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Integrating Local Wisdom into Climate Literacy: Cultural Practices and Climate Resilience in Indonesia

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Abstract

Amid escalating climate risks, climate literacy is crucial for enabling community resilience. In Indonesia, the core principles of climate literacy are embedded in long-standing local wisdom across diverse cultural landscapes. This study employs a qualitative, literature-based approach to explore how indigenous practices, ranging from forest and coastal conservation to water, soil, and disaster management, embody climate knowledge. Thematic analysis reveals that these practices reflect adaptive, context-specific strategies aligned with sustainability science. However, formal climate policies often overlook or marginalize traditional knowledge due to epistemic biases. The findings advocate for integrating local wisdom into climate education and governance through participatory and co-productive models. Such integration not only validates indigenous knowledge but also enhances the cultural relevance and effectiveness of climate strategies. Recognizing local wisdom as a legitimate foundation for climate literacy offers a path toward more inclusive, resilient, and grounded responses to the climate crisis.

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Abstrak

Di tengah meningkatnya risiko iklim, literasi iklim sangat penting untuk memungkinkan ketahanan masyarakat. Di Indonesia, prinsip-prinsip inti literasi iklim tertanam dalam kearifan lokal yang telah lama ada di berbagai lanskap budaya. Studi ini menggunakan pendekatan kualitatif berbasis literatur untuk mengeksplorasi bagaimana praktik-praktik masyarakat adat, mulai dari konservasi hutan dan pesisir hingga pengelolaan air, tanah, dan bencana, mewujudkan pengetahuan iklim. Analisis tematik mengungkapkan bahwa praktik-praktik ini mencerminkan strategi adaptif dan spesifik konteks yang selaras dengan ilmu keberlanjutan. Namun, kebijakan iklim formal sering kali mengabaikan pengetahuan tradisional karena bias epistemik. Temuan-temuan tersebut menganjurkan untuk mengintegrasikan kearifan lokal ke dalam pendidikan dan tata kelola iklim melalui model-model partisipatif dan koproduktif. Integrasi semacam itu tidak hanya memvalidasi pengetahuan masyarakat adat tetapi juga meningkatkan relevansi dan efektivitas budaya strategi iklim. Mengakui kearifan lokal sebagai landasan yang sah untuk literasi iklim, menawarkan jalan menuju respons yang lebih inklusif, tangguh, dan membumi terhadap krisis iklim.

INTRODUCTION

In recent decades, climate change has become a widely discussed topic due to its significant impact on life on Earth (IPCC, 2013). This issue poses challenges not only for the current generation but also for future generations, potentially in even more serious forms (Kolawole et al., 2016). Consequently, comprehensive responses have been pursued at both national and international levels, including policy development, international agreements, and adaptation strategies aimed at mitigating climate-related risks.

Among the various approaches to addressing climate change, climate literacy has become a pivotal component. Climate literacy refers to the ability to understand climate science and to make informed decisions regarding climate change mitigation and adaptation. began gaining traction in the early 2000s as the need for greater public awareness about climate change became more pressing. One landmark moment occurred in 2009, when the U.S. National Climate Assessment emphasized the importance of climate literacy in preparing future generations to face and address climate-related challenges. This call to action was followed by initiatives such as the Climate Literacy: Essential Principles of Climate Science document, published by the U.S. Global Change Research Program in 2009. This document outlined the essential knowledge and skills needed to understand climate science, enabling individuals to make informed decisions about climate change mitigation and adaptation.

While the concept of climate literacy is relatively new in the global context, the underlying values of environmental awareness and stewardship have long existed within Indonesia's cultural traditions. Local wisdom, often passed down through generations, reflects sustainable practices in natural resource management that are inherently adaptive and resilient to environmental changes. Many local communities in Indonesia have developed methods for managing their environment by local wisdom (Supangat et al., 2021).

However, despite the rich reservoir of local wisdom, many of these traditional methods are underutilized or neglected in the face of modern development and global climate challenges (Triana et al., 2017; Rühlemann & Jordan, 2021). The marginalization of indigenous knowledge systems has been exacerbated by modernization, urbanization, and a growing preference for externally developed solutions. As a result, local strategies that have historically ensured ecological balance are at risk of being lost.

This paper aims to explore how Indonesia's local wisdom can be integrated into climate literacy efforts to enhance societal resilience to climate change. Specifically, it addresses the gap between global models of climate education and locally rooted environmental practices.

METHOD

This study employed a qualitative exploratory design to investigate the role of local wisdom as a form of climate literacy within diverse socio-ecological contexts in Indonesia. The research was conducted through a systematic review and comparative analysis of secondary data sources, including peer-reviewed journal articles, ethnographic documentation, institutional reports, and climate-related policy literature.

Data selection followed predetermined inclusion criteria to ensure analytical relevance and academic rigor: 1) the source must pertain to the Indonesian context; 2) be published between 2000 and 2023; and 3) address themes intersecting local knowledge, environmental management, and climate change adaptation or mitigation. Only sources from recognized academic publishers or credible institutions were considered to ensure the credibility and validity of the data.

Data were analyzed using thematic analysis, employing an inductive coding strategy. The analytical process consisted of several stages: initial reading and familiarization with the material, generation of open codes, identification of axial categories, and synthesis of overarching themes related to indigenous climate knowledge and environmental governance. Coding reliability was enhanced through iterative cross-checking and thematic saturation.

A comparative case analysis was applied to selected community-based practices such as Tabaru in Halmahera, Mollo in East Nusa Tenggara (NTT), and Bajo in Sulawesi to deepen interpretative insight. This comparative lens aimed to identify both recurring patterns and context-specific adaptations, thereby facilitating conceptual generalization within a

qualitative paradigm. The generalizations produced are theoretical in nature and not intended for statistical inference.

The study employed triangulation by synthesizing data across diverse literature types and disciplines to ensure methodological transparency and trustworthiness. This methodological integration allows for a more robust understanding of how traditional ecological knowledge (TEK) systems contribute to localized forms of climate literacy and resilience.

RESULT AND DISCUSSION

Development of Climate Literacy

Scientific recognition of the climate crisis began in 1938, when British engineer Guy Callendar demonstrated a correlation between increased atmospheric carbon dioxide and a 0.3°C rise in global temperatures over the preceding five decades. In 1954, solar energy was first utilized to expand telephone networks, marking a significant milestone in sustainable technology. Four years later, in 1958, Dr. Charles David Keeling introduced the Keeling Curve, which documented changes in atmospheric carbon dioxide over time. By 1967, the first model of Earth's climate change was published by Syukuro Manabe and Richard Wetherald. The following year, glaciologist Dr. John Mercer found evidence that sea levels had risen by six meters compared to 120,000 years ago.

Climate literacy advanced further in 1969 when NASA's Nimbus III satellite measured Earth's temperature from space for the first time. This breakthrough laid a foundation for policymakers to plan future climate actions. The progress continued with numerous climate-based discoveries, culminating in 1988 when the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) established the Intergovernmental Panel on Climate Change (IPCC).

The IPCC released its first assessment report in 1990, focusing on global warming reduction agreements and addressing the impacts of climate change. Its second report, published in 1997, introduced the Kyoto Protocol, a landmark international treaty. Climate literacy received a further boost in 2008 with the release of The Climate Literacy Guide by the U.S. Global Change Research Program. Over subsequent years, scientists conducted extensive studies on the climate crisis, contributing to global awareness and policy-making.

Scientists projected in 2015 that global warming could reach 1.5°C by 2040, far earlier than initially anticipated. Such a level of warming would lead to more frequent heatwaves, severe storms, droughts, and floods. These findings were highlighted in the latest IPCC assessment report, which emphasized the urgency of addressing the climate crisis.

A thematic analysis of the literature reveals a conceptual shift in climate literacy from a model focused solely on scientific dissemination to a more integrated paradigm that emphasizes community participation, socio-political empowerment, and the inclusion of local and indigenous knowledge systems while these milestones represent the chronological evolution of global climate discourse (Leal Filho et al., 2018). However, despite this shift, the influence of global frameworks on climate education in Indonesia remains uneven. National education policies and curriculum content continue to reflect a predominantly top-down, technocratic interpretation of climate knowledge, often marginalizing or excluding culturally embedded ecological wisdom (Simarmata & Indrawati, 2022).

This disconnect is particularly evident in rural and indigenous communities, where traditional environmental management practices though aligned with climate resilience are rarely recognized as legitimate knowledge within formal education systems. The findings of this study suggest a persistent epistemological gap between institutional climate narratives and the lived, experiential knowledge of local communities. To enhance both the effectiveness and equity of climate literacy initiatives, it is essential to bridge this gap through a contextualized integration of local wisdom, participatory pedagogy, and culturally responsive frameworks. Without such integration, climate literacy risks becoming an abstract, externally imposed construct rather than an inclusive tool for community-based adaptation and mitigation. These insights reinforce the argument that advancing climate literacy in Indonesia must be informed not only by international science but also by the diverse local knowledge systems that have long sustained ecological balance across archipelago.

Local Wisdom and Climate Change

Indonesia is a nation endowed with rich cultural diversity and a deep reservoir of TEK, often referred to as local wisdom (Simarmata & Indrawati, 2022). This form of knowledge is not merely cultural heritage, but a dynamic system encompassing environmental stewardship, social organization, and adaptive practices that have evolved over generations (Setyowati, 2013; Thamrin, 2013).

In this context, local wisdom is not merely a cultural artifact, but a living, integrated system of socio-environmental governance that contributes to community resilience, particularly in the face of climate uncertainty. For instance, the Subak system in Bali, a UNESCO-designated cultural landscape, exemplifies a highly coordinated community-based water management system based on the Tri Hita Karana philosophy, which emphasizes harmonious relations among humans, nature, and the spiritual realm. The system involves hydrological expertise, collective decision-making, and seasonal adjustments, demonstrating alignment with climate literacy principles such as systems thinking, climate variability awareness, and the role of human actions in ecosystem resilience (Lansing, 2006). Likewise, the Amarasi system in NTT integrates rotational grazing, customary land tenure (mamar), and traditional ecological zoning that reflects deep understanding of seasonal cycles and landscape productivity. These practices are not only ecologically viable but also socially reinforced through customary law (adat), which ensures compliance, intergenerational transfer, and long-term sustainability (Adade Williams et al., 2020).

These systems embody practical applications of the Climate Literacy: Essential Principles of Climate Science (USGCRP, 2009), particularly in areas such as understanding the climate system, applying scientific evidence to local decision-making, and recognizing the feedbacks between human activities and environmental responses. For example, local communities actively monitor environmental signals such as changes in wind patterns, flowering cycles, and water table levels which inform adaptive behaviors rooted in empirical observation and validated by historical experience. This indicates that indigenous knowledge systems, while distinct in epistemological foundation, share functional parallels with modern scientific frameworks of climate literacy.

Despite their relevance and demonstrated effectiveness, these knowledge systems remain peripheral in national policy discourse, particularly in formal climate education curricula. While the Paris Agreement emphasizes science-based, top-down strategies for climate mitigation and adaptation, it often underrepresents the value of bottom-up, community-based knowledge that is contextually embedded. Yet in Indonesia, many indigenous and rural communities have practiced forms of climate adaptation for centuries—employing land-use planning, seasonal timing, and risk-spreading strategies that are inherently sustainable. Numerous Indonesian communities offer examples of culturally embedded climate literacy:

Local Wisdom in Forest Conservation

Local communities in Indonesia possess a deep ecological intelligence in managing and preserving forests (Hiwasaki et al., 2014a). For them, forests are perceived not merely as natural landscapes, but as a "supermarket of life", a source of daily necessities that sustains their livelihoods (Abas et al., 2022). This perception reflects a holistic understanding of the forest's role in providing food, medicine, water, and materials for shelter, all of which are integral to the socio-economic and cultural survival of these communities. Their close relationship with the forest fosters a stewardship ethic, where conservation practices are embedded in tradition, belief systems, and everyday life.

Tabaru Community

The Tabaru people, an indigenous ethnic group residing in Halmahera Island, Eastern Indonesia, maintain a deep-rooted tradition of forest conservation through a customary practice known as Sasi. This system reflects their ecological wisdom and emphasizes the integration of environmental stewardship with spiritual and communal values. Sasi functions as a cultural mechanism that regulates the use of natural resources, particularly in plantation areas, through a set of norms, rituals, and sanctions (Widarmanto, 2018).

Under this system, individuals or families who manage plantation lands, cultivating crops such as coconut (*Cocos nucifera*), nutmeg (*Myristica fragrans*), clove (*Syzygium*

aromaticum), cacao (*Theobroma cacao*), langsat (*Lansium domesticum*), rambutan (*Nephelium lappaceum*), salak (*Salacca zalacca*), and durian (*Durio zibethinus*), are required to make a spiritual commitment to protect the land. This begins with a ceremonial vow to God, followed by a communal prayer led by traditional leaders.

As part of the communal responsibility, plantation owners are obliged to contribute a portion of their harvest typically 10% to the customary authority. This contribution is not merely material, but symbolic of shared responsibility and collective benefit. Once a plantation is formally recognized under Sasi, it is publicly announced to the community and marked with distinct symbols as a form of boundary and spiritual protection.

Violations of Sasi are considered serious breaches of communal ethics and are met with social or material sanctions. Beyond its regulatory role, Sasi fosters a culture of respect for nature and ensures that land use remains within the limits of ecological sustainability

From the perspective of climate literacy, the Tabaru practice of Sasi directly aligns with several essential principles as outlined by the USGCRP (2009). Firstly, it demonstrates a localized understanding of the climate system through timing of planting cycles, recognition of environmental limits, and adaptive land-use based on seasonal cues. Secondly, the practice reflects an acknowledgment of the interdependence between human activity and environmental health, as shown by the formalization of resource use restrictions. Finally, it exemplifies informed decision-making that enhances climate resilience and mitigation, particularly through resource rotation, forest conservation, and socially enforced sustainability norms. Thus, traditional governance institutions such as Sasi are not merely remnants of indigenous heritage but are active, functional systems of climate governance. Recognizing and integrating these knowledge systems into formal climate education and policy frameworks can serve as a culturally relevant, context-sensitive, and socially inclusive strategy for enhancing national climate literacy and building sustainable, locally grounded, and bottom-up resilience to climate change impacts across diverse communities and ecosystems (Al Muhdhar et al., 2019).

Mollo Community

The Mollo community, an indigenous group from NTT, maintains a profound cultural and ecological connection to the natural environment, particularly to the forested region of Gunung Mutis. For the Mollo people, the forest is essential for meeting a wide range of life necessities including livestock grazing, access to clean water, and the collection of non-timber forest products such as honey. More than just a natural resource, the forest is embedded in their cultural and spiritual beliefs.

In their customary land use system, the Mollo divide the forest landscape into three functional zones: sacred forest, grazing areas, and settlement zones. The sacred forest, locally known as nais tala, refers to a preserved area that remains untouched and is considered spiritually significant. This area is reserved for ritual purposes and serves as the site for clan-based sacred stones called Faut Kanaf and Oe Kanaf, which are used in ancestral worship ceremonies.

The community enforces strict customary laws to protect the sacred forest. No resources may be extracted and no trees may be cut without explicit permission from traditional leaders. These regulations are guided by longstanding cultural principles and are overseen by elders and the king, ensuring that the forest remains intact for future generations (Mulyadi et al., 2022).

From the lens of climate literacy, the Mollo land-use model exemplifies a culturally grounded form of climate resilience. By preserving primary forests and regulating land use based on TEK, the community maintains critical ecosystem services such as water regulation, carbon sequestration, and microclimate stabilization which directly support both local adaptation and global mitigation efforts. These practices align with key principles of climate literacy, including understanding climate systems, human-environment interactions, and evidence-based decision-making for sustainability (USGCRP, 2009).

Tigawasa Village

Tigawasa is a traditional village located in the Buleleng region of northern Bali. The community holds deep spiritual ties to the surrounding forests, which are regarded as sacred spaces and integral to the village's cultural identity. There are eleven customary

forests in the area. Nine of them are designated for religious worship, while the remaining two are preserved as burial grounds. Entry into these forests is strictly restricted and permitted only during specific ritual ceremonies. This regulation reflects the villagers' belief that the forests are sacred gifts from God, imbued with divine presence and spiritual power.

The forests are also considered the dwelling places of Bhatara Gunung, mountain deities who are believed to offer protection to the village from harm. This belief system reinforces the sanctity of the forests and ensures that they are treated with the utmost reverence and care.

A significant cultural narrative within the community is the myth of Bhatara and the Macan Duwe, or the Tiger Guardian. According to oral tradition, the forest deity is accompanied by a giant tiger that serves as its spiritual guardian. This tiger is believed to safeguard the deity's resting place from human intrusion. Each of the eleven forests is thought to be protected by a tiger with a different color of fur, although the exact appearance or presence of these mystical beings cannot be clearly confirmed by the villagers. The myth functions not only as a spiritual tale but also as a cultural mechanism to strengthen community adherence to forest protection norms (Candraningsih et al., 2018).

Local Wisdom in Fire Prevention

Kanayatn Dayak Community

The Kanayatn Dayak community in West Kalimantan practices a traditional agricultural system known as Bahuma Batahutn, a deeply rooted form of subsistence farming that reflects a strong ecological ethic. This system is characterized by a single annual harvest, allowing the land ample time to regenerate before the next planting season. By limiting cultivation to once a year, the community minimizes environmental degradation and supports the natural recovery of soil fertility, demonstrating an understanding of sustainable land use passed down through generations.

Farming under Bahuma Batahutn is never an individual effort. It is carried out collectively through a group of farmers known as Aleatn Uma, which promotes a spirit of mutual cooperation and shared responsibility. This collective system strengthens social cohesion while simultaneously serving as a local adaptation strategy for managing natural resources and addressing agricultural challenges.

The agricultural cycle is accompanied by a series of sacred rituals and ceremonies, reflecting the community's spiritual relationship with nature. Permission to cultivate is sought from ancestral spirits, and before any clearing or planting begins, traditional experts known as petalla guru are consulted to interpret environmental cues such as wind direction and seasonal changes. This practice reflects a cognitive dimension of climate literacy, where environmental signals are observed, interpreted, and used as the basis for evidence-based agricultural decision-making (USGCRP, 2009). The involvement of petalla guru illustrates the community's awareness of seasonal variability and their ability to adapt agricultural practices to natural climatic patterns.

One of the key environmental safeguards in Bahuma Batahutn is the practice of creating firebreaks, clearings between one and four meters wide that prevent the spread of fire during land preparation. This method, combined with regulated land use and traditional fire knowledge, not only contributes to the community's resilience against forest and land fires, but also reflects an implicit understanding of the long-term environmental and health impacts of fire events. These practices indicate that the Kanayatn Dayak possess an integrated understanding of how local fire use connects to broader climate and atmospheric dynamics, aligning with principles of both mitigation and adaptation (Fajarwati & Masruri, 2019).

Banjar Community

The Banjar community in South Kalimantan possesses TEK for managing peatlands in a way that supports sustainable agriculture while minimizing environmental risk. One of their key practices is known as Tapulikampar, a local method of land preparation that aims to reduce the use of fire when opening agricultural land, particularly on peat soils that are highly flammable and ecologically sensitive (Hastuti et al., 2019). Through Tapulikampar, community members clear agricultural plots by cutting grass and other ground vegetation, which is then gathered and repurposed as organic fertilizer. This approach not only avoids the immediate risk of fire but also contributes to soil enrichment by utilizing decomposed biomass. The community complements this practice with the use of

additional organic and inorganic fertilizers, such as composted chicken manure, urea, and nitrogen, phosphorus and potassium (NPK), to support crop productivity without degrading the peat layer.

Although in certain circumstances controlled burning may still be used, it is carried out with caution. When burning is deemed necessary, the dried vegetation is collected into a single, concentrated area and ignited in a contained manner to prevent the spread of fire beyond the designated space. This contrasts sharply with large-scale land clearing practices that often lead to uncontrollable peat fires, resulting in severe haze and long-term environmental damage (Arisanty et al., 2023).

Peatland burning is considered one of the most significant sources of greenhouse gas emissions in Indonesia, particularly CO_2 and methane, due to the high carbon content of peat soils. These emissions not only contribute to atmospheric warming but also cause persistent air pollution and severe public health impacts across Southeast Asia (Miettinen et al., 2016). In this context, the Tapulikampar practice represents a form of local adaptation that contributes directly to climate change mitigation by reducing the likelihood of peat combustion and sequestering biomass back into the soil.

Moreover, this traditional system is based on intergenerational knowledge, collective norms, and environmental ethics, providing an excellent example of how indigenous practices can be integrated into community-based climate education programs. By highlighting the risks of peat fires and demonstrating sustainable alternatives, the Banjar approach contributes to raising awareness and empowering local actors to make climate-conscious decisions.

The fire prevention strategies of the Kanayatn Dayak community and those of other indigenous groups illustrate how traditional knowledge systems have evolved into risk management frameworks rooted in social cohesion and ecological understanding. These shared characteristics represent a key dimension of contextual climate literacy: the capacity of communities to assess environmental risks and respond with culturally relevant, sustainable practices informed by lived experiences, intergenerational wisdom, and deep connections to the natural environment (USGCRP, 2009).

Local Wisdom in Soil and Water Conservation

Aek Latong, Tapanuli, North Sumatera

Local wisdom belonged to Aek Latong society was derived from disasters coming all the time to the society (Haris et al., 2019). Since the ancestors did not move or leave their village they had been living for hundreds of years, they had to find out the best way to mitigate and to adapt to the condition. Aek Latong society had tried some efforts in controlling soil movement to reduce the impact on their life and their environment. Among the efforts are:

1. Planting Vegetation

Planting vegetation having long roots in bare area for buffering the susceptible soil movement, or cutting down the sliding area of the usual soil movement. This is aimed to strengthen the soil by using the vegetation roots. Then, the roots are also able to transmit more water to deeper soil profile. This is due to the fact that the dead roots provide soil macropores continuing from the soil surface into deeper profile. This will increase soil water recharge and reduce water movement on soil surface (runoff) causing soil movement. Furthermore, more vegetation on soil surface causes more water can be transpired from the soil, as a consequence, the soil surface becomes drier. As the soil is drier, it becomes more solid and strong. Therefore, if there is tremor the soil is not easily moved. In addition to stabilizing the soil, vegetation also contributes to the carbon and water cycles. Plants absorb atmospheric CO_2 through photosynthesis and store carbon in biomass and soil, helping mitigate greenhouse gas concentrations. Transpiration and canopy interception also regulate microclimate conditions, contributing to temperature moderation and increased humidity stability. This indicates a local understanding of the link between land cover and environmental balance, especially in slope and rainfall-sensitive areas.

2. Constructing a Dam

Constructing dam is aimed to cut the sliding area or to reduce area impacted by the soil movement. The type of dams can be derived from stones arranged in a wire or sand put in container and then arranged together to create a buffer to the soil movement.

3. Avoiding a very Susceptible Area

The Aek Latong society did not want to leave the village but they just moved to the least risky area, and used land for agriculture which is away from the very susceptible one.

4. Building Strong House against Earthquake

The Aek Latong society used to build their houses from wood in order to get less impact during earthquake.

5. Praying (Istighosah)

The Aek Latong society were dominated by moslems. They believed that they could not go anywhere to avoid the disaster except they have to be closer to the Almighty God. Therefore, besides conducting physical efforts, they also prayed to the Creator to be out from the disaster.

6. Socializing and Educating the New Generation.

Since they did not want to move from their own village, the elder socialized the types of disasters they were used to face along the year. Then, young generation will be educated how to recognize indicators of disasters and what types of impact will come out, and what the action or how to solve the problem. Those types of knowledge are always delivered to the new generation all the time.

Lerep Village

The village of Lerep in Semarang, Central Java, maintains a longstanding local tradition known as Iriban, a communal practice focused on the periodic cleaning and management of natural water springs (Yuliani & Aprilina, 2020). This tradition is an expression of local wisdom passed down through generations and continues to be actively preserved by the community as a central part of their cultural identity and environmental stewardship.

Iriban involves a coordinated effort by villagers, community leaders, and local authorities to clean the two main water springs in the area: Si Udel and Si Domble, both located in the hamlets of Soka and Lerep. The activity is typically held prior to the rice planting season and is scheduled during culturally significant times, such as on Wednesdays that coincide with the Javanese Kliwon day or during the Islamic month of Rajab. The entire event is accompanied by traditional ceremonies and communal gatherings, emphasizing both its spiritual and practical dimensions.

Beyond its ritual aspect, Iriban serves a critical environmental function. It represents a locally rooted model of water resource management that ensures the sustainability of irrigation systems for agriculture. The community conducts physical cleaning of the springs by removing debris and waste that may obstruct water flow. Additionally, they manage the distribution of irrigation water and maintain the infrastructure around Embung Sembligo, a local water reservoir that supports farming activities in the village.

In the context of climate change, this practice is increasingly relevant. Global warming has been linked to altered rainfall patterns, reduced spring discharge, and declining groundwater levels in many regions (IPCC, 2013). By safeguarding and maintaining natural springs and local reservoirs, the Lerep community contributes to long-term water security and builds adaptive capacity against hydrological uncertainties. These actions reflect climate literacy principles related to the human-water-climate nexus and emphasize informed community-based action for sustainable resource management (USGCRP, 2009).

Through this practice, the people of Lerep demonstrate how indigenous traditions can be effectively aligned with ecological goals. Iriban is not merely a cultural event; it is a functional mechanism for safeguarding local water systems, promoting agricultural productivity, and reinforcing the collective responsibility of communities in environmental conservation.

Osing People

The Osing people, an indigenous ethnic group in Banyuwangi, East Java, have long practiced traditional methods for the preservation of freshwater sources. This local wisdom is embedded in both their ecological knowledge and cultural-religious practices, forming a cohesive system of environmental stewardship that has been sustained across generations.

One of the key elements of their conservation strategy involves protecting areas around vital water springs such as Belik Lanang and Belik Wadon. These springs are surrounded by forest vegetation, and the community strictly prohibits the cutting down of trees in their vicinity. The vegetation plays a crucial role in

maintaining water quality and quantity by preventing erosion and preserving groundwater recharge. The forested buffer zones play multiple ecological roles: they stabilize soil and reduce surface runoff, which helps prevent flash floods during high-intensity rainfall events. Tree roots enhance groundwater recharge by increasing soil infiltration capacity, thus supporting year-round spring discharge and water availability. Additionally, preserving tree cover contributes to carbon sequestration, making this a low-cost, community-driven method for reducing atmospheric carbon emissions (Locatelli et al., 2015). By maintaining natural cover around water sources, the Osing people contribute significantly to the long-term sustainability of local water supplies and the resilience of their agro-ecosystems.

Central to their conservation ethic is an annual ritual known as Selamatan Rebo Wekasan, which is held near these sacred water sources. During this event, offerings are made to God and to the guardian spirits of the springs in a symbolic gesture of gratitude and reverence. The ritual also imposes a temporary prohibition on drawing water from the springs, giving the sources a period of ecological rest. This practice demonstrates a clear link between spiritual belief and ecological function, where ritual becomes a form of regulation that helps conserve vital natural resources.

Additionally, the Osing community recognizes Mbah Buyut Cili, a revered ancestral figure associated with the protection of water sources. The cultural memory and myth surrounding this figure further strengthen communal commitment to preserving water resources (Sumarmi, 2015).

The Osing example illustrates how values-based and spirituality-grounded environmental systems can complement modern climate mitigation frameworks. While dominant approaches often focus on technical or policy mechanisms, indigenous knowledge systems embed environmental protection in ethical, cultural, and spiritual obligations—thereby enhancing compliance, legitimacy, and fostering sustained, long-term behavioral change across generations. Such integrative approaches offer valuable insights for designing community-based mitigation and adaptation strategies that are both socially resonant and ecologically effective in diverse local contexts (Hiwasaki et al., 2014b).

Local Wisdom in Disaster Mitigation

Minangkabau People

The Minangkabau people of West Sumatra have long cultivated an understanding of the natural hazards inherent to their region, which is located in one of Indonesia's most seismically active zones. This awareness is deeply embedded in their cultural traditions, including architectural practices that reflect adaptive strategies to environmental risks. One of the most prominent examples of this integration between tradition and disaster preparedness is the Rumah Gadang, the iconic traditional house of the Minangkabau.

Architecturally, the Rumah Gadang is not only a symbol of Minangkabau social structure and matrilineal heritage, but also a reflection of their ecological intelligence. The house is built on a series of long, flexible wooden stilts that elevate the structure approximately three meters above the ground. This elevation provides a protective buffer against floods and allows water to pass underneath the house during heavy rainfall or overflow events. More importantly, the stilted design functions as a flexible foundation that can sway with ground movement, making the structure more resistant to earthquakes.

The form of the house, often compared to a ship's hull, is intentionally crafted to withstand the dynamic forces of nature. The curved, upswept roof and elevated floor create a structure that distributes stress and absorbs shock. This reflects a philosophical worldview rooted in the natural environment, where houses are envisioned not as rigid structures, but as adaptable vessels navigating the waves of the earth's motion (Habibi & Santosa, 2018).

The Rumah Gadang demonstrates its capacity to absorb seismic shocks and drain excess water, serving as a real-world example of disaster-resilient housing rooted in indigenous innovation. It reflects climate and geological risk adaptation through architecture grounded in community-based disaster mitigation. The design, shaped by generations of local experience and environmental observation, offers a model for adaptive housing in areas vulnerable to floods and earthquakes. Rather than depending on modern materials or imported technologies, the Minangkabau approach can provide structurally sound, context-sensitive, and sustainable climate solutions for vulnerable communities.

Kampung Naga

Kampung Naga, a traditional settlement in West Java, exemplifies how indigenous spatial planning and cultural values can contribute to long-term environmental sustainability. Situated in a fertile valley and surrounded by natural boundaries such as forests, rivers, and rice fields, the village reflects a harmonious relationship between humans and their environment. The community has maintained this balance through a well-defined land use system that prioritizes ecological preservation.

A key principle in the land management of Kampung Naga is the allocation of land in a ratio of three to one, where three parts are preserved as buffer zones for every one part used for human activity. This zoning strategy supports the preservation of ecological functions while allowing sustainable use of land for agriculture and habitation. The application of techniques such as swales and terracing, reinforced with stone barriers, helps prevent erosion and minimizes the risk of landslides, particularly on sloped terrains. These practices reflect a deep understanding of local geomorphology and hydrology, ensuring the structural integrity of both agricultural and residential areas.

Forests surrounding the village are maintained not only as sacred spaces but also as functional ecosystems that serve climatological, hydrological, and ecological roles. By preserving forested areas, the community ensures clean water infiltration, protects river ecosystems, and supports biodiversity.

These forested zones also function as critical carbon sinks, absorbing CO_2 and regulating microclimates in the village and surrounding farmlands. By maintaining forest cover and natural irrigation systems, the Kampung Naga community has implemented a landscape-based approach that not only supports biodiversity and water security but also contributes to reducing climate-related risks such as flooding and drought. This holistic system aligns with key principles of climate literacy, showing that community-based knowledge and land use can directly support both local resilience and broader climate mitigation objectives (USGCRP, 2009).

Houses in Kampung Naga serve not only as physical shelters but also embody cultural values and ecological adaptation. They serve as dynamic social spaces where family life, daily activities, and cultural ceremonies take place. Each home embodies the life cycle of its inhabitants and symbolizes the interconnectedness between human existence and the cosmos. The design and function of these homes are informed by traditional beliefs and a worldview that integrates environmental stewardship with spiritual values (Ratnasari et al., 2023).

Local Wisdom in Coastal Protection

The Bajo people have inhabited the Tomini Bay area since the early 19th century. In 1901, the Dutch Colonial Administration formally recognized this region as a Bajo settlement, although at the time, they still lived a nomadic, seafaring lifestyle aboard boats (Zacot et al., 2008). The community has long relied on the coastal and marine resources of Tomini Bay as their primary source of livelihood, engaging in fishing and other marine-based activities (Obie, 2020).

As an indigenous coastal group in Sulawesi, the Bajo possess a rich body of local ecological knowledge, particularly in marine conservation, reflected in the practice of pamali, a set of taboos that prohibit activities deemed harmful to the marine environment. These taboos include restrictions on fishing in coral reef areas or harvesting certain species regarded as sacred. This belief system stems from a spiritual connection with the sea and an understanding that ecological balance is fundamental to their survival. As such, cultural values play a key role in advancing sustainable resource management and conservation practices.

In the Bajo context, pamali functions not only as a social norm but also as an effective ecological safeguard. For instance, prohibitions on fishing around coral reefs help preserve critical marine habitats. Certain marine species are believed to be embodiments of Mbo, the sea deity in Bajo cosmology, making it strictly forbidden to harm or capture them. Violating these taboos is thought to bring misfortune upon individuals or the broader community, reinforcing adherence to these traditional rules (Basri et al., 2017).

Beyond pamali, the Bajo also practice bapongka, a form of communal fishing conducted during specific periods. This practice fosters social cohesion while promoting a more sustainable approach to fishing that minimizes

ecological disruption. Additionally, the Bajo draw upon generationally transmitted knowledge of weather patterns, celestial navigation, and natural indicators, which guide their maritime activities to this day.

Bridging Local Practice with Scientific Validation

Local wisdom within Indonesian communities reflects a rich body of ecological knowledge that is highly relevant for addressing the challenges of climate change. Rooted in generations of lived experience and environmental observation, this knowledge has demonstrated strong adaptive value across time. A clear example is the traditional seasonal calendar Pranata Mangsa used in Java, which guides agricultural planning based on recurring weather and climate patterns. Recent studies have shown significant correlations between its indicators and modern climate data such as rainfall and temperature trends recorded by Indonesia's Meteorology, Climatology, and Geophysics Agency (BMKG), confirming its empirical foundation (Nabila & Wirawan, 2023).

Despite this potential, such knowledge systems are often excluded from formal scientific discourse due to a lack of systematic documentation and limited validation through quantitative methods. Dominant top-down approaches in modern science and policy frequently marginalize or disregard local knowledge. This marginalization is rooted in colonial legacies, where science was positioned as the authoritative means of knowing and fragmented knowledge into rigid disciplines, while traditional systems were dismissed as anecdotal or inferior (Alessa et al., 2016). In reality, local knowledge is evidence-based, validated through communal acceptance, and tested across generations (Agrawal, 2002). The requirement for local knowledge to be validated by Western science reflects a persistent epistemic hierarchy, undermining equity in knowledge systems. As a result, many climate adaptation and conservation initiatives, designed through technocratic frameworks, fail to align with the sociocultural realities of local communities (Yeh, 2016). This misalignment often leads to ineffective outcomes, public resistance, or the disruption of long-standing environmental governance systems that have sustained ecosystems and supported community resilience for decades across diverse regions.

In coastal communities across Indonesia, TEK includes taboo systems (pamali) that prohibit the overexploitation of marine resources, such as coral reefs, mangroves, and spawning zones. These cultural prohibitions often serve the same function as modern zoning or seasonal bans in marine protected areas, yet they are socially enforced and culturally embedded. For instance, taboos that restrict fishing during full moons or monsoon transitions reflect an understanding of fish migration cycles and coastal turbulence, allowing natural regeneration of fish stocks. Similarly, prohibitions on harvesting coral or sea cucumbers near sacred coastal sites help protect reef structures that function as natural barriers against erosion, saltwater intrusion, and extreme wave events, risks that are intensifying with sea-level rise and climate variability (McLeod et al., 2021).

These systems form the foundation of community-based marine resource management, offering scalable models of indigenous coastal resilience. By maintaining coastal buffer ecosystems, regulating extraction patterns, and embedding accountability within spiritual and social norms, such practices contribute to nature-based solutions for climate adaptation. Their value lies not only in ecological outcomes but also in fostering compliance, legitimacy, and intergenerational knowledge transmission.

Bridging this divide requires bottom-up, collaborative approaches as essential strategies for inclusive and effective climate action. Co-production of knowledge, where scientists and local communities work together from planning through evaluation, offers a pathway toward more inclusive and effective strategies. In this model, scientific validation is not a tool to judge the legitimacy of traditional knowledge, but rather a bridge between distinct epistemologies: experience-based observation and data-driven analysis. Through participatory engagement, climate strategies become not only more ecologically relevant, but also socially just and culturally responsive.

However, as an exploratory study grounded in secondary data and literature analysis, this research does not include empirical field validation or direct engagement with community stakeholders. The selected case studies, while diverse, are based on documented sources and may not capture the full range of indigenous knowledge systems across Indonesia.

Future research should include coastal and marine contexts, examining how traditional knowledge systems contribute to blue carbon management, climate-resilient fisheries, and disaster risk reduction in island and shoreline communities. Participatory methods, including field-based inquiry and impact assessment, are necessary to deepen understanding and support scalable integration of traditional knowledge into climate policy frameworks.

CONCLUSION

Indonesia's local wisdom offers valuable, culturally rooted models of climate literacy that reflect deep ecological awareness and have supported community resilience for generations. Recognizing and integrating these traditions into formal climate policy and education can significantly enhance the relevance, inclusivity, and effectiveness of climate action. This requires a paradigm shift: from viewing local knowledge as merely supplementary, to acknowledging it as a foundational element of climate literacy. Achieving this transformation depends on collaborative, co-productive approaches that bridge scientific and indigenous knowledge systems through mutual respect and shared authority.

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