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Biodiversity Inventory: Implications for Conservation and Environmental Education

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Abstract: This study conducted a comprehensive biodiversity inventory of Buluan Lake, Mindanao, focusing on aquatic plants, fish, and bird species during October 2024. Field observations over 30 days documented 11 aquatic and semi-aquatic plant species, 7 fish species, and 5 bird species. Tilapia (*Oreochromis niloticus*) emerged as the most abundant fish, while native species such as Taruk (*Libero rohita*), Gourami (*Trichopodus pectoralis*), and Striped snakehead (*Channa striata*) were also present. Invasive and predatory species, including Midas cichlid and Blackbelt cichlid (*Amphilophus citrinellus* and *Vieja melanurus*) and Bighead Carp (*Hypophthalmichthys nobilis*), were noted, suggesting potential shifts in ecosystem dynamics. Aquatic plants such as water hyacinth (Eichhornia crassipes) and lotus (Nelumbo nucifera) provided essential habitat and contributed to water quality, while bird species such as the Great Egret (*Ardea alba*) and Black Bittern (*Ixobrychus flavicollis*) indicated overall ecosystem health. This inventory highlights the ecological richness of Buluan Lake and underscores the importance of integrating such data into conservation planning and environmental education initiatives.

Keywords Buluan Lake, biodiversity, aquatic plants, fish species, birds, conservation, environmental education

I. Introduction

Buluan Lake, located in Mindanao, Philippines, is a biologically diverse freshwater ecosystem that sustains numerous aquatic plants, fish, and bird species. These organisms play vital ecological roles, including maintaining balance in nutrient cycling, enhancing water purification, and providing critical habitats for other species. Beyond ecological services, biodiversity within the lake supports the livelihoods of local fisherfolk and offers rich opportunities for environmental education, allowing students and communities to develop a deeper sense of stewardship toward nature.

Despite its ecological importance, freshwater ecosystems such as Buluan Lake face increasing pressures from anthropogenic activities and environmental change. Aziz et al. (2021) reported that freshwater fish diversity in Asian lakes is rapidly declining due to climate stress and overexploitation, a trend that resonates with observed changes in Buluan Lake where native fish species are showing signs of decline. Similarly, De Carvalho et al. (2025) highlighted that aquatic plants act as indicators of ecological health, providing food, shelter, and water filtration services—functions clearly mirrored in Buluan Lake's lotus (*Nelumbo nucifera*) and water hyacinth (*Eichhornia crassipes*), which stabilize habitats and sustain fish and bird communities.

Local and regional studies reinforce the need for baseline biodiversity inventories. For instance, Corpuz, Paller, and Ocampo (2016) found that fish assemblage distribution in Lake Taal was strongly influenced by water depth, vegetation, and proximity to the sea, demonstrating how habitat conditions shape species diversity—insights that are directly applicable to Buluan Lake's fisheries management. Likewise, Lador and Seronay (2017) documented 74 bird species in the Lake Mainit watershed and emphasized their role as ecological indicators, supporting the relevance of avifaunal monitoring in assessing the health of Buluan Lake. Recent research by Mapi-ot, Alaman, and Calago (2024) on Lake Duminagat in Mindanao also revealed high amphibian endemism and highlighted the urgency of species inventories as baselines for conservation of freshwater ecosystems.

On a broader scale, Hughes (2023) stressed that biodiversity baselines are essential for setting realistic conservation targets in Asia, while Bull et al. (2014) argued that without clear baseline data, conservation outcomes cannot be properly evaluated or sustained. Together, these findings highlight that species inventories are not merely lists of organisms but critical tools for detecting ecological shifts, informing conservation policy, and fostering environmental education.

In this context, documenting the biodiversity of Buluan Lake serves multiple purposes: it establishes a scientific foundation for ecological monitoring, informs conservation strategies, and strengthens environmental education by helping communities and students understand interspecies relationships and the impacts of human activities.

II. Materials and Methods

Species Inventory

The Species Inventory of the lake ecosystem used a range of methods to study different flora and fauna within the lake. For Lake Flora, researchers laid out transect lines from the shoreline into the lake at 10-meter intervals, noting plant species found along these lines. Cameras were used to capture images of these plants to aid in their identification later, and these photos were included in learning materials for educational use. Fish were sampled using traditional fishing techniques familiar to local residents, such as fish traps (bubu) and hook and line. These tools were set up in three randomly chosen spots around the lake. Captured fish were

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photographed to assist in identification and were also included in the learning materials. For birds, the Bird Watching Technique was used, which involved systematically observing and identifying bird species around the lake. Confirmation of the species identified was done by an expert in the field.

Study Area

The study was conducted in Buluan Lake, Mindanao, Philippines. Observation sites were selected to cover diverse habitats, including deep zones, shallow shorelines, areas near fish pens, and vegetated regions.

Figure.1 Buluan Lake, Maguindanao

Data Collection

Field observations were conducted over 30 consecutive days in October 2024. Data collection focused on three groups, fish, plants and birds species.

Data Analysis

The data collected were carefully validated by experts to ensure the correct identification and naming of species. The resulting inventory serves not only as a reliable reference for ecological monitoring but also as an important educational resource for raising awareness and deepening understanding of Buluan Lake's biodiversity.

III. Results and Discussion

Aquatic Plant Diversity

A total of 10 plant species were documented (Table 1). Common species included Eichhornia crassipes, Pistia stratiotes, Ipomoea aquatica, and Nelumbo nucifera. These plants provide critical ecosystem services, including habitat provision, food for aquatic fauna, prevention of soil erosion, and water purification (De Carvalho et al., 2025). Their presence reflects ecological health, while their distribution can indicate potential eutrophication or habitat alteration.

Table 1. Aquatic and semi-aquatic plant species documented in Buluan Lake (October 2024)

No.	Scientific Name	Common Name	Observed habitat
1	Eichhornia crassipes	Water hyacinth	Shoreline
2	Pistia stratiotes	Water lettuce	Deep lake zones
3	Ipomoea aquatica	Morning glory	Shoreline
4	Nelumbo nucifera	Lotus	Near fish pens
5	Hydrilla verticillata	Water thyme	Deep water zones
6	Sesbania drummondii	Sesbania pea	Shallow mid-lake
7	Decalobanthus peltatus	Flowering vine	Shallow mid-lake
8	Cyperus spp.	Rice flat sedge	Shoreline
9	Cyperaceae spp.	Yellow nutedge	Shoreline

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Fish Species Diversity

Seven fish species were recorded during the survey (Table 2). Tilapia (Oreochromis niloticus) was the most abundant, with a minimum catch of 60 kilograms per day over seven consecutive days. This was followed by Taruk (Labeo rohita, 30 kg), Gourami (Trichopodus pectoralis, 25 kg), and Aluwan (Channa striata, 10 kg). Invasive and predatory species were also noted, including Utip (Amphilophus citrinellus and Vieja melanurus, 15 kg) and Bighead Carp (Hypophthalmichthys nobilis, 10 kg), which suggest emerging changes in community structure. However, the sample size for fish was relatively small and limited to traditional fishing methods, which may have underrepresented elusive or nocturnal species. Moreover, while invasive species were identified, their population density and ecological impact were not quantitatively assessed, leaving gaps in understanding their influence on native fish assemblages. Overall, fish pen owners reported a decline in fish diversity compared to previous years, attributing this to climate change and the increasing number of fish pens. These findings align with earlier studies indicating that introduced species can disrupt freshwater ecosystems (Aziz et al., 2021).

Table 2. Fish species documented in Buluan Lake (November 2024)

No.	Scientific Name	Common/Local Name	Observed Habitat
1	Labeo rohita	Taruk	Moderate to deep areas
2	Channa striata	Mudfish / Aluwan	Shallow, vegetated areas
3	Oreochromis niloticus	Tilapia	Coastal, moderate vegetation
4	Trichopodus pectoralis	Gourami	Dense aquatic vegetation
5	Hypophthalmichthys nobilis	Bighead carp	Deep slow-moving water
6	Gobiidae spp.	Goby fish/Dulog	Shallow nearshore
7	Amphilophus citrinellus / Vieja melanurus	Utip	Moderate depths

Bird Species Observations

Five bird species were observed during the survey (Table 3). Birds were primarily concentrated in areas with dense vegetation and in proximity to fish pens. The Great Egret (*Ardea alba*) and Black Bittern (*Ixobrychus flavicolli*s) are commonly recognized as ecological indicators, as their presence suggests sufficient food resources and relatively intact wetland habitats (US Geological Survey, 2021). Species-specific observations highlighted distinct habitat-use patterns: the Black Bittern was mostly seen in dense vegetation near pens, while the Great Egret frequently perched on fish pen fences. The Java Pond Heron (*Ardeola speciosa*) was often observed near floating vegetation or fish pens, the Philippine Swamphen (*Porphyrio pulverulentus*) was recorded walking on floating plants, and the Common Moorhen (*Gallinula chloropus)* was associated with shallow, plant-filled areas. These habitat associations suggest a degree of ecological partitioning among species, likely influenced by both natural vegetation cover and the presence of aquaculture structures.

Table 3. Bird species documented in Buluan Lake (October 2024)

No.	Scientific Name	Common Name	Observed Habitat
1	Ixobrychus flavicollis	Black Bittern	Dense vegetation near pens
2	Ardea alba	Great Egret	Perching on fish pen fences
3	Ardeola speciosa	Java Pond Heron	Floating vegetation/fish pens
4	Porphyrio pulverulentus	Philippine Swamphen	Walking on floating plants
5	Gallinula chloropus	Common Moorhen	Shallow, plant-filled areas

Importance of the Species Inventory for Conservation and Education

The species inventory of Buluan Lake highlights the intricate interdependence of plants, fish, and birds within the ecosystem. Each species contributes to maintaining ecological stability, supporting sustainable fisheries, and preserving water quality. Such an inventory does not merely document the presence of biodiversity; it provides a scientific foundation for understanding ecological relationships and the potential consequences of disruption.

From a conservation standpoint, species inventories serve as essential baseline data. They allow researchers and policymakers to track changes in species composition and abundance over time, thereby identifying emerging threats such as overexploitation, pollution, or habitat degradation. By doing so, inventories inform evidence-based conservation strategies and guide the development of policies that aim to protect both biodiversity and the livelihoods that depend on it.

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Equally important is the educational role of such documentation. Integrating species inventories into school curricula promotes environmental literacy and fosters stewardship among students. When learners recognize the interconnectedness of ecological systems and the impact of human activity, they become more conscious of their responsibility toward environmental sustainability. Furthermore, by involving local communities in biodiversity monitoring, inventories nurture a sense of ownership and encourage active participation in conservation initiatives.

In this light, the Buluan Lake biodiversity inventory functions as both a scientific resource and an educational tool. It bridges research and community engagement, ensuring that conservation is not only guided by data but also embraced by the people whose lives are closely tied to the lake.

Fishing Malpractices

Destructive fishing techniques, such as electric fishing and the use of illegal nets, were reported. In addition, the introduction of invasive species and artificial feeding practices disrupts the ecological balance. Weak enforcement of existing regulations and limited awareness of sustainable practices further exacerbate the problem.

Respondents and municipal representatives identified inconsistent disposal practices, including dumping of plastics and human waste into the lake. Informal sanitation systems near fish pens contribute to water quality degradation. A lack of infrastructure and community engagement undermines proper waste management and lake conservation efforts.

Community Perspectives on Resource Use and Conservation

Interviews with fish pen owners, fisher folk, and municipal representatives revealed that local stakeholders are aware of both the benefits and risks of aquaculture practices. While aquaculture contributes to household income and food supply, respondents also recognized that unsustainable techniques, such as overstocking and reliance on invasive species, threaten long-term productivity. Community members also expressed concerns about declining fish diversity, increased waste, and limited regulatory enforcement. Incorporating these perspectives strengthens the socio-ecological understanding of lake management and emphasizes the need for participatory approaches in conservation.

Spatial Mapping of Fishing Pressure and Biodiversity Hotspots

The lack of spatial planning in aquaculture expansion contributes to ecological degradation. A GIS-based mapping of fish pens, waste disposal points, and observed bird and fish species could highlight biodiversity hotspots, invasive species zones, and areas of high fishing pressure. Such spatial visualization would provide valuable insights for policymakers, helping to identify priority zones for conservation, stricter enforcement, and sustainable aquaculture development.

Limitations and Future Directions

This study provided important baseline data on the fish and bird communities in the study site; however, several limitations should be acknowledged. For fish, the sample size was relatively small and restricted to traditional fishing methods, which may have underrepresented elusive or nocturnal species. Moreover, while invasive species such as *Amphilophus citrinellus*, *Vieja melanurus*, and *Hypophthalmichthys nobilis* were documented, their population density, trophic roles, and ecological impacts on native fish assemblages were not quantitatively assessed.

Similarly, the bird observations, although valuable, were primarily descriptive and lacked statistical treatment. Habitat-use patterns were noted for species such as the Great Egret, Black Bittern, and Philippine Swamphen, but systematic surveys (e.g., point counts or transects) and quantitative analyses (e.g., diversity indices, habitat preference modeling) were not conducted. This limits the extent to which the findings can be generalized to broader ecological patterns.

Future research should therefore employ more comprehensive sampling techniques, including gill nets, electrofishing, and nocturnal surveys for fish, and standardized transect or point-count methods for birds. Quantitative analyses such as Shannon-Wiener or Simpson's diversity indices, coupled with population density estimates, would provide a more robust understanding of community structure. Additionally, integrating ecological data with socio-economic perspectives from local fish pen owners and communities would capture the combined effects of aquaculture expansion, climate change, and species introductions on biodiversity. Such an interdisciplinary approach will enhance conservation strategies and inform sustainable fisheries and wetland management in the region.

IV. Conclusion

This study documented the persistence of native biodiversity alongside the emergence of invasive and predatory species that may alter community dynamics. Tilapia and other cultured fishes dominated catches, while invasive species such as *Amphilophus citrinellus, Vieja melanurus,* and *Hypophthalmichthys nobilis* signaled potential ecological shifts. Bird observations, including the presence of indicator species such as the Great Egret and Black Bittern, further underscored the ecological importance of vegetated and aquaculture-associated habitats. Although largely descriptive, these findings provide a valuable baseline for assessing the combined impacts of climate change, aquaculture expansion, and species introductions on freshwater biodiversity.

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Recognizing the study's limitations, including small sample size, reliance on traditional fishing methods, absence of advanced statistical analysis, and lack of water quality data, the results nonetheless establish a crucial foundation for future ecological monitoring. By incorporating biodiversity assessments with key physico-chemical parameters (e.g., pH, dissolved oxygen, nutrient levels), future studies will be better able to link species diversity with underlying ecosystem conditions. Furthermore, integrating systematic sampling methods, diversity indices, habitat-use modeling, and invasive species impact assessments will strengthen the ecological interpretation of results.

In conclusion, this study contributes novel baseline information on the interplay between aquaculture and biodiversity in a vulnerable freshwater ecosystem. Despite its limitations, the research underscores the urgency of monitoring invasive species, habitat changes, and water quality, providing insights that are both ecologically relevant and practically significant for fisheries management, wetland conservation, and policy development. Lake. In this way, the inventory not only documents biodiversity but also contributes to fostering a culture of shared responsibility for conservation and sustainable resource use.

V. Acknowledgement

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