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Bat Conservation Strategy In Duasudara Mountain Nature Reserve As Ecotourism Potential Of North Sulawesi, Indonesia

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Sulawesi is a geologically complex island with unique fauna, including significant bat populations. This study aimed to identify bat species diversity, endemism, conservation status, and recommend conservation strategies in the Gunung Duasudara Nature Reserve. The research, conducted from May to August 2018 using mist nets across seven vegetation types, recorded 15 bat species with 475 individuals. Notable species include Acerodon celebensis, Boneia bidens, and Thoopterus nigrescens, categorized as near threatened by the IUCN. Newly discovered species M. tailiniensis, R. tangkokoensis, and T. tailiniensis exhibit distinct characteristics. The study's analyses suggest that maintaining the Nature Reserve's status is crucial for its development as a center for education, research, and ecotourism, emphasizing the need for supportive regional policies and stakeholder involvement to ensure sustainable conservation efforts.

1. Introduction

Sulawesi is the most uniquely shaped, largest and geologically complex island in the Wallacea region. It comprises thousands of oceanic islands and is a transition zone between the plants and animals of the Oriental (Asia) and Austrolo-Papuan (Australia) regions. Sulawesi Island is endemic for its fauna, and is reported to support some of the most important bat populations in Indonesia (WCS, 2001). Of the twenty-one species of bats recorded on Sulawesi, eight (38%) are endemic and of these eight, two (sometimes three) are classified as endemic to genera level (Corbet and Hill, 1992). Ecologically, these animals have their own position and role in the ecosystem (Nowak, 1995).

Conservation efforts on Sulawesi Island began in the early 1900s, when the Dutch colonial government established several nature reserves and continue today with the establishment of new areas by the Government of Indonesia (Kinnaird, 1997). Sulawesi Island has 54 conservation areas out of 373 conservation areas in Indonesia (WCS, 2001). Furthermore, North Sulawesi has important conservation areas, namely: Mount Duasudara Nature Reserve, Ambang Nature Reserve, Mount Lokon Nature Reserve, Bogani Nani Wartabone National Park, Bunaken National Park and Manembo-nembo Wildlife Sanctuary represent a variety of ecosystems from valleys and mountain peaks to the bottom of its waters (Kinnaird, 1997). This means that North Sulawesi has enormous potential in biodiversity compared to other regions in Indonesia

Gunung Duasudara Nature Reserve is one of the most important built-in conservation areas in North Sulawesi today. Geographically, it is also located at 124°8' - 125°8' East Longitude and 134°8' North Latitude (Kinnaird and O'Brien, 1996). The reserve has an area of approximately 8,867 ha and includes three volcanoes, namely: Mount Tangkoko at 1,109m above sea level with a caldera with a centerline of 1 km, Mount Batuangus at 450m above sea level and Mount Duasudara at 1,351m above

sea level.

Gunung Duasudara Nature Reserve features diverse vegetation types, from coastal forests to moss forests, and is home to various endemic species like the Black Monkey (Macaca nigra), Tangkasi (Tarsius spectrum), and several bat species. Previous research has proposed conservation strategies in other regions, such as the Gombong Karst, where caves are protected as conservation areas due to their ecological importance. However, data on bats in Gunung Duasudara is lacking, and no bat conservation strategies have been reported, despite ongoing habitat disturbances like forest fires, land clearing, and hunting.

Bats in Gunung Duasudara Nature Reserve face significant threats due to habitat loss and hunting. Local communities hunt bats for commercial purposes and personal consumption, with species like Acerodon celebensis, Cynopterus brachyotis, Dobsonia exoleta, Rousettus celebensis, and Thoopterus nigrescens being captured and sold at local markets. Bats reproduce slowly, with long gestation periods and typically only 1-2 offspring per birth, making their populations highly vulnerable to decline under the pressures of hunting and habitat destruction.

Bats play a crucial role in ecosystems and the economy by dispersing seeds, pollinating valuable plants, controlling insect pests, producing guano, and offering ecotourism opportunities. Megachiroptera bats, essential for pollinating 186 species of plants, are particularly important. Despite their ecological and economic value, bats in Gunung Duasudara Nature Reserve are underutilized as a tourist attraction. Without proper conservation management, the decline in bat populations could lead to significant ecological disruptions and economic losses.

2. Research Method

This research was conducted in Gunung Duasudara Nature

Reserve, Bitung City, North Sulawesi Province (Fig. 1). The study covered seven main vegetation areas with an altitude of 0-1351 m above sea level. Data identification was conducted at the Biology Research Center of LIPI Bogor. Data analysis was conducted at the Ecology Laboratory, Faculty of Mathematics and Natural Sciences, Sam Ratulangi University. The first research will be conducted in February - November 2018.

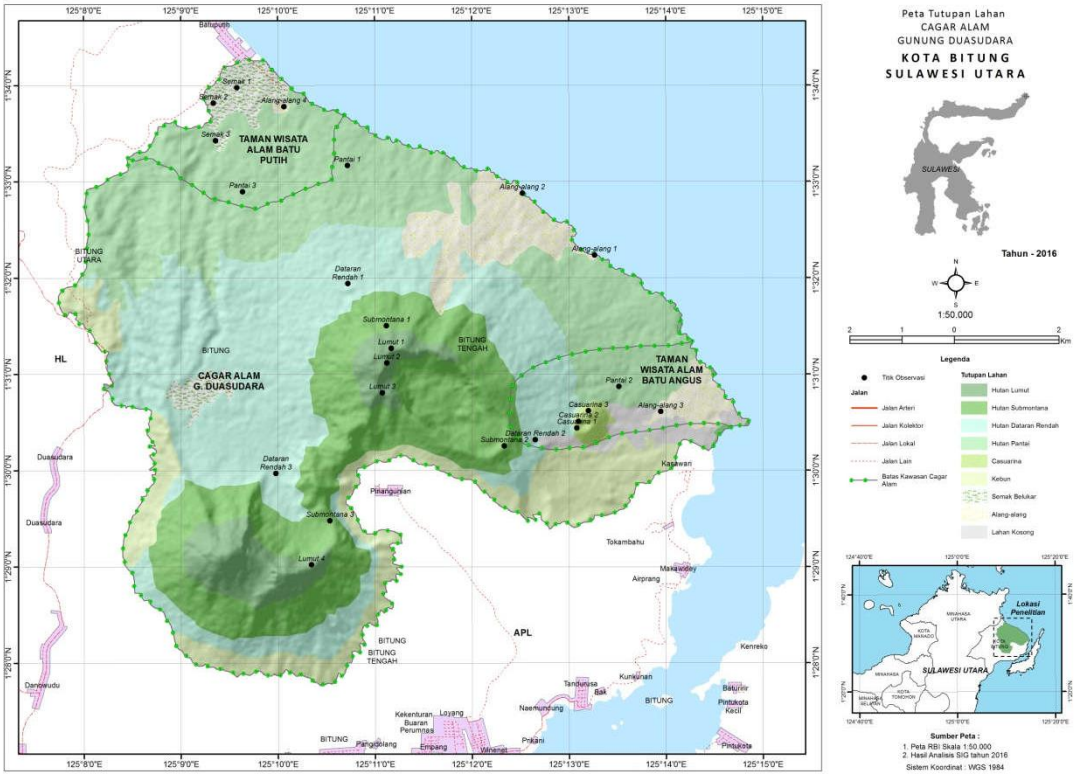

Fig.1. Research location in Gunung Duasudara Nature Reserve

The materials used in this research are bats netted in Gunung Duasudara Nature Reserve and the area boundary map from BPKH Region VI Manado, North Sulawesi.

This research is descriptive exploratory conducted by survey method and mistnet installation at locations in each zone. The independent variables of this study were the research area (each zone in Gunung Duasudara Nature Reserve), and species. The dependent variables include the number of species and individuals, endemic status, species diversity, Gap Analysis, SWOT Analysis and Root Cause Analysis.

1. Abundance

To identify species abundance, the capture rate equation

was used. Capture rate (Lt) was determined based on the ratio of the number of bats to the length of mistnetting (WCS, 2001; Jorgensen, et al., 2005) by following the equation:

$$\text{Capture Rate (Lt)} = \frac{\text{Number of Bats}}{\text{Duration of Mist Netting}}$$

where : Lt = Capture rate

Number of Bats = Number of bats netted

Duration of Mist-Netting = Net Length multiplied by the length of mistnetting hours times the number of days of netting.

Criteria according to Jorgensen et al. (2005) :

Lt close to 0 = Low catch rate
Lt close to 1 = High catch rate

2. Diversity

Community diversity is characterized by the number of species of organisms that make up the community. The greater the number of species the higher the diversity. The diversity index (H') shows the relationship between the number of species and the number of individuals that make up a community. The diversity index (H') describes diversity, productivity, pressure on the ecosystem, and ecosystem stability (Shannon-Wiener, 1949; Margalef, 1958; Odum, 1993).The diversity index (H') is determined by the equation:

$$\text{Diversity Index (H')} = \sum_{i=0}^{s} Pi\ Ln\ Pi$$

where : S = Number of all species

Pi = Ni / N = Share of total individuals belonging to the i-th species

Ni = Number of individuals belonging to species i

N = Total number of all individuals

Criteria:

H' < 1.00 = Low diversity

1.00 < H' < 3.00 = Medium diversity

H' > 3.00 = High diversity

3. Result and Discussion

Based on Table 1, it shows that the gap analysis of the number of species and individuals, endemic species and species diversity of bats is positive. This indicates a good expectation for protection and preservation for bats in Gunung Duasudara Nature Reserve due to perceptions and information from previous research. According to research from Sugianto and Kristanti (2014), that attractiveness shows a positive perception so that there is no gap between perceptions and expectations. This means that visitors feel interested in ecotourism in the Gunung Duasudara Nature Reserve.

Table 1. Gap Analysis of bats in Gunung Duasudara Nature Reserve

No	Variables	Kelelawar CA Gunung Duasudara	Pustaka	Gap analysis
1	- Number of species and individuals. - Number of species and individuals from different zones	- 15 species and 475 individuals. - Moss forest (7 species, 121 individuals), submontane forest (13 species, 104 individuals), lowland forest (10 species, 79 individuals), casuarina forest (8 species, 16 individuals), coastal forest (9 species, 75 individuals), shrubs (5 species, 34 individuals), reeds (3 species, 46 individuals).	The number of species in Tangkoko- Duasudara CA is 10 species (WCS, 2003); 9 species and 843 individuals (Lengkong, 2009).	+
2	Endemic species (Indonesia*, Sulawesi**)	*Acerodon celebensis**, *Boneia bidens***, *Cynopterus minutus**, *Macroglossus tailiniensis***, *Rousettus celebensis**, *Rousettus tangkokoensis***, *Thoopterus nigrescens**, *Thoopterus tailiniensis***	(WCS, 2003); Acerodon celebensis* Dobsonia exoleta* Rousettus celebensis*, Thoopterus nigrescens*	+
3	Species abundance, and	- Species abundance (catch	Species abundance (catch	+

	species abundance from different zones	rate) is low (0.072). - Low species abundance in catch rates from different habitat zones (moss, submontane, lowland, casuarina, beach, shrub and reed)	rate) low by elevation (moss, submontane, lowland, coastal) (Lengkong, 2009)	
4	Species diversity, and species diversity of different zones	- Medium species diversity (2.037). - Medium species diversity from different habitat zones (moss, submontane, lowland, casuarina, beach, shrubs and reeds)	Species diversity low by altitude (moss, submontane, lowland, coastal) (Lengkong, 2009).	+

Table 2 highlights key internal and external factors for the protection and conservation of Gunung Duasudara Nature Reserve. Strengths include its legal conservation status, effective management, available facilities, and high bat diversity, making it a priority for protection. Weaknesses involve challenges in area designation, policies allowing local habitation, and insufficient supervision. Opportunities include supportive regional policies, engaged stakeholders, community-led tour guides, and potential for ecotourism. Threats encompass frequent fires, hunting due to high meat demand, the high value of wood for construction, and limited security infrastructure.

Table 2. *SWOT Analysis* of bats in Gunung Duasudara Nature Reserve

Internal Factors	*Strengths*	1. Legal status of CAGD as a conservation area. 2. The concept of area management by the government, known as Batu Putih Nature Park and Batu Angus Nature Park. 3. The existence of facilities for research by building houses by the government and establishing residences for research. 4. The composition of the number of species and individuals, the number of species and individuals from various zones; endemic animals of Indonesia and Sulawesi; medium species diversity in nature reserves, and medium species diversity from various zones.
	Weaknessess	1. The capacity to determine the area and designation of the area was not established until 2014, so the community has already exploited it. 2. There are policies that allow people living around the area to enter and take natural resources. There are no strict actions and rules of order for visitors to the Nature Tourism Park. 3. There is still a lack of officers in supervising the entire nature reserve area.

External Factors	*Opportunities*	1. Local policies support the proposed protection and preservation of the area. 2. Stakeholders involved and concerned about the protection and preservation of the area are quite high both locally and to foreign countries. 3. The existence of tour guide groups formed by the community in supporting tourism. 4. Similar locations have become areas and locations for ecotourism bench marking.
	Threats	1. Frequent fires due to prolonged summer and also caused by the population's intentions for plantation expansion. 2. The high demand from consumers and the high price of meat in the market have led to people hunting bats for their own consumption and selling in the market. 3. The high price of timber for building and boat building has led people to cut down trees. 4. Limited facilities and infrastructure around the area to support area security activities.

Table 3 highlights three key issues in Gunung Duasudara Nature Reserve. Unregulated access since 2004 has led to unchecked exploitation of natural resources due to the absence of visitor regulations and insufficient forestry officers. Endangered species, including Acerodon celebensis, Boneia bidens, and Thoopterus nigrescens, are at risk from habitat destruction caused by hunting and plantation expansion. Frequent fires, driven by prolonged dry seasons and human activities, are worsened by inadequate monitoring infrastructure. The recommended solutions include socializing new regulations, increasing supervision, enforcing penalties, and improving infrastructure for monitoring and fire prevention.

Table 3. *Root Cause Analysis* of bats in Gunung Duasudara Nature Reserve

No.	**Problem**	**Root of the Problem**	**Alternative Solution**	**Recommendations**

1	- The designation of the new area was established in 2014. - The community was given the freedom to enter and take natural resources. - There were no rules for visitors to the Nature Tourism Park. - There was a lack of forestry officers.	- Previously there were no policies and regulations establishment of the area. - There was no prohibition or strict action from forestry officials. - Officers forest supervisors are still limited.	- Strict supervision from the government and forestry officials by acting decisively and enforcing penalties.	- It is expected that the government and forestry officers ontinue to work together in protecting and preserving the Nature Reserve consistently and consistent and sustainable in action and firm on the rules. - Synergize with other experts for continued ecotourism development
2	- There are three endangered species, namely *Acerodon celebensis*, *Boneia bidens* and *Thoopterus nigrescens.*	- This is due to the destruction of habitat in caves and tree holes due to hunting and the removal of palms as bat habitat, - The presence of towers to catch bats. - The expansion of plantations.	- Strict supervision from government and forestry officials by acting decisively and enforcing penalties.	- It is expected that the government and forestry officers continue to work together in protecting and preserving the Nature Reserve consistently and consistent and sustainable in action and firm on the rules. - Synergize with other experts for continued ecotourism development.

3	- Frequent fires every year due to prolonged dry season and due to human activities. - High demand for meat and meat prices. - High timber prices. - Limited facilities and infrastructure to support area monitoring activities.	- Forestry officials are not quick to anticipate the arrival of the dry season. - Strict action or punishment for residents who deliberately burn forests for plantation expansion, hunting and illegal logging.	- Establish water reservoirs and monitoring posts in each village surrounding the area.	- It is expected that the government can create water reservoirs near the locations of fire hotspots that are suspected of frequent fires and create monitoring posts in each village that borders with the population. - Development of visitor regulations nature reserve.

The conservation strategy for Gunung Duasudara Nature Reserve focuses on leveraging strengths like its legal status and biodiversity, and opportunities like supportive regional policies and ecotourism potential. The main strategies include maintaining the area's status for education, research, and ecotourism while developing tour guide groups to enhance community involvement and stakeholder collaboration. The goal is to preserve the reserve's sustainability while promoting ecotourism that aligns with conservation efforts, social, and economic conditions. This approach aims to attract both domestic and international tourists, bolstering local participation and cooperation with relevant institutions.

4. Conclusion

The analysis of Gunung Duasudara Nature Reserve reveals positive results in species count, endemism, catch rates, and biodiversity. Key factors influencing the protection and preservation of the reserve include its legal status, area management, and existing infrastructure, alongside the challenges of monitoring capacity and external threats like fires and hunting. To address these challenges, there is a need for increased government and forestry officer engagement, including public education on area regulations, stricter

enforcement, and improved infrastructure such as water reservoirs and monitoring posts. The primary strategy should focus on maintaining the reserve's status, emphasizing its role in education, research, and ecotourism, which are vital for supporting broader government initiatives.

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