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Assessment of the Watershed Condition in Lugait, Misamis Oriental, Philippines

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Abstract

Current land-use practices in the Lugait watershed, Misamis Oriental, Philippines, play a significant role in the local economy, but they may also pose a threat to biodiversity and watershed health. This study aimed to evaluate the forest health in relation to the overall watershed condition of the said locality. Three representative sites (Barangay Kaluknayan, Upper Talacogon, and Poblacion) were chosen based on elevation. Floral assessment employed the Point-Center-Quarter-Method (PCQM). Fauna assessed included bats, birds, and hepetofauna. Soil sampling and analysis of chemical properties were conducted. Coconut (*Cocos nucifera*) dominated the watershed with an importance value of 199%. Fauna across sites were mostly common, adaptable species. Forested areas had medium organic matter, while agricultural lands (corn, pineapple) ranged from medium-low to low. Coconut plantations maintained medium organic matter. Both forest and agricultural lands had medium to high phosphorus content. Available potassium was sufficient in both areas. Land-use changes, particularly deforestation for cropland, led to decreased soil pH. The dominance of coconut plantations and conversion of forest to cropland highlight the need for diversified agricultural practices and sustainable management strategies. While fauna appear adaptable, biodiversity monitoring remains crucial. The declining soil pH warrants further investigation into potential long-term impacts on plant growth and water quality. This study emphasizes the importance of integrating ecological considerations into land-use planning to ensure long-term environmental and economic sustainability for the watershed and its communities.

Keywords: biodiversity; environment; Lugait; Misamis Oriental; watershed

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1. Introduction

Forests play a significant role in watersheds globally, providing vital ecological services that ensure clean water access for the public [1]. These forest ecosystems perform a critical function by absorbing rainfall and snowmelt, mitigating floods, slowing storm runoff, reducing soil erosion, enhancing water infiltration rates, and aiding in aquifer recharge [2]. Additionally, they act as natural filters, removing pollutants like sediments, fertilizers, and pesticides from agricultural and urban runoff, while also providing crucial habitats for fish and wildlife, thus contributing to both terrestrial and aquatic biodiversity [3].

Despite the invaluable ecological services they provide, forests face numerous threats and challenges that significantly impact their overall well-being. One of the most pressing issues is the conversion of forests into agricultural land, a problem that has persisted for decades and adversely affects forest cover in the Philippines [4]. In the context of watersheds, forests are undeniably the optimal vegetation cover, as they facilitate greater water infiltration into the ground [5].

The municipality of Lugait, situated in Misamis Oriental, was selected by researchers for their study. This area encompasses a total of 64 hectares of forest land within its boundaries. Out of the municipality's total land area of 3,645.67 hectares, approximately 61.74 percent, or 2,251 hectares, is earmarked for agricultural use. Based on slope classification, the southwestern portion of the land is divided into agriculture, open grassland, mining, and industrial areas, which were originally forested. Notably, many mountains have been converted into agricultural plots, primarily covered with coconut trees and some grasses.

The prevailing land uses for economic purposes pose a significant threat to the overall health of the watershed, including its existing biodiversity [6,7]. Consequently, this study was conceived to evaluate the state of the forest in relation to the watershed's condition in Lugait, Misamis Oriental.

The primary objective of this study was to assess the flora and fauna within the forest and its relationship to the watershed's condition in Lugait, Misamis Oriental. Additionally, the study aimed to 1) conduct a rapid assessment of the forest cover in the watershed area, including an examination of the associated faunal diversity, to verify the existing baseline data provided by the Local Government Unit (LGU) of Lugait, Misamis Oriental; 2) identify and evaluate the effectiveness of existing forest protection and conservation programs implemented by the LGU and local communities in addressing forest and watershed protection concerns; and 3) document any changes in land use or forest conversions for alternative purposes, such as residential, commercial, and agricultural uses, and to assess the impact of these changes on soil fertility status.

2. Materials and Methods

2.1 Research Setting

The study was conducted in the municipality of Lugait, Misamis Oriental, where the researchers identified three representative sampling sites: Barangay Kaluknayan, Upper Talacogon, and Poblacion. The selection was based on the elevation of these areas.

2.2 Flora Assessment

For assessing the forest community in the watershed area, the researchers employed the plotless sampling technique known as the Point-Center-Quarter-Method (PCQM). This method allowed for the determination of key community parameters such as density, dominance, frequency, and importance value of the tree species present.

Within each sampling area, especially their Asdang Lasang sections, three 50-m transect lines were randomly laid at 10-m intervals with a 20-m separation between lines. At each sampling point, four imaginary quadrants were created. Inside each quadrant, the distance to the nearest tree or shrub from the sampling point, as well as its Diameter at Breast Height (DBH), was measured. This resulted in five samples per sampling point.

Local residents and a field guide provided assistance in identifying tree species, primarily using local or common names. For species not readily identified, photo documentation was collected for later laboratory identification using identification keys.

2.3 Faunal Assessment

2.3.1 Bats

Three mist nets were set up in each sampling site. At one-hour intervals, bat species were retrieved from the nets. Local guides and taxonomic keys assisted in identifying the captured bats. To avoid recapturing the same individuals, captured bats were marked with nail polish.

2.3.2 Birds and Hepetofauna (Reptiles and Amphibians)

The presence of other fauna in the sampling area was documented using the visual encounter method. Local guides and taxonomic keys aided in their identification, primarily based on the species' appearance and coloration.

2.4 Soil Sampling

To gain a general overview of variations within the study area, a general field survey was conducted. Two barangays, Barangay Kaluknayan and Barangay Upper Talacogon, were chosen as representative sampling sites – Kaluknayan for upland areas and Upper Talacogon for midland areas. Within each barangay, three representative sites were selected for agricultural land use types. Ten soil sub-samples were collected from each agricultural site, at a depth of 3 in. The agricultural sites covered crops like coconut, corn, and pineapple.

For forest land, one representative site was chosen in each barangay, again with ten soil sub-samples collected at a depth of 6 in. During sample collection, areas with dead plants, furrows, old manure, wet spots, trees, and compost pits were excluded. This aimed to minimize differences arising from dilution of soil organic matter due to cultivation practices and other factors.

The collected soil samples were then analyzed at the Department of Agriculture Regional Soil Testing Laboratory in Cagayan De Oro City using standard laboratory procedures for the chosen chemical analyses.

2.5 Analysis of Soil Chemical Properties

2.5.1 Soil pH

Soil pH was determined using the potentiometric method, with measurements performed in duplicate. Twenty grams of soil were weighed into each of two 50-mL polyethylene bottles. Twenty mL of distilled water were then added to each bottle, followed by shaking for ten minutes at 250 rpm. The solutions were then left undisturbed for one hour. Calibration of the pH meter was done using standard buffer solutions of pH 4.0 and pH 7.0. After allowing the soil suspensions to settle, each sample was gently stirred, and the pH electrode was immersed in the upper part of the suspension. The pH value was recorded to the nearest 0.1 unit when the reading stabilized.

2.5.2 Available Phosphorous

The available phosphorus in the soil was analyzed following the standard procedure of Olsen et al. [8]. A 2.5-g scoop of soil was shaken for 30 min with 50 mL of 0.5 M sodium bicarbonate solution adjusted to pH 8.5. The mixture was then filtered through Whatman filter paper. The ortho-phosphate concentration in the filtered extract was determined using a spectrophotometer, and the results were reported as parts per million (ppm) of phosphorus (P) in the soil.

2.5.3 Available Potassium

The available potassium content was determined using the cold sulfuric acid method. Five grams of soil were mixed with 12.5 mL of distilled water and 0.5 mL of concentrated sulfuric acid. The solution was then allowed to stand for 30 min, followed by filtration and washing with 0.1 N sulfuric acid. The 0.1 N sulfuric acid was prepared by diluting 3 mL of concentrated sulfuric acid to 1 L of distilled water. Finally, the results were determined by reading the filtrate using a flame photometer.

2.5.4 Available Organic Matter

Organic matter significantly influences numerous physical, chemical, and biological properties of soils. Examples include soil structure, compressibility, and shear strength. Additionally, it impacts water holding capacity, nutrient contributions, biological activity, and water and air infiltration rates. To determine available organic matter, 0.1 g of soil were mixed with 2 mL of potassium dichromate solution and 5 mL of sulfuric acid and left for two hours. Afterward, 20 mL of water were added, and the mixture was left overnight. The result was then obtained by reading the solution using a spectrophotometer.

Table 1: Forest assessment in the three different sampling sites in Lugait watershed.

Tree species	Site 1				Site 2				Site 3			
	Relative density	Relative dominance	Relative frequency	Importance value	Relative density	Relative dominance	Relative frequency	Importance value	Relative density	Relative dominance	Relative frequency	Importance value
Mahogany	33%	11%	33%	77%	67%	43%	67%	176%	0%	0%	0%	0%
Coconut	50%	84%	50%	184%	13%	44%	13%	70%	100%	100%	100%	300%
Gmelina	8%	2%	8%	19%	0%	0%	0%	0%	0%	0%	0%	0%
Kolokoy	3%	0%	3%	7%	0%	0%	0%	0%	0%	0%	0%	0%
Narra-like	2%	1%	2%	4%	0%	0%	0%	0%	0%	0%	0%	0%
Malapapaya	2%	1%	2%	5%	0%	0%	0%	0%	0%	0%	0%	0%
Hagimit	2%	0%	2%	4%	0%	0%	0%	0%	0%	0%	0%	0%
Madre de Cacao	0%	0%	0%	0%	7%	2%	7%	15%	0%	0%	0%	0%
Salong-salong	0%	0%	0%	0%	3%	9%	3%	16%	0%	0%	0%	0%
Ipil-ipil	0%	0%	0%	0%	2%	0%	4%	1%	0%	0%	0%	0%
Magtingale	0%	0%	0%	0%	2%	0%	3%	1%	0%	0%	0%	0%
Iba-iba	0%	0%	0%	0%	2%	0%	4%	1%	0%	0%	0%	0%
Ipos-ipos	0%	0%	0%	0%	2%	0%	3%	1%	0%	0%	0%	0%
An-an	0%	0%	0%	0%	2%	0%	3%	1%	0%	0%	0%	0%
Binunga	0%	0%	0%	0%	2%	1%	4%	1%	0%	0%	0%	0%

Table 2: Consolidated data of tree species in the three sampling sites.

Tree species	Relative density	Relative dominance	Relative frequency	Importance value
Mahogany	33%	8%	33%	74%
Coconut	54%	90%	54%	199%
Gmelina	3%	0%	3%	6%
Madre de Cacao	2%	0%	2%	5%
Kolokoy	1%	0%	1%	2%
Narra-like	1%	0%	1%	1%
Malapapaya	1%	0%	1%	1%
Hagimit	1%	0%	1%	1%
Salong-salong	1%	1%	1%	3%
Ipil-ipil	1%	0%	1%	1%
Magtingale	1%	0%	1%	1%
Iba-iba	1%	0%	1%	1%
Ipos-ipos	1%	0%	1%	1%
An-an	1%	0%	1%	1%
Binunga	1%	0%	1%	1%

3. Results and Discussion

3.1 Forest Assessment

Table 1 above presents the results of the forest assessment in three distinct sampling sites within the Lugait watershed. This evaluation focused on three parameters: relative density (number of individuals per unit area, expressed as a percentage of the total individual count across all species), relative dominance (sum of the basal area of a species as a percentage of the total basal area for all species), and relative frequency (percentage of inventory points occupied by a species compared to the occurrence of all species). Each of these values is represented as a percentage and ranges from 0 to 100.

Importance Value (IV) serves as a metric for a species' dominance within a specific forest area. Within sampling site 1, *Cocos nucifera* exhibits the highest IV of 184%, further solidifying its dominance in sampling site 3 with an IV of 300%. Meanwhile, sampling site 2 exhibits dominance by the introduced exotic tree, Mahogany (*Swietenia macrophylla*). A high IV indicates that Species A is well-represented within the stand due to either a) a high number of individuals of Species A compared to other species within the stand or b) a smaller number of individuals of Species A, but with considerably larger trees compared to others.

Analyzing the consolidated data from the three sampling sites, *Cocos nucifera* is observed to dominate the majority of the watershed area with an IV of 199% (Table 2). This finding suggests that the watershed's vegetation cover has already transitioned to an agricultural state. Consequently, the watershed necessitates intensive management practices to ensure the preservation of its ecological functions [9].

3.2 Bats Species

Twenty-eight individual bat species belonging to the Pteropodidae family were recorded. Among these, *Cynopterus brachyotis* was the dominant species across all three sampling sites. This adaptable bat inhabits diverse habitats, ranging from orchards and gardens to forested tracts. It roosts solitarily or in small groups, primarily in palms – especially their seed clusters – within rural and urban landscapes, as well as forested areas. Compared to *C. sphinx*, this species seems to prefer higher elevations, potentially making it a specialist of hill forests. Table 3 details the individual counts of bat species encountered across all sampling sites.

3.3 Birds

A total of five individual bird species were observed in all sampling sites. *Passer montanus* was found to be the dominant species observed. Most of the bird species encountered were common and of least concern. These species tend to thrive and are adapted to various land use changes. Table 4 shows the individual count of bird species encountered in all sampling sites.

3.4 Herpetofauna

Three reptile species were encountered in all sampling sites. Additionally, one amphibian species, the introduced *Rhinella marina*, was found in all study sites.

3.5 Soil Analysis

3.5.1 Organic Matter Content Analysis

Table 6 reveals that forested areas exhibit medium-range available organic matter, while agricultural lands planted with corn and pineapple show medium-low to low ranges. Coconut plantations, however, maintain medium organic matter content. Generally, land cultivation leads to reduced organic matter. Several factors contribute to this decline in the study area include 1) conversion

Table 3: Individual counts of bat species encountered in all sites.

Species name	Barangay Kaluknayan (High elevation)	Barangay Upper Talacogon (Mid elevation)	Barangay Poblacion (Low elevation)	Total
Bat species (mist netting)				
Cynopterus brachyotis (native)	5	9	2	16
Ptenochirus jagori (endemic)	0	3	2	5
Macroglossus minimus (native)	3	1	0	4
Eonycteris spelaea (native)	1	1	0	2
Rousettus amplexicaudatus (native)	1	0	0	1
Total	10	14	4	28

Table 4: Individual counts of bird species encountered in all sites.

Species name	Barangay Kaluknayan (High elevation)	Barangay Upper Talacogon (Mid elevation)	Barangay Poblacion (Low elevation)	Total
Bird species				
Todirampus chloris (native)	1	0	0	1
Pycnonotus goiaver (native)	3	1	0	4
Passer montanus (native)	5	4	1	10
Rhipidura javanica (native)	0	0	0	0
Geopilia striata (native)	1	1	0	2
Total	10	6	1	17

Table 5: Individual counts of herpetofauna species encountered in all sites.

Species name	Barangay Kaluknayan (High elevation)	Barangay Upper Talacogon (Mid elevation)	Barangay Poblacion (Low elevation)	Total
Reptile species				
Lamprolepis smaragdina (native)	0	1	0	1
Eutropis multicarinata (native)	1	0	0	1
Gekko gecko (native)	1	1	0	2
Amphibian species				
Rhinella marina (introduced)	1	1	3	5
Total	3	3	3	9

Table 6: Available organic matter content in two different land uses.

Land use	Available Organic Matter	Description
Forest area		
Sample 1	3.81	Medium
Sample 2	3.75	Medium
Agricultural area		
Sample 1 (coconut)	3.96	Medium
Sample 2 (coconut)	3.76	Medium
Sample 3 (corn)	1.11	Low
Sample 4 (corn)	1.12	Low
Sample 5 (pineapple)	2.63	Medium low
Sample 6 (pineapple)	2.60	Medium low

Table 7: Available phosphorus in two different land uses.

Land use	Available Phosphorus	Description
Forest area		
Sample 1	28	Medium high
Sample 2	28	Medium high
Agricultural area		
Sample 1 (coconut)	28	Medium high
Sample 2 (coconut)	29	Medium high
Sample 3 (corn)	24	Medium high
Sample 4 (corn)	28	Medium high
Sample 5 (pineapple)	24	Medium high
Sample 6 (pineapple)	21	Medium

Table 8: Available potassium in two different land uses.

Land use	Available Potassium	Description
Forest area		
Sample 1	344	Sufficient
Sample 2	338	Sufficient
Agricultural area		
Sample 1 (coconut)	475	Sufficient
Sample 2 (coconut)	500	Sufficient
Sample 3 (corn)	217	Sufficient
Sample 4 (corn)	222	Sufficient
Sample 5 (pineapple)	289	Sufficient
Sample 6 (pineapple)	273	Sufficient

Table 9: Level of pH in two different land uses.

Land use	pH	Description
Forest area		
Sample 1	7.78	Mildly alkaline
Sample 2	7.90	Moderately alkaline
Agricultural area		
Sample 1 (coconut)	6.08	Very slightly acidic
Sample 2 (coconut)	6.12	Slightly acidic
Sample 3 (corn)	6.54	Slightly acidic
Sample 4 (corn)	6.54	Slightly acidic
Sample 5 (pineapple)	6.47	Slightly acidic
Sample 6 (pineapple)	6.55	Slightly acidic

of grasslands, forests, and natural vegetation to arable land; 2) deep plowing of arable soils, inducing rapid mineralization of organic matter; and 3) possible leaching issues due to the light texture of soils, potentially further reducing organic matter [10].

3.5.2 Phosphorous Analysis

Phosphorus (P) is often referred to as the master key to agriculture due to its critical role in plant growth. Insufficient available P in the soil limits the development of both cultivated and uncultivated plants [11]. As shown in Table 7, the phosphorus content in both forest and agricultural land ranges from medium to medium high.

3.5.3 Potassium Analysis

Analysis results indicate sufficient available potassium levels for both forested and agricultural areas. However, Table 8 reveals higher values within the forest ecosystem compared to the agricultural ecosystem planted with corn and pineapple.

3.5.4 pH Analysis

Land use changes, particularly from forest to cropland, have contributed to a reduction in soil pH across the study area. This is evident in the contrasting values from the highest pH of 7.90 recorded under the forest to the lowest pH of 6.08 found in agricultural land (Table 9). Several factors likely contribute to this decline in organic matter include 1) depletion of base cations through crop harvest and their loss via drainage and erosion-generated runoff; and 2) decreased rainfall, potentially as a result of climate change [12].

4. Conclusions

The watershed's vegetation cover is predominantly agricultural, as remaining forest stands have been converted. Implementation, study, and monitoring of the municipality's Asdang Lasang program are inadequate due to dominance of introduced species, data scarcity, and limited knowledge of native tree cultivation.

Reforestation efforts should prioritize indigenous, local, and endemic trees, supported by prior scientific studies in the area. This will benefit watershed protection, enhance biodiversity, and facilitate effective land-use plan implementation.

Land use influences organic matter content, which is reduced in agricultural areas. Organic matter plays crucial roles in: (a) water management by protecting the soil surface from raindrop impact; (b) minimizing leaching loss through its ability to retain substances; (c) providing nutrients (N, P, S, and most micronutrients) and growth-promoting substances; (d) stabilizing soil structure; and (e) supplying energy for microbial activity. Therefore, initiatives to improve soil organic matter content are essential.

Land use also affects soil pH, which decreases with cultivation. Decreased rainfall may further contribute to this decline. As different crops have varying soil pH requirements, soil analysis is necessary to determine appropriate methods for raising or lowering pH levels.

Most fauna observed across all sampling sites are common species of least concern, demonstrating adaptation to various land uses.

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Conflict of Interest Statement

The authors declare no conflict of interest.

Author Contributions

All authors have contributed equally. They have read and agreed to the published version of the manuscript.

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