



Assessment of Community Participation in Mitigating Human–Sumatran Elephant Conflict around Gunung Leuser National Park, Indonesia

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ABSTRACT

One of the key conservation priorities surrounding Gunung Leuser National Park, Indonesia, is human-elephant conflict (HEC) mitigation. Crop raiding into agricultural lands and settlements has caused significant losses, including crop damage, social disruption, and economy that threaten local livelihoods. It also impacts long-term elephant conservation efforts. Successful conflict mitigation relies heavily on community involvement. Understanding local participation is crucial for designing effective and sustainable management strategies. This study aimed to analyze the level of community participation in HEC mitigation in Sapo Padang Hamlet, Batu Jongjong Village, North Sumatra, Indonesia. Data collection through structured interviews, field observations, and focus group discussions involving 40 respondents. They were analyzed using descriptive statistics and Spearman's rank correlation tests, based on the variables of gender, age, and education level. The mean value of community participation based on Likert scale was highest in elephant patrol and driving activities (4), followed by the adoption of alternative crops (3.95), modified farming practices (3.85), land allocation for HEC mitigation (3.85), financial contributions (3.77), and the use of land for wildlife corridors (3.6). Educational attainment was positively associated with respondents' knowledge of HEC mitigation, whereas age showed a significant negative relationship with community participation. These findings demonstrate that successful HEC mitigation requires integrating conservation education, technical assistance, and collaborative community-based management to strengthen community participation and improve human–elephant conflict mitigation programs.

Keyword: Community Participation, Conservation, Gunung Leuser National Park, Human–Elephant Conflict, Mitigation

1. Introduction

Over the past two decades human–elephant conflict (HEC) has intensified particularly in human dominated landscapes. Hundreds of conflict incidents are reported annually in Indonesia, especially in Aceh, Riau, Bengkulu, Lampung, and North Sumatra, where agricultural land and settlements to be part of these conflicts. The most common form that causing substantial economic losses and negatively affecting local livelihoods is crop raiding. This situation poses a severe threat to human communities and the survival of the elephant population through injury or mortality [1], [2]. Further, it contradicts with the status of the Sumatran elephant (*Elephas maximus sumatranus*), currently classified as Critically Endangered by the IUCN. It faces escalating threats from habitat conversion for agriculture, plantation expansion, infrastructure development, and human settlement. Due to this fragmentation, and compromised connectivity of their natural habitats, elephants are driven into agricultural lands for their sustenance that intensifies human–elephant conflict [3]–[5].

One of the HEC's location is Sapo Padang Hamlet, located in Batu Jongjong Village, Bahorok District, Langkat Regency, North Sumatra, Indonesia. It's an enclave within the buffer zone of Gunung Leuser National Park (GLNP). It is a UNESCO World Heritage Site that covering approximately 2,357 hectares (23.57 km²) and comprises a mix of tropical forest, agricultural land, and plantations. The area supports local livelihoods and serves ecologically as a corridor for Sumatran elephants. One of HEC's driving factors is overlapping area between forest land use and agricultural land use. This increased potential interaction between elephant movements and human activities [6].

Effective mitigation of human-elephant conflict requires the active involvement of communities living in conflict-prone areas. Consequently, any ecological intervention necessitates local community participation. Various mitigation measured such as electric fencing, elephant herding, crop guarding, and early warning systems have been implemented in many conflict zones. However, the long-term success of conservation efforts hinges largely on the willingness and capacity of communities participation. To design sustainable mitigation strategies, indigenous knowledge regarding elephant behavior, movement patterns, and seasonal conflict dynamics constitutes valuable information that should be documented as local wisdom [7], [8]. In the other hand, a lack of community participation and local knowledge can heighten risks to elephants, such as poisoning, snaring, and illegal killing. Therefore, enhancing conservation awareness must be accompanied by initiatives to foster a sense of local ownership and responsibility, as well as to encourage collaborative management in conflict areas. [9], [10].

Long-term HEC mitigation initiatives remain constrained by financial resources, technical expertise, and institutional capacity. Furthermore, enhancing public understanding of the ecological importance of Sumatran elephants as umbrella species is crucial to ensuring sustainable and effective conservation outcomes [11], [12]. Even though previous studies have documented the ecological drivers of HEC, but relatively few have evaluated the level of community participation and its relationship with mitigation effectiveness in the buffer zone of Gunung Leuser National Park. Therefore, this study aims to evaluate community participation in Human–Elephant Conflict mitigation and its implementation. The findings aim to provide concrete evidence to strengthen community-based HEC management and support effective, sustainable conservation where humans and elephants co-exist.

2. Methods

2.1. Location

The study was conducted in March 2025 in Sapo Padang Hamlet, Batu Jongjong Village, Bahorok District, Langkat Regency, North Sumatra, Indonesia (Figure 1). The study site is situated within the buffer zone of Gunung Leuser National Park (GLNP).

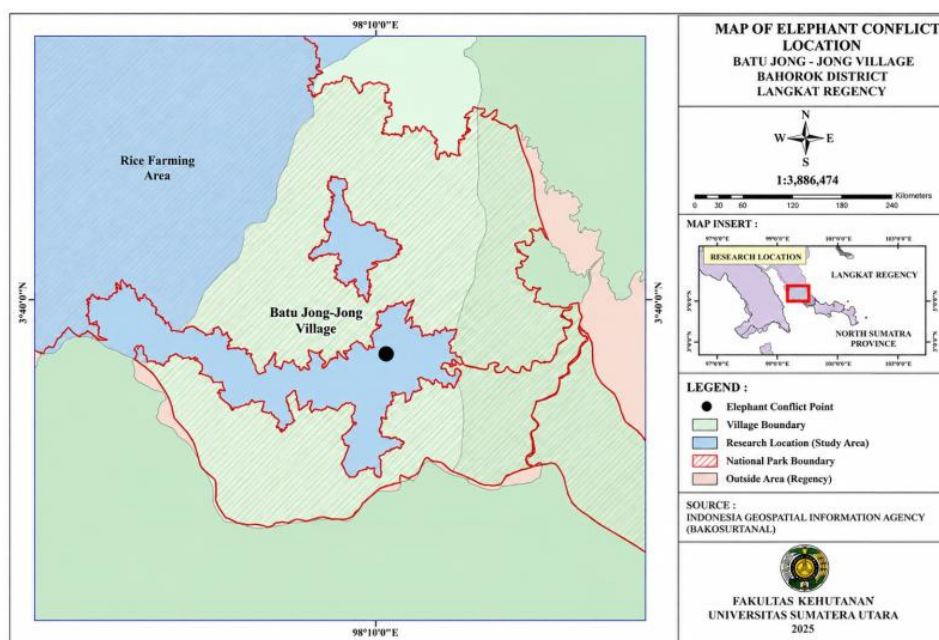


Figure 1. Map of research location

Sapo Padang located at the interface between human settlements and the natural habitats of several protected species, making it a hotspot for human–wildlife conflict. There are some flagship species within this buffer zone, including the sumatran elephant (*Elephas maximus sumatranus*), sumatran tiger (*Panthera tigris sumatrae*), sun bear (*Helarctos malayanus*), and sumatran orangutan (*Pongo abelii*).

2.2. Materials

Primary data was collected through structured questionnaires and field documentation. It's also supplemented by official government records. Statistical data was processed by using Microsoft Excel and IBM SPSS Statistics, respectively.

2.3. Data Collection

2.3.1. Interview

Semi-structured interviews involved 40 directly affected respondents within the conflict zone. They were asked regarding perceptions, experiences, and mitigation techniques. We did a deeper discussion about local knowledge and community perspectives of HEC and applied census sampling due to small population [13]. Each respondents filled the questionnaires items Likert scale. It ranged from 1 (strongly disagree) to 5 (strongly agree). The average of each category was quantified by dividing the sum of Likert scale scores with the total number of respondents.

2.3.2. Observation

Field observation were conducted to assess human–elephant interactions, landscape characteristics, and environmental condition within Sapo Padang Hamlet. The observations complemented and validated the interview findings [18].

2.3.3. Focus group discussion

Focus Group Discussion (FGD) was conducted with community members to explore their perceptions, experiences, and mitigation strategies related to human–elephant conflict mitigation based on community agreement [15].

2.4. Data Analysis

2.4.1. Descriptive statistics

Data were analyzed using descriptive statistics and presented as frequencies, percentages and tables. Qualitative data from interviews, field observations, and focus group discussions were analyzed thematically through an interpretative approach by comparing the findings with relevant theories [16].

2.4.2. Spearman's rank correlation analysis

Spearman's rank correlation analysis was employed to examine the relationships between respondents' socio-demographic characteristics (age, sex, and educational attainment) and their knowledge of, and participation in HEC mitigation [17]. Associations were considered statistically significant at $p < 0.05$, and the strength of the correlations was interpreted based on coefficient according to the classification (Table 1).

Table 1. Spearman's correlation coefficient

Spearman's Correlation Coefficient (r _s)	Strength of Correlation
0.00–0.19	Very weak
0.20–0.39	Weak
0.40–0.59	Moderate
0.60–0.79	Strong
0.80–1.00	Very strong

3. Result and Discussion

3.1. Respondent Characteristic

The respondents of Sapo Padang consisted of 57.5% ($n = 23$) males and 42.5% ($n = 17$) females. Both men and women played similar roles and shared comparable responsibilities in agricultural activities. They worked to sustain their livelihoods by exploiting the local natural resources. All respondents were within the productive working-age range (15–65 years), with the largest age group being over 41 years (37.5%, $n = 15$). They were mature and responsible enough to work in agricultural sector. In contrast, many young generation today show low intention in pursuing careers in this sector, a trend that risks reducing the agricultural workforce [18].

Furthermore, the government will face significant challenge of attracting young people to this field, as their engagement is crucial for ensuring future food security.

Educational backgrounds of respondents varied, with the largest proportion consisting of high school graduates (45%, $n = 18$). Meanwhile, only one respondent (2.5%, $n = 1$) had completed a bachelor's degree. Most respondents worked in the agricultural sector after finishing secondary school. The main reason of dropping out of school was financial constraints that limited access to higher education. They received very limited knowledge regarding sustainable agriculture practices during their formal education. This situation can drive agricultural practices that harm the environment, including wildlife habitats. According to [19], individuals' perspectives could be influenced by education levels as well as their ability in understanding and responding to environmental and social issues.

It's quite interesting that almost half of the respondents (47.5%; $n = 19$) lived in the village for more than 21 years. It indicated that the majority of residents intimately familiar with the characteristics of their environment. The remaining respondents lived in the village for 11–20 years (25.0%) and 1–10 years (27.5%). However, they lived there also driven by a lack of the capital needed to seek a livelihood elsewhere. Therefore, they need to adapt with wildlife interaction, such as elephants crop raiding. It's also related with environmental awareness and indigenous knowledge [20].

Regarding household incomes, it's still in the low level 47.5% ($n = 19$) only IDR 1,000,000 per month. While only 17.5% ($n = 7$) respondent income over IDR 3,000,000 (exchange rate: US\$ 1 = IDR 15,000). This nominal is still under the minimum standard for Langkat Regency as much as IDR 3,402,892 (US\$ 227). It's a big challenges how to maintain residents with ecofriendly behavior to elephant and other wildlife. There are concerns that low income levels will influence public attitudes and perceptions regarding the importance of conservation efforts [21]. Furthermore, many people still viewed elephants as animals that threaten their livelihoods, regarding them as creatures that must be protected solely due to legal regulations. Detail of demographic characteristics of the respondents are presented in Table 2.

Table 2. Respondent characteristic

No	Characteristic	Frequency (n)	Percentage (%)
1	Sex		
	a. Female	17	42.5
	b. Male	23	57.5
2	Age		
	a. 26-30	1	2.5
	b. 31-35	12	30
	c. 36-40	12	30
	d. >41	15	37.5
3	Education		
	a. Primary school	16	40
	b. Junior secondary school	5	12.5
	c. Senior secondary school	18	45
	d. University	1	2.5
4	Occupation		
	a. Farmer	40	100
5	Duration of Residence		
	a. 1-10	11	27.5
	b. 11-20	10	25
	c. >21	19	47.5
6	Income Per Month		
	a. 1,000,000	19	47.5
	b. 2,000,000	14	35
	c. >3,000,000	7	17.5

3.2. Community Participation in Human–Elephant Conflict Mitigation

Even HEC incidents were not happened each year in Sapo Padang, but the effect gave them a physiological trauma. They tried to mitigate by several methods, but they couldn't fully successful in driving the elephants away due to the movement cycles of elephant through this path. Therefore community participation in HEC mitigation was varying. Respondents demonstrated a different responses to participate in HEC mitigation (Table 3).

Table 3. Community participation in HEC mitigation (n = 40) with total of Likert Scale

No	Respondents' Responses					
	Use of private land for wildlife corridors	Alternative crops	Modified farming practices	Land allocation for HEC mitigation	Financial contributions	Direct participation
Total	144	158	154	154	151	160
Mean	3.6	3.95	3.85	3.85	3.77	4

Respondents have six choices regarding HEC mitigation efforts. We can see that direct participation in mitigation activities received the highest level of community support (mean score = 4.00), followed by the cultivation of alternative crops (3.95) and changes in farming practices (3.85). These results show that they have open mind and ready to participate in HEC mitigation. They really looked for effective method in reducing HEC. This finding is consistent with [22], who reported that community involvement was still high in HEC mitigation in Sumatera to reduce negative interactions between elephants and local communities. They also followed suggestion from official authority in practice. In particular, alternative crops such as citronella and chili were widely accepted by communities because they function as elephant deterrents while providing additional household income, making them more attractive to modify farming practices. Human-elephant interaction within Sapo Padang can be seen in Figure 2.



Figure 2. (a) Crop raiding; (b) Elephant dung; (c) Sapo Padang landscape

By contrast, the use of privately owned land for wildlife corridors received the lowest level of support (mean score = 3.60). Most respondents were reluctant to allocate productive agricultural land for conservation purposes because it represents their primary source of livelihood. It's one of big challenges to give awareness how important the role of wildlife corridor in HEC mitigation. It is not easy to shape perceptions regarding the ecological benefits of connecting elephant habitats within community livelihood areas. It must be addressed through awareness-raising and sustainable livelihood initiatives to foster the right perceptions and encourage active community participation in HEC mitigation [23].

Respondents demonstrated a readiness to modify their farming practices to be more environmentally friendly, as indicated by a mean score of 3.85. Supporting this shift requires government assistance to provide technical guidance on implementation. Regarding financial contributions to mitigation efforts, the community preferred direct, hands-on participation over making monetary payments, with mean scores of 3.77 compared to 4.0, respectively. This showed that the community faces economic constraints in funding conflict mitigation programs [24]. It means that government need collaborative management to engage many stakeholders to involved in HEC mitigation which need capital and integration program among stakeholders around the area.

The use of privately owned land for mitigation measures was more positively perceived (mean score = 3.85), particularly among respondents who had experienced repeated HEC incidents. It's actually good opportunity for mitigation effort. We suggest that providing feeding site could be an alternative step to give food stock and avoid elephant movement into agricultural land. Long-term residents were generally more supportive of preventive measures aimed at reducing recurring conflicts. It reflects the principles of community-based conservation, which emphasize collaboration between local communities and management authorities while addressing local livelihood needs.

As HEC mitigation related with respondent characteristics, therefore we selected some variables to be analyzed in relation with specific characteristics -namely gender, age, and educational attainment-regarding community participation in mitigation activities by using Spearman's rank correlation analysis (Table 4)

Table 4. Spearman's rank correlation analysis of community participation in HEC mitigation

Correlations						
			Gender	Age	Education	Community participation
Spearman's Rho	Gender	Correlation Coefficient	1.000	0.093	-0.142	-0.015
		Sig. (2-Tailed)		0.568	0.382	0.929
		N	40	40	40	40
	Age	Correlation Coefficient	0.093	1.000	-0.240	-.420**
		Sig. (2-Tailed)	0.568		0.136	0.007
		N	40	40	40	40
	Education	Correlation Coefficient	-0.142	-0.240	1.000	0.236
		Sig. (2-Tailed)	0.382	0.136		0.142
		N	40	40	40	40
	Community participation	Correlation Coefficient	-0.015	-.420**	0.236	1.000
		Sig. (2-Tailed)	0.929	0.007	0.142	
		N	40	40	40	40

** . Correlation is significant at the 0.01 Level (2-Tailed).

Spearman's rank correlation analysis (Table 4) revealed that age was the only variable significantly associated with community participation in HEC mitigation (Spearman's $\rho = -0.420$, $p = 0.007$). According to the correlation coefficient classification, this represents a moderate negative correlation, indicating that community participation declined with increasing age. This finding is consistent with [25], who reported that younger individuals tend to participate more actively in community-based conservation activities because of physical capacity, motivation, and social engagement. Although the role of older individuals cannot be overlooked, particularly given their accumulated experience in dealing with human–elephant conflicts, physical capacity also plays an important role. We looked that a balanced division of tasks between the younger and older individuals expected to foster more equitable participation involving all parties in HEC mitigation efforts.

In the other hand, it's quite interesting that gender (Spearman's $\rho = -0.015$, $p = 0.929$) and education (Spearman's $\rho = 0.236$, $p = 0.142$) showed no significant relationships with community participation. This demonstrates that anyone (whatever gender), regardless of educational background, can engage in conflict mitigation. This aligns with the statement of [26] that real constraints encountered in the field play a more significant role in conflict mitigation techniques than demographic characteristics.

3.3. Perspective of Mitigation

Deep discussions with the community and key stakeholders revealed a shared perspective regarding the factors driving HEC. They agreed that the loss of elephant habitat due to the conversion of forests into agricultural land is the primary trigger. This reduced the availability of elephant forage, causing the elephants to move closer to cultivated areas near human settlements. This finding is consistent with previous studies demonstrating that deforestation and land-use change increase the frequency of HEC by reducing habitat quality and intensifying spatial overlap between elephants and human activities [27]. Communities' perspective on HEC mitigation is summarized in Table 5.

Table 5. Perspective of HEC mitigation based on FGD

No	Question	Answer	
		Community	Key Stakeholders
1	Drivers of human–elephant conflict	1. Declining availability of natural elephant forage 2. Insufficient government support for protected area management 3. Conversion of forests into agricultural land	Conversion of forests into community agricultural land
2	Community participation in mitigation efforts	1. Limited community participation in HEC mitigation 2. Strong support for technology-based mitigation 3. Technology-based mitigation as a means of improving local infrastructure	Community participation is often motivated by direct personal benefits
3	Innovative and sustainable HEC mitigation strategies	1. Technology-based mitigation strategies 2. Traditional and environmentally friendly mitigation strategies	1. Technology-based mitigation strategies 2. Traditional and nature-based mitigation strategies

Respondents also highlighted insufficient government support for protected area management as a contributing factor to the persistence of HEC. Limited routine patrols and monitoring of illegal forest conversion by forest rangers, were perceived to accelerate habitat degradation and affected declining availability of natural elephant forage and increase the risk of HEC. We observed that continued forest conversion, combined with low environmental awareness among some community members, has intensified habitat fragmentation and sustained high levels of crop damage in recent years.

Community participation in HEC mitigation was generally supportive but remained conditional. Although most respondents expressed willingness to support mitigation initiatives, active participation was often dependent on receiving direct economic benefits, such as agricultural material support or compensassion. Many facts showed the same thing that community involvement in conservation programs is driven by the community's pragmatic perception of the benefits that can be obtained from the program [28].

The community strongly supported the implementation of technology for HEC mitigation. However, this is insufficient if there is no improvement of essential infrastructure for a decent livelihood, such as roads and telecommunications networks. Deficiencies in these areas hindered the reporting of conflicts. Residents didn't want mitigation efforts to remain merely short-term measures. They thought the elephant-driving away operation employed in the past hadn't improved their overall well-being yet. They felt that the severity of the resulting impacts and the losses hadn't been taken seriously. This indicates that achieving long-term coexistence between humans and elephants in the area surrounding Gunung Leuser National Park requires prioritizing preventive efforts to minimize community losses and increase the standard of livelihood. There is concern that community frustration stemming from these conflicts could further discourage local participation in HEC mitigation efforts. This is a real homework that needs collaboration from all stakeholders surrounding GLNP.

4. Conclusion

Public participation in mitigating human-elephant conflict within Sapo Padang Hamlet is notably high. The community showed a strong motivation for direct involvement (mean score = 4.0). However, land allocation for wildlife corridors garnered the least support (mean score = 3.6). Regarding community characteristics, age has significant correlation with the level of participation, while educational attainment was positively associated with respondents' knowledge of HEC mitigation. It is important to note that strengthening community capacity through conservation education, technical support for livelihoods. Conflict prevention and improvement of livelihood standard is expected to enhance participation and ensure the long-term sustainability of HEC mitigation programs by involving multi stakeholders surrounding GLNP.

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