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Assessing local farmer's perspectives on the role of bat in providing ecosystem services in the Batang Toru ecosystem, North Sumatra, Indonesia

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Abstract. *Harahap HA, Yonariza. 2022. Assessing local farmer's perspectives on the role of bat in providing ecosystem services in the Batang Toru ecosystem, North Sumatra, Indonesia. Biodiversitas 23: 4322-4328.* Bats play an important role as pollinators in maintaining the ecosystem services and improving the local economy in Batang Toru Ecosystem (BTE). However, the anthropogenic impacts negatively affect their sustainability, making the evaluation of their services increasingly needed. This study was conducted to examine the local farmers' action against bats in BTE. The objectives were to analyze: (1) farmers' knowledge of the role of bats in ecosystem services, (2) the perception of bats, (3) awareness of bat population loss and its impact on durian production, and (4) farmers' actions against bats on their land. The results showed that 1 out of 7 farmers exhibited negative actions toward bats in their agroforest lands. They also had significantly low knowledge about bat services in agroforestry. Most farmers regarded bats as meat for food and medicine rather than as pollinators of durian fruits. We recommend that the government and conservation institutions carry out initiatives to educate farmers regarding the importance of bat services, and conservation efforts should be made to maintain the viable population of bats.

Keywords: Agroforestry, durian, human-wildlife interaction, pollination, wildlife consumption

INTRODUCTION

Pollinators are vital for people and nature, and their decline could have a negative influence on biodiversity and agricultural production (Christmann 2019; Lever et al. 2014). Several pollination processes are assisted by wild animals called pollinators, including more than 20,000 species of bees, insects, bats, birds, and other vertebrates (IPBES 2016). These animals play a very important role in sustaining the ecosystem services and increasing crop production (Bartomeus et al. 2014; Garibaldi et al. 2014; Ollerton 2017; Fijen et al. 2018; Sawe et al. 2020).

Despite the importance of pollination services for people and the planet globally, there is a decline in pollinator populations caused by habitat degradation and destruction, the use of chemicals, invasive species, and climate change (Potts et al. 2010; Lever et al. 2014; Vanbergen 2018; Christmann 2019; Dicks et al. 2020). According to a study, a continuous decline in pollination services will change the ecological function, leading to food insecurity and cascades of extinction (Dirzo et al. 2014). The assessment report from the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES 2016) revealed that more than 90% of the 12% of main global crops might be lost when pollination services are lost. These numbers show how important pollination services are for human food and economic value. It was found that pollinator services are estimated to be worth between US$ 195 billion and US$ 387 billion (US$ 267-657) billion per year in March 2020 (Porto et al. 2020).

Bat (*Chiroptera* Blumenbach, 1779) is one of the wild animals involved in the pollination process and plays other important and diverse roles in providing additional services. They provide agriculture services such as spreading seeds, providing organic fertilizer, improving soil structure, and controlling pests (Ghanem and Voigt 2012; Wanger et al. 2014; Hassi 2018).

Pteropodidae, an old-world fruit bat, is a family frequently found in the tropics and subtropics and consists of nearly 200 species (Scanlon et al. 2014). It plays an important role in pollination services by taking part in Chiropterophily, a pollination interaction between bats and flowers. A well-known case of chiropterophily occurs in durian (*Durio zibethinus* L.) pollination in tropical countries, such as the Southeast Asia region (Aziz et al. 2017; Sheherazade et al. 2019; Chaiyarat et al. 2020). Bat has been shown to contribute to the economic valuation of the plant. In Sulawesi, Indonesia, bat pollination services in each durian season are estimated to reach approximately € 97 ha^{-1} (Sheherazade et al. 2019). Durian plays an important role in the global market with estimated exports of €488.614 million in 2013. In Southeast Asia, the export value of durian reached € 212.12O million in the same year (Indonesia Ministry of Agriculture 2014).

Although Pteropodidae supports the national economy, their status is threatened in Southeast Asia due to the deforestation of its forest habitats which are then converted

into agricultural land for other use (Kingston 2013). Consequently, bats are not only threatened by human activities which degrade their habitat but are also often hunted and killed for being a pest to farmers (Mildenstein et al. 2016). Among the Pteropodidae family, half of the extant species were recorded as hunted in various tropics regions such as Asia, Africa, as well as Central and South America (Voigt and Kingston 2015).

In Belize, Central America, the government promotes farmers to catch and kill vampire bats to reduce conflict with humans and inhibit disease transmission (Shapiro et al. 2020). Furthermore, except for Singapore, bat hunting is prevalent in various areas of Southeast Asia, which is the largest bat hunting region in Asia (Mildenstein et al. 2016). In Indonesia, local hunting and bat consumption are practiced on the three main islands, namely Sumatra, Kalimantan, and Sulawesi (Sheherazade and Tsang 2015). Given that bushmeat consumption is still widespread, bat trade in the markets is often found, while tangible strategies for action against rampant hunting are missing (Sheherazade and Tsang 2015).

To formulate a conservation strategy, it is very important to understand the drivers of farmers' actions against bats. Therefore, this study was conducted in Batang Toru Ecosystem (BTE), North Sumatera, to gain a better understanding of farmers' knowledge and perceptions of bat services. It also aimed to determine the awareness of farmers about bat population decline, how it affects durian production, and demographic and economic factors that influence bat-control efforts. The results will be used to formulate recommendations to stakeholders such as conservation organizations, governments, researchers, and educational institutions to form sustainable ecosystem management strategies.

MATERIALS AND METHODS

Study area

This study was conducted in BTE, covering three districts in North Sumatra Province, namely, North, Central, and South Tapanuli (Figure 1). BTE is located at an altitude of 194 m a.s.l. to 1781 m a.s.l. and consists of various forest types ranging from lowland tropical rain to mossy forests in the highlands. With this height variation, most of Batang Toru forest is above 800 m a.s.l. with very steep topographic conditions (Fredriksson and Usher 2013).

BTE is a complex forest, but it is fragmented by the Sumatra highway. It consists of three main forest blocks. The first is Sibual-buali Nature Reserve, with an area of 5000 ha according to the Decree of the Minister of Agriculture Number 215/Kpts/Um/4/1982. The other two blocks are the East and West measuring 54,950 ha and 78,891 ha, respectively (Fredriksson and Usher 2013). Referring to the Decree of the Minister of Forestry (SK) No. 44 of 2005, these fragmented forest areas are attributed to various statuses, where the largest fraction is Production Forest (39.10%), and the remaining area is designated as other land use (39.08%), limited production forest (12.55%), nature reserve (6.27%), and the two least types are protection (2.93%) and conservation forest (0.06%).

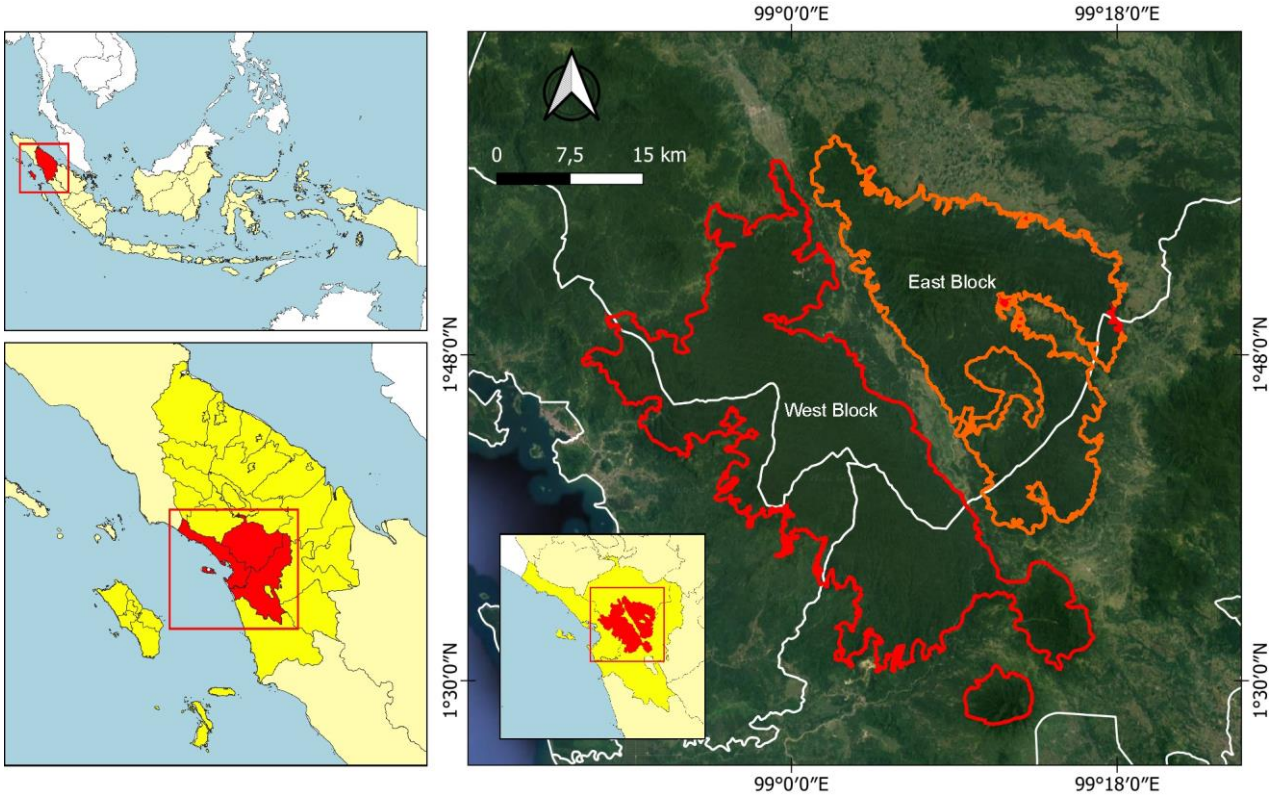

Figure 1. Batang Toru ecosystem map, North Sumatra, Indonesia

BTE is inhabited by around 523.300 residents and the communities depend on agroforest and natural forests for their livelihoods. Farmers' mixed gardens have considerable economic value as their main and seasonal income (SMILE Batang Toru, 2022). The cultivated plants include rubber (*Hevea brasiliensis* Müll.Arg.), sugar palm (*Arenga pinnata* Merr.), durian (*Durio zibethinus*), *petai* (*Parkia speciosa*) and *kemenyan* (*Styrax benzoin* Dryand.). Furthermore, Siagian (2011) found that three types of bats are hunted and traded in BTE, namely the large flying fox (*Pteropus vampyrus* Linnaeus), cave nectar bat (*Eonycteris spelaea* Dobson, 1871), and the Dayak fruit bat (*Dyacopterus spadiceus* Thomas 1890).

The elevation of cultivated land varies between 200 m to 1500 m a.s.l. The land cover varies between agroforest and natural forest with primary conditions. The indigenous Batak community in Batang Toru has cultivated and sustainably managed forest products for a long time. This is evidenced by the plant composition on agroforest land, which is more controlled by farmers than natural forests (Tata et al. 2013), where less intervention can be observed.

Sampling technique

This study used household-level data collected in a survey conducted in December 2020. The samples were 102 households scattered in 6 villages around Batang Toru forest. The systematic sampling was used to select 17 respondents according to the data intervals at each village office. The sample villages were selected based on the criteria that the communities depend on the ecosystem for their agriculture and agroforestry fruits, which also represent each district in the BTE. North Tapanuli was represented with the three villages namely Lobu pining, Sidua bahal, and Sitolu bahal, Central Tapanuli consisted of Huta gurgur, while South Tapanuli was represented by Simaninggir and Aek nabara. These villages consist of three different religions, namely Islam, Protestant Christianity, and Catholicism. The selected villages represent the entire Batang Toru forest block, comprising the west and the eastern blocks and the Sibual-Buali nature reserve.

The villagers in the selected area are dominated by the ethnic Batak people and Nias immigrants. Furthermore, the survey was conducted using Indonesian and Batak languages because many farmers are more comfortable speaking their local languages. Data were collected using a pre-printed questionnaire.

Ethical considerations

Before commencing this study, we asked permission from the district governments in North, Central, and South Tapanuli. After obtaining the permits, we submitted the permit to each village head. After the respondents' names were obtained, they were visited at home or in the fields for interviews which began by asking permission from farmers, followed by introduction, and explanation of the study objectives. Subsequently, after they were well informed and agreed to participate, the interview began by reading out a list of questions that had been compiled. This lasted for about 30-45 minutes, and during the interview, participants were allowed to withdraw at any time. The information gathered was utilized solely for the objectives, and participants were informed that their information would be kept private.

Survey design

Farmers' knowledge about bat pollination services was surveyed with close-ended yes or no questions, including whether they know that bats act as pollinators in agriculture. Furthermore, the perception of bats' presence around the land was identified with closed questions. The provided choices were beneficial, detrimental, and had no effect. The awareness about the effect of losing bat population on agriculture was surveyed by asking farmers whether the loss of bat population will affect durian yields. The given choices include having an influence or not, and no idea. Action towards bats was also posed as a closed question by asking farmers how they treat those animals, with choices: hunting them or not. In addition, open questions were asked about hunting to determine whether bats are only consumed, used for traditional medicine, or traded.

Data analysis

All statistical analyses were conducted with IBM SPSS Statistics 25. Descriptive analyses were used to characterize farmer attributes such as religion, age, ethnicity, education, hunting tools ownership, belief in sacred forests, durian tree ownership, and the total number of durian trees. The principle factor analysis was also performed to assess whether knowledge, perception, awareness, and action against bats can be used to create a scale variable, which averages responses over questions with multiple answers. Furthermore, Pearson correlation (r) was used to measure the percentage level of correlation between the variables. Evans (1996) suggested that absolute r values ranging from 0.00-0.19 = very weak, 0.20-0.39 = weak, 0.40-0.59 = moderate, 0.60-0.79 = strong and 0.80-1.0 = very strong.

The factorial and multi-way ANOVAs were also employed in determining whether there were interaction effects between predictor variables on action against bats. The independent and dependent variables for these analyses met normality assumptions (George and Mallery 2010). Subsequently, multiple regression analysis such as the R square test was conducted to quantify the influence of the independent variable on the dependent. To identify autocorrelation in the regression analysis, the Durbin-Watson test, whose values range from 0 to 4, was used. Non-autocorrelation is indicated by a number close to 2; a value shows positive autocorrelation near 0, while a value close to 4 indicates negative autocorrelation (Turner 2020).

RESULTS AND DISCUSSION

Farmer demographics

The characteristics of the household surveyed are presented in Table 1. The total number of respondents was 102, mostly adhering to two religions, namely Protestant

Christianity (45%) and Islam (45%), while a minority was Catholic (10%). The majority belonged to the age group of 41-50 years (35%), followed by 51-60 (28%). Furthermore, the respondents were mainly of Batak ethnic group (83.3%), and the rest were Nias (16.7%). More than half revealed that their education level was Elementary and Junior High School (58%), while only 3% went to university.

Regarding the ownership of hunting tools, 75% of the respondents claimed they did not have any hunting tools, while 25% claimed to have tools such as air rifles, nets, and machetes. In terms of beliefs in sacred forests, 55% believed in the sacred forest. Furthermore, 33% claimed to own durian trees, with numbers most frequently from 1 to 5 (19%), while only 1% owned more than 20. The average number of durian trees owned by the respondents is 3 with min = 0; max = 50.

Knowledge toward bats

Bats play several roles and services in agroforestry; for example, their regulatory services have been commonly reported by various literature, namely pollination and pest control. However, in the field, these services were not the most frequently mentioned by farmers regarding bats. The service that appeared most often, according to farmers, was provisioning. They consider the role of bats is providing food and traditional medicine. In 2020 (Figure 2), 26% of the respondents claimed to have hunted bats for consumption purposes: 19% for food, 6% for traditional medicine, and 1% as a natural fertilizer. In addition, more than 75% admitted that they did not know that bats had a role in pollinating their crops in agroforest lands.

The factors that correlate with farmers' knowledge were also investigated, and the results are presented in Table 2. Among the six factors tested, three factors were correlated with knowledge. The belief in the sacred forests was positively correlated with farmers' knowledge (p = 0.000), but the correlation was weak (r = 0.370). The possession of a durian trees was positively correlated with farmers' knowledge (p = 0.000), and the correlation was strong (r = -0.675). In contrast, the number of durian trees was negatively correlated with farmers' knowledge (p = 0.000), and the correlation was moderate (r = -0.552).

Table 1. Characteristics of households surveyed

Characteristics	Category	Percentage abundance
Age	20-30	7% (7)
	31-40	14% (14)
	41-50	35% (36)
	51-60	28% (29)
	61-70	16% (16)
Education	No education	13% (13)
	Elementary School	26% (26)
	Junior High School	31% (32)
	Senior High School	26% (27)
	University	4% (4)
Possession of hunting tools	Yes	74% (75)
	No	26% (27)
Belief in sacred forest	Yes	56% (57)
	No	44% (45)
Possession of durian trees	Yes	33% (35)
	No	67% (67)
Number of durian trees	Do not have	67% (67)
	1-5	19% (20)
	6-10	9% (9)
	11-20	4% (4)
	More than 20	1% (2)

Note: The number in paranthesis is the number of respondents

Figure 2. Bat services according to local farmers

Table 2. Socioeconomic variables that affected farmers' knowledge, perception, awareness and action

Predictor	Statistic Test	Correlation coefficient			
		Knowledge	Perception	Awareness	Action
Education	Pearson correlation (r)	0.038	-0.208*	0.053	-0.013
	Sig. (2-tailed)	0.704	**0.036**	0.600	0.900
Possession of hunting tools	Pearson correlation (r)	-0.131	0.007	-0.091	0.114
	Sig. (2-tailed)	0.190	0.947	0.361	0.255
Belief in the sacred forest	Pearson correlation (r)	0.370**	0.226*	0.337**	-0.221*
	Sig. (2-tailed)	**0.000**	**0.022**	**0.001**	**0.025**
Attendance in forestry training	Pearson Correlation (r)	0.092	0.095	0.024	-0.020
	Sig. (2-tailed)	0.357	0.343	0.811	0.843
Possession of durian tree	Pearson correlation (r)	0.675**	0.238*	0.643**	-0.467**
	Sig. (2-tailed)	**0.000**	**0.016**	**0.000**	**0.000**
Number of durian trees	Pearson correlation (r)	-0.552**	-0.107	-0.569**	0.399**
	Sig. (2-tailed)	**0.000**	0.283	**0.000**	**0.000**

Note: * correlation is significant at the 0.05 level (2-tailed); ** correlation is significant at the 0.01 level (2-tailed); the bold numbers are significant at level ($p < 0.05$). The number of observations is 102

Perception of bats

The analysis results showed that only 1% of respondents considered bats beneficial to their agroforest. Approximately 26% of farmers thought their presence was detrimental to the agroforest land. In contrast, the majority (73%) thought bats had neither a positive nor a negative influence, indicating low indigenous knowledge about their services.

Table 2 shows that the factors positively correlated with farmers' perceptions were belief in sacred forest (p = 0.022) and possession of durian (p = 0.016), but the correlation was weak. In contrast, education was negatively correlated (p = 0.036) with farmers' perceptions, but the correlation was weak. The other factors were not correlated with the farmers' perception.

Awareness about bats

Approximately 13% of respondents stated a total decline in bat population would reduce their yields, while 10% claimed otherwise. The majority (77%) did not know the effect of losing bat population on the durian yield. This proves that several farmers are unaware of the important role played by bats in their agroforestry. Table 2 indicates that the factors positively correlated with farmers' awareness about losing bat population were belief in sacred forests (p = 0.001), but the correlation was weak (r = 0,337) and the possession of durian trees (p = 0.000*)* with a strong correlation (r = 0,643). The total number of durian trees was negatively correlated with farmers' awareness of bats on their agroforest lands (p = 0.000), and the correlation was strong (r = -0,569).

Action toward the bats

Approximately 13% of respondents claimed they had hunted bats in 2020, while 87% had not (Figure 3).

The factor positively correlated with the farmers' action toward bats was the number of durian trees (p = 000), but the correlation was weak (r = 0.399). In contrast, the factors negatively correlated with the farmers' action were belief in sacred forest (p = 0.025; r = -0.221, weak correlation) and possession of durian trees (p = 0.000; r = -0.467, moderate correlation). The other factors were not correlated with the farmers' actions toward the bats.

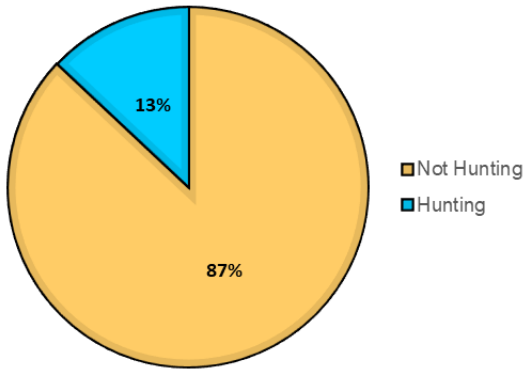

Figure 3. Famer's action against bats

The results indicate that belief in sacred forests, durian tree ownership, and the number of durian trees account for 76.9% of farmers' actions against bats in their agroforest land. Furthermore, to find autocorrelation in the regression analysis, the Durbin-Watson test, whose values range from 0 to 4, was used. Non-autocorrelation is indicated by a number near 2, while positive and negative autocorrelation values are close to 0 and 4, respectively (Durbin and Watson 1971). The statistical result shows that the value obtained was 2, which means negative autocorrelation, indicating that the significant variables tested are good predictors of farmer's actions against bats.

Discussion

The contribution of bats to the functioning of ecosystems is vital, but a comprehensive evaluation of their services has not been studied extensively (Ramírez-Fráncel et al. 2021). Specifically, in BTE, bats' role in the agroforest landscape has not been investigated. To fill the gaps, this study assessed the knowledge, perception, and awareness of local farmers about bat services.

Based on the results, farmers in the agroforest landscape are familiar with the presence of bats. However, their knowledge and awareness of environmental services are still very low. Most of the farmers interviewed stated that they were unaware of bat services. They did not know whether the presence of bats was detrimental or beneficial for their cultivation. These results are similar to a previous study (Musila et al. 2018), where nearly 1/3 of respondents were unaware of bats' benefits.

The communities had very little knowledge about bat services in their agroforest lands, which was demonstrated in the high percentage of people who regarded bats as food rather than pollinators of their fruits. The majority of respondents claimed to use bats for traditional medicine and particularly enjoy consuming them as a meal while drinking *tuak*, a fermented drink from palm sugar and coconut. According to them, bat meat as medicine can cure asthma; hence, it is steamed, boiled, fried, or baked. However, only a few farmers utilized bat guano as a natural fertilizer. Regarding regulating services, only 22% of respondents admitted that bats were instrumental in pollinating their agroforestry land. Furthermore, most farmers were unaware of any effect caused by the potential loss of the bat population. They did not understand that a loss of the population would negatively affect their crops' productivity. There is a debate on people's actions against bats. The sentiment and negative actions toward bat populations are not unique to BTE. Several studies reported that people dislike bats for a variety of reasons, including myths (Prokop and Tunnicliffe 2008), a lack of understanding (Musila et al. 2018), and a lack of engagement with this nocturnal taxon (Kingston 2016). The results are consistent with that of Kross et al. (2018), Talukdar and Gupta (2018), and Osterman et al. (2021), which stated that farmer's actions against bats are influenced by the belief in sacred forests and farm ownership, in this case, durian trees. Based on the results, farmers' actions in not hunting bats were supported by their

belief in sacred forests and the number of durian trees they owned.

The paradox of services provided by bats (more farmers regard bats as food or medicine rather than pollinators) is worrying. The awareness of the medical benefit of eating bats has exacerbated unsustainable treatments (O'Shea et al. 2016). Although the COVID pandemic was linked to bats as the most likely ecological reservoir of the virus (Hu et al. 2015; Fan et al. 2019; Kim et al. 2020), it was found that approximately 25% of respondents still consumed bats during the pandemic while 6% consume it for medicine purpose. The utilitarian importance of bats reflected in the valuation of ecosystem services and ecotourism has been pointed out by studies on social views carried out in conservation sites with a large bat population (Kasso and Balakrishnan 2013: Castilla et al., 2020). However, this nuance that coexists with the utilitarian sense has remained unrecognized.

This study concluded that most farmers perceived bats as a source of meat and their knowledge and awareness of the role of bats as pollinators were low. We recommend that village and central governments, as well as educational and conservation institutions, carry out initiatives to educate farmers regarding the importance of bat services. Also, conservation measures are needed to maintain the bat population and sustain the ecosystem services they provide. Further studies are suggested on the influence of other variables such as the experience of farmers with bats, the trade market cycle, or quantifying the economic value of bats' ecosystem services.

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