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Anthropogenic Threats Affecting Birds and their Habitats in Lake Solai, Kenya

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Abstract

Anthropogenic activities including urbanization, agriculture, and infrastructure development are major drivers of biodiversity loss, with significant impacts on avifaunal diversity in freshwater ecosystems. This study assessed the perceived threats to birds and their habitats around Lake Solai, Kenya, a key wetland supporting diverse resident and migratory bird species. Perceived threats, mitigation measures and effectiveness of conservation efforts were assessed through structured questionnaires administered to 100 households across five villages bordering Lake Solai; Majitamu, Kapndege, Kasururei, Tuiyotich, and Machine. The data were analyzed using SPSS software version 20 where descriptive statistics and chi-square tests were used to examine the perception of threats, preferred mitigation measures and associations with demographic and livelihood factors. Habitat degradation (85%), climate variability (78%), human disturbance (65%), and pollution (58%) emerged as the predominant threats, with variations linked to primary livelihood activities rather than demographic characteristics (age, gender and village). Support and funding and education were prioritized by the respondents as critical mitigation strategies, although there was high reliance on local community initiatives, formal conservation efforts were not recognized. The differences in village preferences of mitigation measures highlights the importance of localized conservation approaches specific to socio-economic contexts. Generally, the conservation efforts were limited with only 30% of the respondents being aware of them, they mostly highlighted informal actions including awareness creation and volunteering, with minimal formal actions. The findings emphasize the need for strengthened governance, enhanced community engagement, and integrated, livelihood-sensitive conservation planning to safeguard avian biodiversity in this human-modified landscape.

Keywords: *Anthropogenic threats, Lake Solai, Bird Conservation, Community perceptions, Wetland biodiversity*

Introduction

The principal drivers of biodiversity loss are anthropogenic activities including urbanization, infrastructure development and agriculture both globally and with pronounced effects in the rapidly developing regions of East Africa (Achieng *et al*. 2023). Habitat fragmentation and degradation within vital freshwater ecosystems in Kenya has been intensified by increasing human population pressure which has led to decline in bird diversity and abundance (Githiru *et al*. 2002). Birds are ecological indicators of ecosystem integrity but are vulnerable to changes in habitat structure, landscape connectivity and resource availability (Miriti & Waswala, 2024).

Lake Solai in the Rift Valley of Kenya is a biologically significant wetland which is complex and supports diverse assemblages of both resident and migratory bird species (Renaut & Owen, 2023), and is also an important stop over for waterfowls migrating between Lake Bogoria and Lake Nakuru. Despite the lake's ecological importance, it is under threat due to anthropogenic pressure such as deforestation, agricultural encroachment, resource extraction and settlements expansion, which risks the integrity of bird habitats and the ecological functions they support.

Although the Lake's value to biodiversity is clear, there is limited data on how human driven threats are affecting birds and their habitats. Many existing avifaunal studies in Kenya focus on protected areas or larger lakes, which leaves a critical knowledge gap in our small yet ecologically important wetland Lake Solai. Addressing this gap is critical for development of targeted conservation strategies.

This research aims to examine the anthropogenic threats impacting birds and their habitats across villages around Lake Solai. It also explores the local community perceived mitigation measures to those threats and their

awareness of any ongoing conservation efforts. This work intends to provide important information on conservation planning and sustainable management of bird diversity in the human-altered environments.

Materials And Methods

Study area

Lake Solai is a shallow alkaline lake in the semi-arid area of the Eastern Rift Valley to the North East of Nakuru town on the Nakuru- Nyahururu road about 50 km south of Nakuru town (Nyaga et al. 2019). This lies in between 0 30 0 00 North, and 36 9 0 00 East and is 1667m in height above the sea level. It comprises one lake with the maximum depth of 1.5 m and total area of 9 km2 changing together with a meteorological condition in the surrounding region (Goman et al. 2017). It experiences high rainfall of 700-900 mm per year and evapotranspiration much higher than the rainfall at 1800 mm/year which makes it experience seasonal drying (Herrnegger et al. 2021). It is mainly fed by seasonal rivers such as Maji Tamu though it does not have a surface outflow (Goman et al. 2017). Around it, there are acacia woodlands and the saline swamps, as well as wetland fauna with more than 100 species of birds, such as migratory birds (Herrnegger et al. 2021). The locals practice agro-pastoralism or irrigation farming, fishing, riding of boats, and small-scale trade (Nyaga et al. 2019) (Figure 1).

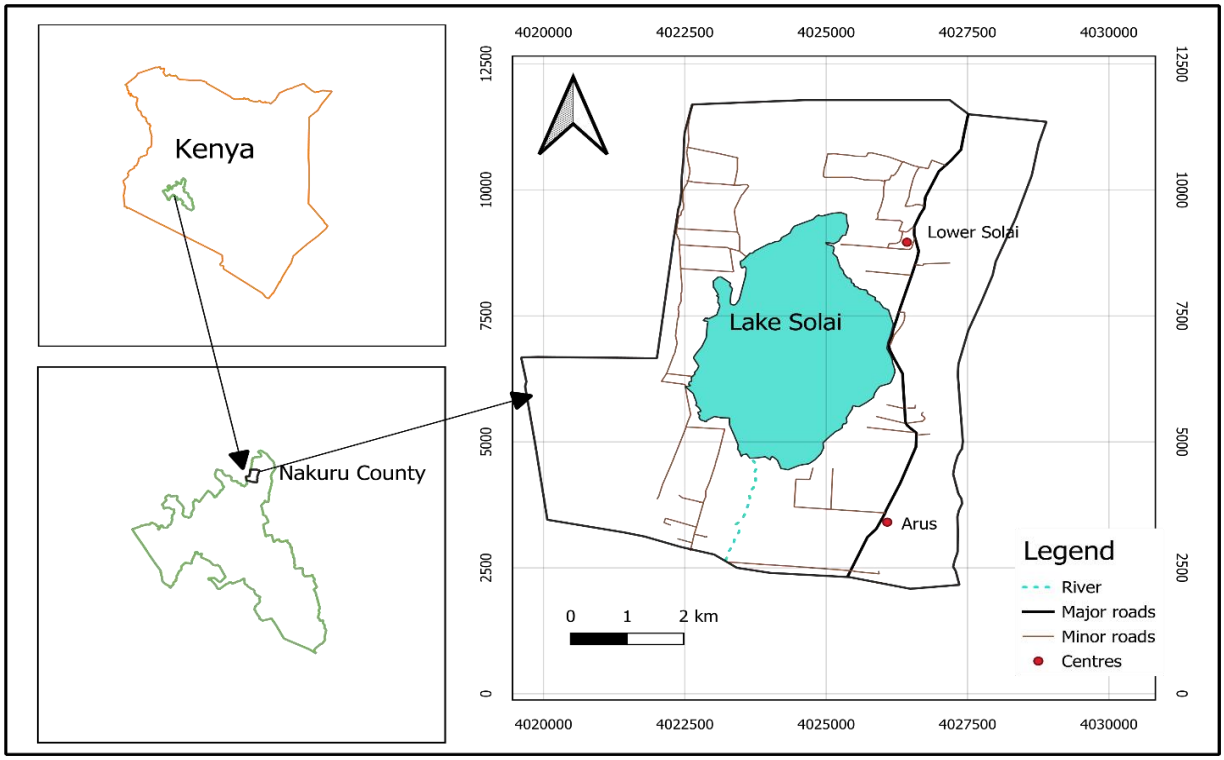

Figure 1. Map of Lake Solai, Kenya.

Sampling design

The study was conducted in five villages surrounding Lake Solai; Majitamu, Tuiyotich, Machine, Kapndege, and Kasururei comprising a total of 609 households. A sample size of 100 households was determined using Yamane, 1973 formula:

$$n = \frac{N}{1 + N(e)^2}$$

where n is the sample size, N is the population size (609), and e is the margin of error (9%). This margin was chosen to balance statistical reliability with logistical constraints and falls within the acceptable range of 5–10% for small-scale social and environmental studies (Israel, 1992).

Household distribution among villages was: Majitamu (173), Kapndege (132), Kasururei (124), Tuiyotich (98), and Machine (82). The distribution of households was estimated by assuming an average household size of five individuals, based on regional demographic data (Statistics, 2019). The number of households sampled per village was proportionally allocated based on Nelly et al. (2021), where each village's sample size was determined by the proportion of the cluster's population relative to the total population multiplied by household sample size. The resulting village-level sample sizes were: Majitamu (28), Kapndege (22), Kasururei (20), Tuiyotich (16), and Machine (14). Systematic sampling was employed by selecting every 6th household to participate in the survey. Questionnaires with both open and closed-ended questions were administered face-to-face to ensure clarity and accuracy of responses.

Data analysis

Data from structured questionnaires on perceived threats to birds and their habitats around Lake Solai were cleaned, coded, and entered into Microsoft Excel before being exported to SPSS version 20 for analysis. Descriptive statistics summarized socio-demographic characteristics and frequencies of perceived threats. Chi-square goodness-of-fit tests were used to determine whether differences in threat, mitigations or effectiveness of conservation efforts frequencies were statistically significant. Associations between categorical variables and perceived threats were assessed using chi-square tests of independence. For significant results, contingency tables were examined to interpret variations in perceived threats across different economic activities.

Results And Discussions

Socio-demographic characteristics of respondents

The questionnaire surveyed 100 respondents from five villages surrounding Lake Solai. The demographic characteristics of the respondents varied across age, gender, and livelihood activities. The majority were aged between 20 and 40 years, while males constituted a higher proportion than females. Farming was the predominant livelihood activity, followed by cattle rearing and fishing, with few respondents engaged in eco-tourism and local trade (Figure 2).

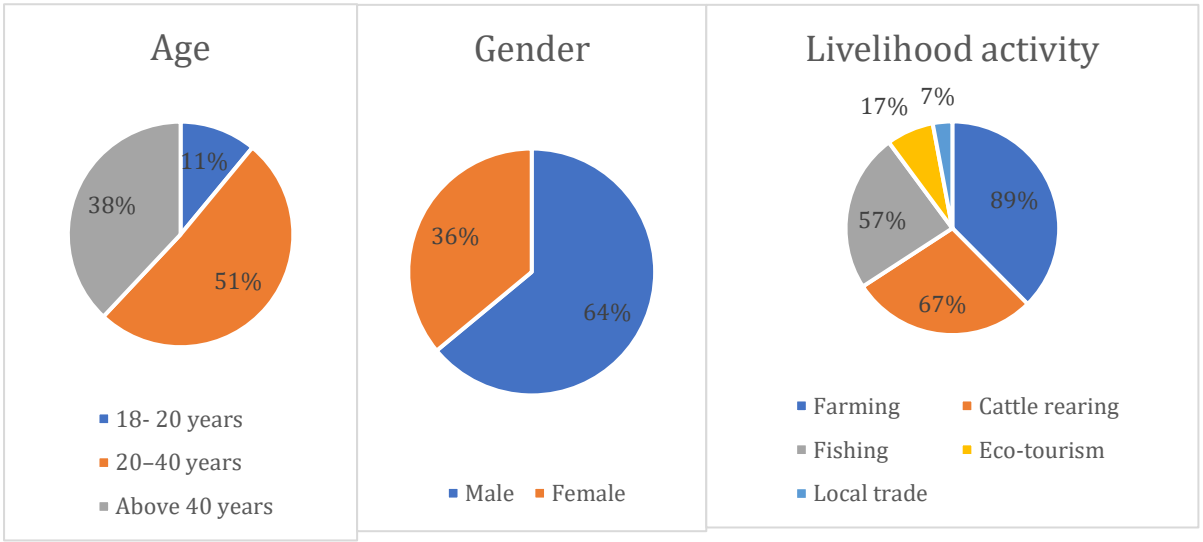

Figure 2. Distribution of respondents by age, gender, and livelihood activities around Lake Solai.

Perceived threats to birds and their habitats around Lake Solai

Respondents most frequently cited habitat loss/degradation (70%), extreme weather changes (65%), human disturbance (55%) and pollution (40%) as threats to birds and their habitats around Lake Solai, and illegal hunting/poaching (7%) mentioned less often, and overfishing (4%), tree cutting (3%), increased livestock grazing (2%) and limited conservation funding (1%) reported by only a few. These reporting differences were highly significant ($\chi^2 = 296.80$, df = 10, $p < 0.001$).

Perceived threats showed a significant difference with economic activity ($\chi^2 = 219.91$, df = 40, $p < 0.001$) while no significant association was found between threat perceptions and village, age or gender. Fishers most often reported habitat degradation (38%) as a threat, farmers prioritized climate change and pollution (each 24%), cattle rearers highlighted climate change (24%) and human disturbance (16%), eco-tourism stakeholders noted human disturbance (9%) and disease outbreaks (2%), while traders cited only limited conservation funding (1%) as a concern (Figure 3).

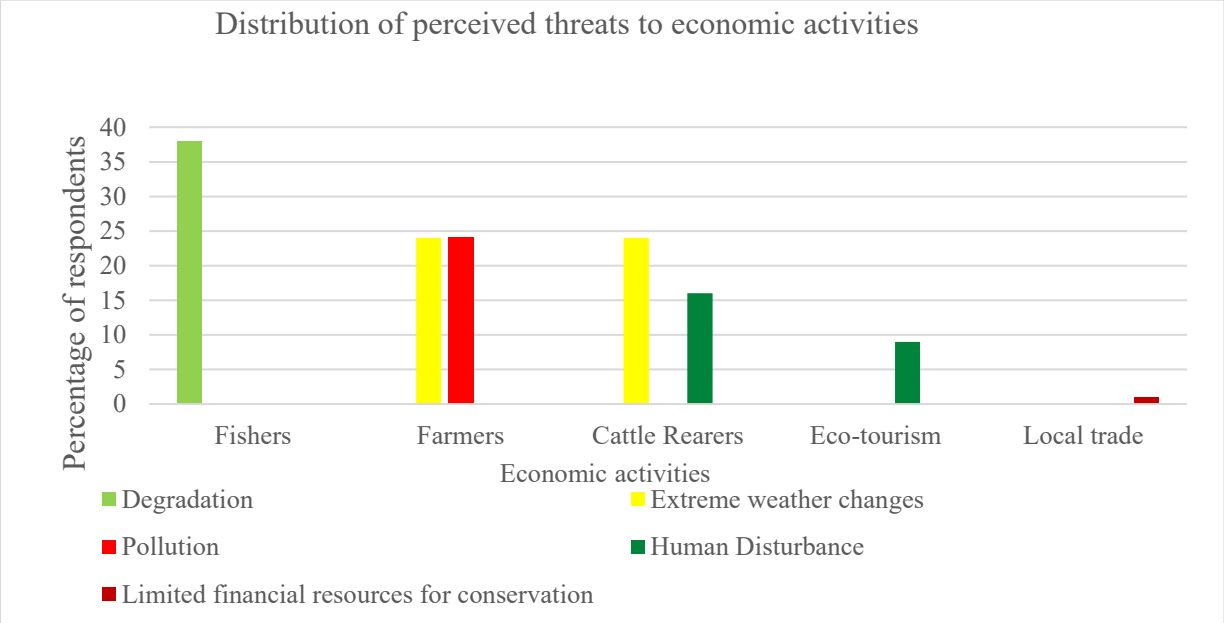

Figure 3. Percentage of respondents identifying perceived threats across economic activities.

The community's prioritization of habitat degradation, climate variability, human disturbance, and pollution in Lake Solai highlights strong local awareness of the key drivers contributing to bird population decline in the area. This aligns with my findings where these four threats were consistently ranked highest across groups. For example, farmers and cattle rearers emphasized the impacts of climate variability (particularly irregular rainfall and prolonged droughts) which they associated with declining bird sightings and drying wetland patches. This finding is consistent with Karanja, 2022 and Dunee et al. 2025, who reported similar concerns in semi-arid landscapes of Kenya and Ghana, respectively. However, the intensity of concern in Lake Solai may be amplified due to their heavy dependence on rain-fed agriculture and open grazing, which makes the community more vulnerable to climate extremes. Human disturbance, cited prominently by pastoralists and eco-tourism operators, was linked to noise, movement, and presence near nesting sites, especially during the dry season. This concurs with Martinez-Fernandez et al. 2021, who found that unregulated tourism led to decreased breeding success among shorebirds in Mediterranean wetlands. This suggests that even low volume human activity in Solai can have noticeable effects, possibly due to the confined nature of the habitat. Pollution concerns, mainly raised by farmers, were attributed to fertilizer runoff and improper disposal of pesticides. This supports findings by (Dubey & Dutta, 2020), who identified agricultural runoff and chemical pesticide use as major pollution threats in rural Indian wetlands,

Lesser ranked threats such as poaching, and overfishing were not prioritized by respondents, possibly due to their less visible or indirect effects. Still, (Mayfield et al. 2021) caution that these factors have long-term cumulative impacts, echoing my recommendation for proactive community sensitization campaigns. Since only livelihood type only influenced threat perceptions, conservation interventions that align with dominant local livelihoods and integrate traditional ecological knowledge are likely to achieve strong community engagement and build resilience in bird habitat management.

Perceived mitigation measures to threats to birds and habitats.

The respondents identified four main categories of perceived mitigation measures to threats to birds and habitats: Support and funding (39%), Education (38%), Protection (13%), and Environment (10%). Support and funding were the most cited, comprising conservation support (26%), government cooperation (2%), and financial support (11%). Education, specifically creating awareness, was highlighted by 38% of respondents, reflecting a strong demand for community engagement and knowledge dissemination. Protection measures, including safeguarding endangered species (12%) and establishing sanctuaries (1%), were noted by 13% of participants. Environmental actions such as tree planting (5%), banning charcoal burning (4%), and regulating water flow (1%) accounted for 10% (Table 1).

Table 1. Perceived mitigation measures to threats to birds and habitats

Thematic category	Mitigation measure	Frequency	Percentage
Education	Creating awareness	38	38%
Sub total		**38**	**38%**
Support and funding	Conservation support	26	26%
	Govt cooperation,	2	2%
	Financing	11	11%
Sub total		**39**	**39%**
Protection	Protection of endangered species,	12	12%
	Create sanctuary	1	1%
Sub total		**13**	**13%**
Environment	Regulate water flow,	1	1%
	Tree planting	5	5%
	Ban charcoal burning	4	4%
Sub total		**10**	**10%**

Perceived mitigation measures showed a significant relationship with village of residence ($\chi^2 = 31.448$, df = 12, $p < 0.001$), indicating that community priorities varied across locations. However, no significant associations were found for age ($\chi^2 = 7.782$, df = 6, $p = 0.254$), gender ($\chi^2 = 3.482$, df = 3, $p = 0.323$), or economic activity ($\chi^2 = 2.508$, df = 6, $p = 0.868$), hence these factors did not influence perceptions of mitigation strategies.

A contingency analysis revealed village-level differences in mitigation preferences. Education was most prioritized in Tuiyotich (13%) and Machine (7%). Support and funding dominated in Kapndege (14%) and Majitamu (11%), while protection was emphasized mainly in Majitamu (7%). Environmental actions were also most cited in Majitamu (4%) but were minimal or absent in other villages (Figure 4).

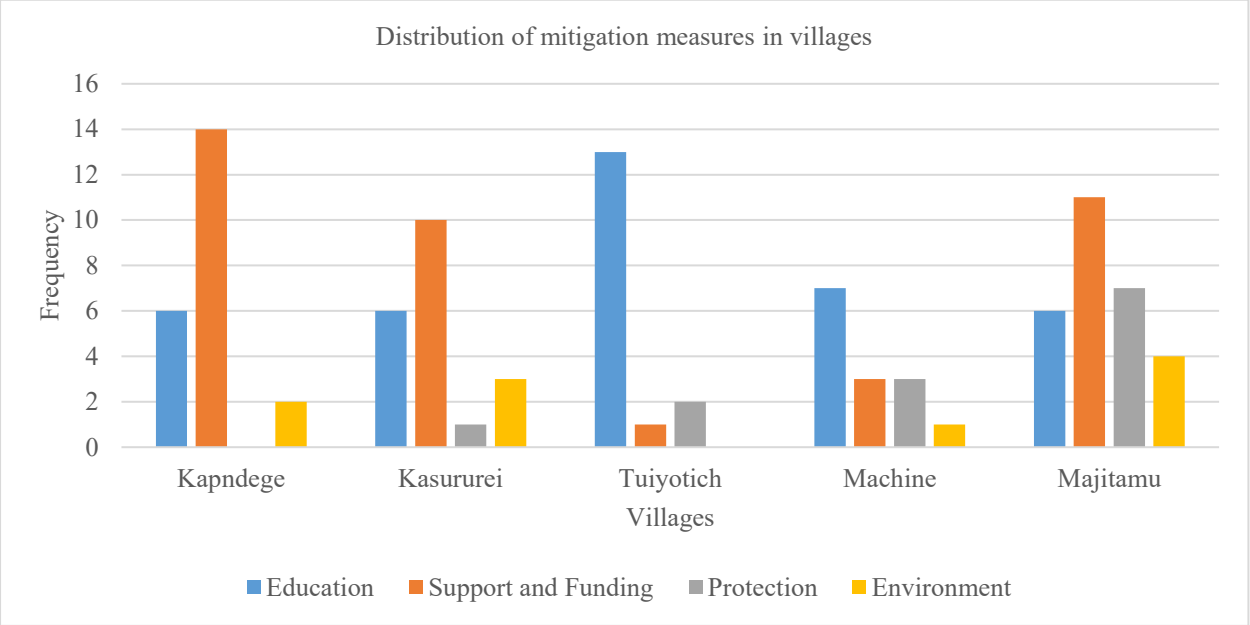

Figure 4. Percentage frequency of perceived mitigation measures per village.

The strong emphasis by the respondents on support and funding indicates their trust in policies and regulatory frameworks for conservation which supports Brockett et al. (2023), who stated that legal protection plays a critical role in biodiversity outcomes. Education was widely prioritized which shows that residents value awareness creation initiatives to support conservation efforts. This is consistent with Ardoin et al. (2020) who links environmental education to increased public engagement and ecosystem stewardship. Despite protection and environment being less cited, they still reflect support for direct interventions like species protection and habitat restoration as echoed by Kukkonen et al. (2025). Village level differences were clearly evident. Education was favored in Tuiyotich and Machine, likely due to previous exposure to awareness programs similar to findings by Jacobson et al. (2015). Kapndege and Majitamu prioritized governance, suggesting confidence structure policies, a pattern also observed by Gibbon's 2021 study. Majitamu and Kasururei villages had concerns on protection and habitat, this is likely due to their proximity to degraded areas or critical habitats where conservation feels more urgent as also noted by (Carlen et al. 2024). These findings highlight the need for tailoring conservation strategies to village specific priorities to ensure alignment with community values and to increase chances of effectiveness.

Perceived effectiveness of conservation efforts.

From the survey, only 30% of respondents were aware of ongoing conservation efforts around Lake Solai, which indicates limited efforts and largely informal activities. Community volunteering (13%) and awareness creation (10%) were the most commonly reported actions, while formal interventions such as registered wetland conservancy presence (2%), tree planting (4%), and fishing regulation (1%) were rarely mentioned. A significant variation was observed on how conservation efforts were perceived across categories ($\chi^2 = 18.333$, df = 4, p = 0.001). There was no significant difference between perceived conservation efforts and demographic variables; village, age, gender and economic activities. This suggests that awareness of conservation activities is not influenced on demographic characteristics.

The lack of formal structures of conservation and prevalence of informal efforts like creation awareness and volunteering highlights the dependency on locally driven efforts. The findings correlate with those of Luz & Ruiz-Mallen, (2020), who identified similar trends in regions where institutional frameworks were absent. Although the creation of awareness is critical towards gaining conservation support, its effectiveness hinges on its ability to gain long-term financial resources and direct messages as mirrored by Dorris et al. (2025). The limited recognition of conservation measures, including wetland conservancies and fishing regulations highlight a gap between conservation planning and local community involvement in the area. As noticed by Thapa et al. (2025), the

perceived effectiveness of conservation can depend on the apparent success and concrete outcomes of interventions of which both are low in Solai.

The insignificance of the demographic factors in how they are perceived implies one of the following variables, mostly that the level of awareness concerning the formal expression of conservation is low, and is similar throughout the community. This is consistent with the trends reported by Obradovic et al. (2023) where the measures taken in the identification of conservation strategies were not very compatible with local situations and communication modes. These results show the necessity of making inclusive, locally developed approaches which make them more visible, participatory, and ownership.

Conclusion And Recommendation

This analysis demonstrates a highly complex tapestry of risks to birds and their environments in the Lake Solai landscape, with many anthropogenic pressures being found. Pollution, habitat degradation, variability in climate and human disturbance were the principal threats identified. The threats are not only ecologically significant but are also recognized by the community which suggests their strong awareness on environmental change. The connection of livelihood type to threat perception suggests that their environmental cognition is affected by their dependence on natural resources. The lack of formal institutional measures of conservation implies that improved governance and communication of conservation can be achieved in the area. The difference in the choice of mitigation actions based on villages highlights the necessity of context-related, locally-based interventions. The findings suggest participatory forms of conservation that incorporates local knowledge, strengthens conservation legitimacy, and improves ecological benefits to birds and habitat.

For effective conservation in Lake Solai, community-based conservation efforts must build sustainable governance systems, strengthen awareness, and align interventions with local livelihoods. Village-specific approaches, enhanced communication, and advance planning and implementation could be done to deal with emerging threats. Future research could focus on the long-term observation of bird species and quality of habitats in order to indicate the ecological changes caused by climate change and human beings. Seasonal and annual comparative studies could also determine the trends in time and the emergence of threats.

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