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Rare, Endangered, Endemic, and Protected Species (REEPS) conservation in the Cisokan, West Java, Indonesia

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Abstract. *Husodo T, Megantara EN, Mutaqin AZ, Kendarto DR, Withaningsih S, Wulandari I, Shanida SS, Febrianto P. 2024. Rare, Endangered, Endemic, and Protected Species (REEPS) conservation in the Cisokan, West Java, Indonesia. Biodiversitas 25: 5094-5102.* The Upper Cisokan Pumped Storage (UCPS) hydropower construction poses significant challenges to local biodiversity, particularly Rare, Endemic, Endangered, and Protected Species (REEPS). This study aimed to describe the distribution of REEPS threatened by the construction and analyze the trend of their presence during the development. Methods applied include sign surveys, camera trapping, and literature review across a 47-grid study area. The findings show that ten REEPS continue to occupy forest patches and corridors despite ongoing construction activities. All REEPS species were consistently recorded from 2009 to 2022, indicating that their habitat can still meet their survival needs. However, habitat fragmentation and overlapping land use due to construction threaten these species' long-term sustainability. The grid-based analysis identified nine grids as core habitats for multiple REEPS species, emphasizing the need for ongoing biodiversity management. This includes preserving critical corridors and forest patches, which are crucial for the survival of these species. Long-term monitoring ensures coexistence between wildlife and human activities, maintaining ecosystem balance while advancing the hydropower project. This study highlights the importance of integrating wildlife conservation with infrastructure development in biodiversity-rich areas.

Keywords: Cisokan, Conservation, forest patched, habitat fragmentation, REEPS

INTRODUCTION

PT PLN (Persero) plans to construct the Upper Cisokan Pumped Storage (UCPS) Hydropower Plant with a capacity of 1,040 MW, making it the first pumped storage hydropower plant in Indonesia to meet the increasing peak load electricity demand and enhance the reliability of the Java-Bali interconnected system. To facilitate the power distribution from UCPS, PLN plans to construct two 500 kV transmission lines with a total length of 29.5 km. The locations for the UCPS construction and the 500 kV transmission lines are in the West Bandung and Cianjur regencies of West Java Province. The total area used for construction, including the dam, transmission lines, power generation facilities, access roads, and other activities, is approximately 720 hectares.

The Upper Cisokan Pumped Storage (UCPS) has entered the construction stage, resulting in various land use changes. This construction phase has impacted the loss or decline in the quality of wildlife habitats, such as those of the Javan leopard (*Panthera pardus melas*) and pangolin (*Manis javanica*) (Husodo et al. 2024). The increasing human population and rapid development on Java Island have put pressure on the natural habitats of wildlife, including the remaining forest ecosystems on the island. This poses a serious threat, as most wildlife in Java is associated with or dependent on forested areas (Mohamed et al. 2016). As a company responsible for the protection and natural resource management and the environment and to meet the criteria set forth by funding agencies (World Bank) in OP 4.04 regarding Natural Habitat and the BMP document (Husodo et al. 2019b), PT PLN (Persero) must undertake biodiversity management efforts for the species still found at the project site and surrounding areas, particularly monitoring wildlife with significant conservation status and their habitats.

Several surveys of flora and fauna have been conducted previously, including studies on flora, mammals, avifauna, and herpetofauna (Ayundari et al. 2017; Shanida et al. 2018a; Shanida et al. 2018b; Withaningsih et al. 2018; Husodo et al. 2019a; Husodo et al. 2019c; Megantara et al. 2019; Mustikasari et al. 2019; Dirgantara et al. 2021). Previous studies have identified mammal species categorized as Rare, Endemic, Endangered, and Protected Species (REEPS), including the Javan gibbon (*Hylobates moloch*), Javan leopard (*P. pardus melas*), pangolin (*M. javanica*), Sunda porcupine (*Hystrix javanica*), Java mouse-deer

(*Tragulus javanicus*), Javan langur (*Trachypithecus auratus*), grizzled leaf monkey (*Presbytis comata*), leopard cat (*Prionailurus bengalensis*), Asian small-clawed otter (*Aonyx cinereus*), and Javan slow loris (*Nycticebus javanicus*). These REEPS species are key targets for biodiversity management in the Cisokan area (Husodo et al. 2019b). They are listed on the IUCN Red List and P106. Additionally, these species are protected under the CITES Checklist, which regulates wildlife trade.

Monitoring the presence of REEPS is crucial for ensuring these species' survival and assessing their habitats' current conditions. Some species act as keystone species, such as the Javan leopard and the small-clawed otter; thus, protecting these species indirectly safeguards other species and maintains ecosystem balance. Mammals are considered bioindicators within terrestrial ecosystems due to their roles in conserving other species and maintaining ecological balance (Udy et al. 2021). The role of mammal species includes seed dispersal of vegetation. For instance, the Javan gibbon, through its feeding habits, helps in the regeneration of certain plant species, thereby maintaining the balance of the rainforest ecosystem (Lacher et al. 2019). Additionally, several species are recognized as endangered and endemic to Java, such as the Javan gibbon and the Javan slow loris.

According to the introduction, this study aims to provide the most recent information on REEPS in the UCPS area. By mapping the distribution and habitat conditions of REEPS, the findings of this study can serve as a foundation for developing more effective conservation recommendations for endangered species. The policies that result from this research, including the establishment of protected zones, more prudent land-use management, and efforts to restore habitats affected by construction activities, will be crucial, and your expertise will be integral to their development.

MATERIALS AND METHODS

Study area

The study was conducted in February-March 2017, July 2020, and August 2022 in the Cisokan Watershed, designated for the UCPS hydropower development in West Java, Indonesia (Figure 1). Administratively, the UCPS hydropower plant development area and its associated infrastructure cover 775.64 hectares, located in two regencies: West Bandung Regency (two sub-districts) and Cianjur Regency (three sub-districts). The UCPS hydropower plant is situated in the upper catchment area of the Cisokan River, a tributary of the Citarum River, which flows from south to north toward the Java Sea.

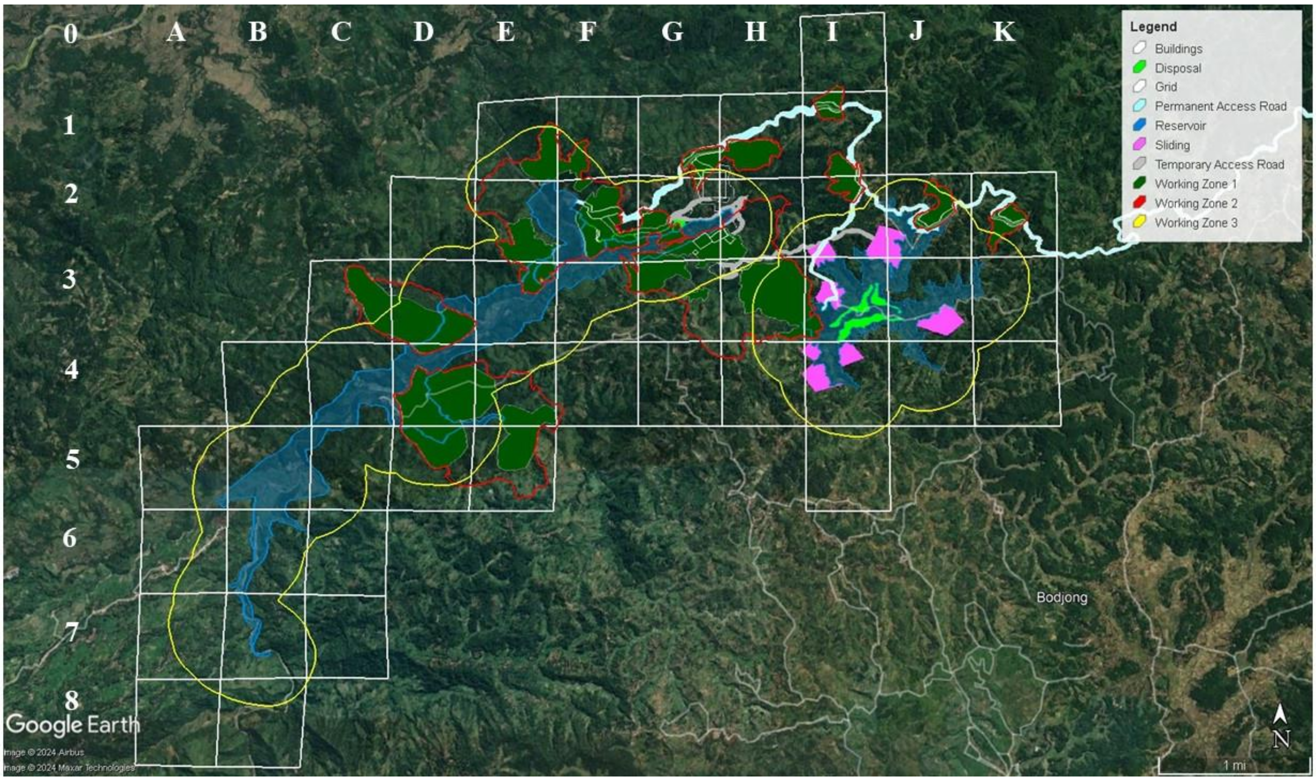

Figure 1. Cisokan, West Java, Indonesia (48 M 746030.02 m E 9231551.58 m S)

The construction of the UCPS hydropower plant, which includes two dams for water storage and power generation, a reservoir to store water, transmission lines to carry electricity, a power station to convert water energy into electricity, access roads for construction and maintenance, quarries for sourcing construction materials, and various other facilities, is estimated to require approximately 723.15 hectares. This area encompasses around 337.89 hectares of community land and approximately 385.25 hectares of forested land in the West Bandung and Cianjur Regencies; the surrounding UCPS area is Perhutani land.

The UCPS development area, rich in various vegetation types, is a testament to our commitment to the Biodiversity Management Plan. This includes natural forests, riparian zones, shrubs, production forests (such as pine (*Pinus* spp.) and teak (*Tectona grandis*), mixed gardens, monoculture gardens, irrigated rice fields, and swidden cultivations. The UCPS hydropower area is organized into a study area represented by a 1 km x 1 km grid (Figure 1). There are 47 grids in the study area, covering a total of 47 km². The grids were established based on the environmental document of the Biodiversity Management Plan 2020 (CESS 2020).

The UCPS area is non-protected; therefore, PT PLN (Persero) takes measures to safeguard the forest patches potentially used by REEPS identified through previous studies. These areas have been designated as Biodiversity Important Areas (from now on referred to as BIA) across 15 locations (Figure 1), also known as Working Zone 1. The establishment of these working zones ensures comprehensive environmental protection. Among these BIAs are corridors connecting adjacent forest patches, called Working Zone 2. Lastly, there is a buffer area, also called Working Zone 3.

Procedures

Primary data was collected from February to March 2017, July 2020, and August 2022. In 2017, 18 surveyors conducted a more intensive survey through sign surveys and camera trapping over six weeks. In 2020 and 2022, 10 surveyors conducted rapid surveys using sign surveys and camera trapping for two weeks to monitor the REEPS encountered 2017. Information regarding species from 2009 to 2014 was obtained through a literature review.

Sign survey

The sign survey was conducted from 6:00 a.m. to 4:00 p.m. (10 hours) and 7:00 p.m. to 10:00 p.m. (3 hours) for two weeks, focusing on footprints and feces left behind. The survey was carried out along trails at a walking speed of 1 km/hour. Every 10-minute interval, the observer would stop to check for the presence of arboreal species. Seven observers and four local guides were used during one month of observation. Searches were conducted on trails, paddy fields, riverbanks, dry riverbeds, large rocks, and shrub edges. Indirect evidence is advantageous when observing rare, elusive creatures like carnivores, found in low densities and are challenging to capture. Therefore, the presence of medium and large animals was also precisely indicated through indirect evidence (Borges et al. 2014; Dereje et al. 2015). Their calls and their locations could identify primates' presence were recorded using a GPS (Garmin 62s).

Camera trapping

Camera traps have assessed various ecological processes, including behavior, occupancy, biodiversity, and density (Burton et al. 2015). Specific objectives, sampling strategies, and data determine which analytical techniques are employed to evaluate these processes (Keim et al. 2019). Camera traps are widely utilized in Southeast Asia for conservation and research, particularly for inventorying the diversity of ground-dwelling large mammals within conservation landscapes (Moo et al. 2018). We deployed 15 units in 2017 and 9 in 2020 and 2022 to optimize observation time for 24 hours. Each year, after encountering evidence (feces or footprints) from the sign survey, we deployed camera traps near these sightings. We also considered information from previous research and local communities regarding encounters with Java mouse-deer during farming or other activities in the forest. Cameras were positioned 30-50 cm above and perpendicular to the ground. They were set in hybrid mode and left for two weeks. All photographs were manually checked, and the author identified mammal encounters at the species level (Gray 2018). The precise placement of cameras was based on visible animal trails, footprints, animal scents, activity areas, and/or proximity to streams (Sasidhran et al. 2016).

Literature review

We reviewed studies conducted in the UCPS Hydropower area regarding wildlife, such as Javan leopards (Shanida et al. 2018b), leopard cats (Shanida et al. 2018a; Husodo et al. 2022), Java mouse-deer (Megantara et al. 2024), pangolins (Withaningsih et al. 2018), Sunda porcupines (Mustikasari et al. 2019), small-clawed otters (Dirgantara et al. 2021), and mammals (Husodo et al. 2019a; Husodo et al. 2019c; Megantara et al. 2019).

Data analysis

The species distribution was tabulated using Microsoft Excel according to grids and periods (years). It was also mapped using Google Earth Pro to illustrate its distribution in the Biodiversity Important Areas (BIAs), the development area, and the grids. Based on the recorded encounters of REEPS, grids were grouped into several clusters (Table 1).

Table 1. Description of clusters

Clusters	Description
Cluster 1 (Red)	It is an area of production forest and/or limited production forest with protective functions due to steep or very steep topography, including zones 1, 2, 3, and/or their combinations; it serves as the core habitat for REEPS.
Cluster 2 (Orange)	It is an area of production forest and/or limited production forest with protective functions due to steep or very steep topography and a production forest with gentle to moderately steep topography or other land use areas. It includes areas classified into zones 1, 2, 3, and/or combinations of zones 1 and 3; it is an area with findings of REEPS.
Cluster 3 (Yellow)	It is an area of production forest with gentle to moderately steep topography and/or other land use areas; it is a region that falls within the combination of zones 2 and 3; it is an area with findings of REEPS.
Cluster 4 (Green)	It is land with the status of Other Land Use, falls within Zone 3, and has already been managed by the community through shifting cultivation and rice fields. It is also an area with REEPS findings.
Cluster 5 (Blue)	It is land with the status of Other Land Use and falls within Zone 3. The community has already managed the land through shifting cultivation, rice fields, and lemongrass gardens. It is an area without REEPS findings.

RESULTS AND DISCUSSION

This study revealed ten mammal species classified as Rare, Endangered, Endemic, and Protected Species (REEPS) were identified in the Cisokan area of West Java. All species can generally be found in the UCPS hydropower development area for at least 10-13 years (Table 1). According to the data, all ten species are listed on the IUCN Red List, with six being endemic to the island of Java and nine protected under Indonesian national regulations, including Ministry of Environment and Forestry Regulation No. P106/2018 (Table 2). These REEPS species in Cisokan exhibit diverse habitat distribution, from natural forests to mixed gardens and rice fields across various grids (Table 3), indicating that their habitats can still meet their needs despite ongoing construction activities. This area is changing due to the construction of the UCPS. As of the end of 2019, ongoing construction activities included the development of permanent and temporary access roads. By 2022, construction activities had expanded to include building staff housing and offices and mobilizing heavy equipment.

In 2009-2024, not all REEPS were recorded, which may be influenced by the duration of camera trap use, observation time, and surveyors. Then, in 2017-2022, more REEPS were encountered, with encounters tending to fluctuate. On average, the small-clawed otter had the highest number of encounters with 9 occupancies/year, followed by the grizzled leaf monkey and Javan langur with 8 occupancies/year. The small-clawed otter is easy to find along rivers near rice fields with low water flow or in dry rivers, leaving its shell-filled droppings on large rocks and footprints in the mud. Many encounters may indicate that the rivers in Cisokan are suitable habitats for them, and they may even breed by nesting on the riverbanks (Dirgantara et al. 2021). Grizzled leaf monkeys and Javan langurs are easy to find because they live in groups, making their movements easy to detect. They can still be found in disturbed forest areas.

The lowest average occupancy was for Javan mouse-deer and Javan slow loris at 3 occupancies/year. Java mouse-deer tended to be small, found in dense canopy cover such as shrubs, and difficult for humans to reach, making encounters more difficult. Javan slow loris was found to be the least common, probably due to less night observation than during the day. Javan slow lorises were found in vegetation near the community's plantations and bamboo groves. Some studies were conducted during the rainy season, which made it difficult to observe this species.

Java mouse-deer

The Java mouse-deer was found in 11 grids from 2009 to 2022 (Figure 2). Of these 11 grids, it was reencountered in E2, G1, and H3. Some of its presence overlaps with the UCPS construction area. They occupy the Biodiversity Important Area (BIA), corridors, and buffer zones, indicating that these areas can serve as habitats for 14 years. Java mouse-deer can be found in mixed gardens, farms, shrubs, riparian zones, and production forests. They are frequently encountered in shrubs of calliandra (*Calliandra calothyrsus*), sugarcane (*Saccharum spontaneum*), and siam weed (*Eupatorium odoratum*). These shrubs tend to have dense canopies that are difficult for humans to access. In natural forests, they are found in sloped areas near waterfalls (Megantara et al. 2024). Their discovery suggests that *T. kanchil* prefers habitats of dense evergreen closed-canopy forests (Hazwan et al. 2020). In the 2022 study, where slash-and-burn practices were occurring, they were difficult to find in the exact locations, although they were present in dense shrubs near agricultural areas.

Small-clawed otter

The small-clawed otter was found in 27 grids from 2009 to 2022 across BIA, corridor, and buffer areas (Figure 2). This species occupies more area compared to other REEPS. Based on its distribution pattern, this species tends to be found near water bodies and wetlands, such as rice fields and agroforestry. The small-clawed otter is easier to identify through its droppings scattered along dry riverbeds and on rocks. Some findings, such as food remnants, feces, and footprints, were also discovered near shrubs and rice fields. Grid H3 consistently showed the presence of the species over the years, with surrounding grids recorded 3 to 4 times from 2009 to 2022. From these findings, it can be inferred that H3, G2, G3, and H2 serve as foraging and sheltering sites for the species. Its distribution, which tends to rely on water bodies, will be significantly impacted by habitat loss, mainly nests, due to their conversion into dams. Nests have been found in the Cisokan, Citali, and Cilengkong rivers. The nests in the Cisokan River are active, as evidenced by the capture of otter groups via camera traps and footprints (less than one day old) (Dirgantara et al. 2022). The small-clawed otter (*A. cinereus*) is interesting to study further because it is not regulated in the Minister of Environment and Forestry of Republic of Indonesia Regulation No. P106/2018, while the IUCN declared it a threatened animal (Vulnerable).

Table 2. Occupancy grid of REEPS Wildlife

Taxa	Common name	Status		Endemic	Grid occupancy					
		P106	IUCN		2009	2012	2014	2017	2020	2022
Artiodactyl										
Tragulus javanicus	Java mouse-deer	P	DD	Java	3	1	3	6	1	1
Carnivore										
Aonyx cinereus	Small-clawed otter		VU		17	4	0	13	8	13
Panthera pardus melas	Javan leopard	P	CR	Java	0	2	3	10	14	4
Prionailurus bengalensis	Leopard cat	P	LC		0	2	0	13	0	11
Hystricidae										
Hystrix javanica	Sunda porcupine	P	LC		0	1	3	7	10	6
Pholidota										
Manis javanica	Pangolin	P	CR		0	1	5	13	1	5
Primate										
Presbytis comata	Grizzled leaf monkey	P	EN	Java	10	10	0	9	9	8
Hylobates moloch	Javan gibbon	P	EN	Java	1	3	5	6	7	2
Nycticebus javanicus	Javan slow loris	P	CR	Java	0	0	6	7	3	3
Trachypithecus auratus	Javan langur	P	VU	Java	1	3	10	10	11	12

Sources: Husodo et al. (2019a); Husodo et al. (2019c); Primary Data (2020, 2022). Notes: P106: Regulation of the Minister of Environment of the Republic of Indonesia P.106/2018 on the Protected Plant and Animal Species; IUCN: The International Union for Conservation of Nature; DD: Data Deficient; LC: Least Concern; VU: Vulnerable; EN: Endangered; CR: Critically Endangered; P: Protected

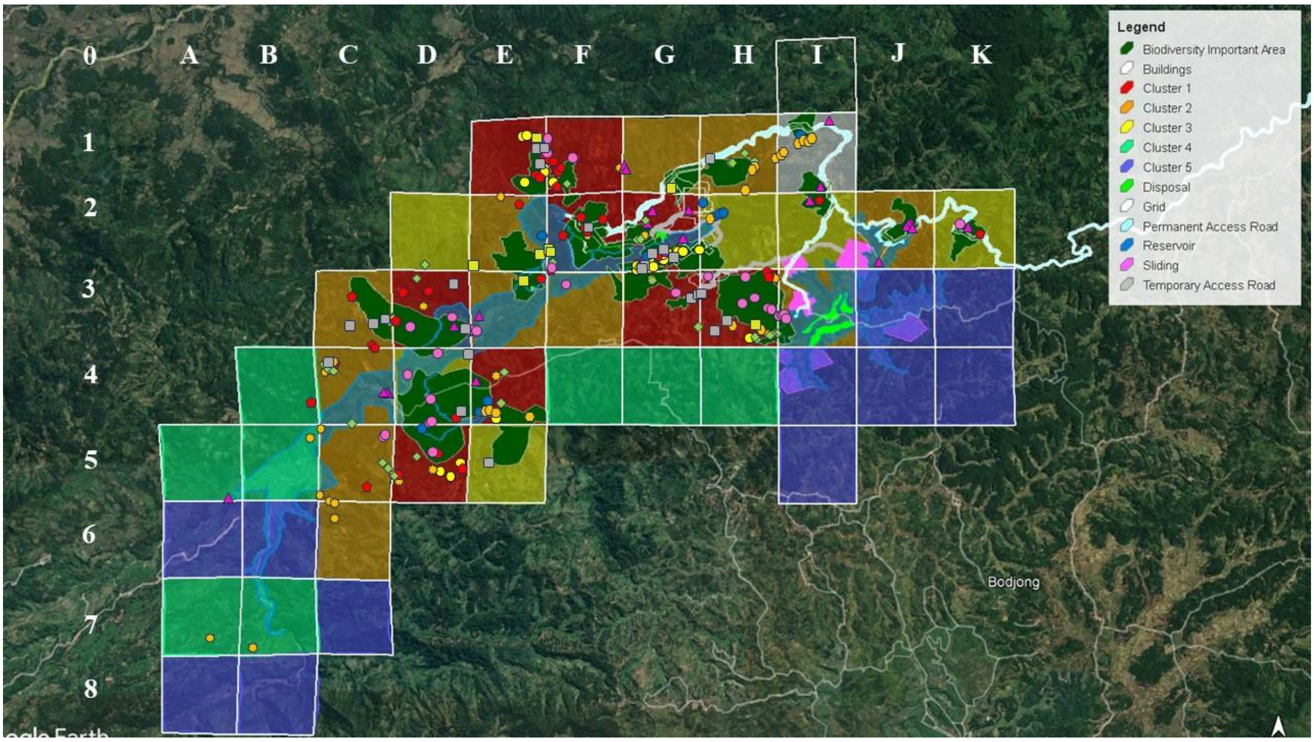

Figure 2. Distribution of REEPS Wildlife and clustering grid. Note: ⬟: *Panthera pardus melas*; ✪: *Hystrix javanica*; ◆: *Manis javanica*; ●: *Prionailurus bengalensis*; ▲: *Nycticebus javanicus*; ■: *Tragulus javanicus*; ●: *Hylobates moloch*; ■: *Trachypithecus auratus*; ●: *Presbytis comata*; ⬟: *Aonyx cinereus*

Javan leopard

The Javan leopard was recorded from 2012 to 2022. Although the access road was completed in 2019, followed by the main construction, leopards were still found in 2020 and 2022. The leopard occupied 19 grids. Compared to other grids, leopards were frequently found in grids D3, E1, F1, and G2 (Figure 2), with sightings occurring up to three times. If Shanida et al. (2018) assume that there is a Javan leopard in the UCPS area, it is estimated that individuals use a habitat spanning 19 km² from BIA 14 and 15 to BIA 1, where four km² (four grids) is the area most frequently used by females. These grids are forest patches that include BIA 8, BIA 6, BIA 7, and BIA 11, with some areas in these BIAs still covered by natural forest. Additionally, leopards also utilize corridors and buffer areas.

As Husodo et al. (2019c) stated, the Javan leopard is more commonly found in natural forests than other land covers, suggesting it relies on natural forests to meet its daily needs. The primary habitat for the Javan leopard consists of heavily vegetated forests that are difficult for humans to access, as well as areas with steep topography (>40% slope) and remote locations, such as deep valleys or high hills that are hard to reach. They are also found in pine forests mixed with coffee plants (Shanida et al. 2018b).

Leopard cats

Leopard cats were recorded from 2012 to 2022, occupying 16 grids (Figure 2). These grids include several Biodiversity Important Areas (BIAs), such as BIA 1, 3, 6, 7, 8, 9, 11, 13, and 14. In addition to being found in multiple BIAs, leopard cats were also encountered in corridor areas, including D3, E3, F3, and H3, as well as in buffer zones. After 5 to 10 years, the leopard cats continued to utilize the same area, represented by eight grids. This indicates that 50% of the grids where leopard cats were found are still being used by them, suggesting that the habitats affected by construction may still meet their living needs.

In the 2022 monitoring, we did not find leopard cats on the hillside by the river, where slash-and-burn practices were occurring; however, leopard cat droppings were discovered on the opposite side of the river, which consists of a rice field awaiting harvest. Leopard cats tend to adapt to levels of human activity, often found in areas with low human presence, even near human settlements.

Javan pangolin

The Javan pangolin was found in 16 grids from 2012 to 2022 (Figure 2). These grids were reencountered, including Grid C4, D5, E4, F1, and G3 (Figure 2). They were discovered not only in BIAs but also in corridor areas. Signs of their presence varied and included burrows, footprints, food scraps, and tail tracks (Withaningsih et al. 2018). Javan pangolins are reported to inhabit forest ecosystems (both natural and production forests), shrub areas, and orchards (Husodo et al. 2019). Pangolins can thrive in various habitat types, including primary forests, secondary forests, rubber and palm oil plantations, and even open spaces near human settlements (Challender et al. 2014).

A previous study by Withaningsih et al. (2018) estimated the pangolin population in the Cisokan area to be between 6 and 20 individuals. This estimate was derived from meticulous location, time, and individual morphology analyses. The researchers extrapolated the existence of Javan pangolins from the presence of their nests and burrows, most of which are rock burrows. This finding underscores the importance of their work in understanding and conserving these elusive creatures.

Studying Javan pangolins presents unique challenges due to their nomadic nature. Burrow and nest traces were found at all sample sites, along with a few footprints, tail tracks, food scraps, and scratches. These findings are a testament to the researchers' perseverance, as Javan pangolins tend to move their burrow and nest locations daily, making it difficult to track them. The durability of burrows and nests, compared to other traces that can be easily washed away by rain, further complicates the study of these animals (Withaningsih et al. 2018).

Sunda porcupine

From 2012 to 2022, the Sunda porcupine was found in 17 grids (Figure 2). It is commonly located in rocky areas within natural forests, shrubs, swidden cultivation, banana plantations, and mixed gardens. They were encountered in areas that overlap with the construction area and those far from it. Some grids were revisited, specifically Grid C4, D3, D5, and F1, which indicate that these areas may serve as refuges from ongoing construction activities.

We found burrows, footprints, feces, quills, scratches, and feeding sites of the Sunda porcupine. The most frequently observed sign is the burrow, which is the easiest to identify because other signs can be washed away by rain or covered by soil, while burrows are more durable and more significant in appearance. A total of 18 burrows were identified in the designated area of the Cisokan Hydropower project. Four of these burrows had multiple openings of various sizes, ranging from 16 cm x 16 cm to 100 cm x 65 cm (Figure 2), with a maximum depth of only 3 m (Mustikasari et al. 2019). Active burrows can be identified by footprints, feces, scratches, or quills nearby.

Our study area, located in the designated area of the Cisokan Hydropower project, played a crucial role in our research. The Sunda porcupine burrows were covered by roots and shrubs, creating a unique moist environment. The soil surrounding the burrows was solid and clear (Mustikasari et al. 2019). We also identified some unique feeding sites, including buds and tubers of Asiatic bitter yam (*Dioscorea hirsuta*). Farida (2015) further explained that porcupine feeding sites typically consist of tubers (*D. hirsuta*), bamboo shoots, fruits, and pteridophyte buds. The significance of our study area in understanding the habitat and behavior of the Sunda porcupine cannot be overstated.

Porcupines share similar burrowing habits with pangolins, raising the possibility of competition for burrow space. Almost all types of porcupine burrows can be occupied by pangolins, as they can dig their burrows using their foreclaws to reach considerable depths. However, if another species already lives in a burrow, the porcupine will seek out or construct a new burrow.

Grizzled leaf monkey

The grizzled leaf monkey is commonly found in natural forests, secondary forests, and pine forest habitats distributed across 17 grids (Figure 2). The most frequently used trees by the grizzled leaf monkey include fig (*Ficus* sp.), parasol leaf tree (*Macaranga tanarius*), terap (*Artocarpus elasticus*), and albizia (*Paraserianthes falcataria*). These species have been observed as both feeding and resting sites. Based on its distribution, the grizzled leaf monkey was consistently recorded from 2009 to 2022 (with no data obtained in 2014), with Grids E1 and G2 recorded yearly. These grids are assumed to be its core habitat, as surrounding grids also recorded the presence of this species. They correspond to BIA 8, 6, 12, and the southern part of BIA 5, which overlap with the main construction and planned reservoir areas.

Additionally, the grizzled leaf monkey was also observed in areas farther from construction, such as BIA 14, although these areas overlap with agricultural land that is also human-modified. The presence of the grizzled leaf monkey is often associated with the Javan langur and long-tailed monkeys. They have frequently been found near riverbanks with relatively low plant density. The monkeys also extensively utilize corridor areas and surrounding regions of BIAs, such as Grids D3, E1, E2, F2, G2, G3, H2, H3, and I1. This suggests that these areas can still meet the needs of the grizzled leaf monkey.

Revegetation in the corridor areas is necessary if land-clearing activities impact them. Grids E3, F3, and K2 were identified as new sightings in 2022. Grids E3 and F3 are planned reservoir construction areas, while surrounding grids like G2 and G3 are currently under active construction, indicating that the grizzled leaf monkey may have moved to areas with lower human activity. Grid K2 was found in a pine forest but is isolated due to soil nailing and paved access road construction, resulting in open areas around the pine forest. Our role in this revegetation process is crucial.

Javan gibbon

The Javan gibbon has been consistently recorded from 2009 to 2022 (Figure 2). Its distribution indicates that their presence is divided into three areas: Cibungbulang - Citali Waterfalls/Corridor of BIA 14 and 15 (Grids C4-D4-D5-E4), Gowek - Sarongge/ BIA 8 and its corridor (Grids E1-E2-F1), and Walet - Cilengkong Waterfalls/ BIA 11 and 7 (Grids G2-G3-H2-H3-I3). The occupancy of these grids shows that the Javan gibbon utilizes corridors D5, E2, and H3 as its habitat. Walet - Cilengkong Waterfalls is consistently recorded every year, as this area consists of natural forests that remain undisturbed by construction activities, with continuous canopy cover, steep topography that makes conversion to agricultural land difficult, and proximity to rivers and waterfalls. Agricultural activities, such as rice farming, tend to be located at a distance due to separation by the river.

A pair of Javan gibbons was observed in Gowek-Sarongge from 2012 to 2020 but was not seen in 2022. In 2023, communication with the contractor revealed that Javan gibbons had moved to the E2-F2 area (BIA 6) and had an infant. This suggests that the absence of Javan gibbons in the Gowek - Sarongge area in 2022 indicates that the group may have relocated in search of a suitable breeding habitat. The group appears to have chosen the E2-F2 area, indicating its appropriateness for raising the infant, which is estimated to be seven months old.

They often rest in trees such as parasol leaf tree (*M. tanarius*) and pigeon wood (*Trema orientalis*). The fruits consumed by the Javan gibbon include spiked pepper (*Piper aduncum*), sembarak (*Oreocnide rubescens*), huru (*Macaranga rhizinoides*), white hamerang (*Ficus padana*), kareumbi (*Homalanthus populneus*), pigeon wood (*T. orientalis*), and fig (*Ficus* sp.) For movement, they frequently utilize the parasol leaf tree (*M. tanarius*) and pigeon wood (*T. orientalis*).

Further surveys are necessary to monitor the group's presence, particularly in light of construction activities, as part of the E2-F2 area will be designated as a disposal area. Javan gibbons tend to be selective in their habitat choice and have a low reproductive rate due to their monogamous nature.

Javan slow loris

From 2014 to 2022, the Javan slow loris was found in 15 grids (Figure 2). Several grids were revisited, specifically Grid C4, F2, and J2. In the rapid survey, four individuals were detected: three were found in a mixed garden near Kampung Ciawitali, and one was in a *Calotropis* shrub near Kunti Waterfall.

The limited detection of the Javan slow loris can be attributed to the short sampling duration, limited human resources, and high rainfall. The slow loris has the potential for conflict with humans, as evidenced by its presence in settlements, plantations, and agroforestry. According to Withaningsih (2019), local people living around the habitat of the Javan slow loris engage in high-intensity activities, increasing the risk of habitat damage and the likelihood of direct contact with these animals. Therefore, local communities play a crucial role in protecting the species by refraining from hunting or destroying their habitat.

Javan langur

The Javan langur was found in 18 grids from 2009 to 2022 (Figure 2). Grid G2 consistently recorded the presence of the Javan langur throughout the years and is located in a natural forest. However, this grid overlaps with the construction of the main buildings, such as the administration building, surge tank, switchyard, and others. It is assumed that in subsequent monitoring, the langur may not use Grid G2 as its core habitat but may move to other grids, such as G3, H3, and H2, which still have natural forests. The Javan langur is also frequently found in Grid E5, far from the construction area. Mixed gardens and agricultural land dominate this grid. The Javan langur tends to use BIAs, but this species is also found in corridor areas.

Based on the recorded distribution of REEPS wildlife, we created REEPS clusters, as shown in Figure 2. Nine grids are categorized as Cluster 1, representing core habitat areas for REEPS wildlife. The designation of Cluster 1 is based on the presence of Javan gibbon, which is selective in its habitat choice. Javan gibbon tends to be found in natural forests with stratified trees, continuous canopy cover, and minimal human activity. The habitat utilized by Javan gibbon can also support other species due to the high quality of the environment. Some locations included in this cluster are Cibungbulang (part of BIA 14, the corridor between BIA 14 and BIA 15, and the buffer area for inundation), Gowek Forest (part of BIA 8, the corridor for BIA 8, and the buffer area for inundation), Walet Waterfall (mostly BIA 11, the corridor for BIA 9-10-11-7), and Japarana Waterfall (BIA 9 and the corridor for BIA 9-10-11-7).

From 2009 to 2022, encounters with all species were primarily found in Cluster 1. Several species were consistently observed during this period, indicating that they continue to use the same areas as their habitat. Some areas of Cluster 1 are also designated as Biodiversity Important Areas (BIAs) and forest patches, including BIA 6, 7, 8, 9, 10, and 11, which still contain natural forests. These natural forests are located on steep hills, making them difficult for the community to access, and they remain relatively undisturbed. The preservation of tree species in these areas is maintained. High species diversity in an ecosystem is likely to enhance the stability of the plant community and vice versa (Boeck et al. 2018). Generally, BIA 8 is covered by natural forests and shrubs. The natural forest is dominated by sembarak (*O. rubescens*), ki tambaga (*Eugenia cuprea*), terap (*A. elasticus*), jelatang gajah (*Dendrocnide stimulans*), lisang (*Symplocos odoratissima*), and leichhardt pine (*Kibatalia arborea*).

Other areas of Cluster 1 comprise parts of BIA 13, 14, and 15 and surrounding corridor areas. This region tends to be used for agriculture, mixed gardens, production forests (teak), and shrubs. Some dominant species include teak (*T. grandis*), big-leaf mahogany (*Swietenia macrophylla*), terap (*A. elasticus*), needlewood tree (*Schima wallichii*), jackfruit (*Artocarpus heterophyllus*), cluster fig (*Ficus fistulosa*), and spiked pepper (*P. aduncum*)

The construction of the UCPS hydropower project significantly impacts the core habitat for REEPS. Some grids in Cluster 1 are located within areas designated for access road construction, disposal sites, reservoirs, surge tanks, administration buildings, and other structures. Although the BIAs serve as a last refuge after the construction of the UCPS hydropower plant, several BIAs are still directly affected by development. For example, BIA 6 is bisected by an access road and will partly be used as a disposal area, a critical habitat for the Javan gibbon family.

Eleven grids are categorized as Cluster 2, indicating the presence of REEPS, although occurrences in this cluster are not as frequent as in Cluster 1. Some areas within Cluster 2 also serve as BIAs for REEPS species, such as Javan leopard and Javan pangolin, both classified as Critically Endangered (CR). These habitats can be found in several areas within Cluster 1, including BIA 6, BIA 7, BIA 11, and around BIA 14 and 15. Cluster 2 overlaps with the construction of access roads, reservoirs, administration buildings, and other structures.

Eight grids are categorized as Cluster 3, where nearly all REEPS are found, albeit at lower occurrence rates. Javan slow-loris is frequently located in mixed bamboo gardens near human settlements in this cluster. Eight grids are classified as Cluster 4, which serves as a buffer area for the reservoir. This cluster still contains some REEPS but with lower occurrence rates. The land cover in Cluster 4 is primarily dominated by dry land and rice fields. Javan leopard is still present in this cluster. Cluster 5 consists of 11 grids where no REEPS were recorded; however, it is assumed that specific grids still serve as home ranges for REEPS. Some areas in Cluster 5 do not encompass BIAs but consist instead of managed agricultural land, including rice fields and plantations.

In conclusion, the use of Biodiversity Important Areas (BIAs) and corridors indicates that, despite the threats from development, specific locations continue to function as vital habitats for these species. Locations such as Walet Waterfall and Gowek, which are situated within BIAs 6, 7, 8, 9, and 11, have shown consistent usage by various REEPS species over more than a decade (2009-2022), indicating that the habitat's carrying capacity remains sufficient for endemic species. The clustering of grids based on the intensity of REEPS presence highlights the need for improved habitat management, particularly in areas affected by infrastructure projects. This emphasizes the need for efficient mitigation techniques that minimize the damaging impacts of construction on ecosystems.

The involvement of local communities in habitat preservation is crucial. Communities around these areas should be encouraged to participate in conservation efforts through education about the importance of conservation and by developing sustainable economic alternatives. Monitoring and further research on changes in the population and distribution of REEPS should be conducted over time, especially after construction. This information can assist in making better decisions regarding conservation and natural resource management. Long-term coexistence between wildlife and humans will enhance our understanding of forest ecosystems. This coexistence will positively impact the project and the environment, as the UCPS project requires a sustainable water supply and will continue to provide electric power to urban areas while REEPS need their habitat.

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REFERENCES

Ayundari A, Megantara EN, Withaningsih S, Parikesit, Husodo T. 2017. Study population and efforts of protection of the slow loris

(*Nycticebus javanicus* E. Geoffroy, 1812) by local communities at Cisokan's PLTA, West Java. Biotika 15 (2): 21-29. DOI: 10.24198/bjib.v15i2.19300. [Indonesian]

Borges HLM, Calouro AM, Botelho ALM, Silveira M. 2014. Diversity and habitat preference of medium and large sized mammals in an urban forest fragment of south western Amazon. Iheri Ser Zool 104 (2): 168-174. DOI: 10.1590/1678-4766201410421681.

Burton AC, Neilson E, Moreira D, Ladle A, Steenweg R, Fisher JT, Bayne E, Boutin S. 2015. Wildlife camera trapping: A review and recommendations for linking surveys to ecological processes. J Appl Ecol 52 (3): 675-685. DOI: 10.1111/1365-2664.1243.

CESS [Center for Environment and Sustainability Science]. 2020. Review and Update of Biodiversity Monitoring Plan (BMP) Study of PLTA Upper Cisokan Pumped Storage 1040 MW. [Technical Report]. Center for Environment and Sustainability Science, Directorate of Innovation and Corporation Universitas Padjadjaran, Bandung. [Unpublished]

Challender DWS, Waterman C, Baillie JEM. 2014. IUCN SSC Pangolin Specialist Group Conservation Action Plan: Scaling Up Pangolin Conservation. Zoological Society of London, London, UK.

Dereje N, Tsegaye G, Tadese H. 2015. The diversity, distribution and relative abundance of medium and large-sized mammals in Baroye Controlled Hunting Area, Illubabor Zone, Southwest Ethiopia. Intl J Mol Evol Biodiv 5 (4): 1-9. DOI: 10.5376/IJMEB.2015.05.0004.

Dirgantara AP, Megantara EN, Husodo T, Febrianto P, Wulandari I, Shanida SS. 2021. The existence of Asian small-clawed otter (*Aonyx cinereus* Illiger, 1815) in the UCPS Hydropower, Cianjur, West Java, Indonesia. Biodiversitas 22: 4391-4401. DOI: 10.13057/biodiv/d221032.

Gray TNE. 2018. Monitoring tropical forst ungulates using camera-trap data. J Zool 305 (3): 173-179. DOI: 10.1111/jzo.1254.

Hazwan M, Samantha LD, Tee SL, Kamarudin N, Norhisham AR, Lechner AM, Azhar B. 2020. Habitat fragmentation and logging affect the occurrence of lesser mouse-deer in tropical forest reserves. Ecol Evol 12: e8745. DOI: 10.1002/ece3.8745.

Husodo T, Febrianto P, Megantara EN, Shanida SS, Pujianto MP. 2019c. Diversity of mammals in forest patches of Cisokan, Cianjur, West Java, Indonesia. Biodiversitas 20 (5): 1281-1288. DOI: 10.13057/biodiv/d2005.

Husodo T, Megantara EN, Mutaqin AZ, Kendarto DR, Wulandari I, Shanida SS. 2022. Short Communication: Leopard cat (*Prionailurus bengalensis*) distribution in the Cisokan Hydropower Plant, West Java, Indonesia. Biodiversitas 23 (12): 6247-6253. DOI: 10.13057/biodiv/d231220.

Husodo T, Megantara EN, Mutaqin AZ, Kendarto DR, Wulandari I, Shanida SS. 2024. The protection effort of leopard cats (*Prionailurus bengalensis* Kerr, 1792) in the Upper Cisokan Pumped Storage, West Java, Indonesia. Biodiversitas 25 (1): 169-176. DOI: 10.13057/biodiv/d250119.

Husodo T, Shanida SS, Febrianto P, Pujianto MP, Megantara EN. 2019a. Mammalian diversity in West Java, Indonesia. Biodiversitas 20 (7): 1846-1858. DOI: 10.13057/biodiv/d200709.

Husodo T, Shanida SS, Megantara EN. 2019b. Biodiversity management plan in the non-conservation area, Cisokan hydropower plan area, Cianjur, West Java, Indonesia. Biodiversitas 20 (6): 1524-1536. DOI: 10.13057/biodiv/d200606.

Lacher T, Davidson A, Fleming TH, Gomez-Ruiz EP, McCracken GF, Owen-Smith N, Peres CA, Wall SBV. 2019. The functional roles of mammals in ecosystems. J Mammal 100 (3): 942-964. DOI: 10.1093/jmammal/gyy183.

Megantara EN, Shanida SS, Husodo T, Febrianto P, Pujianto MP, Hendrawan R. 2019. Habitat of mammals in West Java, Indonesia. Biodiversitas 20 (11): 3380-3390. DOI: 10.13057/biodiv/d2011.

Megantara EN, Husodo T. Kendarto DR, Mutaqin AZ, Withaningsih S, Wulandari I, Shanida SS, Febrianto P, Hendrawan R. 2024. Short Communication: Records of Java mouse-deer (*Tragulus javanicus* Gmelin, 1788) in the Cisokan forest patches, West Java, Indonesia. Biodiversitas 25 (8): 2713-2719. DOI: 10.13057/biodiv/d25084.

Mohamed A, Ross J, Hearn AJ, Cheyne SM, Alfred R, Bernard H, Boonratana R, Samejima H, Heydon M, Augeri DM. 2016. Predicted distribution of the leopard cat *Prionailurus bengalensis* (Mammalia: Carnivora: Felidae) on Borneo. Raffles Bull Zool Suppl 33: 180-185.

Moo SSB, Froese GZ, Gray TNE. 2018. First structured camera-trap surveys in Karen State, Myanmar, reveal high diversity of globally threatened mammals. Oryx 52 (3): 537-543. DOI: 10.1017/S0030605316001113.

Mustikasari IA, Susanti W, Erri NM, Teguh H, Parikesit. 2019. Population and distribution of Sunda porcupine (*Hystrix javanica* F. Cuvier, 1823) in designated area of Cisokan Hydropower, West Java, Indonesia. Biodiversitas 20: 762-769. DOI: 10.13057/biodiv/d2003.

Sasidhran S, Adila N, Hamdan MS, Samantha LD, Aziz N, Kamarudin N, Puan CL, Turner E, Azhar B. 2016. Habitat occupancy patterns and activity rate of native mammals in tropical fragmented peat swamp reserves in Peninsular Malaysia. For Ecol Manag 363: 140-148. DOI: 10.1016/j.foreco.2015.12.037.

Shanida SS, Megantara EN, Husodo T, Mutaqin AZ, Kendarto DR, Wulandari I. 2023. Habitat preference of leopard cats (*Prionailurus bengalensis* Kerr. 1792) in the Cisokan Hydropower Development Area, West Java, Indonesia. Biodiversitas 24 (4): 2284-2293. DOI: 10.13057/biodiv/d240442.

Shanida SS, Partasasmita R, Husodo T, Parikesit, Febrianto P, Megantara EN. 2018b. Short Communication: The existence of Javan leopard (*Panthera pardus melas* Cuvier, 1809) in the non-conservation forest areas of Cisokan, Cianjur, Indonesia. Biodiversitas 19 (1): 42-46. DOI: 10.13057/biodiv/d190107.

Shanida SS, Ruhyat P, Teguh H, Erri NM. 2018a. Short Communication: Javan leopard cat (*Prionailurus bengalensis javanensis* Desmarest, 1816) in the Cisokan non-conservation forest areas, Cianjur, West Java, Indonesia. Biodiversitas 19: 37-41. DOI: 10.13057/biodiv/d19010.

Udy K, Fritsch M, Meyer KM, Grass I, Hanß S, Hartig F, Kneib T, Kreft H, Kukunda CB, Pe'er G, Reininghaus H, Tietjen B, Tscharntke T, van Waveren CS, Wiegand K. 2021. Environmental heterogeneity predicts global species richness patterns better than area. Glob Ecol Biogeogr 30 (4): 842-851. DOI: 10.1111/geb.13261.

Withaningsih S, Noorahya F, Megantara EN, Parikesit, Husodo T. 2018. Nest existences and population of Pangolin (*Manis javanica* Desmarest, 1822) at the designated area of Cisokan Hydropower, West Java, Indonesia. Biodiversitas 19 (1): 153-162. DOI: 10.13057/biodiv/d1901.

Withaningsih S, Parikesit, Nasrudin A. 2021. Correlation between landscape structure and distribution of Javan pangolin (*Manis javanica*) in an extreme landscape. Biodiversitas 22 (2): 920-932. DOI: 10.13057/biodiv/d220248.