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Research Article

Farmers' Perception and Participation in Bat Conservation in Agricultural Areas of Banyuwangi, East Java, Indonesia

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ABSTRACT

Pests in the agricultural sector cause huge losses to farmers' production and income. Sustainable pest management, such as the utilization of natural predators, is important to maintain agricultural productivity. In Banyuwangi, East Java, Indonesia fruit-eating bats pose a threat to horticultural yields, although their ecological roles as pollinators and seed dispersers are recognized. Conflicts between bat conservation efforts and farmers' needs arise because most farmers view bats as pests. This study examines farmers' perceptions of bats and their participation in bat conservation in Banyuwangi, as well as the factors that influence their attitudes. Based on interviews and data analysis in three sub-districts, this study found that farmers' knowledge on the benefits of bats is not always directly proportional to their positive attitude towards them. To resolve this conflict, a management strategy that includes education, incentives and collaboration with farmers is suggested. Through this approach, a balance between bat conservation and agriculture sustainability is expected to be realized, providing long-term benefits for the ecosystem and agricultural productivity in the region.

Keywords: agricultural sustainability; bat conflict management; bat ecosystem service; horticultural pests

INTRODUCTION

Pests are one of the main challenges in the agricultural sector as they can cause significant losses in crop yields. The impact of pest attacks not only reduces the quality and quantity of production, but also affects farmers' income and food security (Kunz *et al*., 2011). Therefore, effective pest management is essential to maintain agricultural productivity and the sustainability of food production. One appropriate method is sustainable pest management using natural predators and crop rotation, which not only maintain yield, but also ecosystem balance (Sapaat *et al*., 2017).

Banyuwangi Regency, located in the easternmost part of Java Island, has great agricultural potential due to its suitable geographic and climatic conditions (Karim *et al*., 2023). The region has a varied topography, ranging from lowlands to mountains, and a warm tropical climate, making it suitable for various types of crops, especially horticulture crops (Suwandi & Kurniawati, 2020). However, one of the challenges faced is disturbance from vertebrate animals such as fruit-eating bats, birds, squirrels, and rats. Bat attacks can potentially reduce crop yields—for example, they have affected 42% of guava cultivation areas and 32% of papaya cultivation areas in Banyuwangi (Adelia, 2023).

Despite fruit-eating bats playing an important role in ecosystems as pollinators and seed dispersers which assist in plant regeneration and maintain biodiversity (Ramirez-Fráncel *et al*., 2022), their ecological benefits are often overlooked by farmers who focus more on the adverse effects of bat feeding in their production systems (Kunz *et al*., 2011). The presence of foraging bats in agricultural areas is often perceived as a threat, leading to conflicts between conservation efforts and farmers' in-

terests. While bat populations are important for maintaining ecosystem balance, farmers need assurances that their crops will be protected. If this conflict is not managed properly, it could threaten bat populations due to excessive control measures by farmers (Maryati *et al.*, 2008).

Previous research shows that farmers' knowledge of the ecological roles of bats can positively influence their willingness to participate in conservation efforts. For instance, Olimpi and Philpott (2018) found that American farmers with higher knowledge levels were more likely to adopt bat-friendly farming practices. Similar findings were reported in Europe, where awareness campaigns significantly improved farmers' actions to support bat conservation (Russo *et al.*, 2024). These examples demonstrate that knowledge can be a strong driver of action in certain conditions. However, as will be shown in this study, the case in Banyuwangi differs: high levels of knowledge do not necessarily align with positive attitudes or conservation actions. This contrast highlights the complexity of socio-cultural, economic, and emotional factors that mediate the knowledge–action relationship.

A balanced management strategy therefore needs to involve the active participation of farmers to overcome potential conflicts. Farmers' perception of the role of bats and their involvement in conservation efforts are key factors for the success of this strategy. Farmers with a positive understanding of the role of bats tend to be more supportive of bat conservation efforts, as they perceive bats to provide benefits to agriculture and the environment. Negative understanding refers to farmers' perception that bats are pests that are detrimental to their crops and gardens and tend to resist participation in conservation efforts (Boyles *et al.*, 2011). Therefore, this study is important to assess the perceptions and participation of farmers in Banyuwangi towards bats and the factors that influence their involvement in sustainable bat management (Olimpi & Philpott, 2018; Tuneu-Corral *et al.*, 2023).

Through understanding farmers' perceptions and the factors that influence their participation, this study aims to determine farmers' perceptions and participation in horticultural agricultural environmental conservation efforts and to formulate management strategies that involve farmers as key stakeholders. These strategies should include education, incentives, and collaboration in decision-making to balance bat conservation and sustainable agricultural efforts.

MATERIALS AND METHODS

The research was conducted in Banyuwangi Regency and involved crop damage assessments, yield loss estimations, and structured interviews with farmers. Interviews were conducted using a structured questionnaire in three sub-districts, namely Cluring, Purwoharjo, and Tegaldlimo, which are representative horticultural production centers in the region. Farmers in these locations primarily cultivate guava, papaya, banana, mango, chili, and rice, all of which are commodities directly affected by fruit-eating bats.

A total of 180 respondents participated in this study. Respondents were selected using a purposive random sampling method to ensure coverage of diverse demographic and farming backgrounds. The criteria for respondents included: being an active farmer residing in the study area; having at least two years of farming experience, cultivating horticultural crops vulnerable to bat attack, and willingness to participate in the survey and interviews.

The selection of these sub-districts was based on agricultural characteristics that reflect geographical diversity and natural resources supporting agricultural productivity. The land types in these areas varied from irrigated rice fields to dry land farming systems, enabling the cultivation of a wide range of horticultural commodities targeted in this study.

The data obtained were processed using Microsoft Excel 365 and further analyzed with R Studio to measure the strength of relationships among the studied variables. The results of the analysis were presented in tables to facilitate interpretation. Descriptive analysis was employed to describe farmers' perceptions and participation in bat conservation efforts. The relationships among knowledge, attitudes, and actions were analyzed using the Spearman correlation with the following formula:

$$rs = 1 - \frac{6 \sum d_i^2}{n(n^2 - 1)}$$

Notes: *rs* = Spearman correlation coefficient, d_i = Difference in rank between variables, *n* = Number of samples, $\sum$ = Sum notation.

The resulting correlation coefficient ranges from -1 to +1. A positive value indicates a unidirectional relationship, while a negative value indicates an inverse relationship. Values closer to ±1 indicate stronger relationships, while values near 0 indicate weak associations. This analysis examines how farmers' perceptions relate to their participation in bat conservation.

Farmers' perception and participation levels were categorized based on the scores obtained from the questionnaire. Respondents were grouped into three categories: high, medium, and low (Table 1). This classification provides a comprehensive understanding of farmers' perceptions and actions in supporting bat conservation efforts in agricultural areas of Banyuwangi.

Tabel 1. Classification criteria for knowledge, attitude, and action levels

Category	Knowledge	Attitude	Action
High	Total correct answers ≥ 75%	Total respondent answers "Strongly Agree" and "Agree" x ≥ 75%	Total correct answers ≥ 75%
Medium	Total correct answers ≥ 50% to < 75%	Total respondents' answers "Strongly Agree" and "Agree" 50 ≤ x < 75%	Total correct answers ≥ 50% to < 75%
Low	Total correct answers < 50%	Total respondents' answers "Strongly Agree" and "Agree" x < 50%	Total correct answers < 50%

RESULTS AND DISCUSSION

Farmer's different demographic and socioeconomic factors influenced their farming mindset, attitude, and behavior. Several factors such as age, education, farming experience, and land ownership/size had important influence on farmers willingness to accept changes and innovations. In this study, the "changes" referred to the adoption of new agricultural practices, such as the use of integrated pest management (IPM) in their production system, reduction of pesticide dependence, installation of artificial bat houses, and maintenance of rost trees as part of conservation-friendly farming. These are considered as new methods compared to conventional practices that heavily rely on pesticides or crop exclusion.

Analysis from 180 farmers showed that younger farmers, those with higher education, and those with longer farming experience had positive perception to changes (Table 2). For example, farmers aged 20−39 years and those with senior high school education or a diploma were more open to applying IPM and tolerating bats as natural predators. In contrast, older farmers, especially above 50 years, with lower education levels and limited experience were more likely to maintain traditional methods such as continuous pesticide spraying and manual scaring of bats. Private land ownership and larger farm sizes were also associated with higher willingness to change, as they perceived more responsible for sustainability and had more flexibility to test new methods. Conversely, land renters or farmers with small plots tended to stick with traditional practices.

Farmers' perceptions of bats also varied. Our survey showed that while 148 respondents (82%) had medium to high knowledge of bats' ecological roles. However, this was not fully translated into positive attitudes or actions. Specifically, 90 farmers (50%) expressed negative attitudes, 49 were neutral, and only 41 (23%) expressed positive attitudes towards bats. This result supported earlier research (Aycart-Lazo *et al.*, 2025), but our data add nuance: many farmers knew about bats' benefits in pest control and pollination, yet still perceived them as pests due to their direct crop damage. Cultural perceptions may also played a role in these results. Focus group discussions revealed that some farmers associated bats with disease or bad omens which reinforce negative views on bats despite farmers knowledge.

Tabel 2. Characteristics of farmers' perception

Characteristics	Sub- Characteristics	Perception		Total
		Positive	Negative	
Age	<20	12	7	19
	20-29	27	15	42
	30-39	48	26	74
	40-49	20	10	30
	>50	10	5	15
Education	Elementary School	10	5	15
	Junior High School	15	8	23
	Senior High School	45	25	70
	Under Graduate	47	25	72
Farming experience	<5 year	25	15	40
	5-10 year	47	23	70
	>10 year	45	25	70
Land ownership	Rent	50	30	80
	Privately owned	67	33	100
Land area (m²)	<5.000	40	20	60
	5.000-10.000	50	30	80
	>10.000	27	13	40
Total		117	63	180

Majority of farmers possessed moderate (80 individuals) to high (68 individuals) levels of knowledge, suggesting substantial awareness of bats' ecological functions (Figure 1). This finding is consistent with research conducted in USA by Olimpi and Philpott (2018). However, in terms of action, our data showed that only 54 farmers (30%) adopted any bat-friendly practices, such as reducing pesticide use, tolerating bat roosts, or experimenting with artificial shelters. Meanwhile, 126 farmers (70%) admitted that they did not practice any form of bat conservation, even though some agreed with the ecological importance of bats.

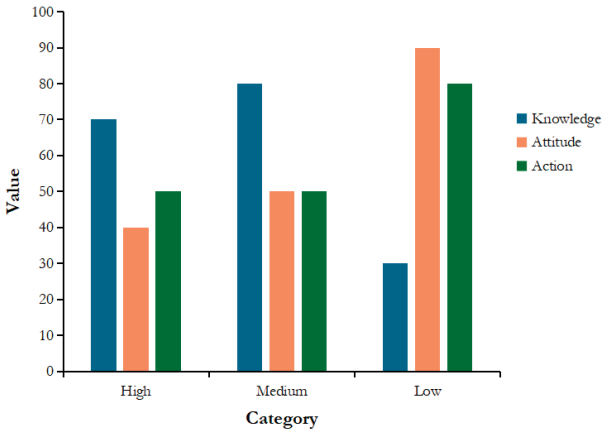

Figure 1. Data on the levels of knowledge, attitudes, and actions of farmers in three sub-districts (Cluring, Purwoharjo and Tegaldlimo) with a total of 180 respondents in October 2024

This mismatch highlighted the knowledge–attitude–action gap within farmers. Based on the correlation test results, the relationship between knowledge and attitude is positive but very weak (r = 0.16) (Table 3). Strong correlation between attitude and action (r = 0.47) indicated that attitudes had a higher influences on action. Conversely, knowledge and action showed a negative correlations (r = −0.46). These results indicated that knowledge alone is insufficient, and other factors such as emotions, culture, partial understanding, and risk–benefit per-

Table 3. Coeficient correlations between knowledge, attitude, and action of respondent farmers in three sub-districts (Cluring, Purwoharjo and Tegaldlimo) with a total of 180 respondents in October 2024

Variable	Spearman Correlation
Knowledge x attitude	0.16
Attitude x action	0.47
Action x knowledge	-0.46

ceptions influenced whether farmer's knowledge translated into action. In terms of pest management practices, our field data showed that: one hundred and twelve (112) farmers (62%) still heavily relied on chemical pesticides; forty six (46) farmers (26%) reported occasional selective pesticide use combined with traditional scaring methods; and twenty two (22) farmers (12%) experimented with IPM approaches or tolerated bats as natural pest controllers.

While literature emphasizes bat-friendly farming strategies such as bat houses, buffer zones, and reduced pesticide use (Frick *et al*., 2019), our findings revealed that awareness of such methods among farmers was still limited. In interviews, only 15% of respondents were aware of artificial bat houses, and none had applied them in their production systems. Opinions on these methods varied where some younger farmers expressed interest with existence of incentives while most older farmers doubted their effectiveness.

Thus, while bat conservation strategies at the policy or scientific level are well-documented, their adoption at the farmer level in Banyuwangi remained very low. Our study contributes by highlighting the reality that farmers' practices are not aligned with their knowledge. Bridging this gap requires not just education but also practical demonstrations, peer farmer examples, and economic incentives to encourage real behavioral change.

CONCLUSION

Negative interactions with fruit-eating bats pose a serious challenge to agriculture as they can significantly reduce crop yields and farmers' income. In Banyuwangi Regency, infestations of fruit-eating bats were found to damage up to 42% of guava and 32% of papaya cultivation areas causing problems for horticultural production. Although bats play an important role in ecosystems as pollinators and natural pest controllers, most farmers still perceived them primarily as pests, creating a conflict between conservation and agricultural efforts.

Our findings highlight a knowledge–attitude–action gap: while many farmers are aware of the ecological benefits of bats, this knowledge does not consistently translate into positive attitudes or conservation practices. As a result, farmer participation in bat conservation efforts remained low, driven by concerns that conservation efforts will interfere with agricultural productivity. To reconcile these conflicting interests, conservation efforts should integrate education, economic incentives, and active farmer collaboration. Farmers' perceptions and willingness to participate are key determinants of success for these efforts.

Future research should further study and assess how continuous education and incentive-based interventions may influence farmer perceptions and behaviors; comparative studies across regions to understand how sociocultural differences may shape farmers' attitudes towards bats; practical trials of bat-friendly farming innovations (e.g., artificial bat houses, pesticide-free buffer zones) to evaluate their acceptance and effectiveness at the farmer level; and economic valuation studies to quantify the contribution of bats to pest control and pollination, providing evidence for incentive schemes. Such research will deepen the understanding of farmers' perceptions, reduce conflict between conservation and agriculture, and support the development of strategies that balance biodiversity protection with sustainable agricultural productivity.

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