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Development and Evaluation of Web-Based Biodiversity Information Management System of Lake Mainit

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Abstract:
Lake Mainit, the fourth-largest and deepest inland lake in the Philippines, is recognized as a Key Biodiversity Area (KBA) due to its rich concentration of native, endemic, and threatened species. However, increasing anthropogenic pressures—such as habitat degradation, overexploitation, and pollution—pose significant risks to its ecological integrity. In response, this study aimed to develop and evaluate a Biodiversity Information Management System (BIMS) specifically designed for the lake. The system serves as a centralized digital platform for documenting, organizing, and accessing biodiversity data to support conservation planning, environmental education, and policy-making. The system was developed following established software engineering principles and assessed using the ISO/IEC 9126 software quality model, focusing on usability, functionality, portability, maintainability, and system satisfaction. The evaluation employed a quantitative research design utilizing a structured Likert-scale survey administered to selected stakeholders, including IT experts, local government officials, faculty members, and students. Results were analyzed using descriptive statistics and intraclass correlation coefficients to determine the level of system conformity and rating consistency among user groups. Findings indicated strong acceptance and high levels of agreement across all software quality attributes. The system was deemed technically sound, user-friendly, and applicable across different sectors. Overall, the BIMS demonstrated significant potential in enhancing biodiversity monitoring, facilitating informed decision-making, and promoting collaborative conservation efforts in the Lake Mainit.

Chapter 1
PROBLEM AND REVIEW OF LITERATURE

This chapter introduces the introduction, review of literature, conceptual framework, statement of the problem, hypotheses, scope and limitation of the study, significance of the study, and definition of terms.

Introduction

Lake Mainit, located in northeastern Mindanao, is the fourth-largest lake in the Philippines and holds the distinction of being the deepest inland body of water in the country, reaching depths of up to 223 meters. It spans an approximate area of 17,060 hectares, bordered by the provinces of Surigao del Norte and Agusan del Norte, and shared among the municipalities of Mainit, Alegria, Kitcharao, and Jabonga. The lake forms part of the Lake Mainit Key Biodiversity Area (KBA), a designated ecological zone recognized for its role in supporting various endemic, native, and migratory species (Seronay et al., 2020).

Recent assessments have confirmed Lake Mainit's high ecological value, housing at least 41 species of fish, 5 species of freshwater crustaceans, 8 mollusk species, and 14 documented aquatic plant taxa, some of which are endemic or threatened (Uy et al., 2015; Torres et al., 2021). Among these is the endangered priapium fish (*Neostethus thessa*), a species known to occur only in this lake, highlighting the uniqueness and conservation significance of its aquatic biodiversity (Torres et al., 2021).

In recent years, however, the lake has been increasingly exposed to environmental degradation. Anthropogenic activities such as mining, unsustainable agriculture, deforestation, and unregulated fishing practices have contributed to sedimentation, pollution, and the alteration of natural habitats. These stressors threaten the ecological balance of the lake and the sustainability of community livelihoods that depend on fishing, farming, and ecotourism (Seronay et al., 2020). Additionally, public health concerns such as the prevalence of water-borne diseases, including schistosomiasis, have been linked to poor sanitation and water management around the lake (Cassion et al., 2013).

Efforts to address these pressing issues are underway. Conservationists, researchers, and local governments have collaborated through the Lake Mainit Development Alliance (LMDA) to promote sustainable resource management and conservation policies. A significant proposal includes the designation of Lake Mainit as a protected area under the National Integrated Protected Areas System (NIPAS), which would provide a legal framework for environmental protection, biodiversity conservation, and community engagement (Seronay et al., 2020).

Given the complex socio-ecological context of Lake Mainit, a robust and integrative biodiversity information management system is essential. Such a system can serve as a centralized platform for documenting species data, monitoring environmental changes, guiding conservation planning, and informing evidence-based policies. This study explores existing literature relevant to Lake Mainit biodiversity, conservation efforts, and the role of digital information systems in environmental management.

Review of Literature

This part presents the related literature and studies sourced out from handbook, primer, research journals, seminar hand-outs, leaflets, brochures, and internet data that contributed to the present study which are organized thematically.

Biodiversity Profile of Lake Mainit

Lake Mainit is a critical freshwater ecosystem in northeastern Mindanao, renowned for its rich biodiversity. It is the deepest (219 m) and fourth-largest lake in the Philippines, with a surface area of about 17,060 ha and 28 tributary rivers feeding into it (Uy et al., 2015). The lake's oligotrophic waters support a high diversity of aquatic species. Recent surveys have documented at least 41 fish species in Lake Mainit, alongside 5 crustacean species, 8 mollusk species, and around 14 species of aquatic plants (Uy et al., 2015). Notably, the native white goby (*Glossogobius giuris*, locally called *pijanga*) and the goby *Hypseleotris agilis* (*bugwan*) are historically among the most important fish in the lake, though their populations have declined over time (Uy et al., 2015; Biña-de Guzman et al., 2013). Several non-native fishes such as tilapia, carp, and catfish have been introduced in past decades, altering the fish community composition (Uy et al., 2015). The lake's invertebrate fauna is likewise diverse – for instance, two endemic freshwater shrimps (*Caridina mindanao* or *isik* and *Macrobrachium lanceifrons* or *ulang*) are abundant in Lake Mainit, as are native bivalves (*Corbicula* sp.) and snails (*Vivipara angularis*, *Pomacea canaliculata*) that contribute to its food web (Uy et al., 2015). Aquatic vegetation includes extensive underwater meadows of *Hydrilla verticillata* and *Vallisneria*, with fringing wetlands hosting water hyacinth (*Eichhornia crassipes*) and the sacred lotus (*Nelumbo nucifera*) among others. This mosaic of flora[6] and fauna indicates a highly productive wetland ecosystem that has been recognized for its biological importance.

Beyond the lake itself, the surrounding watershed harbors significant terrestrial biodiversity. Lake Mainit and its watershed are designated as a Key Biodiversity Area (KBA) due to the presence of many endemic and threatened species (Seronay et al., 2020). A comprehensive biodiversity assessment recorded 244 plant species in the Lake Mainit watershed, of which 41 species (17%) are conservation priority species – including 4 critically endangered (e.g. the newly documented *Rafflesia mixta* in the region), 9 endangered, and 17 vulnerable species (Seronay et al., 2020; Barcelona et al., 2014). Around 40% of the flora in the area are Philippine endemics, underscoring the lake's national ecological value (Seronay et al., 2020). The faunal diversity is likewise remarkable. Surveys of terrestrial vertebrates identified 197 species in the watershed, including 23 species listed as conservation priorities (e.g. the Endangered South Philippine hawk-eagle, Philippine tarsier, Philippine warty pig, and several threatened bats and reptiles) (Seronay et al., 2020). Avifaunal studies have found that Lake Mainit's combined wetland and upland habitats support a rich bird life – *Lador and Seronay (2020)* recorded 138 bird species around the lake (about 20% [7]of all Philippine birds), with 45% being endemic and several listed as Near-Threatened or Vulnerable under the IUCN Red List.

Meanwhile, focused surveys of lakeshore and waterbird species documented at least 29 species of waterbirds (herons, egrets, terns, rails, etc.), including the Vulnerable silvery kingfisher (*Alcedo argentata*) along the lake's margins (Cabalang Jr., 2022). These findings illustrate that Lake Mainit's ecosystem – from its open waters and wetlands to its forested watershed – is a reservoir of biodiversity, hosting a wide array of species of local and global significance. Such a biodiversity profile establishes Lake Mainit as an ecological treasure in Mindanao and justifies its inclusion in conservation priorities.[8]

Environmental Threats to Lake Mainit

Despite its rich biodiversity, Lake Mainit's ecosystem is under mounting environmental stress from various anthropogenic threats. Overfishing and unsustainable resource use have long been identified as critical issues. Lake Mainit's fisheries exhibit the classic signs of over-exploitation: biodiversity loss, high fishing pressure, use of destructive fishing methods, and sharply declining fish catches (Biña-de Guzman et al., 2013). Historical data show a drastic collapse in fish production – annual catch plummeted from ~15,100 metric tons in 1980–81 to only ~832 tons by 2007–08, representing a mere 5.5% of the yield two decades prior (Biña-de Guzman et al., 2013). Overharvest has particularly impacted large and migratory species (e.g. the giant mottled eel, *Anguilla marmorata*, once abundant, has seen severe declines) and caused a reduction in average fish size and catch-per-unit effort, directly undermining fisher livelihoods (Biña-de Guzman et al., 2013). The open-access nature of the fishery and lax enforcement of regulations exacerbated these trends, with many species now rarely encountered compared to records from the 1990s (Uy et al., 2015; Biña-de Guzman et al., 2013).

The introduction of invasive and exotic species adds another pressure – non-native fish like tilapia and carp, as well as the golden apple snail, have established in the lake and compete with or predate upon native species (Uy et al., 2015). These invasive species alter food webs and habitat conditions (e.g.

proliferation of water hyacinth in tributary areas) and are considered among the urgent concerns for Lake Mainit's ecological sustainability (Uy et al., 2015).

Another major threat is habitat degradation, particularly deforestation and land-use change in the watershed. The Lake Mainit watershed's forest cover has steadily declined over the past few decades due to logging (legal and illegal), *kaingin* (slash-and-burn agriculture), and expansion of farms and settlements (Padilla & Vedra, 2015; Maglinte et al., 2020). Satellite-based analyses revealed significant loss of vegetative cover from 1976 to 2014 in portions of the watershed, especially around lower elevation lakeshore areas in municipalities like Mainit, Alegria, and Jabonga (Padilla & Vedra, 2015) The loss of forest and riparian vegetation has led to increased soil erosion and siltation of the lake, as well as the loss of habitat for terrestrial wildlife. Mining activities in the Lake Mainit area further compound these problems. The region is part of the mineral-rich Caraga corridor, and both small-scale mining and large 10
Mineral Production Sharing Agreements (MPSAs) exist in the vicinity of the lake (Lador & Seronay, 2020).

Mining operations (e.g. for gold or nickel) contribute to deforestation, soil disturbance, and pollution from mine tailings. Recent studies have found elevated heavy metal concentrations in Lake Mainit's waters and biota, suggesting mining-related contamination. For instance, Lake Mainit's sediments and fish have been reported as highly contaminated with nickel (Ni) and other metals, with enrichment factors indicating extremely severe Ni pollution at various sites (Agtong et al., 2023). Traces of Ni and chromium have 11
bioaccumulated in economically important fish like the tank goby (*Glossogobius giuris*), posing potential health risks to both the ecosystem and local communities consuming these fish (Agtong et al., 2023). These findings highlight the insidious impact of mining on water quality and aquatic life.

Intensified agricultural activities around the lake introduce additional stressors. The economy of surrounding municipalities relies heavily on agriculture (rice paddies, coconut plantations, etc.), which leads to runoff of fertilizers and agro-chemicals into the lake (Apdohan et al., 2021; Paylangco et al., 2020). Such runoff can cause nutrient loading and localized eutrophication, threatening the lake's oligotrophic status and potentially triggering algal blooms or fish kills. Moreover, conversion of wetlands to farmlands and encroachment on lake shores for agriculture reduce critical habitat for wildlife. Water quality deterioration has been observed, though it has not yet crossed regulatory limits for key parameters. A recent 16-month monitoring of Lake Mainit's water found that parameters like dissolved oxygen, pH, and nutrients remain within DENR standards for Class A/C waters (suitable for drinking after treatment and fisheries) (Vedra et al., 2023). However, that study noted a worrying trend: lake water temperatures have risen by ~0.9°C compared to a decade prior, a "glaring impact of global warming" that could alter 12
stratification and dissolved oxygen dynamics (Vedra et al., 2023). Climate change, manifesting in warming waters and possibly more erratic rainfall, is therefore an emerging threat that may exacerbate existing issues (e.g. by stressing cold-sensitive species or changing the timing of lake mixing).

In summary, multiple converging threats are impacting Lake Mainit biodiversity. These include overfishing, invasive species, deforestation, mining pollution, agricultural runoff, and climate-related changes. Studies uniformly indicate that without intervention, these stressors will continue to erode the lake's ecological integrity. Indicators of this decline are already evident: several native fish reported in the 1990s have not been encountered in recent surveys (Biña-de Guzman et al., 2013), and local residents and experts have observed biodiversity loss and habitat degradation accelerating in recent years (Dengg et al., 2023; Seronay et al., 2020). Indeed, Lake Mainit "experiences the typical syndrome of a threatened fishery resource" – a cascade of environmental and socio-economic issues driven by unsustainable resource use

(Biña-de Guzman et al., 2013). Recognizing these threats is crucial, as it frames the urgent need for effective conservation and management responses, including the development of robust information 13 systems to monitor and address the driving factors of environmental change.

Socio-Economic Implications of Lake Mainit's Biodiversity

The ecological challenges facing Lake Mainit cannot be separated from the socio-economic context of the communities around the lake. The lake is an essential resource for the livelihoods, food security, and well-being of tens of thousands of people in Surigao del Norte and Agusan del Norte. At least 31 barangays across eight municipalities border Lake Mainit, and an estimated 4,000 fisherfolk directly depend on its fisheries for income and subsistence (De Guzman et al., 2015). These fisheries provide vital protein to local diets and support associated industries (fish trading, processing, and marketing). Unfortunately, declining fish catches have meant that many full-time fishers remain impoverished – surveys in the late 2000s showed average fisher incomes around PhP 4,340 per month, which is below the rural poverty threshold (De Guzman et al., 2015). Such marginal incomes underscore the linkage between environmental degradation and poverty: as fish stocks dwindle due to overfishing and habitat loss, the communities whose livelihoods rely on those stocks suffer economically (Biña-de Guzman et al., 2013). Many fishing households struggle to meet basic needs, a situation exacerbated by the open-access 14 nature of the fishery (leading to competition and over-capitalization) and limited alternative employment in these rural areas (Biña-de Guzman et al., 2013).

Indeed, sustainable management of Lake Mainit is directly linked to local development outcomes: healthy fisheries and forests contribute to food security and buffer communities against climate and economic shocks, whereas environmental decline can exacerbate poverty and out-migration. As Apdohan et al. (2021) emphasized, Lake Mainit offers significant livelihood opportunities (fishing, farming, ecotourism) and thus its conservation is integral to ensuring long-term food security and economic stability for the surrounding communities.

In response to socio-economic needs, numerous intervention programs and institutional efforts have been introduced around Lake Mainit. Livelihood diversification projects (e.g. introduction of aquaculture, handicrafts, or sustainable agriculture training) have been implemented by government and NGOs in an attempt to reduce pressure on the lake's resources while improving incomes (De Guzman et al., 2015). The *Lake Mainit Development Alliance (LMDA)* – an alliance of the eight lakeshore municipalities formed in 1999 – has coordinated some of these initiatives, aiming for a development agenda that integrates environmental management and poverty reduction (LMDA, 2010). For instance, the LMDA's Environmental Management Plan and Development Agenda sought to harmonize 15 municipal land-use plans with conservation objectives, and promoted community-based resource management as a strategy for both ecological and social gains (LMDA, 2010).

Nevertheless, the effectiveness of these interventions has been mixed, in part due to limited funding, enforcement, and data to guide decision-making. The literature suggests that empowering local communities with sustainable livelihood alternatives and involving them in stewardship of the lake are crucial for success (Biña-de Guzman et al., 2013; Cabalang Jr., 2022). In sum, Lake Mainit's case exemplifies how biodiversity conservation and local development are inextricably connected – the lake's ecological health underpins the socio-economic prospects of its people, and any strategy for one must consider the other. This reality points to the need for integrative governance tools, such as a Biodiversity

Information Management System, that can inform balanced decisions benefiting both the environment and local communities. 16

Policy and Governance Framework

The conservation of Lake Mainit biodiversity operates within the broader Philippine environmental policy framework as well as local governance arrangements. At the national level, the National Integrated Protected Areas System (NIPAS) Act of 1992 (Republic Act 7586) and its amendment, the Expanded NIPAS Act of 2018 (RA 11038), provide the legal basis for establishing protected areas to conserve critical ecosystems. Lake Mainit has been identified as a candidate for protection under these laws.

In fact, the Lake Mainit watershed is one of the proposed protected areas in the Philippines under RA 11038 (DENR, 2018), recognizing its status as a Key Biodiversity Area and the need to safeguard its unique species and habitats. To advance this goal, the Department of Environment and Natural Resources (DENR) Caraga, in partnership with academia (Caraga State University), conducted extensive biological 17
and socio-economic assessments as part of a Protected Area Suitability Assessment (PASA) for Lake Mainit in the late 2010s (Seronay et al., 2020).

These studies mapped the distribution of threatened flora and fauna and recommended delineation of core "strict protection zones" and multiple-use zones in a proposed Lake Mainit Protected Landscape, in line with NIPAS guidelines (Seronay et al., 2020). The findings – such as the presence of critically endangered species and high endemism – bolstered the case for legal protection. Establishing Lake Mainit as a protected area would mean stricter regulations on resource use (e.g. fishing, mining, land conversion) and dedicated management by a Protected Area Management Board (PAMB), thereby addressing some of the governance gaps that exist currently.

However, it is noteworthy that as of the latest reports, Lake Mainit remains unprotected by national law, reflecting a wider gap in the Philippine protected areas system: many KBAs have no formal protection. Mallari et al. (2016) observed that while the country's protected areas cover about 11% of land area, roughly 64% of identified Key Biodiversity Areas were still outside the protected network at that time. 18
This mismatch means critical sites like Lake Mainit rely on local and ad-hoc measures for conservation in the interim. In the absence of a declared protected area, local governance mechanisms have played a key role.

The formation of the Lake Mainit Development Alliance (LMDA) in 1999 is a cornerstone of local environmental governance (LMDA, 2010). The LMDA is a coalition of the two provincial governments (Agusan del Norte and Surigao del Norte) and eight municipal governments around the lake, along with national agencies and civil society partners, united to coordinate the lake's management. The LMDA provides a platform for joint planning and has crafted an Environmental Management Plan and a Lake Mainit Development Agenda to guide sustainable development efforts (LMDA, 2010). Through this alliance, local ordinances have been harmonized to some extent – for example, fisheries ordinances setting mesh size limits or banning destructive fishing, and watershed management policies limiting logging in critical areas. The LMDA also engages in projects such as reforestation, fisheries management (e.g. fisherfolk organization and enforcement of closed seasons), and environmental awareness campaigns. While the LMDA has faced challenges (e.g. variable municipal commitment and funding constraints), it represents an important governance innovation: an inter-LGU (local government unit) collaboration targeting ecosystem-scale management.

In the Lake Mainit context, policy studies have highlighted the importance of reliable information for governance. For instance, note that many protected areas in the Philippines lack detailed information on the distribution of threatened species within their boundaries. This information gap can hinder proper zoning and management. The Lake Mainit PASA was an attempt to fill that gap prior to declaration, by providing maps of where key species are found and recommending which zones should be strictly protected versus which can be allocated for sustainable use. Similarly, local fisheries management plans have been hampered in the past by limited data on fish population dynamics and water quality. The literature suggests that strengthening environmental governance at Lake Mainit will require both robust policies (e.g. completing its protected area designation, updating local ordinances to align with conservation goals) and strong science-based support systems (e.g. monitoring programs, databases, and decision-support tools).

In summary, the policy framework for Lake Mainit is in transition: moving from largely local governance to potentially a nationally legislated protected area, backed by national biodiversity policies. The success of this framework will depend on effective implementation and the availability of accurate, timely data to guide actions. This is where the concept of a Biodiversity Information Management System becomes highly relevant – as a means to integrate data and inform policy and management decisions for Lake Mainit's conservation.

Existing Biodiversity Information and Conservation Initiatives

Numerous initiatives have been undertaken in recent years to document, monitor, and protect the biodiversity of Lake Mainit, laying the groundwork for a more systematic information management system. As noted, the DENR-Caraga and Caraga State University conducted comprehensive biodiversity surveys (2013–2017) to inform the Protected Area Suitability Assessment. These studies involved creating species inventories, mapping habitats, and identifying critical zones (Seronay et al., 2020; Lador & Seronay, 2020). The data from these assessments are compiled in technical reports and policy briefs (e.g. the Lake Mainit Key Biodiversity Area Policy Brief, 2023) which serve as interim information repositories.

In parallel, academic research by Mindanao-based institutions has contributed detailed knowledge on specific aspects of Lake Mainit's ecology – for example, the MSU Naawan research team's "Aquatic Biodiversity of Lake Mainit" provided an inventory of aquatic species and highlighted long-term trends, while other studies have focused on flora (Maglinte et al., 2020), birds (Lador & Seronay, 2020; Cabalang Jr., 2022), limnology (Vedra et al., 2023), and pollution (Agtong et al., 2023). Each of these efforts generated valuable datasets and reports. However, a recurring observation is that these data remain fragmented and not easily accessible to local decision-makers. They are scattered across journal articles, university archives, and agency files, underscoring the need for a unifying system.

On the community and local government side, the Lake Mainit Development Alliance (LMDA) has attempted to establish a local monitoring system. In the 2000s, the LMDA, with support from donors (e.g. the Canadian-assisted Local Government Support Program and GEF Small Grants Programme), trained community members to conduct simple biodiversity and fish catch monitoring. Community-based organizations and fisherfolk cooperatives were involved in gathering data such as monthly fish catch statistics, observations of invasive species spread, and reporting of wildlife sightings or incidents (LMDA, 2010; De Guzman et al., 2015). These were the rudiments of a local biodiversity information system, though largely paper-based and project-driven.

One notable output was an Environmental Management Plan (EMP) for Lake Mainit (circa 2005–2010) which compiled ecological profiles and identified areas for conservation and rehabilitation (LMDA, 2010). The EMP and subsequent Lake Mainit Development Agenda integrated environmental data with socio-economic plans, signifying an early recognition that good data is key to planning. Still, without [23] continuous updating, the information in those documents has aged; for instance, the EMP relied on surveys from the late 1990s and early 2000s. This has motivated periodic new projects (like the recent PASA surveys) to update the knowledge base.

At the national and regional level, the Philippines has been building platforms for biodiversity data that could support local systems. The Philippine Clearing-House Mechanism (CHM) for biodiversity (BioWEB) is an online portal under the Biodiversity Management Bureau intended to share datasets and information on the country's biodiversity (DENR-BMB, 2016). Through initiatives like the ASEAN Centre for Biodiversity (ACB) and the Global Biodiversity Information Facility (GBIF), efforts have been made to mobilize biodiversity data from the Philippines. For example, the ASEAN Centre for Biodiversity [24] and University of the Philippines Los Baños developed the Makiling Biodiversity Information System (MakiBIS) – an online database of species in Mt. Makiling Forest Reserve – which serves as a prototype for a nationwide system (Elloran & Macandog, 2025).

MakiBIS consolidates species records from various studies into a single repository that is accessible online, and it adheres to international data standards (Darwin Core) enabling global sharing via GBIF (Elloran & Macandog, 2025). The vision, as stated by Elloran & Macandog (2025), is to eventually develop a Philippine Biodiversity Information System (PhilBIS) through inter-agency partnership, scaling up such local portals to cover other key sites. This is directly relevant to Lake Mainit – any Biodiversity Information Management System for the lake could potentially interoperate with national platforms like BioWEB or GBIF, ensuring that Lake Mainit's data contributes to and benefits from broader biodiversity information networks.

In terms of on-ground conservation initiatives, Lake Mainit has also benefited from partnerships and funding aimed at habitat protection and restoration. For instance, reforestation projects in the watershed (often spearheaded by DENR's forestry programs or by NGOs) have been ongoing to curb erosion. There [25] have been community-based fisheries management projects (with support from SEAFDEC and BFAR) that introduce science-based limits (such as fish sanctuaries or closed seasons) and improve catch data collection.

The Critical Ecosystem Partnership Fund (CEPF) and other donors have identified the Eastern Mindanao Biodiversity Corridor, which includes Lake Mainit, as a priority for biodiversity conservation investments (CEPF, 2012). These projects often require baseline and monitoring data to measure their impact, further emphasizing the need for good information management. However, a gap identified in the literature is the lack of a centralized, updated database where one can retrieve all pertinent information about Lake Mainit's biodiversity, threats, and conservation actions. The existing initiatives have generated plenty of data, but without integration, it is difficult to see the "big picture" or to perform analyses across datasets (e.g. correlating fish catch trends with water quality or land cover change).

Thus, while numerous efforts testify to a growing body of knowledge and concern for Lake Mainit, they also collectively point to the necessity of a formal Biodiversity Information Management System (BIMS). Such a system could build upon the results of past projects, serve as a repository for all future data collected, and facilitate continuous monitoring. Importantly, it could also link local efforts with national and international data infrastructures, ensuring that Lake Mainit is not conserved in isolation but as part of the Philippines' commitment to biodiversity conservation.

Toward a Biodiversity Information Management System for Lake Mainit

The literature strongly supports the development of a Biodiversity Information Management System (BIMS) for Lake Mainit, emphasizing its role in addressing fragmented and outdated ecological data (World Bank, 2023). A centralized BIMS would consolidate information on species distribution, habitat quality, water parameters, and threat indicators—allowing for real-time monitoring and responsive conservation planning. Seronay et al. (2020) highlight how spatial data can guide zoning decisions in protected areas, while Güntsch et al. (2025) stress that national biodiversity infrastructures function as platforms for data integration and science-policy alignment. As such, the BIMS would aid local managers in defining protected zones, regulating resource use, and evaluating ecological trends over time.

Beyond technical benefits, the system fosters collaboration among stakeholders, including LGUs, researchers, NGOs, and local communities. Elloran and Macandog (2025) illustrate how platforms like MakiBIS enable the inclusion of local biodiversity data into global repositories such as GBIF, enhancing visibility and data sharing. The BIMS would also facilitate evaluation of conservation outcomes—such as the effectiveness of closed fishing seasons or pollution mitigation—through continuous updates of ecological indicators. In doing so, it supports adaptive management and provides a feedback mechanism for policy refinement.

Finally, the BIMS aligns with broader national and international commitments, including the Philippine Biodiversity Strategy and Action Plan (DENR-BMB, 2016), the Convention on Biological Diversity, and the Post-2020 Global Biodiversity Framework (IPBES, 2019). It ensures that Lake Mainit contributes to and benefits from global biodiversity knowledge systems, positioning the lake as a well-monitored and strategically managed ecosystem.

In conclusion, the literature underscores that a BIMS is not merely a technical innovation but a critical tool for integrated conservation governance, enabling evidence-based action, stakeholder participation, and global knowledge exchange for the protection of Lake Mainit.

Theoretical Framework

The development of the Biodiversity Information Management System (BIMS) for Lake Mainit is underpinned by a multidisciplinary theoretical foundation. This framework integrates principles from software quality assurance, ecological systems thinking, and stakeholder theory to provide a comprehensive scholarly lens for the study.

Central to this research is the ISO/IEC 9126 Software Quality Model, which defines six key attributes of software quality. For this study, four attributes—functionality, usability, maintainability, and portability—along with system satisfaction are emphasized. These dimensions guide the evaluation of the BIMS, ensuring that it meets the standards of software efficiency and user-centered design. This model supports the technical rigor necessary for system assessment and is widely used in software engineering and IT-based research. The quality of a digital biodiversity information system relies heavily on these principles to provide effective service to its users.

The study also draws on Ecological Systems Theory, initially proposed by Bronfenbrenner (1979), which has been adapted in environmental studies to understand the interconnected layers of ecosystems. Applying this perspective, the BIMS is conceptualized as a tool responsive to the dynamic ecological conditions of Lake Mainit. The theory supports the collection and interpretation of biodiversity data in a manner that reflects the lake's complex environmental context, including the interactions among species, habitats, and human interventions. The theory encourages adaptive management through information systems that are reflective of ecological complexity.

In addition, Stakeholder Theory (Freeman, 1984) is utilized to justify the participatory design of the system. Since the BIMS serves multiple users—LGUs, educators, researchers, and community members—this theory provides the rationale for incorporating stakeholder feedback into the development and evaluation processes. It emphasizes accountability and relevance in system design. The effective implementation of BIMS relies on understanding and balancing the varying interests of its users, which Stakeholder Theory appropriately addresses.

Together, these three theories ensure that the BIMS is not only technologically robust but also ecologically relevant and socially inclusive. The integration of these theoretical perspectives underlines the multifaceted goals of the system, bridging environmental science, governance, and information technology. This theoretical lens validates the interdisciplinary nature of BIMS and ensures that it serves both scientific and practical objectives in the conservation of Lake Mainit's biodiversity.

Conceptual Framework

This study is anchored in institutional, sustainability, and software quality frameworks. It builds upon the completed CHED-funded DARE TO project titled "Investing Biodiversity Training Center: A Sustainable Community-Based Ecosystem Approach for the Conservation of Lake Mainit," which emphasized the integration of scientific research, local knowledge, and community participation in biodiversity conservation. Aligned with these objectives, the study develops a Biodiversity Information Management System (BIMS) to support the systematic documentation, organization, and dissemination of biodiversity data for Lake Mainit's aquatic and terrestrial ecosystems. The study further supports the goals of the United Nations Sustainable Development Goals, particularly SDG 14 (Life Below Water) and SDG 15 (Life on Land), by promoting data-driven conservation, education, and ecological monitoring. To ensure software quality and usability, the ISO/IEC 9126 Software Quality Model is employed as the evaluation framework, assessing the system's functionality, usability, maintainability, and portability in alignment with international standards.

The study utilized the Input-Process-Output Model (IPO) and Agile methodology for system development which includes plan, design, develop, test, deploy and review. The study adopts an integrated conceptual framework combining the Input-Process-Output (IPO) Model and Agile methodology to guide the development of the Biodiversity Information Management System (BIMS) of Lake Mainit. The Input stage involves gathering biodiversity data and user requirements from stakeholders such as researchers, educators, and local government units. The Process stage follows Agile's iterative cycle, including analysis, design, development, and continuous validation through stakeholder feedback. The Output includes a functional BIMS platform that enables species data management, supports educational use, and enhances conservation efforts. System performance is evaluated using ISO 9126 standards, ensuring functionality, usability, and maintainability. This integrated approach ensures that the system is both structured and flexible, responsive to user needs, and effective in promoting biodiversity awareness and management.

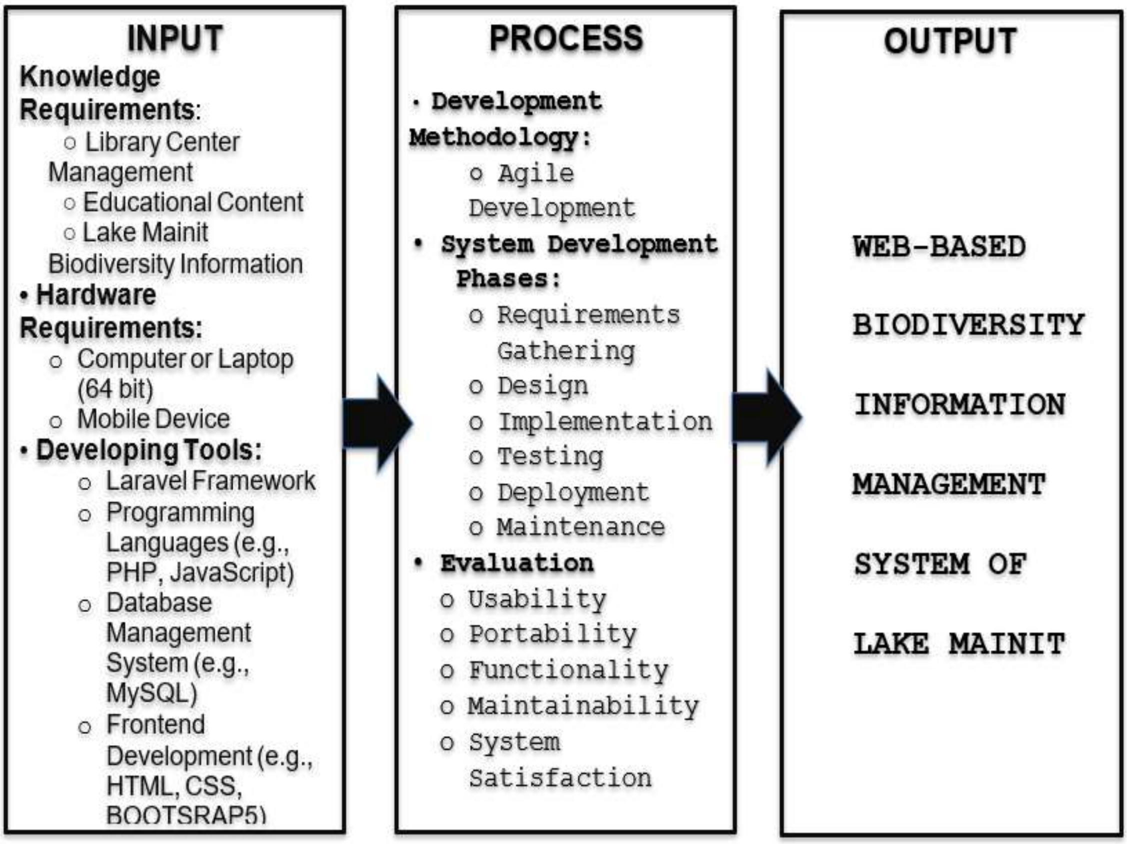

Figure 1

Research Paradigm

Statement of the Problem

This study aimed to develop a biodiversity information management system in Lake Mainit.

1. What are the essential functional and technical features required in the development of the Biodiversity Information Management System for Lake Mainit?

2. What extent does the developed system conform to the software quality standards as evaluated by IT experts' in terms of:

2.1 usability;
2.2 functionality;
2.3 portability;
2.4 maintainability; and
2.5 system satisfaction.

3. How do LGU heads, faculty and students as end-users assess the conformity of the developed system in terms of:

3.1 usability;
3.2 functionality;
3.3 portability; and
3.4 system satisfaction.

4. How does the developed Biodiversity Information Management System (BIMS) contribute to stakeholders' functions in biodiversity monitoring, policy-making, education, and resource management in the Lake Mainit?

Hypotheses

This study is hypothesis-free.

Scope and Limitation of the Study

This study was limited to the following aspects:

The respondents of this study were purposively selected based on their direct involvement in biodiversity management, academic research, and information system development relevant to the Lake Mainit. A total of 3 respondents participated in the study, comprising 3 from Local Government Unit of Mainit Municipality, 5 faculty members, 5 science major students, and 2 IT experts. The MENROs were selected from municipalities surrounding Lake Mainit, including representatives from both Surigao del Norte and Agusan del Norte. Their role in local environmental governance and biodiversity monitoring positioned them as key stakeholders in evaluating the operational usability and institutional applicability of the Biodiversity Information Management System (BIMS).

The academic respondents included faculty members and students from Surigao del Norte State University (SNSU) and other nearby academic institutions. The 5 faculty members, with backgrounds in biology, environmental science, and ecology, provided expert evaluations on the scientific content and research utility of the system. Meanwhile, 5 students majoring in science-related programs contributed perspectives on the system's educational value, accessibility, and potential as a learning tool in the context of biodiversity conservation.

Additionally, 2 Information Technology (IT)/System developer experts, including MIS officers and local system developers, were involved to assess the system's design, technical structure, user interface, and functional scalability. Their technical feedback contributed to the refinement of the system's architecture and performance features. These three respondent groups—LGU, academic researchers (faculty and students), and IT/ system developer experts—ensured a comprehensive evaluation of the BIMS in terms of practical functionality, scientific accuracy, and digital performance.

Significance of the Study

The development of a Biodiversity Information Management System (BIMS) for Lake Mainit holds significant value across multiple sectors engaged in biodiversity conservation, ecological research, and environmental governance. The study's findings and system output will serve as a vital tool in organizing, preserving, and utilizing biodiversity data relevant to Lake Mainit's unique ecosystem.

School Administrators. The system enables school administrators to enrich curricula in environmental science and sustainability by integrating real-time biodiversity data. It also supports institutional research, community extension, and strategic planning for eco-programs, aligning with CHED, DepEd, and SDG mandates.

Academic institutions. This may benefit the faculty and students in the fields of biology, environmental science, ecology, and information technology, will gain from the system as a research and learning resource. Faculty members can use the BIMS to support curriculum enrichment and field-based instruction, while students can access organized data for thesis writing, biodiversity inventories, and scientific analysis.

Local Government Units (LGUs)—particularly Municipal Environment and Natural Resources Offices (MENROs). This will benefit from the BIMS as it provides a structured and accessible platform for storing and retrieving biodiversity-related information. This supports evidence-based policy formulation, strategic conservation planning, and compliance with national environmental mandates such as the Philippine Biodiversity Strategy and Action Plan (PBSAP).

Environmental agencies such as the Department of Environment and Natural Resources (DENR), the Bureau of Fisheries and Aquatic Resources (BFAR), and the Lake Mainit Development Alliance (LMDA). This may be system beneficial in consolidating regional biodiversity data for monitoring, reporting, and policy alignment. The platform can help facilitate data sharing and coordination among multiple stakeholders.

Non-governmental organizations (NGOs) and community-based conservation groups. This may be useful to support grassroots initiatives, community education, and participatory conservation activities. Having access to updated and validated biodiversity information can empower these groups to advocate more effectively for ecosystem protection.

Information Technology (IT) professionals and system developers. This may provide benefit through their involvement in refining and scaling the system architecture, promoting the application of digital tools in environmental resource management, and encouraging local innovation in sustainability solutions.

General public. In particular, the communities living within and around the Lake Mainit watershed, stand to benefit from enhanced biodiversity awareness, improved local governance, and strengthened environmental stewardship fostered by access to accurate and integrated biodiversity information. The system contributes to the long-term vision of sustainable biodiversity management and conservation in the region.

Researchers. This study provides significant support to researchers engaged in biodiversity studies, conservation biology, system design, and environmental informatics. By offering a centralized and validated source of species data, habitat information, and ecological records, the system facilitates empirical investigation, longitudinal monitoring, and scholarly publication. It also promotes interdisciplinary collaboration among ecological, technological, and policy researchers.

Definition of Terms

To ensure clarity and precision in this study, the following key terms are defined both conceptually, based on scholarly and legal sources, and operationally, based on how they are applied within the context of this research. The terms are as follows:

Biodiversity. It refers to the variety of all life forms on Earth—plants, animals, microorganisms—the genes they contain, and the ecosystems they form (Convention on Biological Diversity, 1992). In this study, biodiversity refers to the documented species of flora and fauna within the Lake Mainit ecosystem, particularly those featured in the developed BIMS.

Biodiversity Information Management System (BIMS). It is a technology-based tool used to collect, manage, store, and share biodiversity-related data for decision-making and conservation planning (Chapman, 2005). The BIMS in this study is a web-based system developed to organize and present biodiversity data from Lake Mainit, accessible to stakeholders such as LGUs, researchers, and students.

Functionality. It refers to the Biodiversity Information Management System capability to deliver core features such as species data input, retrieval, taxonomy classification, search filters, and reporting tools. It also covers the accuracy and consistency of the information provided to users for biodiversity management and education.

Maintainability. It is the capability of a software product to be modified, which includes corrections, improvements, or adaptation to changes in environment and requirements (ISO/IEC 9126-1, 2001). Within the context of this study, maintainability refers to the extent to which the BIMS can be efficiently updated, debugged, or expanded by developers.

Portability. It denotes the degree to which a software system can be transferred from one environment to another, including across different hardware, operating systems, or browsers, without compromising performance (ISO/IEC 9126-1, 2001). In this research, portability describes the BIMS's operability across multiple platforms, including desktops, tablets, and mobile devices, as well as its compatibility with various web browsers. It reflects the system's adaptability to different user environments without requiring extensive reconfiguration.

System Satisfaction. In this study, system satisfaction captures the overall perception of users—including faculty, students, LGUs, and researchers—regarding the performance and benefits of the Biodiversity Information Management System. It includes the degree to which the system supports biodiversity education, data access, and conservation planning in the Lake Mainit.

Usability. It refers to the extent to which data is useful, accessible, interpretable, and actionable for users (Batini & Scannapieco, 2006). In this study, usability pertains to the ease with which stakeholders—including educators, students, local government staff, and researchers—can interact with the BIMS platform. This includes the system's intuitive design, clarity of interface elements, navigational flow, and the ability to perform tasks with minimal training or error.

Chapter 2
METHODS

This chapter presents the research design, research environment, research instrument, respondents, ethics, and data gathering procedure, and data analysis.

Research Design

This study employed a combination of developmental and descriptive research designs to conceptualize, develop, and evaluate the Biodiversity Information Management System (BIMS) for Lake Mainit. The developmental design facilitated the systematic structuring of the BIMS platform to manage species data, ecological profiles, and conservation-related records tailored to the lake's biodiversity landscape. Meanwhile, the descriptive design involved the use of structured survey questionnaires and consultations with key stakeholders to assess the system's quality in terms of usability, functionality, portability, maintainability, and overall user satisfaction. The findings from this phase contributed to refining the system to better serve its purpose as a support tool for biodiversity monitoring and conservation efforts in the Lake Mainit.

Figure 2

AGILE METHODOLOGY

AGILE Cyclic Process

The study employed the **Agile methodology** as the primary approach for system development, emphasizing flexibility, stakeholder collaboration, and iterative progress. Agile follows a cyclical process comprising planning, design, development, testing, deployment, and review. In the **planning phase**, objectives are established, and priorities are set in consultation with stakeholders. The **design phase** translates requirements into system architecture and user interface prototypes. During the **development phase**, functional components are incrementally built through rapid coding sprints. The **testing phase** ensures that each module meets quality standards and user expectations. In the **deployment phase**, the system is implemented in its target environment for real-world use. Finally, the **review phase** involves gathering feedback, evaluating performance, and identifying areas for refinement, ensuring continuous improvement throughout the development cycle. This methodology ensures that the system remains user-centered, adaptable, and aligned with evolving needs.

RESEARCH PARTICIPANTS

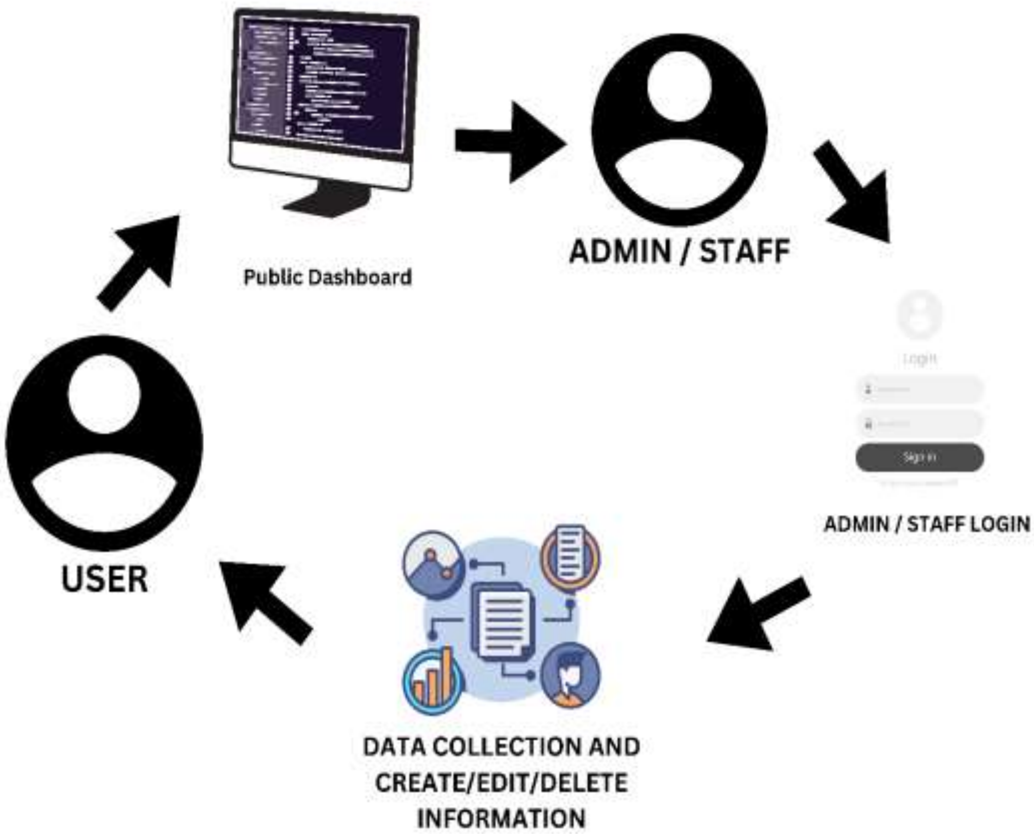

Figure 3

OVERVIEW OF THE SYSTEM

The system architecture of the Lake Mainit Biodiversity Information Management System illustrates the operational flow and structural components that govern user interaction and data management. It is strategically organized into two primary access levels: the public-facing user interface and the administrator-controlled backend, balancing broad accessibility with secure administrative oversight.

a. User Interface

The platform adopts a user-centric design, accessible via its official domain, app.lakemainit-biodiversity.com. It offers open access to the general public, allowing users to explore categorized biodiversity data on various taxa such as fishes, amphibians, reptiles, plants, mollusks, and other species native to Lake Mainit. Each entry includes comprehensive taxonomic information, species descriptions, habitat details, and conservation status. The interface is optimized for usability and searchability, supporting both educational and scientific engagement. This open-access structure reinforces the system's objective of fostering environmental awareness, community participation, and research collaboration.

Features of the Biodiversity Information Management System

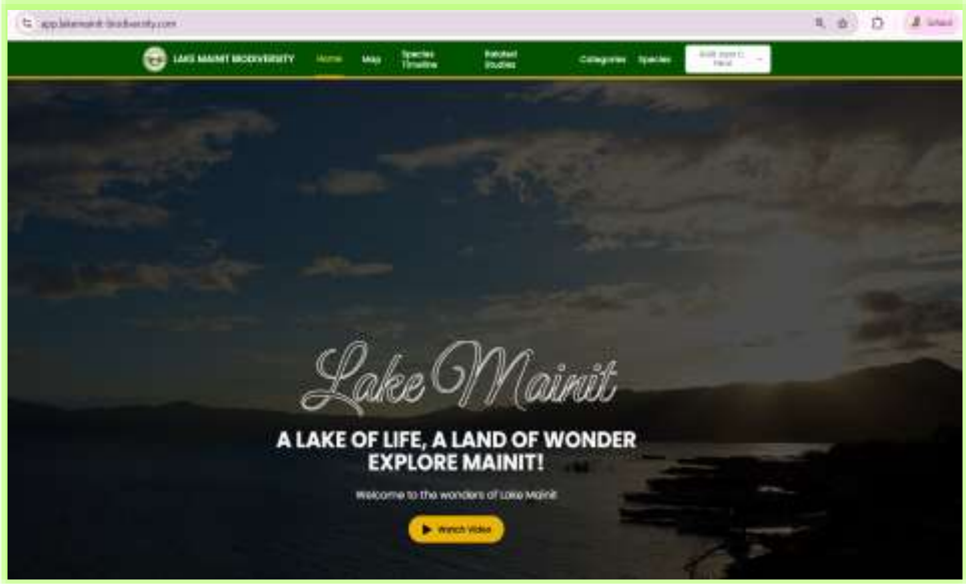

Plate 1

Homepage of the Biodiversity Information Management System of Lake Mainit

The homepage of the Lake Mainit Biodiversity Information Management System accessible at https://app.lakemainit-biodiversity.com/ features a scenic view of the lake and provides access to key modules such as the map, species timeline, related studies, and species database. It highlights the slogan "A Lake of Life, A Land of Wonder" and includes a video link introducing Lake Mainit's biodiversity.

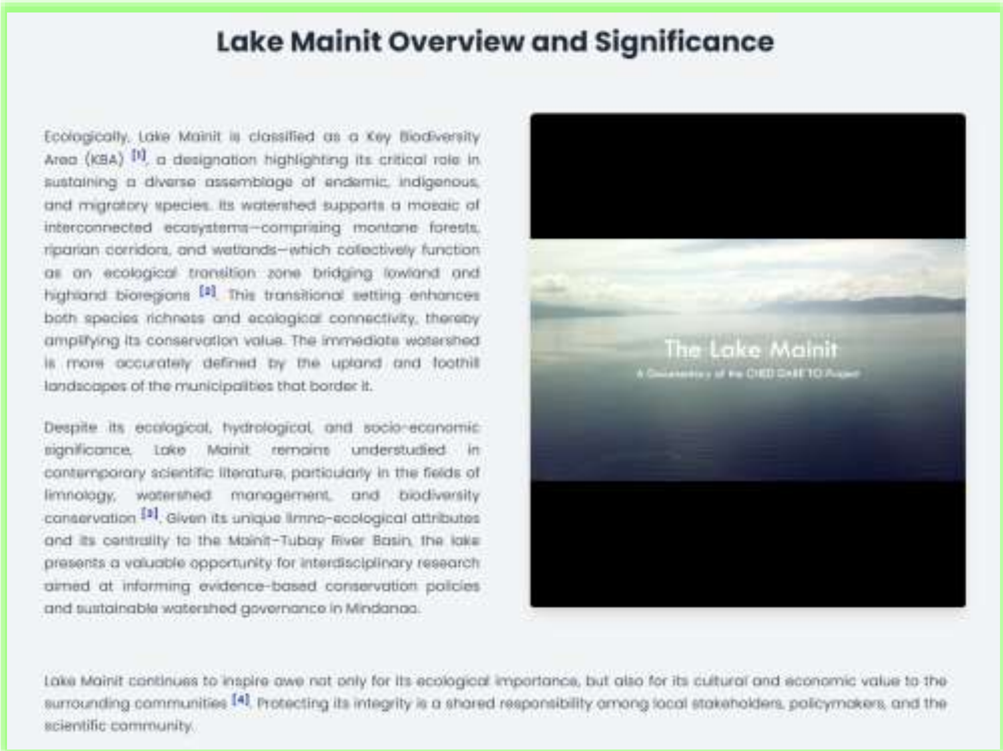

Plate 2

Lake Mainit Overview and Significance

This section highlights the ecological and socio-economic significance of Lake Mainit as a Key Biodiversity Area (KBA). It underscores the lake's role as an ecological transition zone and a subject of interdisciplinary research. A featured video from the CHED DARE TO Project provides visual context on Lake Mainit's natural landscape and conservation relevance.

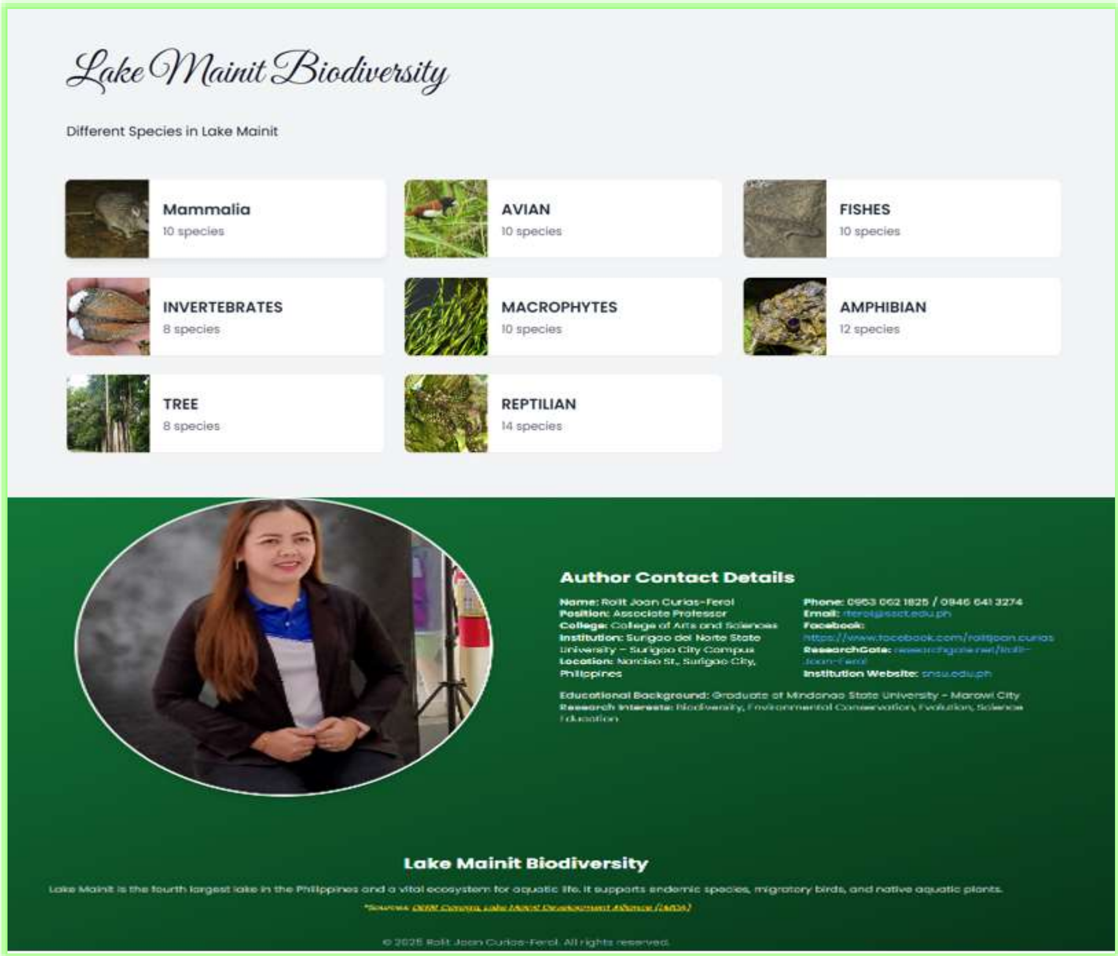

Plate 3

Interactive Species Directory and Author Information Panel

This section presents an interactive interface categorizing the documented species in Lake Mainit by biological groups. It also includes the author's institutional credentials, educational background, and research focus, serving as a point of contact for academic and conservation-related engagement.

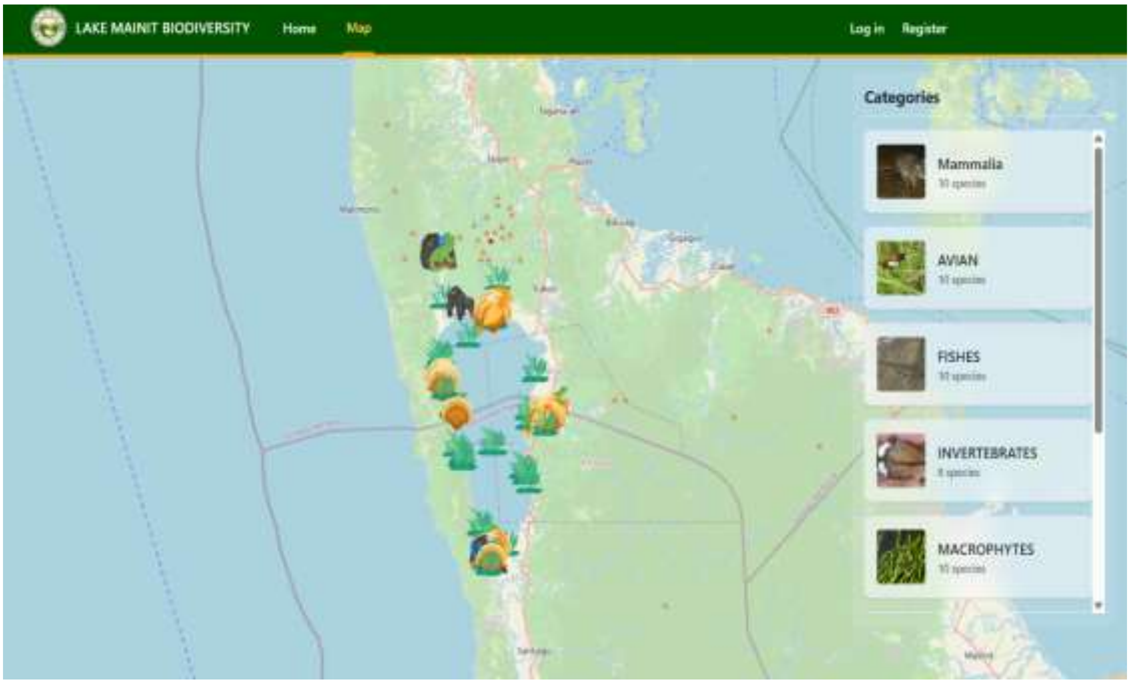

Plate 4

Interactive Map Interface Showing Species Counts and Locations in Lake Mainit
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This figure presents the mapped locations of major biodiversity groups in Lake Mainit, with the following recorded species counts: Mammalia (10), Avian (10), Fishes (10), Invertebrates (8), and Macrophytes (10). Each marker corresponds to a category, enabling users to visualize species distribution in real time.

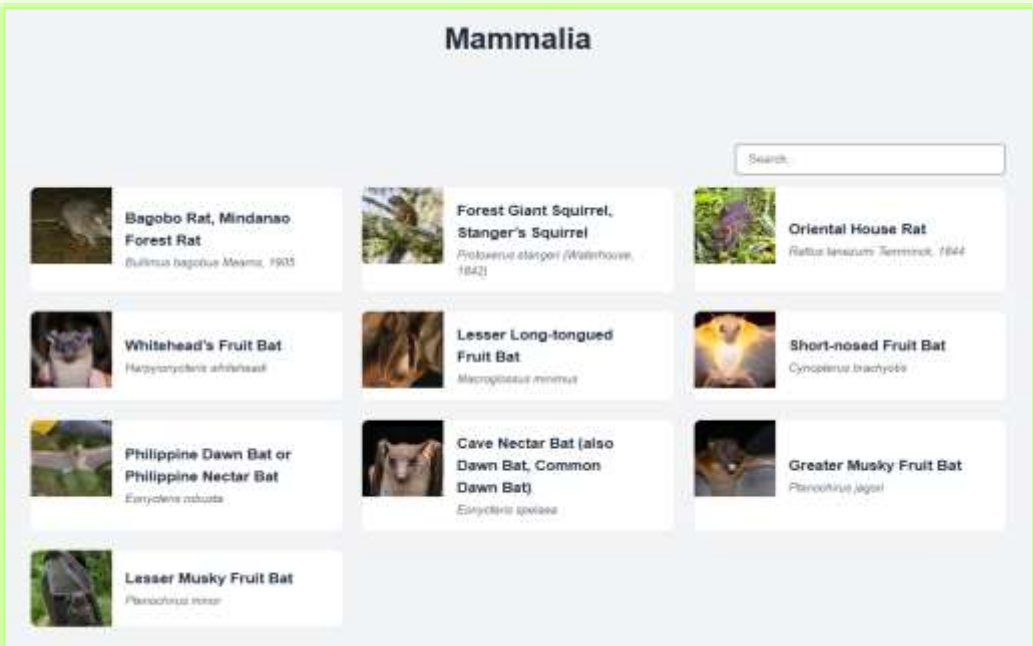

Plate 5

Categorized Visual Listing of Identified Mammal Species Found in the Lake Mainit

This interface displays a categorized visual listing of mammal species in Lake Mainit, featuring images, names, and a search function to support easy identification and biodiversity awareness.

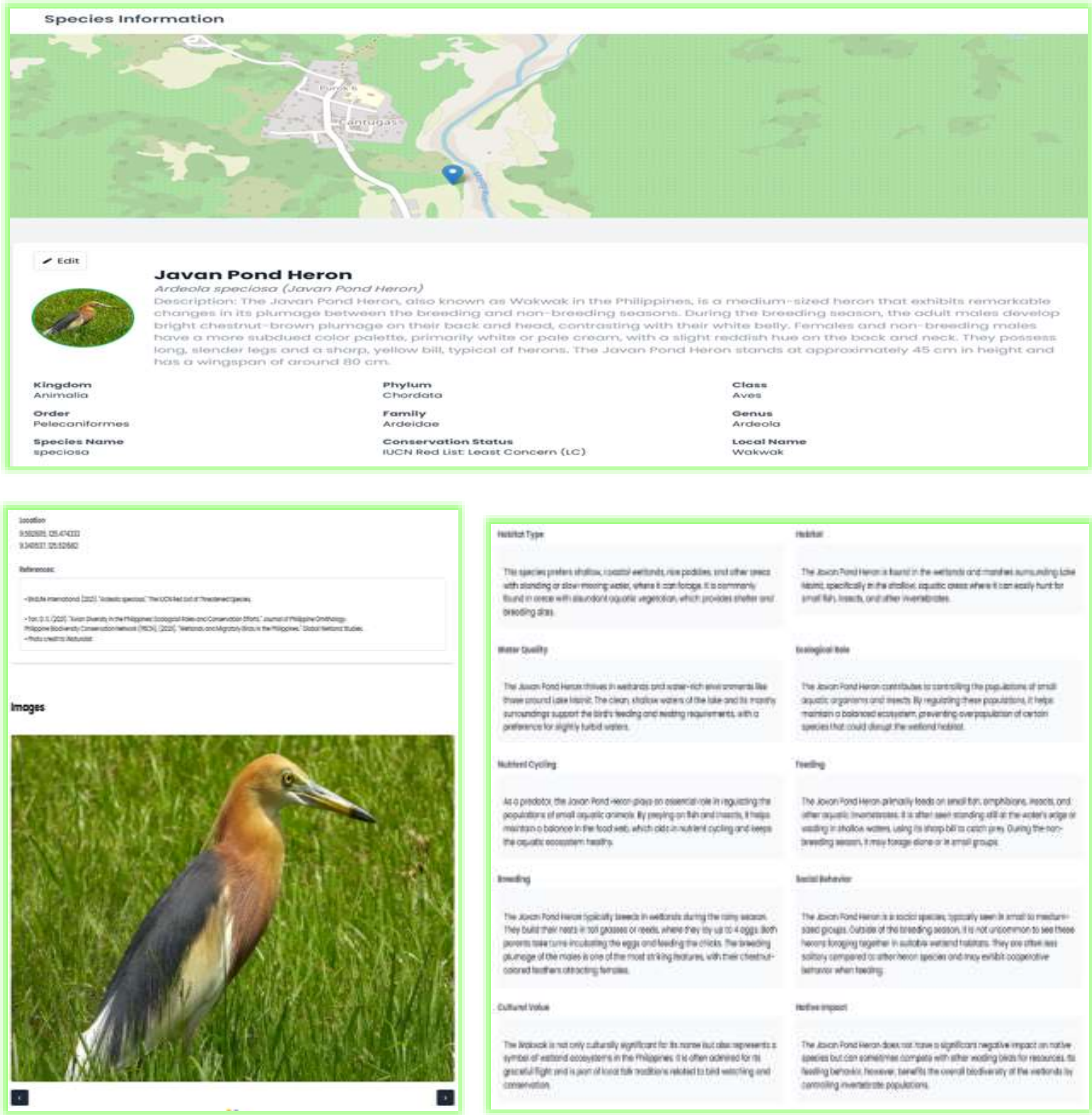

Plate 6

Sample Species Profile in Lake Mainit BIMS

A sample species entry in the system, featuring basic information, taxonomy, description, and mapped location for the Javan Pond Heron (*Ardeola speciosa*).

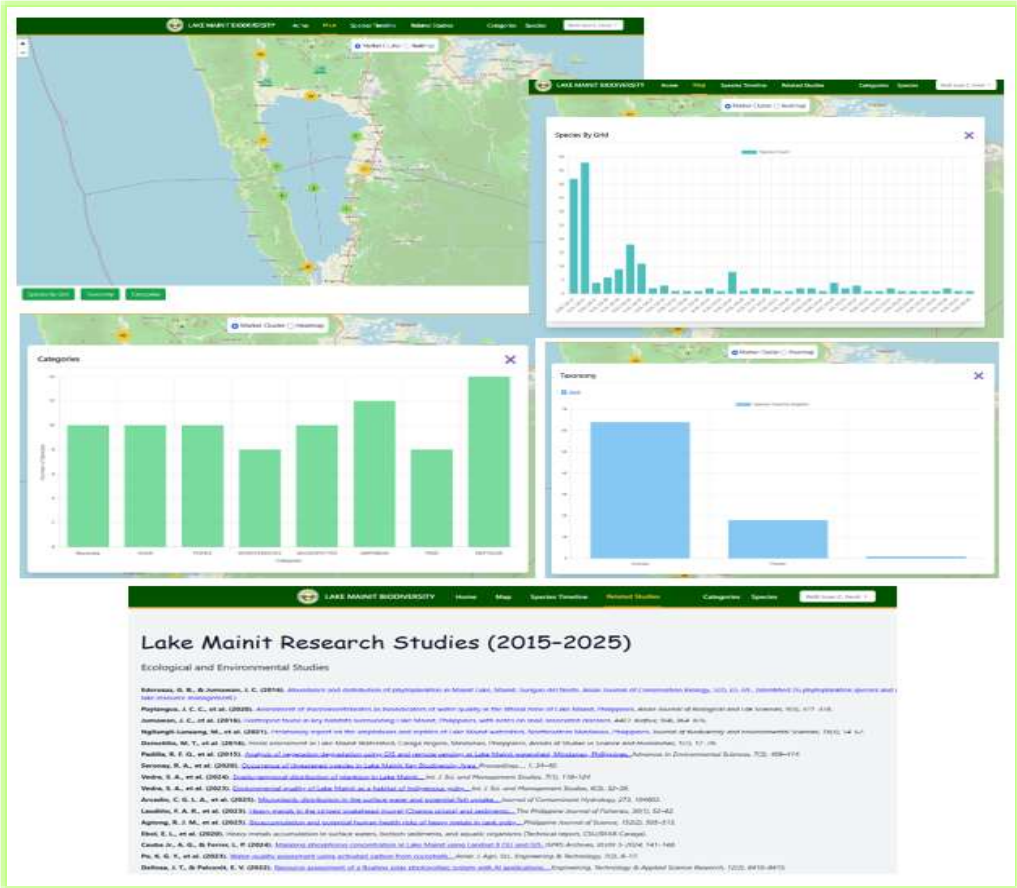

Plate 7
Data Analytics Visualization and Research Repository
It includes map-based species clustering, graphical summaries of species distribution by grid and taxonomy, and bar charts of biodiversity categories. At the bottom, the “Lake Mainit Research Studies (2015–2025)” section provides a compiled list of scientific publications supporting ecological and biodiversity research in the Lake Mainit area.

Plate 8

Admin Login Interface of the Lake Mainit Biodiversity Information Management System

This secure login page provides administrative access to the Lake Mainit BIMS platform. Set against a scenic backdrop of Lake Mainit, the interface includes credential fields, password recovery, and Google login integration. It ensures that only authorized personnel can manage and update the system's backend data and functionalities.

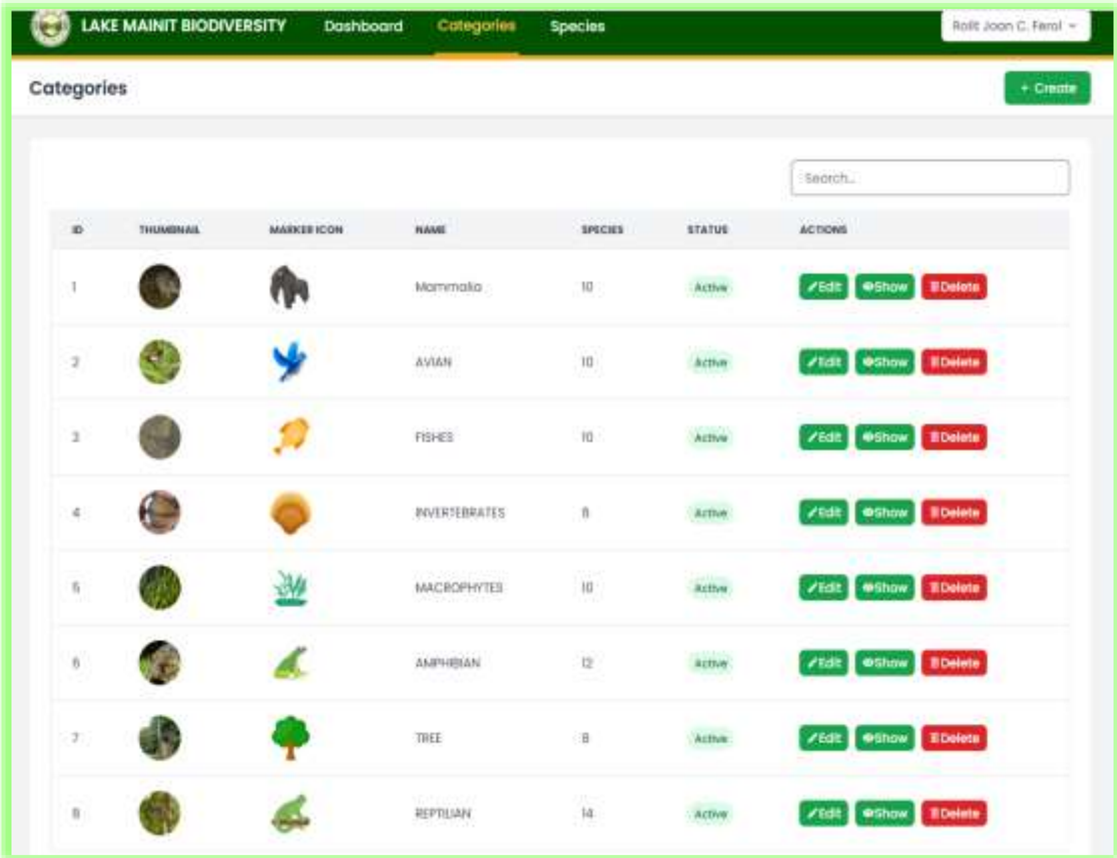

Plate 9

Species Categories Dashboard in the Lake Mainit BIMS

This dashboard displays the main species categories encoded in the Lake Mainit Biodiversity Information Management System. It includes thumbnails, icons, species count, and status for each category, with quick access to edit, view, or delete functions for system management.

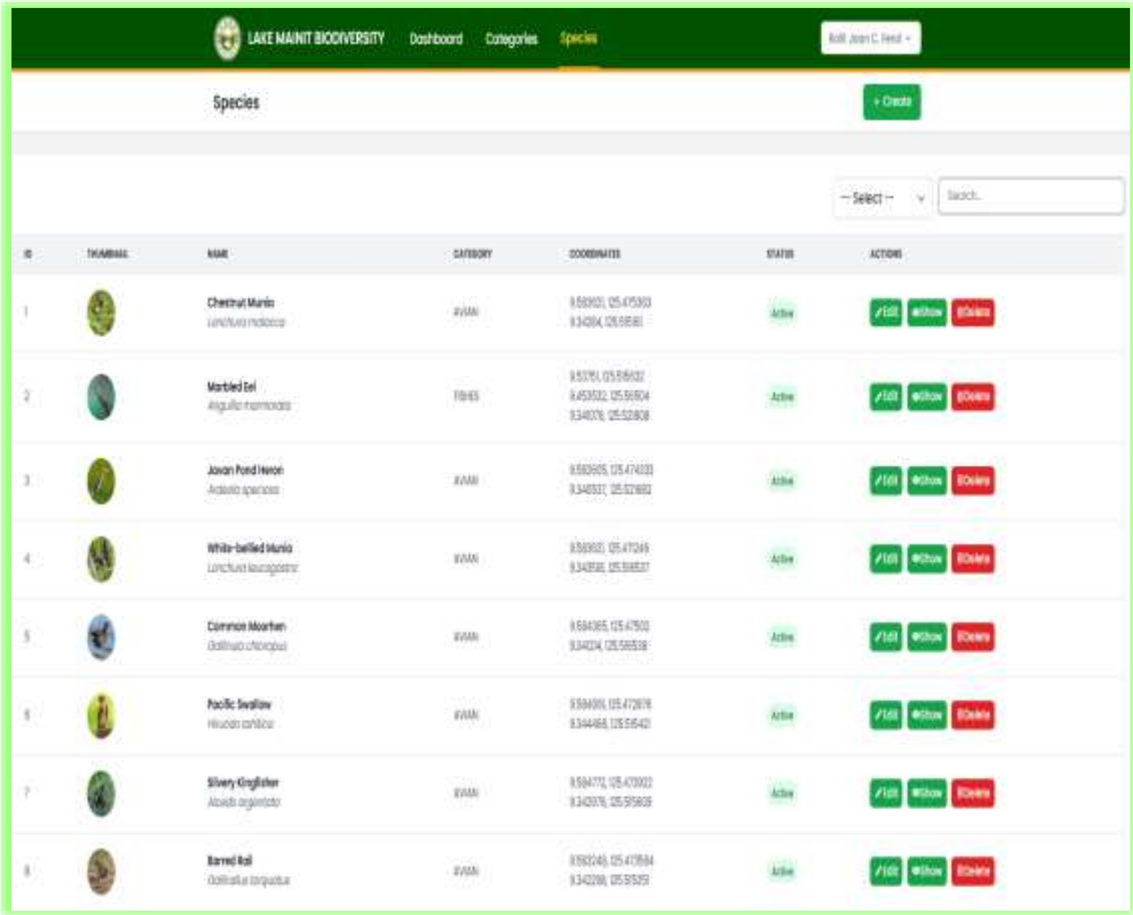

Plate 10

Species Records Interface in the Lake Mainit BIMS

This displays the species management interface of the Lake Mainit Biodiversity Information Management System. It lists species names, categories, geographic coordinates, and status. Each entry includes options to edit, view, or delete records, supporting efficient data organization and real-time updates for biodiversity monitoring.

b. Admin Login for the Dashboard

A secure login interface is exclusively reserved for a single system administrator. This restricted access point ensures that only an authorized individual is able to enter the administrative dashboard, maintaining the system's data integrity and preventing unauthorized modifications. The login mechanism includes standard security protocols such as encrypted credentials and session validation to safeguard the system's backend from potential threats.

c. Administrator Dashboard

The administrative dashboard mirrors the layout of the public user interface in order to preserve consistency in navigation and appearance. However, it is enhanced with additional functionalities tailored for system management. These include modules for adding new species entries, updating existing records, and deleting outdated or erroneous data. This backend capability allows the administrator to continuously curate, refine, and expand the biodiversity database in real time. Through this dynamic control panel, the system ensures that species information remains accurate, up-to-date, and reflective of ongoing research and ecological assessments.

In summary, the system architecture balances usability with control: the public interface supports open access to biodiversity information, while the administrator dashboard provides essential tools for maintaining the scientific accuracy and operational sustainability of the Lake Mainit Biodiversity Information Management System.

Software and Hardware Requirements

Table 1. Software Specifications

Software	Specifications
Development Tools	VSCODE, HeidiSQL, WAMP64
Front-End	HTML, CSS, Bootstrap
Programming Languages	Laravel Framework
Database	MYSQL Database

Table 2. Hardware Specification

Hardware	Specifications
Laptop	Predator Helios Neo 16 PHN16-72-75Z0 OPI BLACK
Processor	Intel® Core™ i7-14700HX processor
Memory	16GB RAM
SSD	512GB SSD
Mouse/Keyboard (backup)	AULA WIND T640 MECHANICAL Keyboard and Mouse Combo

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Table 1 and Table 2 presents the software and hardware specifications ensuring the efficient development and deployment of the Biodiversity Information Management System (BIMS) of Lake Mainit, appropriate software and hardware resources were utilized. The software requirements encompassed development tools, front-end technologies, a robust programming framework, and a relational database system that collectively supported the system's architecture and functionality. Meanwhile, the hardware specifications outlined the computing equipment and peripherals used to facilitate system coding, testing, and demonstration, ensuring optimal performance and compatibility throughout the development process.

Scope and Limitations of the Lake Mainit BIMS: Key Features and Access Constraints

The following are the scope of the BIMS;

1. The system has a user login with only the admin be able to alter or add additional details to the different categories and species of the biodiversity in Lake Mainit.
2. The system includes a same page editing to make the public dashboard as dynamic as possible.
3. The public may view, search and do reviews on the data add by the admin.
4. The system only allows the admin to edit and add details to the categories and species to the system.
5. The system provides a statistics counter to see how many species are in the categories registered in the system.
6. The system provides separate navigations to different categories of species, while also providing a search bar to find specific species.

The following are the limitations of the BIMS;

1. The system's effectiveness relies on having an internet and data connection.
2. The system's only accessible format is more catered on using a computer and in a browser.
3. The system cannot change the user account cannot be logged in arbitrarily; only the administrator can access it.

Research Respondents

The study utilized purposive sampling to engage a total of 15 participants strategically selected to represent diverse stakeholder groups, ensuring a comprehensive and multidimensional evaluation of the Biodiversity Information Management System (BIMS) for Lake Mainit. These respondents comprised three (3) local government officials directly involved in environmental planning, policy implementation, and biodiversity conservation; five (5) faculty members from environmental science, information technology, and related disciplines contributing academic and pedagogical perspectives; five (5) science major students serving as prospective end-users who offered feedback on system usability and educational relevance; and two (2) information technology (IT) experts who provided technical validation, system integrity assessment, and interface recommendations. The inclusion of these diverse stakeholder groups 64
enabled the integration of administrative, academic, user, and technical insights, enhancing the system's functionality, usability, and relevance for research, education, and environmental management.

Research Environment

This study was conducted in the Lake Mainit, located in northeastern Mindanao, Philippines. Lake Mainit is a transboundary freshwater ecosystem shared by the provinces of Surigao del Norte and Agusan del Norte, encompassing the municipalities of Mainit, Alegria, Kitcharao, and Jabonga. As the fourth-largest and deepest inland lake in the country, it is ecologically significant and designated as a Key Biodiversity Area (KBA) due to its rich assemblage of endemic, native, and threatened aquatic and terrestrial species. The research setting involved multiple stakeholder institutions including local government units (LGUs), academic institutions, and environmental agencies operating within the lake's watershed. The lake has also been the focus of conservation initiatives, such as the CHED-funded DARETO project, which 65
emphasizes community-based ecosystem management. The presence of existing biodiversity data, environmental programs, and local interest in sustainable resource management provided an ideal context for the development, deployment, and evaluation of the Biodiversity Information Management System.

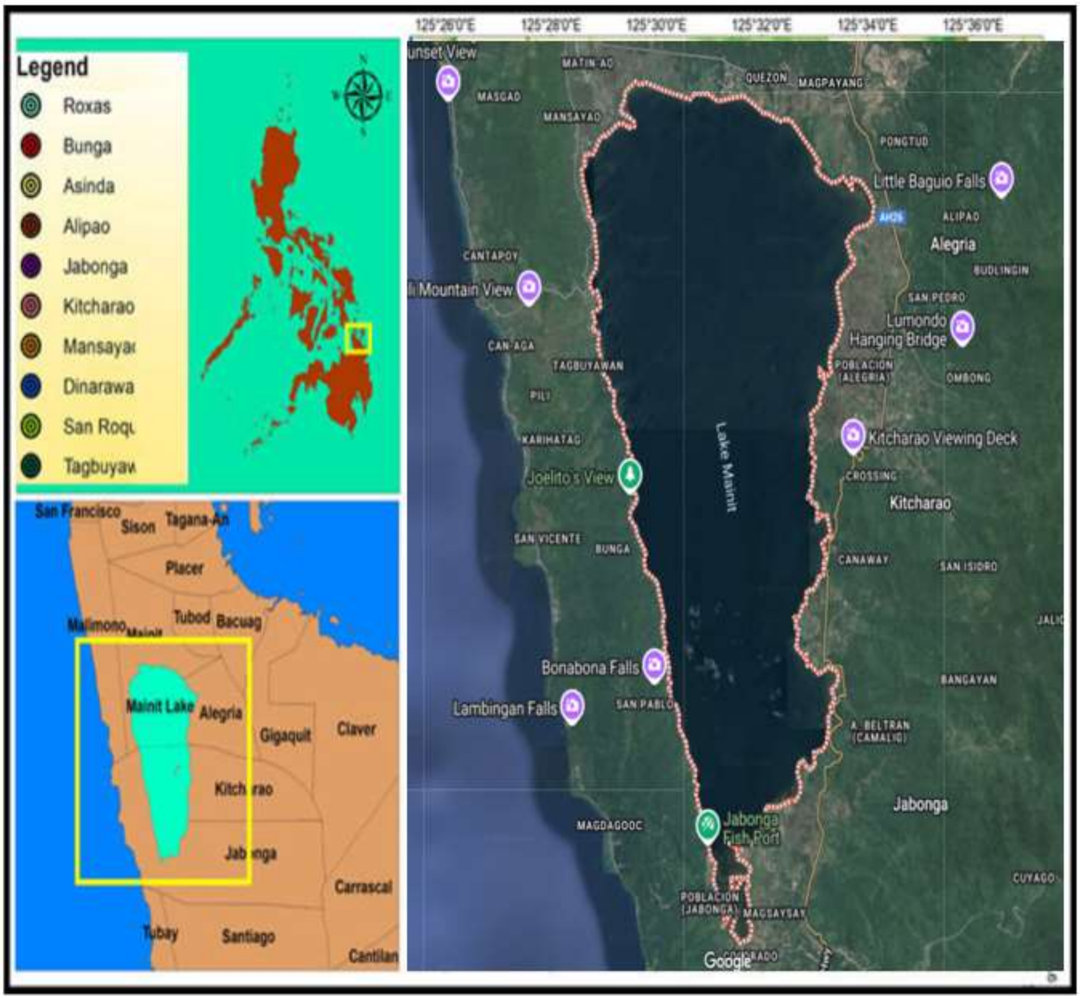

Plate 11

Research Environment

Research Instrument

To systematically evaluate the design, functionality, and usability of the Biodiversity Information Management System (BIMS) of Lake Mainit, this study employed a researcher-constructed survey questionnaire as the primary research instrument. The instrument was developed based on the ISO/IEC 9126 Software Quality Model, which outlines essential quality attributes for evaluating software systems. These attributes include usability, functionality, portability, maintainability, and user satisfaction, each of which was operationalized into measurable indicators to assess user perceptions of the system's performance.

The survey instrument was structured into two parts: The first part is for the Respondents Profile. This section gathered background information from the participants, such as their role as local government unit, faculty, students and IT expert. It was followed by age and gender. These variables were analyzed to determine their potential influence on user experience and system acceptance.

The next part involved users rating based on the following system quality attributes in terms of usability, functionality, portability, maintainability and system satisfaction. Statements were rated using a five-point Likert scale ranging from Strongly Agree (5), Agree (4), Neutral (3), Disagree (2) and Strongly Disagree (1). The developed features were assessed as follows: **Usability** - Items under this section assessed the ease of navigation, clarity of interface, accessibility of content, and user-friendliness of the BIMS.

Functionality – This section focused on the technical performance and reliability of the system. Items measured whether the system's core features (e.g., species search, taxonomic categorization, content retrieval) functioned correctly and consistently. Portability was assessed to determine the system's capacity to operate across multiple platforms and devices. Questions explored compatibility with different browsers, operating systems, and mobile responsiveness. **Maintainability** – This section addressed the administrator's perspective on how easy it is to update, add, or delete data entries in the system. **Overall System Satisfaction** – respondents were asked to evaluate their overall satisfaction with the BIMS, including its usefulness in promoting biodiversity awareness, education, and conservation. This section served as an integrative assessment of the system's impact.

To ensure content validity, the questionnaire was reviewed and validated by experts in biodiversity research, environmental science, and information systems experts. The finalized questionnaire was administered to a targeted sample comprising local government officials (n=3), faculty members (n=5), students majoring in science (n=5), and IT professionals (n=2). This diverse group of respondents provided 69
varied perspectives, contributing to a holistic evaluation of the system's effectiveness.

Ethics and Data Gathering Procedure

The main method of data gathering in this study was the implementation of the survey instruments. The study strictly adhered to ethical standards for academic research involving human participants and environmental data. Prior to data collection, the researcher sought formal approval ensuring that the study complies with ethical principles of informed consent, voluntary participation, confidentiality, and data integrity. All participants—including LGU personnel, faculty, students, and IT experts—were informed of the study's purpose and provided written consent. Participation was voluntary, and data confidentiality was strictly maintained.

Data collection occurred in two phases: first, biodiversity and system requirements were gathered from existing documents and stakeholder consultations; second, the developed BIMS was evaluated using a structured survey based on ISO/IEC 9126 quality attributes. The survey was administered to selected stakeholders to assess system usability, functionality, portability, maintainability, and overall satisfaction.

Data Analysis

Intraclass Correlation Coefficient (ICC). The ICC was used to assess the consistency of ratings among 70
stakeholder groups, such as IT experts, faculty, LGU representatives, and students. It measures the degree of agreement in their evaluations of the system's quality attributes. ICC values above 0.75 indicate good reliability, supporting the credibility of the instrument used.

Mean. The mean, or average score, was computed for each item to determine the general tendency of respondents' ratings. It served as a key indicator of how stakeholders perceived individual system features.

Standard Deviation (SD).SD was used to measure the variability of responses around the mean. A low SD indicated high agreement among respondents, while a high SD suggested more diverse opinions.

Composite Mean. The composite mean was derived by averaging all item means within each quality attribute (e.g., usability or functionality). This provided an overall summary of stakeholder perceptions for each system attribute.

Chapter 3
RESULTS AND DISCUSSION

This chapter presents the interpretation of findings derived from the data collected in relation to the research objectives outlined in Chapter 1.

1. To address the fragmented and often inaccessible biodiversity data landscape surrounding Lake Mainit, a web-based Biodiversity Information Management System (BIMS) was conceptualized and developed. This system serves as a centralized digital platform aimed at facilitating the structured documentation, secure storage, and strategic dissemination of biodiversity information for diverse stakeholders. It is intended not only as a repository of ecological data but also as a practical tool to support the work of researchers, environmental planners, academic institutions, and local government units. The development of this system was guided by a set of essential functional and technical features deemed critical to ensuring scientific accuracy, system usability, and long-term sustainability. The following discussion presents these foundational features that shaped the design and implementation of the BIMS for Lake Mainit.

Functional Features

Species Cataloguing Module

- Enables structured documentation of species data including scientific names, local names, taxonomic hierarchy, habitat information, conservation status, and ecological roles.
- Supports the attachment of multimedia resources such as photographs, distribution maps, and related metadata for enhanced species identification and field validation.

Search and Filter Functionality

- Provides dynamic filtering tools that enable users to search data based on multiple parameters such as taxonomic group (e.g., birds, fishes, reptiles, plants), conservation category, or geographical coverage.
- Facilitates efficient access to species-specific information, enabling users to retrieve relevant data for research, education, or policy-making purposes.

Data Contribution Interface

- Permits authenticated users—such as faculty members, local government staff, and affiliated researchers—to submit biodiversity records using structured digital templates.
- All submissions are subject to administrative review and approval prior to publication to ensure accuracy and prevent misinformation.

Stakeholder Access Portal

- Implements role-based access privileges with varying levels of access based on user roles, ensuring secure and controlled interaction with system data.
- Promotes inclusive participation while preserving data integrity and governance structure.

Dashboard and Reporting Tools

- Provides real-time data visualization including species counts, endemism rates, and conservation status summaries.
- Generates downloadable reports to support environmental planning, regulatory compliance, and academic dissemination.

Technical Features

Web-Based Architecture

- Ensures universal system accessibility via modern browsers across desktop and mobile devices using responsive technologies.

- Optimized for mobile use to support field data collection and real-time access.

Structured Database System

- Uses a relational database system (e.g., MySQL or PostgreSQL) to manage records with efficiency and scalability.
- Follows normalized schema designs to support data consistency and taxonomic relationships.

Security and Data Integrity

- Implements authentication and role-based authorization to protect system content and user operations.
- Includes audit logs, regular backups, and validation protocols to maintain data reliability and security.

Integration Readiness

- Designed for future integration with external systems such as GIS platforms, mobile biodiversity apps, and national data repositories.
- Supports modular development and data interoperability with evolving biodiversity informatics infrastructure.

Standards Compliance

- Adheres to international biodiversity standards (e.g., Darwin Core schema, IUCN classifications) for data consistency.
- Enables compatibility with global biodiversity datasets and collaboration networks.

The development of the Biodiversity Information Management System for Lake Mainit was guided by essential functional and technical requirements that align with the Municipality of Mainit biodiversity conservation goals. These features were strategically selected to ensure the system is scientifically reliable, user-friendly, secure, and interoperable. By providing structured documentation tools, robust access controls, and standards-based data management, the BIMS offers a scalable and sustainable solution for ecological data governance in Lake Mainit.

2. Level of Conformity of the Developed Biodiversity Information Management System by IT Validators

Table 3.
IT Experts' Degree of Conformity of the developed Biodiversity Information Management System of Lake Mainit

System Quality Attributes	Indicators	Mean	SD	VI	Qualitative Description
Usability					
	A. The system's user interface demonstrates a high level of intuitiveness and facilitates efficient user interaction.	5	0.0	SA	Strongly Agree
	B. The learning curve for system navigation and operation is minimal, even for first-time users.	5	0.0	SA	Strongly Agree

	C. Terminology, icons, and navigational elements are consistently and clearly presented throughout the system.	4.5	0.7	SA	Strongly Agree
	D. The system minimizes the likelihood of user error through clear instructions and logical workflows.	4.5	0.7	SA	Strongly Agree
	Composite mean	**4.75**	**0.4**	**SA**	**Strongly Agree**
Functionality	A. The system's core features operate as intended and are capable of supporting biodiversity data retrieval and management.	5	0.0	SA	Strongly Agree
	B. The information provided by the system is accurate, relevant, and consistently presented.	5	0.0	SA	Strongly Agree
	C. Functional tools such as search, filter, and taxonomy display respond reliably to user commands.	5	0.0	SA	Strongly Agree
	D. The system supports the intended use cases effectively, including research, education, and conservation planning.	5	0.0	SA	Strongly Agree
	Composite mean	**5**	**0.0**	SA	**Strongly Agree**
Portability					
	A. The system maintains full functionality and usability across multiple device types (e.g., desktop, mobile, tablet).	5	0.0	SA	Strongly Agree
	B. Cross-browser compatibility is observed, with no significant variation in system performance.	5	0.0	SA	Strongly Agree
	C. The system adapts well to different operating systems and platforms with consistent output.	5	0.0	SA	Strongly Agree

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	D. The system can be accessed without requiring installation of additional software or dependencies	5	0.0	SA	Strongly Agree
	Composite mean	**5**	**0.0**	SA	**Strongly Agree**
Maintainability					
	A. The system's architecture allows for easy updates, upgrades, and future enhancement without compromising performance.	4	1.4	A	Agree
	B. A mechanism is available and functional for reporting system issues or requesting technical support.	4	1.4	A	Agree
	C. Data content (e.g., species entries) can be efficiently maintained or modified by authorized personnel.	5	0.0	SA	Strongly Agree
	D. The system demonstrates adaptability to scale with potential increases in content or user base.	5	0.0	SA	Strongly Agree
	Composite mean	**4.5**	**0.7**	SA	**Strongly Agree**
System Satisfaction					
	A. The system satisfactorily meets the objectives of providing structured, localized biodiversity information for Lake Mainit.	5	0.0	SA	Strongly Agree
	B. The system addresses the information needs of its target users, including researchers, students, and environmental stakeholders.	5	0.0	SA	Strongly Agree
	C. Overall user experience with the system is positive and reflects a high degree of contentment.	5	0.0	SA	Strongly Agree

D. The system is considered a valuable and recommendable resource for biodiversity conservation and academic research.	5	0.0	SA	Strongly Agree
Composite mean	**5**	**0.0**	SA	**Strongly Agree**

Table 3 presents the evaluation of the developed Biodiversity Information Management System (BIMS) by IT experts based on five system quality attributes outlined in the ISO/IEC 9126 Software Quality Model. The results reveal a high level of conformity across all attributes. Usability received a composite mean of 4.75 (SD = 0.40), indicating that the system interface is intuitive, user-friendly, and facilitates efficient interaction. Functionality and portability both achieved perfect ratings of 5.00 (SD = 0.00), suggesting that the system performs its intended operations reliably and is fully compatible across various devices and platforms.

Meanwhile, maintainability obtained a mean of 4.50 (SD = 0.70), which still reflects strong agreement that the system allows for future updates and technical scalability. Lastly, system satisfaction was rated with a perfect score of 5.00 (SD = 0.00), confirming that IT experts were fully satisfied with the system's performance, effectiveness, and overall value for biodiversity conservation and academic use.

These findings affirm the technical soundness, reliability, and stakeholder acceptance of the BIMS developed for Lake Mainit. The high conformity ratings across all five software quality attributes indicate that the system is not only operationally effective but also viable for long-term use, enhancement, and institutional adoption. The perfect scores in functionality and satisfaction confirm that the system meets its intended purpose, while high ratings in usability and portability suggest broad applicability across user groups. Although maintainability showed slightly lower consistency, it offers insights for future system upgrades and administrative improvements. These results support the system's potential as a replicable model for biodiversity data platforms in other key biodiversity areas in the Philippines.

The overall evaluation of the system by IT experts strongly indicates that the developed Biodiversity Information Management System (BIMS) possesses a high degree of technical soundness, operational reliability, and structural coherence. The consistently high ratings, especially the perfect scores in functionality, portability, and system satisfaction, reflect not just successful adherence to software design principles, but also a thoughtful alignment with the actual needs of biodiversity data management. These outcomes suggest that the system's architecture and features are sufficiently robust to support long-term environmental information storage, retrieval, and analysis.

Furthermore, the high usability ratings imply that the system can be readily adopted by both technical and non-technical users, increasing its utility across educational, research, and policy-making domains. While the maintainability component showed slightly more variation, this feedback is constructive, highlighting opportunities to strengthen backend processes and support mechanisms. Overall, the results underscore the system's potential as a scalable and replicable digital solution for conservation-focused information management in other ecologically important areas.

Table 4
Level of Agreement Among IT Expert Validators

System Quality Attributes	ICC	Interpretation
Usability	0.83	Good agreement
Functionality	not applicable(SD=0)	Perfect agreement
Portability	0.8	Good agreement
Maintainability	not applicable(SD=0)	Perfect agreement
System Satisfaction	not applicable(SD=0)	Perfect agreement

Legend: Less than 0.5 – Poor agreement; 0.5 – 0.75 – Moderate agreement;
0.76 – 0.9 – Good agreement; greater than 0.9 – Excellent agreement ;
if SD=0 (scores are identical) – Perfect agreement

The Intraclass Correlation Coefficients (ICC) reported in Table 4 indicate the level of agreement among IT expert validators regarding the quality attributes of the developed Biodiversity Information Management System (BIMS). For the attribute of usability, the ICC value of 0.83 reflects good agreement among the experts, suggesting that their ratings were consistently similar and reliable. Similarly, portability received an ICC of 0.80, also indicating good agreement and strong consensus among the validators. In contrast, the attributes of functionality, maintainability, and system satisfaction all showed O standard deviation in ratings, meaning that all experts gave identical scores for these attributes. As a result, the ICC could not be calculated for these three attributes, but this lack of variability signifies perfect agreement among the raters. Overall, the findings demonstrate a high level of consensus among IT expert validators on the system quality attributes of BIMS, with unanimous agreement on functionality, maintainability, and system satisfaction, and strong agreement on usability and portability.

The high level of agreement reflected in the ICC results reinforces the credibility and consistency of the evaluation provided by the IT expert validators. The uniform ratings across functionality, maintainability, and system satisfaction reveal that these core attributes of the system are not only well-designed but also perceived as uniformly excellent across evaluators with technical expertise. This level of consensus highlights the robustness and reliability of the developed system architecture. Furthermore, the good agreement in usability and portability suggests that while there may be slight variations in perception, the evaluators still share a largely consistent view regarding the system's accessibility and cross-platform functionality. Overall, the absence of significant disagreement among validators affirms that the system has been developed with clear attention to quality standards, user needs, and operational coherence—strengthening the case for its broader application and long-term sustainability in biodiversity data management.

3.A Level of Conformity of the Developed Biodiversity Information Management System by LGU Heads.

Table 5
LGU Heads' Degree of Conformity of the developed Biodiversity Information Management System (BIMS)

Construct	Indicators	Mean	SD	VI	Qualitative Description

Usability					
	1. The system interface allows for efficient navigation.	4.67	0.58	SA	Strongly agree
	2. The system's functions can be learned with minimal instruction.	4.67	0.58	SA	Strongly agree
	3. The icons, buttons, and labels are clearly presented and easily interpretable.	4.33	0.58	SA	Strongly agree
	4. The system generates informative messages in response to user errors.	4.33	0.58	SA	Strongly agree
	Composite mean	4.5	0.5	SA	Strongly agree
Functionality	1. The system performs all necessary biodiversity data functions.	5	0.00	SA	Strongly agree
	2Data outputs are accurate and reliable.	4	1.00	A	Agree
	3. Search and filter tools work effectively.	4.33	0.58	SA	Strongly agree
	4. The system supports biodiversity-related tasks like research or policy planning.	4	0.00	A	Agree
	Composite mean	4.33	0.20	SA	Strongly agree
Portability					
	1. The system is accessible and functional on multiple device types (e.g., desktop, tablet, mobile).	5	0.00	SA	Strongly agree
	2. The system operates reliably across different web browsers.	5	0.00	SA	Strongly agree
	3. The system display adapts appropriately to various screen sizes.	5	0.00	SA	Strongly agree
	4. The system maintains consistent functionality across different platforms.	5	0.00		Strongly agree

				SA	
	Cave	5	0.00	SA	Strongly agree
Overall satisfaction	1. The system performs reliably and meets overall functional requirements.	4.33	0.58	SA	Strongly agree
	2. The system facilitates efficient access to and use of biodiversity data.	5	0.00	SA	Strongly agree
	3. The system demonstrates qualities that make it recommendable to other users.	5	0.00	SA	Strongly agree
	4. The system's performance aligns with user expectations.	5	0.00	SA	Strongly agree
	Dave	4.83	0.10	SA	Strongly agree

Results presented Table 5 were the LGU heads' assessment of the developed Biodiversity Information Management System (BIMS) based on system quality attributes. The results indicate a high level of usability (M = 4.50, SD = 0.50), reflecting that the system is easy to navigate and learn, with clearly presented interface elements**.** Functionality was rated with a composite mean of 4.33**,** suggesting that while the system effectively supports biodiversity-related tasks, there is room for improvement in data output reliability. Portability achieved a perfect score (M = 5.00, SD = 0.00), confirming that the system operates consistently across various devices and platforms. For overall satisfaction**,** the system received a strong rating (M = 4.83), indicating that LGU users were highly satisfied with its performance and usefulness for environmental governance and planning.

These findings affirm that the BIMS meets the practical needs and expectations of local government stakeholders. Moreover, the system's perfect portability rating underscores its potential for field use and multi-platform accessibility—an essential feature for LGU operations that involve mobile data collection and off-site environmental assessments. The slightly lower rating in functionality, particularly on data reliability, highlights the need for ongoing data validation protocols to ensure accuracy in reports used for policymaking.

The strong satisfaction score reflects confidence among LGU officials in recommending the system as a viable tool for biodiversity monitoring and regulatory compliance. Taken together, the results validate the system's readiness for adoption in LGU environmental programs and suggest its strategic value in supporting decentralized conservation governance.

The evaluation by LGU stakeholders offers critical validation of the system's practical relevance to local governance and environmental planning. Their strong agreement across key quality attributes suggests that the system effectively aligns with the workflow realities and decision-making needs of local agencies. The perfect rating in portability is especially notable, as it indicates the system's high adaptability to field-based contexts where mobile access and cross-platform consistency are vital.

The slightly varied responses under functionality, particularly regarding data reliability, serve as a meaningful prompt for the implementers to strengthen data management protocols and ensure that system outputs meet the standards required for formal policy and program use. Overall, the LGU responses underscore the system's operational readiness and confirm that BIMS is not only technically sound but also well-positioned to support evidence-based governance, biodiversity reporting, and decentralized conservation actions at the municipal level.

Table 6. Level of Agreement Among LGU Head Validators

System Quality Attributes	ICC	Interpretation
Usability	0.921	Excellent agreement
Functionality	not applicable(SD is almost 0)	Perfect agreement
Portability	not applicable(SD=0)	Perfect agreement
Overall Satisfaction	not applicable(SD is almost 0)	Perfect agreement

Legend: Less than 0.5 – Poor agreement; 0.5 – 0.75 – Moderate agreement;0.76 – 0.9 – Good agreement; greater than 0.9 – Excellent agreement; if SD=0 (scores are identical) – Perfect agreement

The Intraclass Correlation Coefficients (ICC) presented in Table 6 reflect the level of agreement among LGU head validators in their evaluation of the developed Biodiversity Information Management System (BIMS) with respect to certain system quality attributes. For usability, the ICC value of 0.921 reflects excellent agreement among the validators, demonstrating a very high level of consistency and reliability in their ratings. For functionality, portability, and overall satisfaction, the ICC was not applicable due to the standard deviation being zero or nearly zero, which means that all validators gave identical or nearly identical scores for these attributes.

This lack of variability signifies perfect agreement among the LGU head validators for functionality, portability, and overall satisfaction. Overall, the results reveal a strong consensus among LGU head validators, with unanimous agreement on functionality, portability, and maintainability, and excellent agreement on usability, underscoring the reliability of their assessments of the BIMS quality attributes.

The high level of agreement among LGU head validators, as reflected in the ICC values, reinforces the reliability and credibility of their evaluation of the Biodiversity Information Management System (BIMS). The excellent consistency in their assessment of usability indicates that the interface and navigability of the system were uniformly perceived as efficient and accessible. The perfect agreement across functionality, portability, and overall satisfaction suggests a shared recognition of the system's operational soundness and its alignment with the demands of local environmental governance.

This uniformity in scoring reflects not only technical adequacy but also the system's relevance to actual field conditions and policy workflows. Such consensus among decision-makers at the LGU level is a strong indication of institutional readiness for system adoption and integration, highlighting the platform's potential to become a core digital infrastructure in decentralized biodiversity conservation and planning.

3.B Level of Conformity of the Developed Biodiversity Information Management System by Faculty Members.

Table 7
Degree of Conformity of the developed Biodiversity Information Management System (BIMS) among the Faculty

System Quality Attributes	Indicators	Mean	SD	VI	Qualitative Description
Usability					
	1. The system interface allows for efficient navigation.	5	0.0	SA	Strongly agree
	2. The system's functions can be learned with minimal instruction.	5	0.0	SA	Strongly agree
	3. The icons, buttons, and labels are clearly presented and easily interpretable.	4.8	0.4	SA	Strongly agree
	4. The system generates informative messages in response to user errors.	5	0.0	SA	Strongly agree
	Composite mean	**4.95**	**0.1**	**SA**	**Strongly agree**
Functionality					
	1. The system performs all necessary biodiversity data functions.	4.6	0.5	SA	Strongly agree
	2. Data outputs are accurate and reliable.	4.6	0.5	SA	Strongly agree
	3.Search and filter tools work effectively.	5	0.0	SA	Strongly agree
	4.The system supports biodiversity-related tasks like research or policy planning.	4.8	0.4	SA	Strongly agree

	Composite mean	**4.75**	**0.4**	**SA**	**Strongly agree**
Portability					
	1. The system is accessible and functional on multiple device types (e.g., desktop, tablet, mobile).	4.8	0.4	SA	Strongly agree
	2. The system operates reliably across different web browsers.	4.8	0.4	SA	Strongly agree
	3. The system display adapts appropriately to various screen sizes.	4.8	0.4	SA	Strongly agree
	4.The system maintains consistent functionality across different platforms.	4.8	0.4	SA	Strongly agree
	Cave	**4.8**	**0.4**		**Strongly agree**
Overall satisfaction					
	1. The system performs reliably and meets overall functional requirements.	4.6	0.5	SA	Strongly agree
	2. The system facilitates efficient access to and use of biodiversity data.	4.8	0.4	SA	Strongly agree
	3. The system demonstrates qualities that make it recommendable to other users.	4.8	0.4	SA	Strongly agree
	4. The system's performance aligns with user expectations.	4.8	0.4	SA	Strongly agree

Dave	**4.75**	**0.4**	**SA**	**Strongly agree**

Table 7 presents the degree of conformity of the developed Biodiversity Information Management System (BIMS) as evaluated by faculty members. The results indicate a very high level of usability, with a composite mean of 4.95 (SD = 0.10), suggesting that faculty found the system highly intuitive, easy to learn, and responsive in addressing user inputs and errors. Functionality was also rated highly (M = 4.75, SD = 0.40), reflecting strong agreement that the system reliably performs its core tasks, particularly in biodiversity data handling and support for academic and research functions.

For portability, the system achieved a consistent score of 4.80 (SD = 0.40), indicating that faculty experienced seamless access and performance across different devices, browsers, and platforms. Additionally, overall satisfaction yielded a composite mean of 4.75 (SD = 0.40), confirming that the system met the faculty's expectations and demonstrated its utility in teaching, research, and conservation efforts.

These results affirm that the BIMS is highly acceptable and effective from the perspective of academic stakeholders. The nearly perfect usability score highlights the system's intuitive design, which is critical in academic environments where faculty have limited time for system onboarding or troubleshooting. High functionality ratings also emphasize the system's practical relevance in facilitating biodiversity documentation and promoting data-driven teaching and research. The portability rating indicates flexibility of use in blended learning contexts—across devices and platforms—further aligning with modern academic workflows. Moreover, strong satisfaction levels suggest that faculty view the system as a valuable tool not only for instruction, but also for fostering environmental awareness and supporting institutional sustainability goals.

The responses of faculty members reveal a strong alignment between the system's capabilities and the academic demands of higher education institutions. Their high level of satisfaction and strong ratings across all quality attributes reflect an appreciation not only for the system's ease of use but also for its pedagogical and research-enhancing functions. The system's intuitive design, evident in the nearly perfect usability rating, suggests that it effectively reduces technological barriers for academic users, allowing faculty to integrate biodiversity data into instruction with minimal training. The high functionality and portability scores affirm the system's versatility in supporting various academic applications, whether in traditional classroom settings, online learning environments, or field-based research.

Importantly, these results also point to the BIMS's potential as a strategic tool in promoting environmental literacy and academic engagement in sustainability initiatives. Faculty members' positive reception of the system underscores its institutional value and suggests strong potential for long-term integration into curricula, research projects, and community extension programs.

Table 8
Level of Agreement Among Faculty Validators

System Quality Attributes	ICC	Interpretation
Usability	not applicable(SD=0)	Perfect agreement
Functionality	0.871	Good agreement
Portability	0.93	Excellent agreement

Overall Satisfaction	0.957	Excellent agreement

Legend: Less than 0.5 – Poor agreement; 0.5 – 0.75 – Moderate agreement; 0.76 – 0.9 – Good agreement; greater than 0.9 – Excellent agreement ; if SD=0 (scores are identical) – Perfect agreement

The Intraclass Correlation Coefficients (ICC) reported in Table 8 illustrate the level of agreement among faculty validators in their evaluation of the developed Biodiversity Information Management System (BIMS) across various system quality attributes.

For usability, the standard deviation of the ratings was zero, indicating that all faculty validators assigned identical scores, resulting in perfect agreement for this attribute. Functionality received an ICC of 0.871, which reflects good agreement among the validators, demonstrating a high level of consistency in their ratings. Portability and overall satisfaction both showed excellent agreement, with ICC values of 0.93 and 0.957 respectively, indicating that the faculty validators were highly consistent and closely aligned in their evaluations of these attributes. Overall, the results demonstrate strong consensus among faculty validators, with perfect agreement on usability and excellent agreement on portability and overall satisfaction, underscoring the reliability of their assessments of the BIMS quality attributes.

The strong consistency in the faculty's evaluation of the BIMS, as evidenced by the high ICC values, reinforces the system's credibility and relevance within the academic setting. The perfect agreement on usability signifies that all faculty members uniformly recognized the system's intuitive interface and ease of navigation—critical factors in educational environments where technological efficiency is essential. The excellent agreement in portability and overall satisfaction further confirms that the system performs reliably across various platforms and meets the expectations of academic users in both functionality and educational value. Meanwhile, the good agreement in functionality underscores a shared perception of the system's effectiveness in supporting biodiversity-related tasks, even as it leaves room for constructive dialogue on potential enhancements. Overall, the faculty's consistent assessments validate the BIMS as a well-designed, purpose-driven platform capable of contributing meaningfully to research, instruction, and institutional efforts in biodiversity awareness and environmental stewardship.

3.C Level of Conformity of the Developed Biodiversity Information Management System by Students.

Table 9
Degree of Conformity of the developed Biodiversity Information Management System (BIMS) among Students

System Quality Attributes	Indicators	Mean	SD	VI	Qualitative Description
Usability					
	1. The system interface allows for efficient navigation.	5	0.00	SA	Strongly agree
	2. The system's functions can be learned with minimal instruction.	5	0.00		Strongly agree

				SA	
	3.The icons, buttons, and labels are clearly presented and easily interpretable.	5	0.00	SA	Strongly agree
	4. The system generates informative messages in response to user errors.	5	0.00	SA	Strongly agree
	Composite mean	**5**	**0.00**	**SA**	**Strongly agree**
Functionality					
	1. The system performs all necessary biodiversity data functions.	5	0.00	SA	Strongly agree
	2. Data outputs are accurate and reliable.	5	0.00	SA	Strongly agree
	3. Search and filter tools work effectively.	5	0.00	SA	Strongly agree
	4. The system supports biodiversity-related tasks like research or policy planning.	5	0.00	SA	Strongly agree
	Composite mean	**5**	**0.00**	**SA**	**Strongly agree**
Portability					
	1. The system is accessible and functional on multiple device types (e.g., desktop, tablet, mobile).	4.6	0.55	SA	Strongly agree
	2. The system operates reliably across different web browsers.	5	0.00	SA	Strongly agree

	3.The system display adapts appropriately to various screen sizes.	5	0.00	SA	Strongly agree
	4.The system maintains consistent functionality across different platforms.	5	0.00	SA	Strongly agree
	Cave	**4.9**	**0.14**	**SA**	**Strongly agree**
Overall Satisfaction	1. The system performs reliably and meets overall functional requirements.	4.8	0.45	SA	Strongly agree
	2. The system facilitates efficient access to and use of biodiversity data.	5	0.00	SA	Strongly agree
	3. The system demonstrates qualities that make it recommendable to other users.	5	0.00	SA	Strongly agree
	4. The system's performance aligns with user expectations.	4.8	0.45	SA	Strongly agree
	Dave	**4.9**	**0.14**	**SA**	**Strongly agree**

In Table 9, it shows the degree of conformity of the developed Biodiversity Information Management System (BIMS) as evaluated by student users. The system received a perfect score for usability (M = 5.00, SD = 0.00), indicating unanimous agreement that the interface is intuitive, user-friendly, and easy to navigate without the need for extensive instruction. Similarly, the system achieved a perfect mean in functionality (M = 5.00, SD = 0.00), confirming that students found it reliable in performing essential biodiversity data tasks such as searching, filtering, and supporting academic-related functions.

In terms of portability, the system earned a high composite mean of 4.90 (SD = 0.14), showing strong agreement that it operates consistently across devices and platforms. The students' overall satisfaction was also notably high, with a composite mean of 4.90 (SD = 0.14), suggesting that the system met their expectations and is viewed as a recommendable tool for learning, research, and biodiversity awareness.

Moreover,these results affirm the system’s effectiveness, particularly among student end-users who experienced high levels of usability, performance, and satisfaction. The perfect usability and functionality ratings highlight the system’s accessibility for a younger, digitally literate user base, enhancing its educational value in both classroom and independent learning contexts. The near-perfect portability score further reflects the system’s adaptability across multiple digital environments, allowing students to engage with biodiversity content seamlessly on various platforms. Moreover, the consistently high satisfaction ratings suggest that students see the system not only as a research tool but also as a resource that promotes environmental consciousness, digital engagement, and academic productivity. These insights support the system’s alignment with learner-centered design principles and its potential integration into formal educational programs.

The strong conformity ratings provided by student users highlight the Biodiversity Information Management System’s capacity to meet the expectations of a digital-native generation. The unanimous agreement in usability and functionality suggests that the system’s interface and core features resonate well with students’ technological fluency and academic needs. The system's ability to deliver accurate data outputs and intuitive navigation creates a learning environment where information is both accessible and engaging. The slightly lower, yet still outstanding, score in portability indicates that while the system performs reliably across platforms, there may be minor areas for refinement in ensuring universal responsiveness across all devices. Nonetheless, the high satisfaction ratings confirm that students perceive the BIMS as more than just a functional database—it is a dynamic educational tool that supports biodiversity literacy, independent inquiry, and digital competency. These findings suggest that the system is well-positioned for integration into academic settings and can serve as a model for enhancing environmental awareness among student communities.

Table 10
Level of Agreement Among Student Validators

System Quality Attributes	ICC	Interpretation
Usability	not applicable(SD=0)	Perfect agreement
Functionality	not applicable(SD=0)	Perfect agreement
Portability	not applicable(SD is almost 0)	Perfect agreement
Overall Satisfaction	not applicable(SD is almost 0)	Perfect agreement

Legend: Less than 0.5 – Poor agreement; 0.5 – 0.75 – Moderate agreement. 0.76 – 0.9 – Good agreement; greater than 0.9 – Excellent agreement; if SD=0 (scores are identical) – Perfect agreement

The Intraclass Correlation Coefficients (ICC) presented in Table 10 reflect the level of agreement among student validators in their evaluation of the developed Biodiversity Information Management System (BIMS) across several system quality attributes.

For usability and functionality, the standard deviation of the ratings was zero, indicating that all student validators gave identical scores, resulting in perfect agreement for these attributes. Similarly, for portability and overall satisfaction, the standard deviation was nearly zero, which also signifies near-perfect agreement among the student raters. Because of the lack of variability in their ratings, ICC values could not be computed for these attributes; however, this uniformity clearly indicates a strong consensus among the students. Overall, the findings demonstrate that student validators showed unanimous or near-

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unanimous agreement in their ratings of usability, functionality, portability, and overall satisfaction, highlighting consistent and reliable evaluations of the BIMS quality attributes.

The perfect and near-perfect agreement among student validators reflects a unified perception of the system's quality, suggesting that the BIMS effectively caters to student expectations in terms of design, usability, and functionality. The lack of variance in the ratings implies that the students found the platform uniformly accessible, efficient, and satisfying—key indicators of a well-aligned, learner-centered system. This strong consensus affirms the system's capacity to deliver a consistent user experience across a diverse student population, regardless of individual technical proficiency. Such reliability is critical in academic settings, where equitable access to digital resources directly supports learning outcomes. Furthermore, this level of agreement not only strengthens the validity of the evaluation but also reinforces the system's readiness for educational integration and broad adoption in student-focused biodiversity and sustainability initiatives.

4. Overall Assessment of BIMS Functionality and Impact by Stakeholders

Table 11

Summary of Stakeholder Evaluation of the Biodiversity Information Management System (BIMS) for Lake Mainit

Group	**Overall Rating**	**ICC Agreement**	**Remarks** 102
IT Experts	4.85–5.00	Good to Perfect	High system conformity; technically robust with minimal issues identified.
LGU Heads	4.33–5.00	Excellent to Perfect	Strong institutional support; recommends further validation of biodiversity data entries.
Faculty	4.75–4.95	Good to Excellent	System is highly usable, pedagogically relevant, and functionally portable.
Students	4.90–5.00	Perfect	Fully satisfied with system usability, design, and accessibility.

The development and deployment of the Biodiversity Information Management System (BIMS) for Lake Mainit yielded meaningful outcomes across its intended stakeholder groups, as evidenced by their 103 collective evaluation. More than just numerical ratings, the stakeholders' insights reflected a deeper recognition of the system's practical utility, contextual relevance, and contribution to local biodiversity initiatives.

Among local government representatives, the system was viewed not only as a technological innovation but as a strategic support tool in environmental governance. Their feedback emphasized that BIMS has the potential to streamline biodiversity monitoring and facilitate more data-driven planning and policymaking. While there were suggestions to further validate certain datasets, this reflects a healthy engagement with the platform and an interest in its continuous improvement, particularly in aligning with institutional protocols and regulatory frameworks.

Faculty members, on the other hand, appreciated the system's academic potential, highlighting its portability and ease of use in educational settings. BIMS was perceived as a valuable teaching and research resource, particularly in fields related to ecology, conservation, and information technology. Its organized presentation of species data and user-friendly design make it a viable digital tool to support student learning and faculty-led fieldwork.

Student participants, who represent future environmental practitioners and digital system users, responded with strong satisfaction in terms of usability and accessibility. Their positive evaluation is critical, as it 104 confirms that the system resonates with younger users and effectively meets their expectations for interactive and informative platforms. The high engagement from this group also suggests that BIMS can serve as a gateway for cultivating environmental awareness and stewardship among the youth.

Lastly, feedback from IT experts reinforced the technical soundness of the system. Their assessment confirmed that the platform functions well within its design parameters, maintaining high conformity with expected standards of system performance, security, and efficiency. Their inputs also validated the system's stability and structure, particularly in terms of its admin control features, dynamic content updating, and search functionalities. Overall, the collective stakeholder evaluation affirms that BIMS is not merely a database or viewing portal—it is an integrative platform with the capacity to support conservation action, academic enrichment, and participatory governance. Its impact lies in how it bridges technological tools with community-based biodiversity documentation. By allowing localized data access and encouraging shared responsibility, the system enhances the ability of various sectors to work collaboratively toward sustainable resource management in the Lake Mainit. Positive feedback from 105 institutional and grassroots users highlights BIMS's foundation, suggesting strong potential for scalability, enhancement, and broader adoption.

CHAPTER 4
SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This chapter presents a comprehensive summary of the study's purpose, methodology, and key findings, followed by analytically grounded conclusions and actionable recommendations.

Summary

This study aimed to develop and evaluate a web-based Biodiversity Information Management System (BIMS) tailored for Lake Mainit—an ecologically vital inland water system in northeastern Mindanao, Philippines. The project addressed the long-standing challenge of fragmented, inaccessible biodiversity 106 records in the region by offering a digital solution for structured data storage, retrieval, and visualization. The system was envisioned to support various stakeholder functions such as biodiversity monitoring, educational instruction, policy-making, and conservation management.

To ensure scientific and technical rigor, the development process incorporated essential functional and technical features informed by biodiversity data standards and software design best practices. The evaluation framework was anchored on the ISO/IEC 9126 software quality model, focusing on usability, functionality, portability, maintainability, and system satisfaction. Respondents were purposively selected across key stakeholder groups, including IT experts, local government officials, faculty members, and students. Quantitative data were analyzed using descriptive statistics, and the consistency of stakeholder evaluations was examined through the Intraclass Correlation Coefficient (ICC).

The findings demonstrated strong stakeholder consensus on the system's effectiveness, usability, and practical relevance. The system was perceived as technically robust, context-sensitive, and suitable for integration into academic, governmental, and community-based environmental programs.

Findings

The evaluation of the Biodiversity Information Management System (BIMS) for Lake Mainit, conducted through quantitative measures and stakeholder feedback, yielded several key findings that substantiate the system's technical merit, functional integrity, and stakeholder relevance.

1. On the essential functional and technical features required for BIMS development

The developed BIMS integrated essential features that addressed biodiversity data fragmentation in Lake Mainit. Functionally, it enabled structured species cataloguing, dynamic search and filtering, role-based data contribution, and real-time dashboard reporting. Technically, the system adhered to web-based architecture, responsive design, security protocols, and standards compliance. These features not only facilitated efficient data handling but also reflected a deliberate alignment with the operational needs of 108
biodiversity researchers, LGUs, and educators. The thoughtful integration of user-friendly design and scalable architecture demonstrated the system's readiness for real-world application.

2. On the conformity of the system to software quality standards as evaluated by IT experts

IT professionals affirmed the system's strong adherence to international software quality benchmarks. Usability was praised for its intuitiveness and logical navigation flow, while functionality was deemed fully reliable across core tasks such as data entry, retrieval, and taxonomy-based display. The system's portability across devices and browsers was validated as seamless, and maintainability was recognized as forward-compatible, with provisions for updates and scalability. The unanimous satisfaction expressed by 109
this group signified both technical soundness and development maturity, underscoring the system's potential for long-term sustainability and enhancement.

3. On the system's conformity as assessed by LGU heads, faculty, and students

Evaluations from LGU heads, faculty, and students revealed strong alignment between system design and end-user needs. LGU representatives valued the system's role in environmental governance and viewed it as a promising tool for data-informed planning and biodiversity regulation. Faculty highlighted the system's pedagogical relevance, noting its applicability for research-based instruction and curricular integration. Students expressed a high level of satisfaction with its usability and accessibility, affirming its effectiveness as a learning tool. Across all groups, the system was recognized for enhancing user engagement, promoting data transparency, and empowering local environmental action.

4. On the contribution of BIMS to stakeholders' functions in biodiversity monitoring, policy-making, education, and resource management

Stakeholders widely acknowledged the system's functional contributions to biodiversity-related work. For local governments, the BIMS provided a centralized, updatable source of ecological data to support policy formulation and habitat protection initiatives. For academic institutions, the system served as a digital repository that enriched environmental instruction and promoted applied research. For students and community users, it functioned as a gateway to environmental awareness and participation. The system's integrative value was evident in how it bridged scientific information with administrative, educational, and grassroots-level applications, thus fostering a collaborative approach to biodiversity conservation in 110
the Lake Mainit region.

Conclusions

Based on the study's findings, the following conclusions were drawn:

1. The developed Biodiversity Information Management System successfully fulfilled the identified functional and technical requirements, offering a comprehensive, user-friendly, and standards-based

platform for biodiversity data management in Lake Mainit.

2. The system demonstrated high conformity to internationally recognized software quality criteria, as evidenced by its strong performance in usability, functionality, portability, maintainability, and system satisfaction, thereby affirming its development integrity and readiness for real-world implementation.
3. The system was well-received by diverse user groups—LGUs, faculty, and students—whose evaluations reflected high levels of satisfaction, alignment with professional and academic workflows, and recognition of the system's practical benefits in conservation planning and environmental education.
4. BIMS emerged as a valuable digital resource that supports stakeholder collaboration, informed decision-making, and sustainable environmental management. Its success in the Lake Mainit context suggests replicability in other biodiversity-critical areas in the Philippines, reinforcing the role of localized, technology-enabled solutions in national conservation strategies.

Recommendations

In light of the study's findings and conclusions, the following recommendations are proposed to strengthen the impact, sustainability, and scalability of the developed Biodiversity Information Management System of Lake Mainit:

1. **Institutionalization and Integration**

The system should be officially adopted by LGUs and environmental agencies within the Lake Mainit region. A formal technical working group should be designated to oversee governance, data updating, and continuous system improvement. Integration into municipal planning and environmental monitoring frameworks is essential for sustained use.

2. **Capacity Building and Training**

Regular training sessions should be conducted for system users, including LGU staff, educators, and researchers. Instructional materials, such as user manuals and video guides, should be developed to promote data literacy and consistent system usage, ensuring accuracy and reliability of contributed information.

3. **System Enhancement and Technical Upgrades**

To maintain system relevance, future enhancements may include mobile application support, GIS-based mapping, offline data entry options, and AI-driven species identification features. Continuous user feedback should be solicited to inform agile system updates.

4. **Policy Utilization and Research Integration**

The BIMS outputs—such as species lists, ecological maps, and trend reports—should be systematically used in policy formulation, resource management decisions, and environmental reporting. Academic institutions are encouraged to integrate the system into research projects and thesis work to generate further ecological insights and data enrichment.

5. **Replication and National Collaboration**

The Lake Mainit BIMS should be promoted as a model for similar ecosystems in the country. Collaborative linkages with agencies such as DENR, DOST, and CHED are recommended to support system expansion, align it with national biodiversity data networks, and explore long-term conservation impacts through future studies.

Policy Brief

Enhancing Biodiversity Governance and Conservation in Lake Mainit Through a Digital Information Management System

Executive Summary

Lake Mainit, one of the Philippines' most biologically significant freshwater ecosystems, has long faced data fragmentation and limited access to biodiversity information—hindering conservation, planning, education, and evidence-based policymaking. This study developed a web-based Biodiversity Information Management System (BIMS) tailored to the Lake Mainit region. The platform consolidates species records, enables real-time access to data, and provides tools for visualization, monitoring, and reporting. Evaluated through the ISO/IEC 9126 framework, the system received high to perfect satisfaction ratings from IT experts, faculty, LGU stakeholders, and students. This policy brief advocates for institutionalizing BIMS as an essential digital infrastructure for biodiversity governance in Lake Mainit. 115

The Policy Issue

Despite Lake Mainit's recognized ecological significance and its critical role in sustaining local livelihoods, the region remains constrained by the absence of a centralized and accessible biodiversity information system. Existing biodiversity data are often fragmented, outdated, and largely unavailable in digital formats—limiting their practical utility for evidence-based research, curriculum development, and policy formulation. This data disaggregation hampers the ability of key stakeholders, including environmental planners, educators, and local government units, to effectively track species dynamics, assess ecological interventions, and fulfill national and international reporting commitments on biodiversity. In light of escalating anthropogenic pressures, habitat degradation, and climate-related threats, the development of a standardized, digitally integrated, and multi-stakeholder biodiversity information platform has become both a strategic imperative and a policy necessity.

Key Findings from the Study

The development and stakeholder-based evaluation of BIMS revealed the following outcomes:

- The system incorporates comprehensive features for species documentation, taxonomy-based browsing, and role-based user access, ensuring both scientific rigor and operational usability.
- IT experts affirmed its reliability, maintainability, and compliance with international software and biodiversity standards.
- LGU officials recognized BIMS as a strategic tool for environmental governance, zoning, and resource planning.
- Faculty and students found the system pedagogically useful, facilitating research, instruction, and experiential learning in biodiversity.
- High inter-rater agreement across all respondent groups affirms the system's strong technical and user-centered performance.

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Policy Recommendations

1. Institutional Adoption and Governance

Local government units (LGUs) surrounding Lake Mainit should formally adopt BIMS as part of their Environmental Governance Framework. A dedicated technical working group should be established to ensure system upkeep, data validation, and cross-LGU collaboration. This group should include LGU environment officers, IT support staff, academic partners, and local conservation groups.

2. Integration into Planning and Reporting Mechanisms

The outputs of BIMS—species inventories, habitat status reports, and ecological indicators—should be integrated into the LGUs' Local Conservation Action Plans (LCAPs), Comprehensive Land Use Plans (CLUPs), and environmental impact assessments. These datasets should also contribute to national biodiversity monitoring platforms through coordination with DENR and the Philippine Biodiversity Strategy and Action Plan (PBSAP).

3. Capacity Development and Stakeholder Engagement

Training programs should be institutionalized to enhance user proficiency and ensure data accuracy. Orientation workshops should target LGU staff, educators, barangay environmental units, and youth groups. Manuals, help guides, and support services should be created to foster consistent use.

4. System Innovation and Technical Enhancement

Future enhancements may include GIS mapping, mobile app development for field data collection, AI-driven image recognition for species ID, and interoperability with open biodiversity data systems. These innovations will increase the scalability and impact of BIMS in broader ecological research.

5. Replication and Policy Mainstreaming

The Lake Mainit BIMS should be showcased as a model for other Key Biodiversity Areas in the Philippines. Collaboration with national agencies such as DENR, CHED, and DOST should be pursued for potential funding, policy alignment, and national replication. Academic institutions should embed BIMS into environmental research and policy development training.

Call to Action

The successful implementation of BIMS in Lake Mainit provides compelling evidence that digital systems can enhance biodiversity monitoring, education, and governance. Local decision-makers, conservation leaders, and academic stakeholders are urged to endorse, institutionalize, and scale the system. Through BIMS, Lake Mainit can serve as a pioneer in digital biodiversity conservation, bridging science, policy, and community action.

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