

Ethnoecological perspectives on biodiversity conservation in volcanic landscapes of Mount Merapi National Park, Central Java, Indonesia

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Abstract. *Taqwim MHA, Fitriawan MN, Ibriza NM, Fil'ardiani NU, Arifiani KN, Sutomo, Setyawan AD. 2025. Ethnoecological perspectives on biodiversity conservation in volcanic landscapes of Mount Merapi National Park, Central Java, Indonesia. Asian J Ethnobiol 8: 104-115.* Volcanic protected areas such as Mount Merapi National Park (TNGM) in Indonesia hold exceptional ecological and cultural significance yet face complex conservation challenges due to ecological volatility and socio-economic vulnerability. This study explores ethnoecological perspectives on biodiversity conservation among residents of Tegalmulyo and Sidorejo, two villages located in the national park's buffer zone. Using a qualitative descriptive approach, data were collected through structured interviews with 87 respondents, supported by culturally adapted questionnaires and field observations. Results reveal high levels of community awareness regarding biodiversity regulations and intergenerational heritage values. Conservation is widely perceived as a moral and cultural obligation, expressed through non-extractive practices, taboos, and collective activities such as tree planting and forest monitoring. Local belief systems, including spiritual reverence for forested landscapes and communal ethics such as *gotong royong*, emerge as key drivers of conservation behavior. The study underscores the crucial role of community engagement in biodiversity conservation, as demonstrated by the sustained initiatives of these communities through social cohesion and informal institutions such as the Fire Care Community (*Masyarakat Peduli Api/MPA*) and Forest Police Partner Community (*Marakat Mitra Polhut/MMP*). Unlike previous studies, this research provides in-depth ethnoecological insights from disaster-prone volcanic regions, emphasizing culturally embedded conservation practices that remain underexplored in formal policy discourses. The findings highlight the need to incorporate local ecological knowledge and community values into co-management strategies for more inclusive and adaptive biodiversity governance.

Keywords: Biodiversity conservation, community-based conservation, ethnoecology, traditional knowledge, volcanic landscapes

INTRODUCTION

Indonesia is one of the most megadiverse countries globally, hosting an extraordinary range of flora, fauna, and ecosystems across its vast archipelago. This biological wealth is shaped by complex topography, diverse climatic conditions, and a tapestry of cultural traditions that influence how natural resources are managed (Yunita et al. 2020). Biodiversity conservation in Indonesia is thus not only an ecological priority but also a socio-cultural obligation, especially in ecologically sensitive and culturally significant areas such as national parks. Setiawan (2022) identified at least 74 distinct ecosystems—both natural and human-modified—that face growing threats from environmental changes and anthropogenic pressures.

Conservation in Indonesia typically follows two complementary approaches: in-situ and ex-situ. The in-situ strategy prioritizes the protection of ecosystems in their native context, while ex-situ methods focus on preserving components of biodiversity outside their original environments (Mulyaningsih et al. 2020; Dako et al. 2021). In areas such as volcanic zones, in-situ approaches are

crucial due to the dynamic nature of ecological succession and community adaptation to frequent disturbances. However, recent studies warn of a continued decline in critical biodiversity indicators, calling for transformative conservation models that integrate scientific knowledge and local lived experiences (McPhearson et al. 2021; García-Roselló et al. 2023).

Mount Merapi National Park (Taman Nasional Gunung Merapi or TNGM) exemplifies the interplay between ecological preservation, active volcanism, and deep-rooted cultural values. Straddling Central Java and Yogyakarta provinces, the park harbors endemic and endangered species and is revered for its spiritual and historical significance (Djuwantoko et al. 2005). As a conservation area, TNGM bears responsibility for sustaining both biodiversity and the socio-ecological systems upon which it depends. Tegalmulyo and Sidorejo—two villages in the park's buffer zone—are inhabited by farming communities that are actively involved in both resource use and conservation efforts (Torimbanu et al. 2024). Their dual roles underscore the importance of understanding local

knowledge, perception, and meaningful participation in conservation.

Local Ecological Knowledge (LEK)—the culturally transmitted body of ecological understanding accumulated through generations—plays a pivotal role in community-based conservation (Berkes 2018; Fielding et al. 2023). Embedded in beliefs, rituals, and taboos, LEK often functions as a form of informal environmental governance aligned with conservation goals. On Mount Merapi, cultural notions of sacredness, land-use ethics, and environmental taboos have historically reinforced biodiversity protection—often long before formal policies were introduced. Turo and Medeghini (2021) argue that such values can enhance environmental stewardship when supported by inclusive governance frameworks.

Despite this potential, community participation in formal park management remains limited. Although Law No. 41/1999 on Forestry mandates public involvement, practical implementation is often hindered by unclear tenure rights, weak institutional coordination, and insufficient environmental education (Qodriyatun 2020; Firnanda et al. 2024). In TNGM, zoning schemes and outreach efforts have been initiated (Wijayati and Rijanta 2020), yet there remains a need to assess how communities interact with these mechanisms and what cultural or socio-economic factors shape their engagement.

Empirical research confirms that community perceptions strongly influence conservation outcomes. Ernawati et al. (2018) found that perceptions of ecological value are positively associated with rule compliance. Moreover, information-sharing by park officers and community leaders significantly improves conservation behavior (Purwatiningsih 2022). However, perception does not always translate to participation, especially where livelihoods depend heavily on natural resources. Therefore, a comprehensive ethnoecological perspective—examining

both awareness and active engagement—is essential to evaluate conservation effectiveness.

This study investigates the ethnoecological dimensions of community awareness and participation in biodiversity conservation within Tegalmulyo and Sidorejo Villages, located in the buffer zone of Mount Merapi National Park. It focuses on how local knowledge systems, regulatory awareness, and voluntary engagement intersect in a landscape marked by ecological risk and cultural endurance. By centering on community voices and experiential insights, this research offers a deeper understanding of conservation that connects policy frameworks with ground-level realities. Unlike earlier studies, it foregrounds culturally embedded conservation practices in disaster-prone volcanic settings—an area still underrepresented in biodiversity governance discourse.

MATERIALS AND METHODS

Study area

Mount Merapi National Park (TNGM) is a protected area located on the border of Central Java and Yogyakarta, Indonesia (Figure 1). It spans several administrative districts and serves as a crucial biodiversity sanctuary and ecological buffer within a volcanically active zone. Positioned between 7°26'–7°48' S and 110°21'–110°36' E, the park encompasses lowland forests, montane vegetation, and human-modified landscapes. Its role as a water catchment and its richness in endemic species give it significant ecological and hydrological value (Djuwantoko et al. 2005). TNGM is also situated in a culturally and spiritually important landscape, where local cosmologies influence interactions with nature.

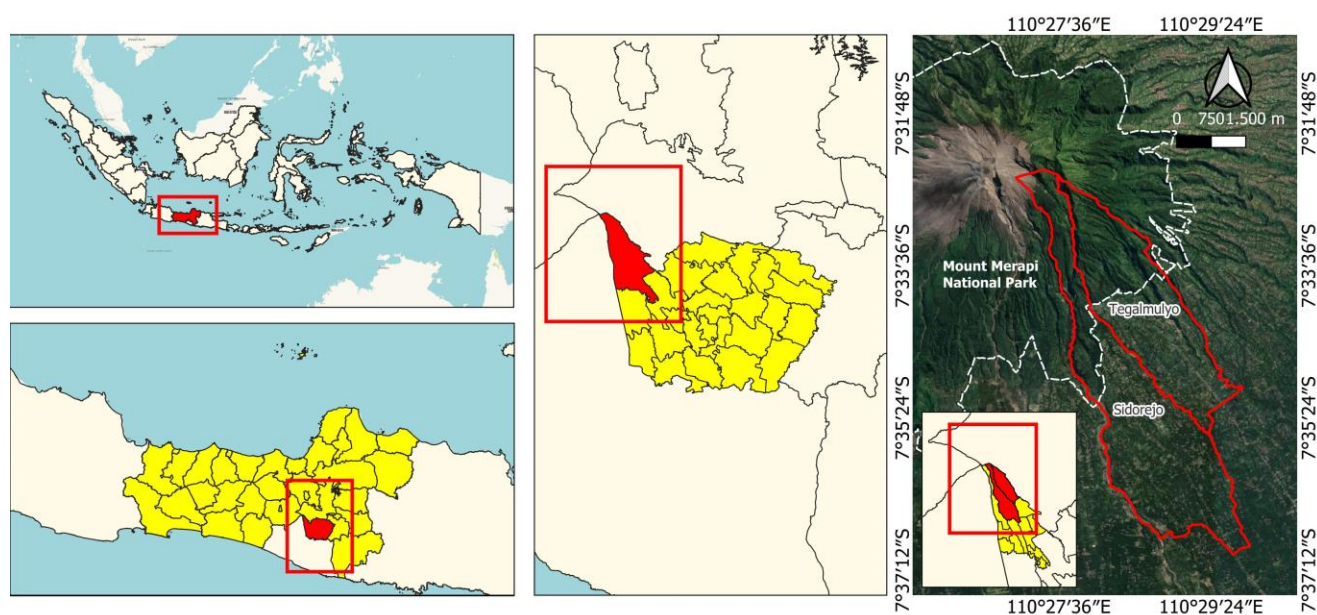


Figure 1. Location in the buffer zone of Mount Merapi National Park, Tegalmulyo and Sidorejo Villages, Kemalang Sub-district, Klaten District, Central Java, Indonesia

This study focuses on two villages in the park's buffer zone: Tegalmulyo and Sidorejo, both in Kemalang Sub-district, Klaten District. Tegalmulyo lies at -7.5671945, 110.4768555, while Sidorejo is slightly southward at -7.6003677, 110.4798348. These villages are approximately 10 kilometers from Klaten town and feature slopes shaped by volcanic activity. The land cover includes mixed dryland farming, forest remnants, and scattered dwellings.

The villages are inhabited mainly by Javanese farmers who depend on seasonal agriculture, livestock, and minor forest extraction such as firewood and grass. Traditional ecological knowledge and awareness of conservation regulations shape their land use (Whittington and Pagiola 2012). Cultural elements like *pamali* (taboos), *adat* (customary law), and religious beliefs reinforce environmental stewardship and influence compliance with formal conservation policies.

The local biodiversity includes tree species such as *puspa* (*Schima wallichii*), *gondang* (*Ficus* spp.), and *ricen* (*Eugenia* spp.), alongside orchids and coffee plants cultivated in home gardens. These species hold both ecological and cultural value (Aji et al. 2022; Marhaento and Faida 2015). Wildlife includes birds, reptiles, and primates like *Macaca fascicularis* and *Trachypithecus auratus*, which interact with both cultivated and forested habitats.

Both villages fall within volcanic disaster-prone zones designated by the Indonesian Disaster Management Agency (BPBD). Tegalmulyo lies in *Kawasan Rawan Bencana/KRB II* (moderate to high risk), and Sidorejo in *KRB III* (lower but still notable risk), reflecting threats from lava flows, pyroclastic surges, and lahars, based on the 2006 and 2010 eruptions (BPBD Klaten 2023). As shown in Figure 1, their location on the southern slope of Mount Merapi makes them highly vulnerable to disturbances, underscoring the urgency of conservation efforts.

In such volatile environments, community-based conservation must navigate ecological risks and socio-cultural realities. Residents face the challenge of balancing resource use, tradition, and disaster preparedness. Thus, conservation in TNGM must incorporate the ethnoecological perspectives of these communities to build models that are both ecologically and socially resilient (Gavin et al. 2015).

Research design

This study employed a qualitative descriptive approach to explore community awareness, local ecological knowledge, and participation in biodiversity conservation within the buffer zone of Mount Merapi National Park (TNGM). This approach was chosen to capture the depth and contextual richness of community experiences and perceptions, which are often embedded in social relations, oral traditions, and everyday interactions with nature. Unlike quantitative methods aimed at generalization, qualitative inquiry allows for nuanced interpretation grounded in participant narratives and cultural meaning systems (Fielding et al. 2023). The descriptive character of

the study helped reveal how local residents articulate conservation values and engage in ecological stewardship.

The ethnobiological perspective informed this methodological choice, emphasizing the cultural embeddedness of ecological understanding. In TNGM, residents of Tegalmulyo and Sidorejo possess long-standing knowledge of species and ecological functions. This knowledge supports local resource management and helps shape community-driven conservation strategies. Open-ended, culturally sensitive interviews were used to elicit both explicit rules and implicit values such as spiritual beliefs and taboos (Berkes 2018).

To uphold ethical integrity, the study incorporated community consent and adhered to protocols from the International Society of Ethnobiology (ISE 2006). Prior to data collection, researchers consulted with village leaders and explained the research in both Indonesian and Javanese. Participants were informed of their rights, and all responses were anonymized. Cultural norms were respected throughout.

Additionally, the study aimed to empower communities by recognizing local conservation practices and facilitating knowledge exchange. Informal discussions with farmer groups and volunteers enriched the data and helped validate interpretations. Multiple community voices were included to ensure reciprocity and align with participatory principles (Cunningham 2001).

By combining qualitative methods with ethnobiological values, this study provides a holistic understanding of conservation as a culturally rooted process. It highlights that effective biodiversity protection arises not merely from regulation, but from the dynamic interface between ecological realities and lived cultural practices—especially in fragile volcanic landscapes like Mount Merapi.

Data collection

Respondent selection and sampling strategy

Data collection was conducted in Tegalmulyo and Sidorejo Villages, which are located in the buffer zone of Mount Merapi National Park. These two sites were selected purposively due to their ecological significance and socio-cultural proximity to the conservation area. The population consists primarily of farmers and livestock keepers who interact directly with the forest ecosystem, making them ideal subjects for examining ethnoecological knowledge and conservation practices. A total of 87 respondents were selected through random household sampling, ensuring that diverse demographic groups—including age, gender, and educational background—were represented. The final sample consisted of 44 males (50.6%) and 43 females (49.4%), with the majority falling within the productive age group of 30-69 years (Table 1).

Questionnaire and interview structure

The study employed a semi-structured interview method supported by a culturally adapted questionnaire designed to explore both general awareness and specific conservation practices. The questionnaire included both closed and open-ended questions organized into three main themes: (i) basic understanding of biodiversity and

regulations, (ii) perceptions of human impact and conservation urgency, and (iii) participation in community-based conservation efforts. Open-ended questions were used to allow respondents to elaborate on their personal experiences, local beliefs, and ecological observations. For instance, they were asked about customary rules governing forest use, knowledge of species they considered sacred or useful, and any changes they had observed in forest health. This flexible format helped accommodate the complexity and variability of ethnoecological knowledge across households (Susandi et al. 2021).

Use of local language and cultural adaptation

All interviews were conducted in Indonesian and Javanese, depending on the respondent's preference and linguistic comfort. The use of the local language was essential not only for clarity and rapport but also to maintain the conceptual integrity of indigenous terms, metaphors, and expressions that often have no direct equivalents in formal Indonesian or English. Before the fieldwork, the research team conducted a cultural familiarization session with local leaders to refine the questionnaire and align it with community norms and sensitivities. Key ecological terms such as *leres alas* (forest order), *pamali* (taboo), and *kawasan keramat* (sacred zone) were retained throughout interviews to capture their contextual meanings. This process of linguistic and cultural adaptation ensures that the data collection is respectful, accurate, and reflective of the local worldview (Turo and Medeghini 2021).

Duration and logistics of fieldwork

Field data were collected over two consecutive days, from 9 to 10 March 2024, with interviews conducted at the respondent's homes or communal spaces such as *pos ronda* (village guard posts) and farmer group meeting places. The research team consisted of trained enumerators and a field coordinator familiar with the area and local dialect. Each interview lasted between 20 and 40 minutes, depending on the depth of response and the need for clarification. All responses were recorded manually on printed tally sheets and notebooks due to limited digital access in certain areas. Observational notes were also taken on non-verbal cues and situational contexts, such as household surroundings, the presence of home gardens, or conservation posters, which later informed the qualitative interpretation. Fieldwork logistics were supported by prior coordination with village heads and the TNGM field office, ensuring smooth community access and cooperation.

Data analysis

The data collected from interviews were analyzed using a qualitative-descriptive approach, supported by simple statistical tabulation for categorical variables. The main goal was to identify patterns of awareness and participation and relate them to local ecological knowledge systems. Analysis began with manual tabulation of structured responses concerning conservation awareness, participation, regulation knowledge, and ecological threats

like hunting and overharvesting. Closed-ended responses were categorized (e.g., Yes/No, Agree/Neutral/Disagree) and presented as frequency distributions (Tables 2 and 3).

In parallel, thematic coding of open-ended responses and field notes was conducted inductively, identifying themes such as forest heritage, *adat* compliance, perceived risk, and willingness to act without incentives. These were interpreted within the context of formal conservation frameworks, including Forestry Law No. 41/1999 and the TNGM zoning system (Wijayati and Rijanta 2020). This dual analysis enabled linkage between individual perceptions and broader socio-ecological dynamics. Awareness data were grouped into agree, neutral, and disagree categories to assess alignment with conservation principles. Participation data were classified as active, passive, or non-participatory, based on self-reported actions such as tree planting, rule compliance, or group involvement.

To ensure credibility, triangulation was employed by comparing interview responses with field observations—such as presence of seedlings, certificates, or conservation posters. This cross-validation improved internal consistency and interpretive accuracy. While statistical inference was not applied due to the study's qualitative focus, the integration of quantified patterns and ethnographic insight yielded a holistic understanding of community dynamics. The focus on both awareness and participation reflected what people know and do regarding conservation—core to ethnobiological research principles (Fielding et al. 2023). Acknowledged limitations included potential social desirability bias and interpretive ambiguity. These were mitigated by consulting local key informants to clarify meanings and ensure cultural fidelity in the findings.

RESULTS AND DISCUSSION

Demographic profile of respondents

Understanding a community's demographic composition is essential for interpreting patterns of ecological awareness and participation. In this study, about 87 respondents from Tegalmulyo and Sidorejo Villages participated in structured interviews. As shown in Table 1, the demographic profile covered variables including age, gender, level of education, and primary occupation.

In terms of age distribution, the majority of respondents were within the productive age range. Specifically, 30 respondents (34.5%) were between 30-49 years old, followed closely by 20 respondents (23.0%) aged 50-69 years. Meanwhile, younger individuals aged 17-29 made up 18.4%, and elders above 70 years constituted only 9.3% of the total sample. The dominance of the middle-aged cohort not only suggests a potential for active involvement in conservation programs but also underscores the importance of their role, as this age group typically possesses both physical capability and decision-making influence within households (Dewi et al. 2021).

Table 1. Demographic characteristics of respondents from Tegalmulyo and Sidorejo Villages, Klaten District, Indonesia

Demographic Variable	Category	Frequency	Percentage (%)
Age	17-29 years	16	18.4
	30-49 years	30	34.5
	50-69 years	20	23.0
	>70 years	11	9.3
Gender	Male	44	50.6
	Female	43	49.4
Education	No schooling	20	23.0
	Elementary school	35	40.2
	Junior high school	19	21.8
	Senior high school	12	13.8
	University	1	1.1
Occupation	Farmer	66	75.8
	Housewife	8	9.2
	Self-employed	4	4.6
	Student	3	3.4
	Government employee	4	4.6
	Driver	1	1.1
	Livestock breeder	1	1.1

Gender distribution was balanced, with 50.6% male and 49.4% female respondents. This balance allows for a comparative understanding of gendered roles in conservation, which is particularly relevant in rural Java, where both men and women engage in natural resource use and environmental practices—albeit often in different domains (e.g., men in farming and patrolling; women in home gardening and medicinal plant use).

The educational background of respondents revealed that most had limited formal schooling. As many as 40.2% are elementary school graduates, while 23.0% have never received any education. Junior high (21.8%) and senior high school (13.8%) graduates represented a smaller portion, with only 1.1% having received university-level education. This educational profile may influence conservation understanding, particularly in terms of scientific or legal aspects, although traditional ecological knowledge is often transmitted orally and independently of formal education (Indah et al. 2021).

As for occupational roles, the majority of respondents were engaged in farming (75.8%), followed by small numbers involved in household work (9.2%), self-employment (4.6%), and other informal sectors such as livestock rearing, driving, and civil service. The dominance of agricultural livelihoods indicates a strong dependency on natural resources, which reinforces the need for conservation approaches that align with rural livelihoods and ecological sustainability.

These demographic attributes have significant implications for conservation engagement. Respondents in the productive age group were more likely to participate in physically demanding conservation activities such as tree planting or forest patrols. The high proportion of farmers suggests that biodiversity initiatives should be integrated with sustainable agriculture and agroforestry schemes. While limited formal education could pose challenges to the uptake of scientific information, it also highlights the importance of leveraging oral transmission and visual methods for environmental communication. Moreover, gender-balanced participation opens up possibilities for designing conservation programs that utilize both male and female knowledge domains, such as integrating women's expertise in home-based ethnobotany and food security.

The demographic structure of the respondents reflects a community capable of and positioned for participatory conservation, provided that the strategies are contextually grounded and culturally respectful. The demographic composition of respondents is summarized in Figure 2, highlighting key variables relevant to conservation engagement.

Community awareness of biodiversity conservation

Community awareness is a critical component of effective biodiversity conservation, particularly in protected areas where local populations maintain close and ongoing interactions with the landscape. In this study, awareness was assessed through questions measuring understanding of conservation rules, the national park's heritage value, and perceived human impact on biodiversity. The results, presented in Table 2, reveal a generally high level of awareness among residents of Tegalmulyo and Sidorejo Villages regarding the ecological and legal significance of Mount Merapi National Park (TNGM).

The overwhelming majority of respondents (100%) confirmed their awareness that the national park holds important heritage values for future generations. This indicates that the idea of biodiversity as an intergenerational asset is deeply rooted in community consciousness. Such understanding aligns with findings from Ernawati et al. (2018), who reported that local communities around TNGM tend to view conservation not merely as a legal obligation but as a moral responsibility tied to ancestral respect and cultural continuity. This sentiment often takes the form of customary expressions like *warisan anak putu* (inheritance for descendants), highlighting the cultural framing of conservation as a legacy (Figure 3).

Table 2. Basic understanding of respondents regarding conservation in Mount Merapi National Park, Indonesia

Question	Yes	(%)	No	(%)
Is using plants (other than grass) and animals in the TNGM area permissible?	3	3	84	97
Is there community participation and effort in protecting plants and animals in the TNGM area?	87	100	0	0
Did you know that TNGM has heritage values that are important for future generations?	87	100	0	0

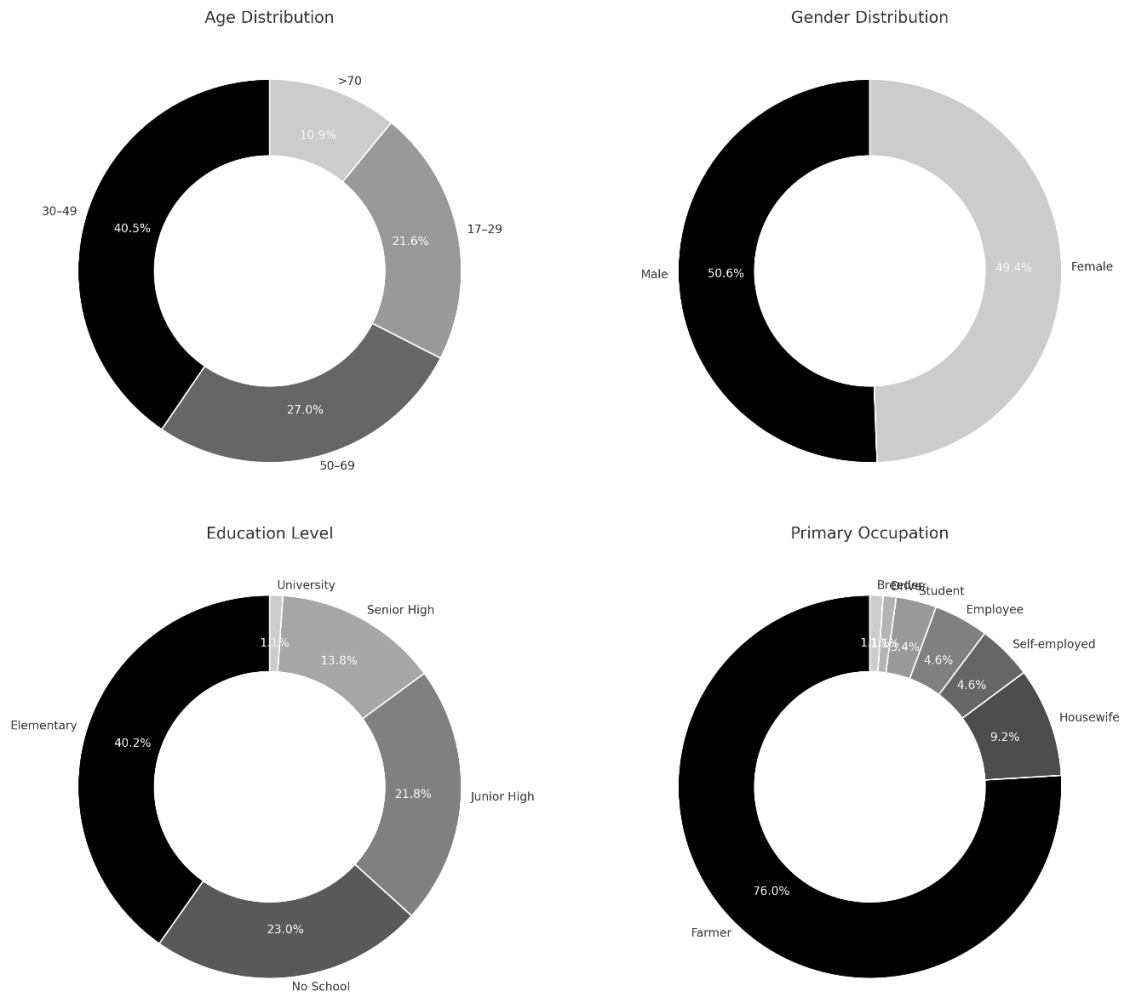


Figure 2. Demographic characteristics of respondents from Tegalmulyo and Sidorejo Villages, Klaten, Indonesia showing distributions by age group, gender, education level, and primary occupation. This profile supports the interpretation of community capacity and potential engagement in biodiversity conservation

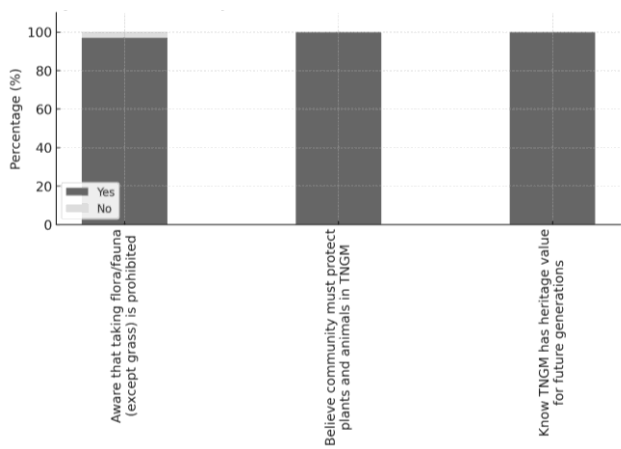


Figure 3. Community awareness levels regarding conservation rules and values in Mount Merapi National Park (TNGM) are based on three key indicators: knowledge of restrictions on flora/fauna extraction, recognition of collective responsibility in protection, and understanding of the national park's intergenerational heritage value

Furthermore, 97% of respondents indicated they were aware that using plants (other than grass) and animals in TNGM is not permissible under current regulations. This suggests strong dissemination of formal conservation laws within the community, likely the result of regular outreach activities by national park authorities and village leaders (Purwatiningsih 2022). Knowledge of such prohibitions demonstrates the successful penetration of legal awareness, although it does not automatically guarantee behavioral compliance, a gap that will be further discussed in the next section.

Another noteworthy finding is that 100% of respondents believed that the community has a role in protecting plants and animals in TNGM. While this figure may reflect an idealized or socially desirable response, it nonetheless indicates that conservation values are widely recognized within the social fabric of both villages. This recognition is essential for fostering collective responsibility and grassroots support for biodiversity governance (Fielding et al. 2023).

The consistency of high-awareness responses supports earlier assertions that conservation communication and education campaigns in the TNGM region have been effective. However, awareness is a multidimensional construct that extends beyond knowledge of rules or values. As suggested by Ajzen and Fishbein (1980), behavioral intention is shaped not only by awareness but also by perceived control and normative beliefs. In this case, while respondents knew the rules, further data (Table 3) reveal variation in their willingness or perceived capacity to act on this awareness, particularly in the form of active participation or sacrifice.

In addition to formal legal knowledge, respondents exhibited a strong understanding of the negative ecological impacts of human intervention. A total of 89% agreed that excessive interference with nature could harm biodiversity in TNGM, with the remaining 11% expressing neutrality rather than disagreement. This level of ecological literacy is vital, especially in a volcanic landscape where both natural and anthropogenic disturbances often strain ecosystem resilience. The ability of residents to articulate causal links between human activity and ecological degradation suggests that they are not only informed but also able to assess environmental risks critically.

These findings indicate that the communities of Tegalmulyo and Sidorejo possess a high degree of conservation awareness that encompasses legal knowledge and value-based commitment. This awareness provides a strong foundation for participatory conservation initiatives. However, the translation of awareness into concrete action remains contingent upon cultural, economic, and institutional factors, which are examined in the following sections.

Patterns of community participation

While awareness of conservation values in Tegalmulyo and Sidorejo Villages is high, the level and nature of actual participation in biodiversity conservation show greater variation. Participation was examined in terms of self-reported involvement in protecting plants and animals, compliance with conservation-related prohibitions, and willingness to engage in shared responsibilities. As shown in Table 3, while 96% of respondents agreed that conservation efforts in TNGM are important, only 56% believed they should personally play a role in maintaining biodiversity. This gap between recognition and

responsibility highlights the complexity of community engagement in conservation initiatives.

The disparity is particularly notable when respondents described their roles as passive protectors rather than active participants. Many expressed that their contribution consisted primarily of not disturbing or not damaging the forest rather than joining organized reforestation or patrol programs. This notion of non-interference as participation reflects a culturally specific understanding of conservation rooted in restraint and respect rather than proactive management. In Javanese customary belief systems, the forest is often viewed as a space of sacred order (*leres alas*), and minimal interference is equated with harmony (Turo and Medeghini 2021).

Formal compliance was also high, with 97% of respondents aware of the prohibition against hunting plants and animals and 93% agreeing that violators should be punished. These figures suggest that legal norms are generally accepted and reinforced within the community. Local enforcement, typically in the form of community warnings and social pressure, appears to be more effective than formal policing. Respondents noted that first-time offenders are usually warned or asked to return collected species to the forest. At the same time, repeated violations may result in required participation in TNGM-led programs such as tree planting or forest education events. This graduated sanctioning system, while informal, helps maintain regulatory compliance while preserving social cohesion (Setiawan 2024). The spectrum of community attitudes toward conservation roles, ecological impact, and sanctions is visualized in Figure 4.

The study also identified perceived limitations that may constrain deeper participation. One such limitation is the economic cost associated with conservation actions. While most respondents supported the idea of conserving biodiversity, 62% disagreed with the notion that material sacrifices (e.g., money or resources) were required. For communities that rely heavily on subsistence farming, the prioritization of livelihood needs often outweighs voluntary financial contributions. Some respondents expressed that conservation is not something to be paid for but rather a communal obligation embedded in religious and cultural practice. This reflects a worldview in which conservation is a moral rather than transactional duty—a perspective that should be acknowledged in the design of participatory programs.

Table 3. Community perceptions and participation in biodiversity conservation in Mount Merapi National Park, Indonesia

Question	Agree	(%)	Neutral	(%)	Disagree	(%)
Is it important to conserve biodiversity (plants and animals) in the TNGM area?	83	96	3	3	1	1
Do you, as a resident, have a role in maintaining biodiversity in the TNGM area?	49	56	31	36	7	8
Can human activities negatively impact biodiversity in TNGM?	77	89	10	11	0	0
Are people not allowed to hunt biodiversity in the TNGM area?	84	97	0	0	3	3
Should those who violate biodiversity regulations be punished?	81	93	5	6	1	1
Do you feel the need to make material sacrifices to support conservation?	24	28	9	10	54	62

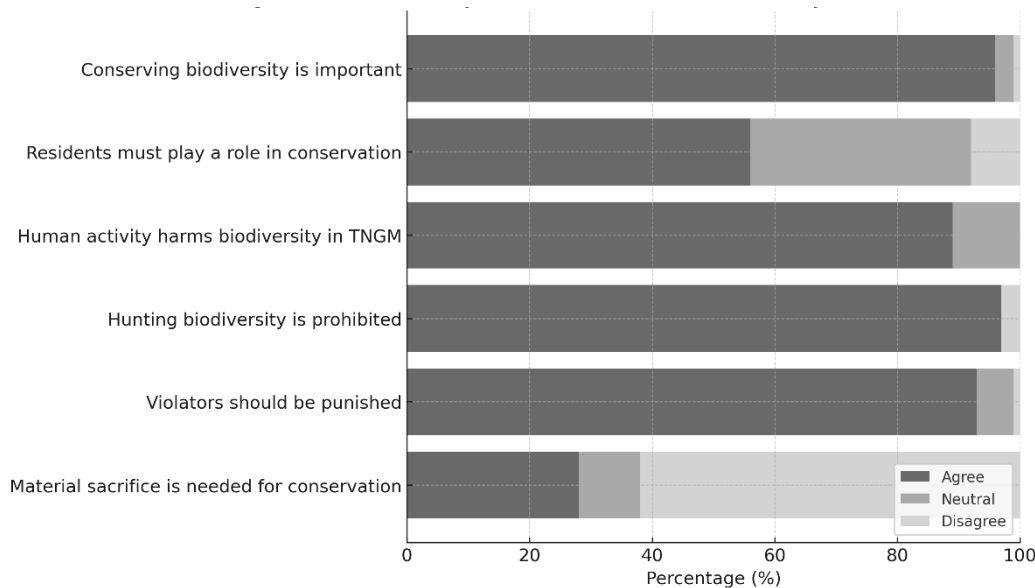


Figure 4. Community attitudes toward biodiversity conservation and participation in Mount Merapi National Park, based on six key indicators. Responses are categorized by level of agreement (agree, neutral, disagree), reflecting variations in perceived responsibility, awareness of impact, acceptance of sanctions, and views on material contribution

Community-based activities such as tree planting, seedling care, and wildlife monitoring were mostly carried out through group-based efforts led by TNGM or civil society organizations. These include local farmer groups, PKK (Family Welfare Movement), and environmental volunteer groups such as *Masyarakat Peduli Api/MPA* (Fire Care Community) and *Masyarakat Mitra Polhut/MMP* (Forest Police Partner Community) (Qodriyatun 2020). Participation in such groups is often informal and periodic, related to seasonal activities or in response to major events such as forest fires or volcanic eruptions. Although episodic, these activities are significant contributions to ecological resilience and community solidarity.

Overall, the findings indicate that compliance with conservation norms—both formal and customary—is high, but active participation remains moderate and highly context-dependent. Cultural values, economic capacity, and perceived roles mediate how conservation is interpreted and implemented in the community. Programs that aim to strengthen local participation should, therefore, build on existing ethical frameworks and avoid imposing external expectations that may not resonate with local realities (Truong 2022). Recognizing communal restraints and obligations as legitimate forms of conservation may provide a more inclusive and culturally congruent foundation for future biodiversity initiatives.

Local beliefs and conservation values

Local beliefs and cultural values play a pivotal role in shaping how communities perceive and engage with conservation efforts, especially in regions where formal state regulations intersect with traditional knowledge systems. In the case of Tegalmulyo and Sidorejo Villages, conservation is not merely understood as a scientific or

legal mandate but also as a culturally embedded obligation passed down through generations. These beliefs—manifested in practices such as taboos (*pamali*), reverence for sacred groves (*alas keramat*), and traditional ceremonies—contribute to informal systems of biodiversity protection that are often more deeply respected than formal policies (Turo and Medeghini 2021).

Respondents often referred to the mystical character of Mount Merapi and the surrounding forests, which are believed to be inhabited by spiritual entities or guardians (*penunggu*). This cosmological framework discourages unauthorized or disrespectful exploitation of natural resources, reinforcing norms of self-control and ecological mindfulness. In such situations, non-compliance is feared not only for its legal consequences but also for potential supernatural retribution. These perceptions provide a strong form of social control that complements the regulatory function of national park authorities (Ernawati et al. 2018).

Cultural institutions also mediate conservation behavior through community rituals and seasonal customs. For example, certain days are considered inauspicious (*hari pantangan*) for entering the forest, while others are reserved for collective offerings to honor ancestral spirits and forest deities. These practices are not arbitrary but serve to regulate the frequency and timing of resource use, allowing forest patches to regenerate naturally. Such ethnoecological rhythms contribute to ecological balance, even in the absence of scientific monitoring or formal management. As highlighted by Berkes (2018), traditional ecological calendars and ritual cycles often function as adaptive strategies to ensure long-term sustainability.

In addition, the concept of *gotong royong* (mutual cooperation) was consistently emphasized by respondents as a foundational value underpinning collective action for conservation. Community members described planting

trees, tending seedlings, and monitoring fire-prone zones as part of their social duty rather than a task requiring compensation. Participation in volunteer groups such as MPA (Fire Care Community) and MMP (Forest Police Partner Community) is not only seen as practical action but also as an expression of moral alignment with the values of harmony (*rukun*) and balance (*selaras*) between humans and nature (Qodriyatun 2020).

Despite the richness of these cultural frameworks, challenges remain in aligning traditional values with formal conservation programs. One issue is that government interventions often overlook or underutilize local belief systems, focusing instead on compliance-based enforcement. Respondents noted that conservation initiatives that disregard local wisdom or are introduced without adequate consultation tend to be viewed as top-down and less legitimate. Conversely, programs that involve traditional leaders and respect customary norms tend to receive stronger support and longer-lasting outcomes. This supports the findings by Firnanda et al. (2024), who stress the need for integrating ecological education with culturally relevant narratives.

Another tension arises when religious interpretations vary across households. While many respondents view caring for nature as a religious obligation (*amanah*), others, particularly younger or more economically marginalized individuals, may prioritize livelihood needs over conservation ideals. This diversity of views highlights the dynamic nature of cultural values, which are neither static nor uniformly held. Conservation planners must, therefore, approach communities not as monolithic entities but as internally diverse collectives with overlapping and, at times, conflicting worldviews (Pretty et al. 2009).

The conservation values held by communities in Tegalmulyo and Sidorejo are deeply rooted in cultural identity, spiritual cosmology, and collective ethics. These values offer both a normative foundation and a practical framework for biodiversity protection. Recognizing, respecting, and working through these local belief systems is not only an ethical imperative but also a strategic pathway for building effective and enduring conservation partnerships in ethnobiologically rich regions such as Mount Merapi. These beliefs are also reflected in community practices and conservation symbols observed across the landscape, as illustrated in Figure 5.

Material sacrifice and incentive perception

Incentives—both material and non-material—play a central role in influencing participation in biodiversity conservation. However, in rural communities such as Tegalmulyo and Sidorejo, where subsistence livelihoods dominate, and market access is limited, the perception of material sacrifice in conservation takes on complex and often contradictory meanings. When asked whether conservation should involve a financial or material contribution, 62% of respondents disagreed, while only 28% agreed that such a sacrifice was necessary (see Table

3, item 6). These responses reveal a tension between moral imperatives and economic constraints that shape how conservation is interpreted and implemented at the local level.

Several respondents expressed the view that conservation should not be bought or paid for but rather understood as an intrinsic communal duty tied to cultural and religious values. In this sense, participation is framed not in terms of compensation but as a form of *ibadah* (worship) or *gotong royong* (mutual aid). This resonates with observations from other ethnobiological studies, where intrinsic motivations, such as spiritual fulfillment, social cohesion, and ancestral respect, frequently outweigh external incentives as drivers of environmental stewardship (Cetas and Yasué 2017). For many villagers, the act of planting trees or protecting forest borders is its own reward, tied to personal virtue and community reputation rather than financial gain.

However, economic realities cannot be completely separated from the dynamics of participation. Farming households in these villages often face seasonal income fluctuations, high dependence on natural inputs, and limited access to agricultural extension services. These conditions limit their ability to provide material support to conservation programs, even when they ideologically support them. For instance, respondents noted that while they were willing to donate time and labor, they could not afford seeds, tools, or transportation to participate in events located far from their homes. This insight highlights the need to distinguish between willingness and capacity—a distinction often overlooked in top-down conservation planning (Qodriyatun 2020).

The study also revealed variations in perception based on age, education, and exposure to formal conservation programs. Older respondents and those with strong ties to community institutions (such as religious groups or farmers' cooperatives) tended to view conservation as a shared moral responsibility. In contrast, a minority of younger respondents—especially those exposed to digital media or urban work migration—expressed more pragmatic views, suggesting that external support (funding, materials, or training) would increase participation. This indicates an emerging generational divergence in conservation motivation, which may require adaptive communication strategies and differentiated outreach by TNGM and partner organizations.

Interestingly, some villagers interpret material sacrifice not as a gift of money but as a release of potential income from extractive practices such as harvesting timber, hunting wildlife, or converting land to cash crops. From this perspective, conservation itself is already a form of economic sacrifice, as it requires self-restraint and long-term thinking in the face of immediate needs. This aligns with the broader ethnoecological understanding of conservation as a *disciplinary ethic*—a form of self-limitation rooted in ecological knowledge and cultural norms (Marhaento and Faida 2015; Berkes 2018).



Figure 5. Ethnoecological scenes from the buffer zone of Mount Merapi National Park, Indonesia. A. Local residents engage in reforestation activities; B. A home garden featuring valued plants cultivated for conservation and subsistence use; C. Signage indicating hunting prohibition and conservation zoning, reflecting the integration of formal regulations into community landscapes

To strengthen conservation engagement, several respondents suggested in-kind incentives that are non-monetary yet practically useful, such as access to seedlings, technical assistance for agroforestry, or recognition of community efforts through awards and social events. These suggestions reflect a preference for support that is relational and empowering rather than transactional. Furthermore, they align with best practices in community-based conservation, which emphasize trust-building, transparency, and mutual accountability over direct payments (Farley et al. 2010).

Perceptions of material sacrifice in Tegalmulyo and Sidorejo are shaped by a delicate balance of moral ideals, livelihood constraints, and evolving social values. While financial incentives are not entirely rejected, they are generally subordinated to notions of collective responsibility and cultural integrity. Conservation strategies in the TNGM buffer zone should, therefore, avoid framing participation solely in economic terms and instead recognize the full spectrum of motivations—including pride, duty, and spiritual reward—that underlie community commitment to biodiversity protection.

Community-based actions and institutional synergy

In biodiversity conservation, especially within high-risk landscapes such as the slopes of Mount Merapi, the success of long-term ecological protection hinges not only on individual awareness but also on the collective mobilization of local communities in synergy with formal institutions. In both Tegalmulyo and Sidorejo Villages, community-based actions have emerged as critical mechanisms through which conservation goals are localized, internalized, and operationalized.

One of the most prominent forms of community involvement is tree planting, which is carried out regularly through collaborative programs between residents and the TNGM management. Following the 2010 Merapi eruption, large-scale ecosystem restoration efforts involved local volunteers in planting endemic and ecologically functional species such as *puspa*, *teseq*, *sarangan*, *gondang*, and *ricen* (Marhaento and Faida 2015; Fadilah et al. 2024). These species not only restore forest structure and soil stability but also support local wildlife by providing food and shelter. In addition, villagers reported cultivating coffee (*Coffea arabica* var. yellow Caturra Bourbon) and native

orchids (*Vanda* spp.) in home gardens and greenhouses, with the intention of reintroducing them into protected forest zones. Such initiatives demonstrate the integration of livelihood activities with conservation objectives, reflecting an ethnoecological model of sustainability that integrates cultural and ecological goals.

Volunteerism also plays a significant role in operationalizing conservation. Residents participate in Fire Care Community (MPA) and Forest Police Partner Community (MMP) groups, which conduct patrols, report violations, and support forest fire prevention efforts (Qodriyatun 2020). These community-based groups operate with limited resources but high local legitimacy, often filling institutional gaps left by understaffed or overstretched state agencies. Their effectiveness derives from local trust, embedded accountability, and the integration of customary norms, making them indispensable allies in protected area management.

Institutional synergy is further strengthened through the zoning system established by the Ministry of Environment and Forestry under Regulation No. P.76/Menlhk-Setjen/2015. However, while 97% of respondents acknowledged awareness of zone-based regulations, such as restrictions on harvesting in core and jungle zones, many expressed uncertainty about the precise boundaries or permitted activities within these zones (Wijayati and Rijanta 2020). This knowledge gap indicates the need for improved communication and participatory mapping, where local residents are involved in spatial planning and zone identification, enhancing both compliance and local ownership.

Another promising area of institutional collaboration lies in the involvement of local women's groups, such as PKK (Family Welfare Movement), in conservation-linked activities like home gardening, medicinal plant cultivation, and environmental education. These gender-inclusive initiatives recognize the differentiated knowledge systems and roles that women hold in managing biodiversity, especially within the domestic and peri-domestic spheres. By supporting these grassroots actors with training and access to native seedlings, conservation agencies can broaden their reach and strengthen the socio-cultural foundation of environmental stewardship (Fielding et al. 2023).

Despite these encouraging practices, institutional challenges remain. Several respondents pointed to the episodic and project-based nature of many conservation interventions, which often lack long-term follow-up or integration with village development plans. There is also a perceived disconnect between community contributions and recognition by authorities, leading to diminished motivation over time. This highlights the importance of reciprocity and visibility in institutional partnerships, where local actors are not merely beneficiaries or implementers but co-owners of conservation outcomes (Brosius et al. 2005).

To address these issues, conservation strategies must move beyond compliance and participation metrics toward models of co-management that integrate indigenous knowledge, local governance structures, and scientific expertise. This includes facilitating dialogues between village leaders, customary elders, and TNGM officials creating feedback loops that enable adaptive learning and responsive policy-making. Moreover, linking conservation actions to tangible co-benefits—such as ecotourism revenue, seedling exchange, or food security—can help sustain local engagement without eroding intrinsic motivations (Setiawan 2024).

Community-based conservation in the buffer zones of TNGM is active, multifaceted, and deeply embedded in local knowledge and practice. While institutional synergy is present, it remains fragile and uneven, requiring continuous investment in relationship-building, capacity development, and mutual accountability. Recognizing the full value of local action, not as a supplement to state conservation but as its foundation, is key to achieving long-term resilience in socially and ecologically dynamic landscapes such as Mount Merapi.

In conclusion, biodiversity conservation in Mount Merapi's buffer zone is driven by traditional ecological knowledge, cultural values, and selective interaction with formal regulations. Communities in Tegalmulyo and Sidorejo show strong environmental awareness rooted in spiritual beliefs, ancestral ethics, and communal practices like *gotong royong*. Their participation is mainly expressed through restraint, rituals, and voluntary actions, with minimal reliance on formal programs. Informal groups and local initiatives sustain conservation despite limited resources. This study highlights the importance of internalized values and relational incentives in shaping conservation, contrasting with top-down, regulation-based approaches. It emphasizes that effective strategies must align with local knowledge and social contexts, particularly in ecologically fragile and disaster-prone regions. To enhance long-term impact, authorities should integrate these ethnoecological insights into participatory and co-management policies that empower local communities and foster resilience.

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