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Ecology–Economy Interface: Understanding Protected Area Awareness Among Forest-Fringe Dairy Farming Communities in Kerala

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HIGHLIGHTS

- Enhancing farmer awareness regarding surrounding protected areas holds a significant role in aligning biodiversity conservation with sustainable agricultural development.
- Dairy farming communities in the forest-fringe areas of Kerala had a medium level of protected area awareness.
- Variables such as gender, education, social participation, and information-seeking behaviour exhibited a strong association with protected area awareness.

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ABSTRACT

Dairy farming communities near protected areas (PAs) face challenges such as land-use restrictions, displacement, and human–wildlife conflict, often leading to negative attitudes and hindering sustainable agricultural development. Increasing awareness regarding PAs is essential to improve perceptions and promote coexistence with wildlife. This study assessed PA awareness and its determinants among 300 dairy farmers living near Silent Valley National Park, Wayanad Wildlife Sanctuary, and Karimpuzha Wildlife Sanctuary in Kerala, India, during 2023-24. Awareness was measured using a structured scale, and determinants were analysed with an ordinal logistic regression model. Farmers generally demonstrated moderate awareness of ecological roles but limited understanding of regulatory provisions and livestock-wildlife health concerns. Most farmers from Silent Valley, Wayanad, and the overall sample had a medium level of awareness, while a higher level of awareness was more common in Karimpuzha. Key predictors of awareness included gender, education, social participation, and information-seeking behaviour. The results highlight the need for targeted, gender-inclusive awareness programmes that promote community engagement, strengthen rural education, and encourage proactive information access.

INTRODUCTION

The ecosystem services provided by natural resources such as air, soil, water, wetlands, grasslands, forests, and mountains are crucial for the survival of mankind, and they contribute significantly to the wealth of a nation (Hettiarachchi et al., 2023). Protected areas (PAs), in particular, are essential for the preservation of biodiversity and supporting life systems due to their ecological and cultural significance (Saviano et al., 2018). Protected areas serve as essential foundations of national and international conservation strategies (Mathur et al., 2019). India's tremendously rich biodiversity is safeguarded legally through the Wildlife Protection Act of 1972, by which a network of 1,014 PAs was created throughout the country, comprising National Parks, Wildlife Sanctuaries, Community Reserves, and Conservation Reserves, categorised based on management objectives and differential levels

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of protection (Press Information Bureau, 2025). These PAs are designated to preserve natural ecosystems, provide safe habitats for species, sustain ecosystem balance, and maintain cycles and processes that are often disrupted in intensively managed landscapes (Dudley, 2008). The PAs are surrounded by eco-sensitive zones that serve as buffer regions, where specific activities are prohibited, regulated, or promoted to minimise ecological disturbances (Khanduri & Sharma, 2025).

Designating a region as a PA presents several challenges to local communities, including land use restrictions, potential displacement, and human–wildlife conflict (Maan & Chaudhry, 2019). Specifically, land use zoning limits access to essential forest resources such as fodder, fuelwood, and non-timber forest products on which forest-dependent communities rely for their sustenance (Savita & Kushwaha, 2018). Dairy farming is particularly affected, as livestock grazing is often banned or severely restricted within PAs. Their vulnerability is further exacerbated by human–wildlife conflict (HWC), which can result in economic losses due to livestock depredation, crop damage, property damage, and even human injury (Nyhus, 2016; Meena et al., 2023). Together, these challenges often contribute to negative attitudes among local farming communities towards PAs and low tolerance towards wildlife, which can lead to non-cooperation, illegal grazing, unauthorised extraction of forest resources, encroachment, or even retaliatory actions against wildlife (Karanth & Nepal, 2011).

In India, where agriculture constitutes the backbone of the rural economy and many PAs are located near or within agrarian landscapes, awareness among farmers regarding nearby PAs is critical for balancing conservation goals with socio-economic development (Macura et al., 2011; World Economic Forum, 2020). According to Model of Responsible Environmental Behavior (Hines et al., 1987), pro-environment actions emerge when individuals possess sufficient environmental knowledge, relevant action skills, favourable attitudes, and a strong sense of responsibility. Consequently, farmers who recognise the ecological and economic interdependence of their livelihoods and embrace a conservation-oriented stewardship are more likely to adopt sustainable practices that reduce HWC and promote coexistence (Bhatia, 2021). While several studies in India have examined community and stakeholder attitudes towards PAs (Badola et al., 2011; Karanth & Nepal, 2011; Talukdar & Gupta, 2017), research focusing on awareness remains limited (Heinen & Shrivastava, 2009; Patankar, 2019).

METHODOLOGY

The fieldwork for this study was carried out during 2023-24 along the fringes of Silent Valley National Park (SVNP), Wayanad Wildlife Sanctuary (WWLS), and Karimpuzha Wildlife Sanctuary (KWLS) in the Nilgiri Biosphere Reserve region of the South Indian state of Kerala. Using proportionate stratified random sampling, 10 local governing bodies adjacent to the PAs were selected: 5 from SVNP (out of 9), 3 from WWLS (out of 7), and 2 from KWLS (out of 4). A random sample of 30 farmers was drawn from each. Selection criteria required farmers to reside within 5 km of the PA boundary, own at least 2 dairy animals, and have 10 years of dairy farming experience. Thus, the study involved interviews of 300 farmers, comprising 150 from the forest-fringe communities of SVNP, 90 from WWLS, and 60 from KWLS.

Protected area awareness was measured using a "protected area awareness scale" designed as a summated rating scale (Likert, 1932). A list of the statements derived from literature and subject matter specialist consultation was tested for relevancy, and those with a weightage below 0.70 were excluded (Kumar & Popat, 2009). The retained statements were administered to 80 dairy farmers from non-sample areas, and based on the t-values above 1.75 (Edwards, 1969), 16 statements were finalised for the scale. Scale reliability was supported by an ordinal alpha of 0.86 (Gadermann et al., 2012). Careful statement selection, sample adequacy, and expert validation via relevancy testing were employed to ensure scale validity. The scale was administered on a five-point continuum (5 = extremely aware to 1 = not at all aware), and farmers were classified into low, medium, and high levels of awareness using the cumulative square root of frequency method.

To assess the overall awareness level of farmers on each item of the protected area awareness scale, weighted mean scores (WMS) were computed using the formula:

$$WMS = \frac{\Sigma^{k}_{i=1} f_i \times w_i}{N}$$

where, f_i denotes frequency of farmers in the ith response category, w_i is the weight assigned to that category, k represents the number of response categories, and N is the total number of respondents. The WMS range from 1.00 to 5.00 and are interpreted using midpoint-based class intervals, where 1.00 to 1.49 indicate 'not at all aware' and 4.50 to 5.00 indicate 'extremely aware.' The WMS facilitated ranking and comparison of statements, as well as meaningful interpretation of the relative strength of farmers' awareness.

To identify the determinants of dairy farmers' PA awareness, an ordinal logistic regression was employed on the overall sample, with awareness level as the dependent variable (Maiti et al., 2014). The ordinal logistic regression approach assumes the existence of an underlying latent variable Y^* representing the "true" awareness score. The relationship between Y^* and the observed awareness categories is defined by two threshold parameters (μ_1 and μ_2):

$Y = 1$, if $Y^* \leq \mu_1$ (Low)
$Y = 2$, if $\mu_1 < Y^* \leq \mu_2$ (Medium)
$Y = 3$, if $Y^* > \mu_2$ (High)

It is assumed that the latent variable Y^* follows a linear relationship with the explanatory variables, modelled as:

$$Y^* = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + ... + \beta_k X_k + \varepsilon$$

where, β_0 is the intercept term on the latent scale, $\beta_1 \ldots, \beta_k$ represents coefficients to be estimated,

$X_1, X_2, \ldots, X_k$ are the explanatory variables, and ε denotes the random error.

Systematic data analyses were carried out using MS Excel and R version 4.4.3 (R Core Team, 2024). Ordinal alpha coefficient was estimated with *psych* and *polycor* (Fox, 2022; Revelle, 2025), ordinal logistic regression with *MASS* (Venables & Ripley, 2002), the Brant test with *brant* (Brant, 1990), Variance Inflation Factor (VIF) with *car* (Fox & Weisberg, 2019), and average marginal effects with the *margins* package (Leeper, 2024) in R.

RESULTS

The majority of farmers were middle-aged (63.67%), and males comprised 56% of the sample. Secondary education was attained by 43.33% of respondents. Additionally, 47% maintained small herds and 68% owned marginal land. The mean distance to the nearby forest boundary was 1.28 km. They exhibited low social participation (41%) and information-seeking behaviour (37.33%). Over half of the farmers (62.33%) used social media as an information source.

Protected area awareness

The scale items were administered to each farmer upon confirmation regarding their familiarity with the term "protected area," to which all answered "yes." Table 1 presents the WMS along with their awareness levels for the 16 statements of the protected area awareness scale. The WMS values ranged from 1.95 to 3.70, indicating considerable variation in the level of awareness among farmers. The statement on the recreational value of PAs ranked first (WMS = 3.70), reflecting a moderate level of awareness. This was followed by statements on the provision of ecosystem services (WMS = 3.68), bequest value (WMS = 3.60), preservation of ecosystem processes (WMS = 3.59), microclimate regulation (WMS = 3.59), and conservation of biodiversity (WMS = 3.54), suggesting that farmers were moderately aware of the key ecological functions of PAs. Farmers also exhibited moderate awareness regarding restrictions on trespassing (WMS = 3.51) and encroachment into PAs (WMS = 3.50). In contrast, they were only somewhat aware of prohibitions on the removal of forest produce without permission (WMS = 3.42) and damaging wildlife habitat (WMS = 3.37), as well as of the existence of eco-sensitive zones (ESZ) around PAs (WMS = 2.94) and restrictions on livestock grazing within them (WMS = 2.87). Awareness was slight with respect to activities in ESZs, including the requirement of approval for cutting trees and introducing non-native species (WMS = 2.23), prohibition of commercial mining and firewood use (WMS = 2.06), and permission for continuation of ongoing agricultural operations (WMS = 2.05). The least ranked item was awareness regarding vaccination practices to control communicable diseases shared between livestock and wildlife (WMS = 1.95).

As indicated in Table 2, the level of awareness among farmers regarding PAs varied across the three study sites. In the SVNP area, over one-third of the farmers (38%) demonstrated a medium level of awareness, followed by low (32%) and high (30%) levels. In the WWLS region, slightly under half of the farmers (44.44%) fell into the medium category of awareness. The remaining farmers were equally divided between low (27.78%) and high (27.78%) levels of awareness. Conversely, in the KWLS area, a slight predominance of high levels of awareness was observed (36.67%), followed closely by low (35%) and medium (28.33%) levels. Across the overall sample, the largest proportion of farmers belonged to the medium awareness category (38%), with nearly equal proportions in the low (31.33%) and high (30.67%) awareness categories.

Determinants of protected area awareness

Before conducting the regression analysis, the proportional odds assumption, a prerequisite for ordinal logistic regression, was

Table 2. Differential levels of protected area awareness

Study area	Low 16.00 to 40.27#	Medium 40.28 to 58.35#	High 58.36 to 80.00#
SVNP (n = 150)	32.00	38.00	30.00
WWLS (n = 90)	27.78	44.44	27.78
KWLS (n = 60)	35.00	28.33	36.67
Overall (n = 300)	31.33	38.00	30.67

Range = 16.00 to 80.00; Mean = 49.59
#Range of scores for level of classification

Table 1. Item-wise farmers' protected area awareness (n = 300)

S. No.	Statements	Weighted Mean Score	Awareness Level
1	Protected areas provide recreational and natural experiences for people.	3.70	Moderately aware (3.50 to 4.49)
2	Protected areas provide natural services, such as habitat for insects that pollinate local crops.	3.68	
3	Protected areas have bequest value for future generations.	3.60	
4	Protected areas preserve ecosystem processes.	3.59	
5	Protected areas regulate the microclimate of landscapes.	3.59	
6	Protected areas conserve biodiversity.	3.54	
7	Trespassing into a protected area is a punishable offence.	3.51	
8	Encroachment into a protected area is a punishable offence.	3.50	
9	Removal of any forest produce from a protected area cannot be carried out without due clearance.	3.42	Somewhat aware (2.50 to 3.49)
10	The habitat of any wild animal shall not be destroyed, damaged, or altered.	3.37	
11	The protected areas are surrounded by an eco-sensitive zone, which serves as a transition zone from highly protected areas to areas involving less protection.	2.94	
12	Livestock grazing is not permitted in protected areas, with exemptions based on local conditions.	2.87	
13	In eco-sensitive zones, cutting down trees and introducing non-native species requires approval from forest authorities.	2.23	Slightly aware (1.50 to 2.49)
14	Activities such as commercial mining and commercial use of firewood are prohibited in the eco-sensitive zones.	2.06	
15	Ongoing agricultural activities are permitted in eco-sensitive zones.	2.05	
16	Immunisation of livestock kept near protected areas is essential for safeguarding against communicable diseases.	1.95	

Table 3. Ordinal regression estimates for protected area awareness

Variable	Estimated Coefficient	Standard Error	p value	Marginal Effect#
Age	0.007	0.018	0.696	-0.001
Gender: Female	-0.853	0.323	0.008**	0.092
Education: No formal education	-2.243	0.819	0.006**	0.235
Education: Primary	-1.820	0.597	0.002**	0.191
Education: Secondary	-1.322	0.491	0.007**	0.138
Education: Higher secondary	-0.373	0.531	0.482	0.039
Herd size	-0.030	0.026	0.239	0.003
Farm size	-0.015	0.210	0.945	0.002
Distance from forest boundary	-0.069	0.133	0.604	0.007
Social participation	0.124	0.037	0.001***	-0.013
Information-seeking behaviour	0.301	0.042	0.000***	-0.032
Social media use	0.486	0.369	0.189	-0.051

Observations = 300; #Average marginal effects, other variables held constant;
** = significant at 0.01 level (2-tailed test); *** = significant at 0.001 level (2-tailed test);
Reference categories: Gender = Male, Education = Graduate and above

tested using the Brant test. The omnibus test was non-significant ($\chi^2 = 13.47$, df = 12, p = 0.34), indicating that the assumption was met overall. Pseudo R^2 statistics were calculated to assess model fit. The McFadden's R^2 value was 0.446, indicating a good model fit. Additionally, maximum likelihood pseudo-R^2 was 0.623, and the Cragg-Uhler (Nagelkerke) pseudo-R^2 value was 0.702, further supporting the explanatory power of the model. The predictors showed no evidence of multicollinearity, as reflected in VIF values under 5.

The ordinal logistic regression results (Table 3) indicate that being a female dairy farmer, along with lower education, limited social participation, and weaker information-seeking behaviour, were associated with significantly lower odds of being in higher PA awareness categories. Average marginal effect analysis revealed that female farmers had a 9.2% higher probability of being in lower awareness categories than males, after controlling for other variables. Formal education attainment had a pronounced influence: compared to graduates, farmers with no formal education had a 23.5% higher predicted probability of low awareness; those with primary-level education had a 19.1% higher predicted probability; and those with secondary-level education had a 13.8% higher predicted probability, ceteris paribus. In contrast, no significant difference was observed between higher secondary and graduate education levels. Behavioural factors played a critical role; greater information-seeking behaviour reduced the probability of low awareness by 3.2 percentage points, while increased social participation reduced this probability by 1.3 percentage points, holding other variables at their observed values. Age, herd size, farm size, distance from forest boundary, and social media use had statistically insignificant effects on farmers' PA awareness levels.

DISCUSSION

The study aimed to empirically assess the PA awareness and its determinants among dairy farmers in the forest-fringe communities. The results show that farmers had moderate awareness of the ecological significance of PAs. They especially recognised the recreational value, provision of ecosystem services, and biodiversity conservation functions of PAs. This aligns with earlier studies that found higher recognition of direct and visible benefits of PAs compared to indirect or regulatory aspects (Karanth & Nepal, 2011). Moderate awareness of restrictions on trespassing and encroachment also suggests that farmers are familiar with rules that affect their day-to-day access to resources. In contrast, awareness of prohibitions on forest-produce extraction, habitat damage, and the existence of ESZs was only somewhat developed. This points to a limited understanding of regulatory mechanisms that are less visible in everyday life. Awareness was particularly low regarding activities which are prohibited, restricted, and even those that are permitted, such as ongoing agriculture. This has contributed to misconceptions among farmers and fostered negative attitudes that authorities intend to curtail farming and claim their land (Kuttappan, 2023). The lowest awareness was observed for strategies to prevent communicable diseases from passing between livestock and wildlife. This highlights a significant knowledge gap in areas central to integrated health and conservation approaches. A medium level of awareness was found in two out of three regions and the overall sample. This suggests that there is ample scope for strategic efforts to improve awareness among dairy farming communities.

Findings of the regression analysis show that gender significantly influenced farmers' awareness levels, indicating similarities with the results of Xun et al. (2017). Female farmers had low awareness levels due to limited access to forest officials, NGO workers, or extension officers, as well as reduced participation in awareness campaigns or political activities in comparison to male farmers. Multiple responsibilities such as household chores, childcare, and farm activities hinder women from attending such programmes, similar to the findings by Paul et al. (2025). So, it is imperative to create conscious opportunities for women in social events such as training programmes to ensure their equitable inclusion, as such initiatives are observed to substantially enhance knowledge levels of women participants (Roy et al., 2024; Kumari et al., 2025). A positive correlation was observed between education and awareness, highlighting the essential role of formal education in improving the ecological and legal awareness among farmers (Xun et al., 2017; Hariohay et al., 2018).

The statistically significant and positive effect of social participation on PA awareness posits that farmers involved in a higher number of social networks, community groups, or local institutions, particularly in leadership roles, are more likely to fall into higher awareness categories. This suggests that social interaction has a crucial role to play in facilitating the flow of information related to the importance and laws related to PAs. Farmers showing active participation in community activities are likely to be better informed, either through formal discussions, peer exchanges, or access to awareness programmes channelled through these networks. A similar finding was reported by Munasib and Jordan (2006) while examining the effect of social capital on farmers' environmental awareness. Strengthening community-based platforms can therefore improve awareness and farmer involvement in PA management. Similarly, farmers who actively seek information through peers, training programmes, or mass media are more likely to understand ecological value and regulations of PAs. This aligns with Pongener and Jha (2024), who found that information source utilisation significantly influenced farmers' awareness of recommended practices in Nagaland. Identifying farmers' information-seeking behaviour and supporting it through accessible communication channels is crucial for enhancing conservation awareness (Reimer, 2025).

Overall, the socio-demographic and behavioural dimensions collectively shape not only farmers' awareness levels but also their adaptive capacity to manage livelihood risks near PAs. Among forest-fringe dairy farmers in Kerala, higher PA awareness can enhance economic resilience by encouraging adaptive practices such as fodder cultivation, stall-feeding, and livestock immunisation. Lack of awareness was found to be a major barrier to the adoption of climate-resilient dairy practices among farmers in Haryana (Reddy et al., 2024). Awareness also promotes livelihood diversification through agri-tourism and facilitates effective engagement with institutional support mechanisms like compensation schemes (Hridya & Meena, 2024). Moreover, it fosters appreciation of ecosystem services that sustain long-term dairy productivity, thereby reinforcing both ecological coexistence and livelihood sustainability at the ecology–economy interface.

CONCLUSION

The study revealed that while farmers were moderately aware of the ecological roles of protected areas, their understanding of eco-sensitive zone regulations and livestock-wildlife health concerns remained limited. A considerable proportion of forest-fringe farmers from Silent Valley National Park, Wayanad Wildlife Sanctuary, and the overall sample showed a medium level of protected area awareness, whereas high levels predominated among farmers from Karimpuzha Wildlife Sanctuary. Gender, education, social participation, and information-seeking behaviour emerged as significant determinants of awareness. These findings highlight the need for integrated strategies that are gender-inclusive, promote education, leverage community-based platforms, and encourage active information-seeking among farmers. Awareness-building efforts should be complemented by capacity-building and financial incentives to help farmers sustain their livelihoods in forest-fringe areas. Collectively, such targeted interventions are vital to conserve protected area ecology, sustain the agrarian community economy, and foster harmonious farmer–wildlife coexistence in agricultural landscapes near protected areas.

DECLARATIONS

Ethics approval and informed consent: Informed consent was sought from the respondents and their organisations regarding the study during the course of the data collection.

Conflict of interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The authors declare that during the preparation of this work, they thoroughly reviewed, revised, and edited the content as needed. The authors take full responsibility for the final content of this publication.

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