INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 24, No. 4, p. 92-103, 2024
http://www.innspub.net

RESEARCH PAPER

OPEN ACCESS

Forest structure and most dominant upper canopy flora species of Mt. Katayagan, Agoo, La Union, Philippines

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Article published on April 10, 2024

Key words: Forest formation, Importance value, Land cover type, Mt. Katayagan, Stand maturity

Abstract

Mount Katayagan, the tallest peak in the Agoo Mountain Range of the Province of La Union, Philippines, is a crucial yet understudied natural resource. This research addresses the biodiversity gap in non-protected areas like Mt. Katayagan, emphasizing its role as a watershed, supplying water for irrigation and households, and providing essential commodities such as fruits and timbers. Despite its ecological and economic significance, there is a lack of research on Mt. Katayagan's biodiversity. This study aims to fill this gap by conducting a comprehensive flora assessment, identifying land cover types, forest formation, stand maturity and dominant upper canopy species. Using the "Terrestrial Ecosystem Biodiversity and Assessment Monitoring Manual," the research reveals Mt. Katayagan's predominantly closed forest with characteristics of a secondary-growth tropical moist deciduous forest. *Pterocarpus indicus* (narra) emerges as the dominant upper canopy species with an Importance Value of 20.85 percent. This research provides essential baseline data for environmental protection laws and emphasizes the urgent need for collaborative conservation efforts involving local communities, government bodies, and research institutions to safeguard Mt. Katayagan's unique biodiversity.

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Introduction

Biodiversity, the term for the variety of life forms and ecosystems on Earth, is crucial to the continuation of life and provides necessary ecosystem services (National Geographic Society, 2021). Since biodiversity is so important, there has been a global push to manage, conserve, and understand it. According to Diaz *et al.* (2019), a healthy, stable and resilient ecosystem is one that has a high level of biodiversity. At the 1992 Rio Earth Summit, the Convention on Biological Diversity emphasized the value of biodiversity and urged countries to give biodiversity management a priority (Tsiounami *et al.,* 2020). The economic, ecological, recreational, cultural, and scientific dimensions of biodiversity's importance all highlight how important it is to both environmental sustainability and human well-being (Australia State of the Environment, 2018). The need to thoroughly evaluate and manage biodiversity is increasing as human activities continue to have an impact on it. Unfortunately, a lot of locations that are being considered for development lack sufficient knowledge regarding biodiversity, which might have permanent consequences like habitat destruction and overexploitation (Paller, 2021).

This study focuses on two related topics in the non-protected region of Mount Katayagan, Agoo, La Union, Philippines, in response to the need for thorough biodiversity surveys. First, over a 2 km transect line at Mount Katayagan, it seeks to identify the land cover types, forest formation, and stand maturity. Second, using the species with the highest Importance Value (IV), it seeks to determine which species is the most dominating in the upper canopy. This study fills in the gaps in laws like the Wildlife Resources Conservation and Protection Act of 2001 and the Philippine Environmental Impact Assessment System (PEIAS), which frequently encounter difficulties because of insufficient data on biodiversity (Convention on Biological Diversity, 2021; Republic Act 9147). This study is significant because it adds to the larger context of biodiversity protection by concentrating on the highest peak in the Agoo Mountain Range, Mount Katayagan. With a surface area of 41.03 hectares and an elevation of 250 meters above sea level, Mount Katayagan is significant both environmentally and commercially. Even though the mountain is significant, there aren't many thorough studies on its biodiversity, which makes it a perfect topic for investigation. Unprotected landscapes such as Mount Katayagan are susceptible to multiple dangers, highlighting the necessity of preservation in order to counteract the loss of biodiversity and tackle global problems (Kohler *et al.,* 2009).

It is significant that vulnerable locations like Mount Katayagan receive little research attention because most studies that quantify biodiversity focus on protected regions. Since 2015, Mount Katayagan has drawn a lot of tourists from La Union because of its vital roles for the local community as well as its picturesque vistas. As a watershed, Mount Katayagan is essential to the towns of Agoo, Tubao, and Sto. Tomas' water supply for domestic use and irrigation. Communities that depend on agriculture benefit from the sloping topography's natural rainwater storage. In addition to its hydrological importance, the mountain provides free water to the locals and is an important supplier of goods like lumber and fruits (Eisma *et al.,* 2015). As a result, by supporting conservation efforts and complying with existing regulatory frameworks, this study lays the groundwork for any future developments. By carefully examining land cover, forest formation, stand maturity, and upper canopy species, this study provides important information that is necessary for managing biodiversity and promoting sustainable development. The study follows the guidelines provided in the 2017 "Terrestrial Ecosystem Biodiversity and Assessment Monitoring Manual" published by the Biodiversity Management Bureau, with modifications made to meet the unique needs of Mount Katayagan in Agoo, La Union.

Material and methods

Research design

In order to fully investigate the land cover, forest formation, stand maturity, and dominating upper canopy plant species of Mt. Katayagan, this study used a quantitative descriptive technique. This research design was chosen because it permits a thorough assessment of the most dominant upper canopy plant species at Mt.

Katayagan (Addison, 2017). At Mt. Katayagan, parameters like relative density, relative frequency, and relative dominance are gathered in order to calculate the Importance Value (IV) of various plant species. The Biodiversity Management Bureau's 2017 "Terrestrial Ecosystem Biodiversity and Assessment Monitoring Manual," with a few modifications to suit the study's requirements, served as a guide for the detailed process of the investigation.

Time and place

The research was carried out at Mt. Katayagan in Agoo, La Union, and ran from May 31, 2022, until October 31, 2022. Using Google Earth Pro (v. 7.3.6.9345), released on January 04, 2023, precise geographic coordinates (16°19'49"N, 120°23'33"E / 16°18'47"N, 120°29'14"E / 16°18'32"N, 120°23'12"E /16°18'34"N, 120°23'03"E) were determined. The collected voucher specimen was authenticated at the Philippine National Museum.

Materials

A number of instruments and apparatuses were employed to enable this investigation. Laminated photos and maps functioned as references, and mapping was done using ARCGIS™ software and Google Earth Pro. Data sheets, surveyor's tapes, visible flagging ribbons, permanent markers, waterproof paper, GPS-equipped mobile phones, a compass, DSLR camera, binoculars, and instruments for obtaining voucher specimens were among the specialized items used for gathering field data.

Procedures

The study's research data was methodically acquired via a multi-phase process. The first stage, which we will refer to as the desktop phase, entailed gathering pertinent literature from multiple sources and creating necessary maps with Google Earth Pro and ARCGIS™ software. The following stage concentrated on involving the local community; this involved obtaining permission from the Municipality of Agoo, informing barangays, and working with barangay captains. Through this interaction, important information on Mt. Katayagan was gathered from community members. After the local community engagement, a reconnaissance survey that included drone assessments and on-site ocular inspections was carried out. The drone was utilized for the purposes of calibration and validation, guaranteeing thorough coverage of the vast terrain. A licensed forester was then required to update the land cover map using the data gathered during the reconnaissance survey. The updated land cover map will determine what suitable sample techniques will be used in the study and how the 2km transect line will be laid-out. Following this, the selection of the site for the 2km transect line took into account factors such as forested areas, elevation gradients, and alignment with existing trails to ensure accessibility.

The Belt-Transect Method, which was employed in the Forest Land Assessment, was essential in describing the Mt. Katayagan forest regions at the community and upper canopy species levels. In order to collect data in a systematic manner, a 2 km transect line with indicated intervals was established. Sections and stations were identified by different colored ribbons. To ensure a methodical approach to data gathering, the GPS device was utilized to mark sites along the transect. Assessments at the community and upper canopy species levels were carried out later. The community-level assessment required filling out the Community Level Assessment data sheet in every 50m section of the transect. This involved classifying each section based on forest formation and stand maturity. The Species Level Assessment data sheet was filled out every 250 meters for the upper canopy species level assessment. To reduce bias, nine quadrats measuring 20x20m were arranged in alternate orientations. Furthermore, the visual documentation of flora specimens adhered to ethical guidelines, including obtaining permits and adhering to established procedures for specimen photography of (Grabowski, 2015). The identification of flora species commenced with the analysis of captured photos, referencing authoritative sources. To ensure accuracy, final authentication was sought from the Jose Vera Santos Memorial Herbarium at UP Diliman, consulting various reputable botanical publications for cross-reference.

Data gathered

The data gathered in this study provides a comprehensive analysis of the ecological dynamics of Mt. Katayagan, focusing on land cover types, forest formation, and stand maturity along a 2km transect line. The research adhered to the Terrestrial Ecosystem Biodiversity Assessment and Monitoring Manual (2017) for land cover classification. Forest formation and stand maturity were evaluated using the framework by Fernando *et al.* (2008), distinguishing between old-growth and second-growth forests. The IV computation for plant species considered parameters such as species density, relative density, species frequency, relative frequency, basal area, and relative dominance.

Data analysis

The land cover types of Mt. Katayagan were classified based on the Terrestrial Ecosystem Biodiversity Assessment and Monitoring Manual (2017). The forest formation of Mt. Katayagan was classified by following the framework proposed by Fernando *et al.* (2008), incorporating twelve distinct types prevalent in the Philippines.

The stand maturity of the forest was assessed using a classification system distinguishing between old-growth and second-growth forests. Old-growth forests were identified by the prevalence of trees with a diameter at breast height exceeding 2.5ft, along with distinctive features such as standing dead trees and a multilayered canopy. Second-growth forests were characterized by smaller trees with a diameter at breast height less than 2.5ft, often resulting from regeneration after significant disturbances.

The IV was determined using the following formula:

Species Density = Number of individuals / Number of area samples

Relative Density = (Species Density / Total density of all species) × 100

Species Frequency = Number of Quadrats where a species occur / Total number of quadrats sampled

Relative Frequency = (Species Frequency Value / Total frequency of all species) × 100

Basal Area = $\pi \times (DBH/2)^2$

Where:

$\pi \approx 3.14$

DBH = Diameter at breast height

Relative Dominance = Basal area of a species / Total basal area of all species

IV = Relative Density + Relative Frequency + Relative Dominance

Research ethics

This research investigation strictly adhered to research ethics protocols, as demonstrated by obtaining a gratuitous permit from the Department of Environment and Natural Resources – Regional Office I. This permit enabled the study to be carried out in Mt. Katayagan, Agoo, La Union, Philippines. Furthermore, a Local Community Engagement initiative was executed to elucidate the study's objectives to the barangay officials who hold jurisdiction over the study site.

Results and discussion

To understand the ecological dynamics of Mt. Katayagan, this study focuses on four key aspects: land cover types, forest formation, stand maturity (Table 1), and the most dominant species in the upper canopy (see Table 4). These findings shed light on the mountain's environmental makeup and offer insights crucial for conservation and sustainable land management.

Table 1. Overview of Mt. Katayagan's land cover types, forest formation, and stand maturity

Category	Classification
Land cover types	Closed forest (70%), Grassland (5%), Annual cropland (15%), and Built-up areas (10%)
Forest formation	Tropical moist deciduous forest
Stand maturity	Secondary-growth forest

Land cover types

The reconnaissance survey conducted on Mt. Katayagan yielded a precise and updated land cover map, revealing the predominant closed forest cover (70%). The summit features a small grassland area (5%), while the base comprises annual cropland (15%) and built-up areas (10%) (Fig. 1). The dominance of closed forest underscores the need for a comprehensive biodiversity assessment to gauge the current ecological condition, particularly given the first-class municipality classification of Agoo, La Union, and the associated rapid urbanization and population growth. The increased infrastructure development around Mt. Katayagan amplifies its vulnerability to diverse influences, including habitat destruction, adverse impacts on water and soil quality, and degradation due to recurring annual harvesting practices. The correlation between urban development and environmental concerns that has been mentioned was extensively studied by Mendiola *et al.* (2015).

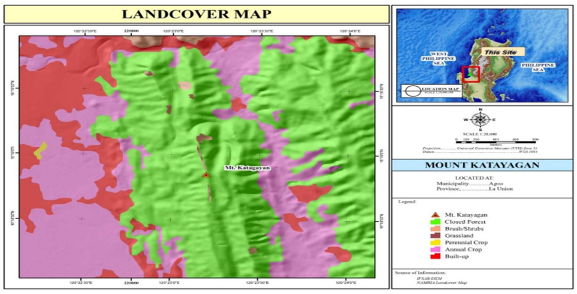

Fig. 1. Updated land cover map of Mt. Katayagan from the department of environment and natural resources

Furthermore, Mt. Katayagan's closed forest plays a vital role in landslide prevention, aligning with insights from the Regional Community Forestry Training Centre for Asia and the Pacific (2012). Trees and forests contribute to landslide risk reduction by forming root buttresses against soil movement, reinforcing soil layers, and anchoring soil to bedrock. They also lower soil moisture levels through mechanisms such as interception, evaporation, and transpiration, reducing the risk of landslides. Additionally, trees act as barriers against rock, debris, and soil slides, limiting the potential distance of a landslide. This ecological function highlights the significance of Mt. Katayagan's closed forest cover in maintaining landscape stability and preventing natural disasters.

Forest formation

Utilizing visual observation and drone-based surveys, the classification of Mt. Katayagan has been identified as a tropical moist deciduous forest, characterized by a dense tree canopy and rich biodiversity (Robles-Tanael, 2017). These forests, typically found near the equator, undergo prolonged dry seasons followed by heavy rainfall, leading to leaf shedding and increased sunlight penetration to the forest floor, fostering robust understory growth. In conjunction with the previously outlined characteristics of a tropical moist deciduous forest, all of which find expression within the ecosystem of Mt. Katayagan, the categorization of its forest formation is influenced by the following factors.

1. *Elevation significance*

The mountain's steep slopes attract avid hikers, and its strategic location encompasses both coastal hillsides facing the South China Sea and leeward slopes, providing a captivating panorama for explorers. The leeward side, characterized by moderated winds and reduced rainfall, proves conducive to agricultural activities, as discussed by Lacson (2017).

2. *Tree composition and leaf morphology*

The tropical moist deciduous forest of Mt. Katayagan hosts robust hardwood varieties such *as Dalbergia sisso* (Indian rosewood), *Shorea robusta* (sal), *Swietenia macrophylla* (mahogany), *Pterocarpus indicus* (narra), *Tectona grandis* (teak), *and Mangifera indica* (mango), alongside bamboo and palm trees (Amruta, 2022). While three species exhibit the highest density, *Dalbergia sisso* and *Shorea robusta* are notably absent. In the context of tropical moist deciduous forests, leaves typically exhibit a large and pointed structure. This adaptation aids in the efficient drainage of rainwater and serves as a deterrent to the growth of fungi, which thrive in warm and damp conditions, as explained by the Biology Dictionary (2019). Building upon this information, many of the predominant species on Mt. Katayagan, such as *Tectona grandis* (teak), *Macaranga tanarius* (parasol leaf), and *Gmelina arborea* (gmelina), display a large and pointed leaf structure;

3. *Soil classification and climatic conditions*

Mt. Katayagan's soil type aligns with zonal soil, specifically annam clay loam, known for fertility and moisture retention, supporting various agricultural practices (Fitzpatrick, 2017). Climatic conditions closely resemble those of tropical moist deciduous forests, with an average annual temperature of 28°C, a relative humidity of 77%, and an annual rainfall of 20 centimeters, aligning with standards reported in Weather and Climate (2023) and INSIGHTSIAS (2023);

Table 2. Elevation, coordinates, and observed disturbances of the nine quadrats along the 2km transect line.

Quadrat	Elevation (masl)	Latitude	Longitude	Observed disturbances
0	109	16°19'10.3"N	120°22'50.9"E	Manmade structures Logging
1	134	16°19'12.3"N	120°22'56.9"E	Logged trees
2	153	16°19'08.5"N	120°23'01.0"E	Logging Trashes Manmade structures
3	172	16°19'09.2"N	120°23'05.3"E	Trashes
4	207	16°19'05.2"N	120°23'08.2"E	
5	225	16°19'00.2"N	120°23'10.5"E	Manmade structures Charcoal Making
6	211	16°18'53.3"N	120°23'11.6"E	Logging
7	199	16°18'47.0"N	120°23'14.3"E	Logging Water extraction
8	168	16°18'39.8"N	120°23'10.3"E	Logging

Table 3. Ecological characteristics of upper canopy (20×20 meters) plant species

Family and scientific name	Common name	Altitude range (masl.)	Quadrat present
Anacardiaceae			
Anacardium occidentale	Kasuy	134-225	1,5
Buchanania arborescens	Balinghasay	199	7
Mangifera indica	Manga	109-207	0,1,2,3,4
Spondias dulcis	Balolong	109	0
Annonaceae			
Annona muricata	Guyabano	207	4
Annona reticulata	Anonas	168	8
Annona squamosa	Atis	109-172	0,3
Apocynaceae			
Tabernaemontana pandacaqui	Kampupot	199	7
Wrightia pubescens	Lanete	109-225	0,1,3,4,5,7,8
Arecaceae			
Caryota sp.	-	153-225	2,3,4,5
Cocos nucifera	Buko	173	3
Roystonea regia	Royal Palm Tree	109	0
Bignoniaceae			
Oroxylum indicum	Pingka-pingkahan	153-211	2,6,7
Boraginaceae			
Ehretia microphylla	Tsaang Gubat	199	7
Caricaceae			
Carica papaya	Papaya	172-207	3,4
Combretaceae			
Terminalia catappa	Talisay	153-225	2,5
Euphorbiaceae			
Hevea brasiliensis	Rubber Tree	172	3
Macaranga tanarius	Binunga	109-225	0,1,4,5
Mallotus philippensis	Banato	109-168	0,8
Melanolepis multiglandulosa	Alim	207	4
Fabaceae			
Albizia sp.	-	225	5
Bauhinia purpurea	Butterfly Tree	109	0
Leucaena leucocephala	Ipil-ipil	134-225	1,2,3,5,8
Peltophorum pterocarpum	Siar	153	2
Pterocarpus indicus	Narra	109-225	0,1,2,3,5,6,7
Samanea saman	Acacia	172-211	3,6
Tamarindus indica	Sampalok	134-172	1,3
Lamiaceae			
Clerodendrum minahassae	Baguak na Puti	168-172	3,8
Gmelina arborea	Gmelina	109-199	0,7,8
Premna serratifolia	Alagau-gubat	225	5
Tectona grandis	Teak	168-207	4,7,8
Vitex negundo	Lagundi	199-211	6,7
Vitex parviflora	Molave	211-225	5,6
Lauraceae			
Litsea sp.	-	225	5

Persea americana	Abukado	134-211	1,4,6
Lythraceae			
Lagerstroemia speciosa	Banaba	199	7
Malvaceae			
Grewia laevigata	Dangli	225	5
Kleinhovia hospita	Tan-ag	153	2
Sterculia foetida	Kalumpang	211	1
Meliaceae			
Azadirachta indica	Balunga	225	5
Swietenia macrophylla	Mahogany	109-225	0,1,2,5,8
Sandoricum koetjape	Santol	109-207	0,4
Moraceae			
Allaeanthus luzonicus	Himbabao	225	5
Artocarpus camansi	Kamansi	134-207	1,4
Artocarpus heterophyllus	Langka	109-134	0,1
Ficus altissima	Council Tree	211	6
Ficus benjamina	Balete	211	6
Ficus minahassae	Hagimit	225	5
Ficus nota	Tibig	172	3
Ficus septica	Hauili	134-225	1,2,4,5,6
Streblus asper	Kalios	153-225	2,3,4,5,7
Musaceae			
Musa acuminata	Lakatan	109	0
Myrtaceae			
Psidium guajava	Bayabas	134-199	1,7
Syzygium cumini	Duhat	199-225	5,6,7
Oxalidaceae			
Averrhoa bilimbi	Kamias	134	1
Phyllanthaceae			
Antidesma bunius	Bignay	134	1
Antidesma ghaesembilla	Binayuyo	199-225	5,6,7
Bridelia stipularis	Kuto-kuto	225	5
Pittosporaceae			
Pittosporum pentandrum	Mamalis	211	6
Rhamnaceae			
Ziziphus talanai	Balakat	211	6
Rutaceae			
Harrisonia perforata	Mamikil	211-225	5,6
Micromelum minutum	Tulibas Tilos	172	3
Salicaceae			
Flacourtia indica	Palutan	134	1
Sapindaceae			
Elattostachys verrucosa	-	199-225	4,5,7
Nephelium lappaceum	Rambutan	109	1
Sapotaceae			
Chrysophyllum cainito	Caimito	109-207	0,1,4
Pouteria campechiana	Tiesa	134-172	1-3
Vitaceae			
Leea manillensis	Abang-abang	172-199	3-7

4. *Local observations and classification framework*

Residing in San Antonio, Agoo, La Union, one of the barangays overseeing Mt. Katayagan, the researcher notes the manifestation of typical tropical moist deciduous forest attributes. Applying Fernando *et al.* 's (2008) classification framework, Mt. Katayagan embodies fundamental characteristics, with an elevation range categorizing it as lowland. The prevalent annam clay loam soil and inland geographical setting contribute to its localized ecological context.

5. *Unique features*

Mt. Katayagan's forest formation is distinguished by unique hydrological attributes, characterized by a moderate annual scarcity. Additionally, the dominance of Dipterocarp species in its forest composition highlights the significant botanical profile of this ecosystem. These findings contribute valuable insights into the distinctive ecological dynamics of Mt. Katayagan's forest formation, offering a comprehensive understanding for conservation and sustainable management strategies.

Stand maturity

By conducting a land investigation, documenting the canopy coverage as well as the cardinal directions in each section of the 2km transect, and collecting information during the local community engagement, the classification of Mt. Katayagan as a secondary-growth forest was ascertained. Secondary-growth forests are those that have regenerated subsequent to deforestation resulting from factors like agricultural practices, insect infestations, logging operations, and wildfires (Butler, 2020). The research revealed discernible indications of human-induced interventions, including evidence of manmade constructions, logging activities, waste deposition, charcoal making, and water extraction. These findings are substantiated through the visual representation presented in Fig. 2. Moreover, a comprehensive detail encompassing elevation, coordinates, and observed disturbances along the 2km transect line can be found in Table 2.

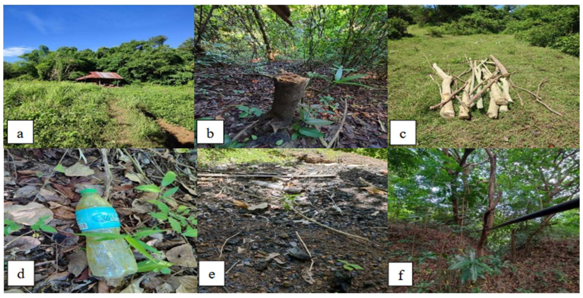

Fig. 2. Disturbances Recorded at Mt. Katayagan, Agoo, La Union: a. Manmade Constructions, b. and c. Logging Activities, d. Waste Deposition, e. Charcoal Production, and f. Water Extraction

Numerous research endeavors have established that within the Philippines, forests primarily populated by dipterocarp species undergo a transformation into ecosystems dominated by short-lived species. This is exemplified by the presence of *Trema orientale*, *Macaranga sp.*, *Alphitonia sp.*, and *Mallotus sp.*, following extensive logging activities (Weidelt and Banaag, 1982). Notably, three out of these four species, with the exception of *Alphitonia sp.*, are prevalent within the confines of Mt. Katayagan. Resembling secondary-growth forests, Mt. Katayagan is dominated by a numerous small tree and a single-layered canopy structure, a result of the uniformity in tree height and age.

Dominant plant species in Mt. Katayagan

The vegetation of Mt. Katayagan in Agoo, La Union, Philippines, boasts a diverse array of plant species across its upper canopy with a total of 68 plant species distributed among 27 distinct families. Table 3 provides a comprehensive list of species of upper canopy plants along with their common name, elevation, and quadrat in which they are found.

Within a sampling quadrat measuring 20x20m, plant specimens meeting the minimum diameter requirement of four inches at breast height were identified. Table 4 provides a detailed breakdown of the upper canopy for the computation of the importance value of species, incorporating relative density, relative frequency, and relative dominance. Notably, *Pterocarpus indicus* (narra) stood out, displaying the highest population density, as 29 individual trees of this species were recognized. This numerical representation equated to 10.9 percent of the overall density observed among the 266 trees identified. Close behind were *Swietenia macrophylla* (mahogany) with 27 individuals and *Tectona grandis* (teak) with 21 individuals, corresponding to relative densities of 10.15 percent and 7.89 percent, respectively. These findings underscore the significance of these three species within the upper canopy sampling quadrats, signifying their pre-eminent status among the recorded plant populations based on population density considerations.

Among the 68 trees identified in the nine 20x20m sampling quadrats, *Pterocarpus indicus* (narra) and *Wrightia pubescens* (lanete) share the distinction of having the highest frequency value. These two species were both observed in seven out of the nine sampling quadrats, resulting in a relative frequency of 5.04 percent for each. Trailing behind are four additional species, *Mangifera indica* (manga), *Leucaena leucocephala* (ipil-ipil), *Streblus asper* (kalios), and *Ficus septica* (hauili), which were each present five times across the nine quadrats, thus yielding a relative frequency of 3.6 percent. This pattern underscores the prevalence of *Pterocarpus indicus* (narra) and *Wrightia pubescens* (lanete) as the most widely distributed species in the Mt. Katayagan area of Agoo, La Union, Philippines.

Table 4. Importance Value of the 68 upper canopy species in Mt. Katayagan using relative density, relative frequency, and relative dominance

Species	Relative density	Relative frequency	Relative dominance	Importance value
Pterocarpus indicus	10.9023	5.03597	4.91336	20.8516
Swietenia macrophylla	10.1504	3.59712	1.14559	14.8931
Wrightia pubescens	6.01504	5.03597	1.40919	12.4602
Tectona grandis	7.89474	2.15827	2.10685	12.1599
Mangifera indica	3.7594	3.59712	4.51139	11.8679
Sterculia foetida	0.37594	0.71942	8.4698	9.56516
Chrysophyllum caimito	1.50376	2.15827	5.8818	9.54384
Leucaena leucocephala	2.63158	3.59712	1.19704	7.42574
Ficus septica	2.63158	3.59712	1.02791	7.25662
Macaranga tanarius	3.00752	2.8777	1.33444	7.21966
Streblus asper	3.00752	3.59712	0.55759	7.16223
Samanea saman	1.12782	1.43885	4.52586	7.09253
Antidesma ghaesembilla	3.00752	2.15827	1.43966	6.60545
Kleinhovia hospital	1.12782	0.71942	4.31122	6.15847
Caryota sp.	2.63158	2.8777	0.60911	6.11839
Vitex parviflora	1.12782	1.43885	3.25456	5.82123
Tamarindus indica	0.75188	1.43885	3.47303	5.66376
Terminalia catappa	2.63158	1.43885	1.32813	5.39856
Persea americana	1.12782	2.15827	2.04381	5.3299
Syzygium cumini	1.8797	2.15827	1.08489	5.12286
Ficus minahassae	0.37594	0.71942	3.96509	5.06045
Gmelina arborea	1.12782	2.15827	1.62931	4.9154
Ficus nota	0.37594	0.71942	3.01357	4.10893
Oroxylum indicum	1.12782	2.15827	0.46345	3.74954
Elattostachys verrucosa	1.12782	2.15827	0.41826	3.70436
Mallotus philippensis	0.75188	1.43885	1.43966	3.63039
Allaeanthus luzonicus	0.37594	0.71942	2.50523	3.60059
Azadirachta indica	0.37594	0.71942	2.50523	3.60059
Sandoricum koetjape	1.12782	1.43885	0.87621	3.44287
Annona squamosa	1.12782	1.43885	0.78323	3.3499
Anacardium occidentale	0.75188	1.43885	1.14964	3.34037
Hevea brasiliensis	0.37594	0.71942	2.1924	3.28776
Psidium guajava	1.12782	1.43885	0.66737	3.23403
Pouteria campechiana	1.50376	1.43885	0.28741	3.23002
Buchanania arborescens	1.12782	0.71942	1.30026	3.14751
Carica papaya	0.75188	1.43885	0.84463	3.03536
Nephelium lappaceum	0.37594	0.71942	1.90043	2.99579
Pittosporum pentandrum	0.75188	0.71942	1.43966	2.91096
Tabernaemontana pandacaqui	1.8797	0.71942	0.27122	2.87035
Artocarpus heterophyllus	0.75188	1.43885	0.66737	2.85809
Lagerstroemia speciosa	1.12782	0.71942	0.9744	2.82164
Harrisonia perforata	0.75188	1.43885	0.62631	2.81704
Ziziphus talanai	0.37594	0.71942	1.62931	2.72467
Grewia laevigata	1.50376	0.71942	0.45767	2.68086
Bauhinia purpurea	0.75188	0.71942	1.14964	2.62094
Cocos nucifera	0.37594	0.71942	1.50157	2.59694
Artocarpus camansi	0.75188	1.43885	0.31543	2.50616
Leea manillensis	0.75188	1.43885	0.28741	2.47814
Annona reticulata	0.37594	0.71942	1.37905	2.47441
Vitex negundo	0.75188	1.43885	0.18835	2.37908
Clerodendrum minahassae	0.75188	1.43885	0.16684	2.35757
Ficus benjamina	0.37594	0.71942	1.26174	2.3571
Averrhoa bilimbi	0.37594	0.71942	0.94109	2.03645
Spondias dulcis	0.37594	0.71942	0.94109	2.03645
Melanolepis multiglandulosa	0.75188	0.71942	0.5481	2.0194
Ficus altissima	0.75188	0.71942	0.51095	1.98226
Litsea sp.	0.37594	0.71942	0.84463	1.94
Ehretia microphylla	0.37594	0.71942	0.66737	1.76273
Albizia sp.	0.37594	0.71942	0.58655	1.68192
Premna serratifolia	0.37594	0.71942	0.44057	1.53593
Roystonea regia	0.37594	0.71942	0.31543	1.4108
Musa acuminata	0.37594	0.71942	0.26069	1.35605

Peltophorum pterocarpum	0.37594	0.71942	0.26069	1.35605
Micromelum minutum	0.37594	0.71942	0.21116	1.30652
Annona muricata	0.37594	0.71942	0.16684	1.26221
Antidesma bunius	0.37594	0.71942	0.16684	1.26221
Bridelia stipularis	0.37594	0.71942	0.12774	1.2231
Flacourtia indica	0.37594	0.71942	0.12774	1.2231

Within a pool of 68 trees identified in the nine 20x20m sampling quadrat, *Sterculia foetida* (kalumpang) possessed the largest basal area, quantifying at 2551.76, alongside a relative dominance measuring 8.47 percent. Sequentially, *Chrysophyllum cainito* (caimito) has a cumulative basal area of 1772.05, followed by *Pterocarpus indicus* (narra) with a total basal area of 1480.28, accompanied by relative dominance percentages of 5.88 percent and 4.91 percent, respectively.

After calculating the IV for every species in the upper canopy, *Pterocarpus indicus* (narra) was found to have the highest significance (20.85%). This highlighted the significance of narra in the ecology of Mt. Katayagan, taking into account its relative frequency of 5.06 percent, relative density of 10.9 percent, and relative dominance of 4.91 percent. Its constant presence in seven quadrats suggests that it is a ubiquitous ecological adaptor to a wide range of environmental situations.

Pterocarpus indicus (narra), recognized as the national tree of the Philippines, belongs to the Fabaceae family and is indigenous to Southeast Asia. Beyond its economic uses, including timber for construction and furniture making, narra plays a pivotal role in ecosystem balance. Thomson (2006) outlines its contributions, such as providing shelter for diverse species, soil stabilization through an extensive root system, carbon sequestration, temperature regulation, and water cycle regulation. The alignment of narra's dominance at Mt. Katayagan with its ecological adaptability and specific environmental conditions, including prolonged dry periods, heavy rainfall, steep elevation, and coastal positioning, highlights its resilience and competitive advantage. The subsequent four plant species with the highest Importance Values after narra were *Swietenia macrophylla* (mahogany) at 14.89 percent, *Wrightia pubescens* (lanete) at 12.46 percent, *Tectona grandis* (teak) at 12.16 percent, and *Mangifera indica* (mango) at 11.87 percent. While these species contribute significantly to the ecological makeup, they do not exhibit the same level of dominance as *Pterocarpus indicus* (narra).

Conclusion

The study's findings provide compelling insights into the ecological characteristics of Mt. Katayagan. The comprehensive analysis of Mt. Katayagan's land cover types, forest formation, and stand maturity provides valuable insights into the ecological dynamics of this region. The predominant land cover type, comprising 70 percent closed forest, along with grassland at the peak (5%), annual cropland (15%), and built-up areas (10%) at the periphery, reflects the diverse landscape of Mt. Katayagan.

The forest formation classification as a tropical moist deciduous forest is substantiated by various factors, including elevation, tree composition, leaf characteristics, soil classification, and climatic conditions. These factors collectively contribute to the distinctive features of a tropical moist deciduous forest, aligning seamlessly with the observed characteristics of Mt. Katayagan.

The assessment of stand maturity underscores Mt. Katayagan's status as a secondary-growth forest, influenced by human-induced interventions. Specific tree species associated with secondary-growth forests further validate this evaluation, with the presence of *Trema Oritentale, Macaranga sp*., and *Mallotus sp.*

Pterocarpus indicus (narra) is the predominant species, leading in relative density and frequency, showcasing its prevalence across the upper canopy with an IV of 20.85 percent. With an IV of 14.83 percent, 12.46 percent, 12.16 percent, and 11.87 percent, respectively, *Swietenia macrophylla* (mahogany), *Wrightia pubescens* (lanete), *Tectona grandis* (teak), and *Mangifera indica* (manga) follow closely behind, making a substantial contribution to the composition of the canopy overall. *Sterculia foetida* (Kalumpang), asserts the greatest relative dominance with a basal area of 2551.76 and a relative dominance of 8.47 percent.

Recommendation(s)

The study suggests two key recommendations for the management and conservation of Mt. Katayagan. Firstly, establish a continuous monitoring program integrating satellite imagery and on-site surveys for a comprehensive assessment of land cover, forest formation, and stand maturity. Utilize advanced remote sensing techniques, like drones, and collaborate with experts to refine monitoring protocols. Secondly, initiate a focused ecological study on dominant species, particularly Pterocarpus indicus (narra), utilizing field observations, reproductive behavior analyses, and advanced techniques like canopy access systems. Collaborate with experts for a multidisciplinary approach. These measures aim to ensure adaptive management and the preservation of key species crucial for Mt. Katayagan's ecological balance.

References

Addison P, Flander L, Cook CN. 2017. Towards quantitative condition assessment of biodiversity outcomes: Insights from Australian marine protected areas. Journal of Environmental Management **198**, 183–191.
https://doi.org/10.1016/j.jenvman.2017.04.054

Amruta P. 2022. Tropical Moist deciduous forests - Environment notes. Prepp. https://prepp.in/news/e-492-tropical-moist-deciduous-forests-environment-notes#Flora

Arengarden. 2017. Ijjay Bantay Katayagan. Blogger. https://arengarden.blogspot.com/2017/10/ijjay-bantay-katayagan.html

Australia State of the Environment. 2018. Importance of biodiversity. Australia State of the Environment Report.
https://soe.environment.gov.au/theme/biodiversity/topic/2016/importance-biodiversity

Biodiversity Management Bureau. 2017. Terrestrial Ecosystem Biodiversity and Assessment Monitoring Manual, 1–136.
http://www.philchm.ph/wp-content/uploads/2019/03/BMS-Manual-1.pdf

Biology Dictionary. 2019. Deciduous Forest. Biology Dictionary. https://biologydictionary.net/deciduous-forest/

Butler R. 2020. Types of forests. https://rainforests.mongabay.com/0103.htm

Convention on Biological Diversity. 2021. International Institute for Environment and Development. https://www.iied.org/convention-biological-diversity?gclid=CjwKCAjw9aiIBhA1EiwAJ_GTSuDf9bUL9S2EJQvoWQXttVRqZ5igfYXfQ6R5bcuwT1zREJp_BJRnixoCi4IQAvD_BwE

Diaz S, Settele J, Brondizio S, Ngo HT, Gueze M, Agard J, Arneth A, Balvanera P, Brauman KA, Butchart SHM, Chan KMA, Garibaldi LA, Ichii K, Liu J, Subramanian M, Midgley GF, Miloslavich P, Molnar Z, Obura D, Zayas CN. 2019. The Global Assessment Report on Biodiversity and Ecosystem Services Summary for Policymakers (ISBN No: 978–3-947851-13-3). Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES).

Eisma RM, Asprin JR, Macusi C, Medina J, Padilla ZJ. 2014. Appraisal of Mt. Katayagan as A Watershed Resource in Agoo, La Union. Unpublished Undergraduate Thesis. Don Mariano Marcos Memorial State University - South La Union Campus.

Fernando ES, Suh MH, Lee J, Lee DK. 2008. Forest Formations of the Philippines. ASEAN-Korea Environmental Cooperation Unit (AKECU), Korea. ISBN 978-89-92239-40-0.
https://www.gettextbooks.com/author/Edwino_S_Fernando

Fitzpatrick E. 2017. What is Annam Clay Loam Soil? https://www.gardeningknowhow.com/garden-how-to/soil-fertilizers/annam-clay-loam-soil.html

Grabowski J. 2015. Best Practices to Follow When Taking Photos for Plant Identification. nrcs.usda. https://www.nrcs.usda.gov/Internet/FSE_PLANTMATERIALS/publications/flpmctn12688.pdf

INSIGHTSIAS. 2021. Tropical Moist Deciduous Forests. https://www.insightsonindia.com/environment/environment-degradation-and-issues/forest-ecosystem/classification-of-natural-vegetation-of-india/moist-tropical-forests/tropical-moist-deciduous-forests/

Kohler T, Maselli D. 2012. Mountains and Climate Change (ISBN: 978–3-905835-16-8). Centre for Development and Environment (CDE), Institute of Geography. http://www.fao.org/3/i2869e/i2869e00.pdf

Lacson R. 2017. The leeward side of the mountain: Exploring the coastal hills of Agoo, La Union. Tourism and Adventure Magazine **8(2)**, 36-40.

Mendiola L, González P, Frontera ÀC. 2015. The relationship between urban development and the environmental impact mobility: A local case study. Land Use Policy **43**, 119–128.

National Geographic Society. 2019. Biodiversity. https://www.nationalgeographic.org/encyclopedia/biodiversity/

Paller VGV, Magcale-Macandog D, de Chavez ERC, Paraso MGV, Tsuchiya MC L, Campang JG, Pleto JVR, Bandal MZ Jr, Cabillon YCL, Elepaño AG, Macaraig JRM, Mendoza SS. 2021. The Seven Lakes of San Pablo: Assessment and Monitoring Strategies Toward Sustainable Lake Ecosystems. Philippine Science Letters **14(1)**, 158-179.

Regional Community Forestry Training Centre for Asia and the Pacific. 2012. Forests and Landslides: The Role of Forests and Forestry in the Prevention and Rehabilitation of Landslides in Asia. https://www.recoftc.org/publications/0000049

Republic Act No. 9417. 2001. An Act Providing for the Conservation and Protection of Wildlife Resources and their Habitats, Appropriating Funds Therefor and for Other Purposes. Official Gazette of the Republic of the Philippines. https://www.officialgazette.gov.ph/2001/07/30/republic-act-no-9417/

Robles-Tanael J. 2017. Philippine Tropical Moist Deciduous Forests: Biodiversity and Conservation. In Tropical Forestry Handbook (pp. 2-30).

Thomson LAK. 2006. Pterocarpus indicus (narra), ver. 2.1. In C.R. Elevitch (Ed.), Species Profiles for Pacific Island Agroforestry. Permanent Agriculture Resources (PAR), Holualoa, Hawaii.

Tsioumani E, Tsioumanis A. 2020. Biological Diversity: Protecting the variety of life on Earth. International Institute for Sustainable Development. https://www.iisd.org/articles/biological-diversity-protecting-variety-life-earth

Weather and Climate. 2023. The Global Historical Weather and Climate. AGOO, La Union, PH Climate Zone, Monthly averages, historical weather data. https://tcktcktck.org/philippines/la-union-philippines/agoo

Weidelt H, Banaag VS. 1982. Aspects and Management and Silviculture of Philippine Dipterocarp Forests. German Agency for Technical Cooperation, Eschbon, Germany, 302p.