliberations (*musyawarah adat*) involving elders (*ninik mamak*) who understand both ecological and cultural values.
- Implementation of community- and custom-based watershed monitoring and management systems.

With the adoption of this ecological spatial approach inspired by *Aua jo Tabiang Sanda Basanda*, the following outcomes are expected:
- Reduced flood risk by preserving catchment zoning.
- Landslide prevention on steep slopes using bamboo.
- Enhanced food security and disaster resilience as areas are divided based on their ecological function.
- Community and customary participation in environmental stewardship becomes a core part of disaster mitigation.

This ecological-based spatial planning is not merely a technical strategy, but a cultural-ecological approach that integrates local knowledge, customary values, and disaster mitigation strategies highly relevant for sustainable development along watersheds in West Sumatra.

4.2 Culturally based natural resource management

Cultural-based environmental management refers to how residents and community leaders utilize natural resources according to traditional cultural values and inherited social systems. In the Minangkabau context, this practice is embodied in the philosophy of *"Aua jo Tabiang, Sanda Basanda"* not just a slogan but a culturally valuable governance model:

- "*Aua*" symbolizes areas rich in biodiversity.
- "*Tabiang*" refers to protected slopes that must not be disturbed due to their protective function.
- "*Sanda Basanda*" reflects the functional and cultural interconnectivity within the ecosystem.

This philosophy is deeply integrated with Minangkabau social structure and cultural norms, based on the following principles:

4.2.1 Collective Ownership and Social Responsibility

Decisions regarding land and nature are made through customary deliberation, not individual ownership, as in communal land (*tanah ulayat*) management.

4.2.2 Customary Taboos and Ecological Restrictions

Customary law prohibits opening land on steep slopes, cutting trees carelessly upstream, or damaging water sources. Violations may be met with social or customary sanctions within the *adat salingka nagari* system.

4.2.3 Symbolic Customary Activities for Nature Conservation

Examples include the tradition of "*mambarasiahan kapalo banda*" (communal riverhead cleaning), which strengthens spiritual and ecological relationships.

Such management creates community-based disaster mitigation systems that:

- Reduce flood and landslide risks through custom-regulated land use.
- Foster collective awareness of the importance of protecting watersheds.
- Strengthen local involvement in environmental monitoring, positioning disasters as a shared responsibility.

Culturally rooted natural resource management demonstrates that Minangkabau communities have long practiced adaptive systems for disaster risk reduction. *Aua jo Tabiang Sanda Basanda* forms a crucial foundation not just for technical mitigation, but also for value-based, cultural, and social resilience building.

4.3 Strengthening community and local wisdom through tradition

The main strength of disaster mitigation based on Minangkabau local wisdom lies in the community and the traditions passed down for generations. These traditions serve as social mechanisms to build resilience against natural changes, including flood and landslide risks in watersheds.

a. Fostering Social Solidarity. Through collective customary practices, people develop a sense of ownership and responsibility toward nature and disaster risks.
b. Strengthening the Role of Traditional Elders (*Ninik Mamak*). These traditions enhance the role of elders in regulating both social and ecological norms, including setting environmental boundaries and enforcing customary sanctions.

The *"Aua jo Tabiang, Sanda Basanda"* wisdom is not passive knowledge it is actively practiced through tradition and becomes a channel for intergenerational ecological knowledge transfer.

This contributes to:

- Preserving traditional ecological zoning: *Aua* must not be buried or built over; *Tabiang* must not be used for farming; and upstream-downstream patterns must be maintained.
- Ecological education through tradition: Young people learn about space function and ecological importance through firsthand involvement in traditional practices.

The strengthening of community through tradition contributes significantly to watershed disaster mitigation by enabling:

- Community-based early warning systems grounded in local values.
- Socially driven conservation area maintenance.
- Cultural adaptation to climate or river flow changes monitored by customary communities.

Tradition serves as a key medium to fortify communities and preserve Minangkabau local wisdom as a foundation for socio-ecological disaster mitigation. *Aua jo Tabiang Sanda Basanda* is not just a spatial concept it is monitored, practiced, and reinforced through traditions across *nagari* communities. Tradition functions as a social glue, a cultural identity, and a guardian of ecological balance along West Sumatra's watersheds.

4.4 Development of an integrative model: traditional and modern comparison

An integrative model combines traditional values, practices, and structures with modern science and technology into a unified management system. In the context of disaster mitigation along watersheds in West Sumatra, this integration merges Minangkabau local wisdom (such as *Aua jo Tabiang Sanda Basanda*) with multidisciplinary and institutional approaches to build an effective, participatory, and sustainable strategy.

Traditional elements include:

- Collective tradition,

- Socio-cultural resource management, and
- Traditional ecological zoning.

These are complemented by modern elements, such as:

- Technology and infrastructure,
- Formal regulations and institutions, and
- Scientific studies supported by data.

Based on these principles, an integrative model is developed, bridging traditional and modern approaches. This comparative framework is presented in table 3.

Table 3. Integrative model of traditional and modern approaches

Aspect	Traditional (Local Wisdom)	Modern (Technology/Regulation)	Integration
Watershed Zoning	*Aua*, *Tabiang*, *Sanda Basanda*	Spatial planning based on maps and risk	Customary ecological zoning + digital mapping
Management	Customary deliberation, *ulayat* ownership	Formal institutions (BPBD, DLH)	Coordination between customary communities and government agencies
Disaster Mitigation	Bamboo planting, prohibition on forest clearing	Embankments, reforestation, early warning systems	Participatory planting + technology
Sanctions	Customary law, social penalties	Local regulations, legal sanctions	Synchronization of customary law and local regulations

Source: 2025 analysis results

The integrativemodel above serves several functions:

1. Enhances mitigation effectiveness by combining local wisdom with technical data.
2. Empowers indigenous community participation, recognizing them as key stakeholders.
3. Strengthens sustainability by ensuring social, cultural, and ecological continuity.
4. Prevents spatial conflict through the harmonization of customary and formal spatial planning.

The development of an integrative model combining traditional and modern elements in the context of *Aua jo Tabiang Sanda Basanda* represents the optimization of local knowledge integrated with scientific and technological approaches. This model becomes an innovative strategy for disaster mitigation based on both cultural and technological methods along West Sumatra's watersheds. It ensures the preservation of local identity while enhancing adaptive, contextual, and sustainable regional resilience. The comparison and integration of these two approaches are not meant to negate one another, but to harmonize their strengths in addressing natural disasters in a holistic manner.

4.5 Establishing stakeholder synergy

The establishment of stakeholder synergy in this model is the result of aligning the visions and roles of various actors involved in disaster risk management based on local wisdom. The *"Aua jo Tabiang Sanda Basanda"* model is deeply rooted in Minangkabau cultural values, emphasizing the integration of people, nature, and customary norms to preserve ecosystem balance and protect communities.

Stakeholder synergy includes:

i. Ninik Mamak / Customary Institutions: Custodians of local values, setting customary norms for land use along watersheds such as bans on land clearing upstream and protecting slope areas (*tabiang*).
ii. Local Residents: The front-line actors who monitor, report, and benefit from the spatial areas along the watershed.
iii. Nagari and Local Government: Functioning through formal regulations, policy support, and community empowerment via participatory planning.
iv. Academics: Providing scientific perspectives to formulate and document local wisdom so that it can be replicated and integrated into broader mitigation systems.
v. NGOs and Communities: Facilitating training, assistance, and linking local communities with external networks.
vi. Regional Disaster Management Agency (BPBD): Promoting integration between local mitigation systems and formal early warning and disaster response mechanisms.

To achieve stakeholder synergy, the following processes are conducted:

a. Dialogue and Nagari. Deliberations These serve as strategic spaces to unify perspectives between customary and formal policies.
b. Integrating Local and Multidisciplinary Values. Through collaboration between traditional leaders and scientists, an integrative approach is born placing local wisdom at the core of contextually appropriate mitigation strategies.
c. Strengthening Joint Commitment. Achieved through forums such as focus group discussions (FGDs), participatory workshops, and program partnerships.
d. Documentation and Legitimacy. Customary rules related to watershed protection are documented and reinforced through nagari regulations providing both legal and cultural authority.

As a result of these processes, stakeholder synergy produces:

1. Participatory spatial planning models, where land use is based on ecological function and the *sanda basanda* principle (layered and hierarchical).
2. Locally based disaster risk mapping, using community knowledge to identify hazard-prone areas and develop collective mitigation strategies.
3. Increased community awareness and capacity, particularly in watershed areas, ensuring knowledge transfer and sustainable regeneration of local wisdom.
4. More effective mitigation, with multi-stakeholder involvement ensuring targeted and sustainable preventive actions.

Figure 1 not only illustrates the advantages of bamboo as a natural barrier against floods and landslides as understood through the Minangkabau philosophy *Aua jo Tabiang Sanda Basanda* but also shows that this practice plays a direct role in maintaining ecological balance. It highlights the interconnection between customary values and natural resource management, indicating that local wisdom is not merely symbolic, but operational in spatial governance.

The local wisdom visualized in this model reflects a social system adaptive to natural disaster mitigation, even if it has not yet been formalized in modern policy. It also indirectly illustrates the establishment of custom-based spatial zoning, aligned with modern conservation principles. The model confirms that local wisdom does not stand alone it is interconnected with social structures and local knowledge systems, including nagari deliberations, the role of customary institutions, and other components. Most importantly, this model not only demonstrates the uniqueness of Minangkabau local wisdom but also shows its potential as a pilot project for addressing disasters along watersheds.

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Glosarium

1. Agam = the name of a regency located in West Sumatra Province, Indonesia.
2. "*Alam Takambang Jadi Guru*" means that the vast natural environment serves as a teacher or source of life lessons, values, knowledge, and guidance for living according to local customs and culture.
3. "*Aua jo tabiang sanda basanda*" = consists of the words aua meaning "aur or bamboo"; jo meaning "with"; *tabiang* meaning "cliff or riverbank"; and *sanda basanda meaning* "leaning on each other." In the context of Minangkabau local wisdom, it refers to bamboo and riverbanks leaning on and strengthening each other to resist erosion from floods and landslides.
4. *Batang* = another term for river.
5. Datuak = a traditional title given to a customary leader in Minangkabau, often followed by other names such as Datuak Mangguang, Datuak Tunaro, or Datuak Sinaro.
6. *Menhut* = abbreviation of the Ministry of Forestry of the Republic of Indonesia.
7. *Musyawarah adat* means a meeting among traditional leaders (such as ninik mamak, penghulu, and community elders) to resolve problems or make important decisions.
8. Nagari refers to a traditional territorial and administrative unit in Minangkabau, consisting of several kampong (villages) or Jorong, inhabited by people bound by customs, culture, and a matrilineal kinship system. A nagari is led by a Wali Nagari and governed with the support of traditional structures such as Ninik Mamak, religious scholars (Alim Ulama), and intellectuals (Cerdik Candai). It serves not only as an administrative unit but also as the cultural and customary center of Minangkabau society.
9. Ninik Mamak are male customary leaders from the maternal line (matrilineal descent) who play important roles as leaders, guides, and protectors of their clans or tribes.
10. *Rabuang* refers to young bamboo shoots that can be cooked and eaten.
11. Rumah Gadang is the traditional Minangkabau house used as a shared residence for an extended family, especially those from the maternal line (matrilineal). Beyond being a home, it functions as a place for deliberation, storing heirlooms, and holding traditional ceremonies that reflect the values of togetherness, mutual cooperation, and respect for women.
12. *Tambo or Kaba* = oral folklore or stories passed down verbally, making them difficult to verify historically.
13. *Tanah Ulayat* is communal land owned collectively by an indigenous group (such as a clan or tribe), inherited across generations and managed according to customary law.
14. *Turab* is a retaining structure or slope reinforcement made of stone or concrete, usually built in tiers, used to prevent landslides, erosion, or water runoff damage.

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