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Flora and fauna diversity in Selangkau forest: A basis for developing management plan of cement industrial complex in East Kalimantan, Indonesia

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Abstract. *Aminatun T, Suwasono RA, Putri RA. 2021. Flora and fauna diversity in Selangkau forest: A basis for developing management plan of cement industrial complex in East Kalimantan, Indonesia. Biodiversitas 22: 4555-4565.* The management of natural resources for economic development often clashes with environmental protection. That is the case in East Kutai District, East Kalimantan, Indonesia which is faced with competing interests between the development of the cement industry and biodiversity conservation. This study is aimed to identify the diversity of flora and fauna in a forest ecosystem to be developed as a cement industrial complex in the Selangkau Village, Kaliorang Sub-district, East Kutai District, and to provide recommendations for environmental management plans as part of the conservation efforts. A vegetation survey using purposive sampling was performed at four vegetation stages: seedlings, saplings, poles and trees. Analysis was done to examine the diversity, dominance, evenness, richness and importance value indices. The fauna study was conducted by the exploration method to collect data on mammals, birds, amphibians and reptiles. The vegetation study recorded 29 species including *Buchanania arborescens* Blume which had the highest importance value in all growth stages. One species of tree (*Shorea glauca*) found in this area is also classified as endangered species with high conservation importance. The fauna study found 42 species of birds, 7 of which are protected, 14 species of mammals, 5 of which are protected and 11 species of amphibians and reptiles. Efforts to save the protected species are necessary in response to the new cement factory construction plan in the study area, for example by reclamation and revegetation using the native plants recorded in this study and by transferring animal species into a new habitat that resembles the initial one.

Keywords: Biodiversity, ecosystem, exploration, forest, Kalimantan.

Abbreviations: CSR: Corporate Social Responsibility, D: Density, RD: Relative Density, Dm: Dominance, RDm: Relative Dominance, IVI: Importance Value Index, R: Richness, E: Evenness

INTRODUCTION

Economic activities through the extraction of natural resources generally have negative impacts on the environment including on biodiversity. The mining sector is one example of extractive economies that causes ecological damages, particularly if mining operation is conducted in forested landscapes (Myroniuk et al. 2020). Mining activities, moreover when conducted using the open-pit mining method, will clear vegetation cover and remove topsoil, leaving the landscape to be open and changing the microclimate of the mined site to be hotter and drier. Therefore, prudent consideration and well planning is needed to minimize the impacts caused by extractive activities, such as mining, on forested landscapes (Potapov et al. 2017).

East Kalimantan, Indonesia is rich with natural resources including quarry mining to develop the cement industry. One area with the potential for the cement industry is Selangkau Village, Kaliorang Sub-district, East Kutai District. The establishment of the cement industry in East Kalimantan is essential to support the Indonesian Government's plan to moving the national capital from Jakarta to East Kalimantan (Yusriyah et al. 2020). It is also expected that the cement industry will positively impact the economic development of the local community and the East Kalimantan Province (Environmental Impact Assessment Report of PT Kobexindo Cement 2020).

Nonetheless, East Kalimantan (and Borneo in general) holds great biodiversity and is among the global biodiversity hotspots (Budiharta and Meijaard, in press). For example, Ismawan et al. (2015) reported that in the Prevab of the Kutai National Park in East Kalimantan live 22 species of birds from 15 families and six orders. Falah et al. (2013) reported that in the Gunung Beratus Conservation Forest in East Kalimantan, 36 species of medicinal plants were identified from 30 families, which the Dayak Benuaq community has used to treat various ailments. Therefore, there are conflicting interests between economic development versus biodiversity conservation in East Kalimantan, prompting dilemmas in policies and decision making. The development of the cement industry will likely impact the biodiversity in East Kalimantan altogether with habitat destruction, the rarity of biodiversity and overexploitation (Harrison et al. 2020)

Currently, the depletion of natural resources as a negative impact of global economic growth has raised the awareness among the business people to pay more attention to the environment and push them to implement more environmentally friendly practices, although there is still room for improvement to create the best practices for the environment (Purwandani and Michaud 2021). In the context cement industry in East Kalimantan, scientific studies are needed to bridge the gap between the development of the cement industry (along with the mining of limestone quarry) and biodiversity conservation. Besides setting aside forests with high conservation values (Fiqa et al. 2019), post-mined reclamation will be required to recover the landscape to a better condition (Lestari et al. 2019). In this regard, integrated planning when developing the cement industry should consider biodiversity conservation and post-mining reclamation activities to minimize the environmental impacts (Hou et al. 2021). An initial step is by characterization and mapping of the biodiversity as baseline information to develop appropriate conservation strategies (Tripathi et al. 2016). Therefore, this study is aimed to identify the diversity of flora and fauna in the forest ecosystem to be developed as a cement industrial complex in the Selangkau Village, Kaliorang Sub-district, East Kutai District, and to provide recommendations for environmental management plans as part of the conservation efforts.

MATERIALS AND METHODS

Study area

This research was conducted in Selangkau Village, Kaliorang Sub-district, East Kutai District, East Kalimantan Province. The area was formerly a limestone hill forest and is planned for a cement factory complex. Vegetation data were sampled at three locations at the coordinates of N 00°47’45.06” E 117°48’03.29”; N 00°48’05.00” E 117°48’38.30” and N 00°48’22.38” E 117°49’10.38” (Figure 1).

Procedures

The tools and materials used in this study were the map of the observation site, machete, compass, measuring tape (50 m), permanent markers, tally sheet, phi-band, camera trap, binoculars, Global Positioning System (GPS), photo camera, handling tools, lithium battery, and flora identification books (Bodegom et al. 1999; Kessler et al. 1999; Kessler 2000; Sidiyasa 2015; Ngatiman and Budiono 2009), fauna identification books (MacKinnon et al. 2000), Nikon P900 camera with 40-2000 mm lens, and flagging tape.

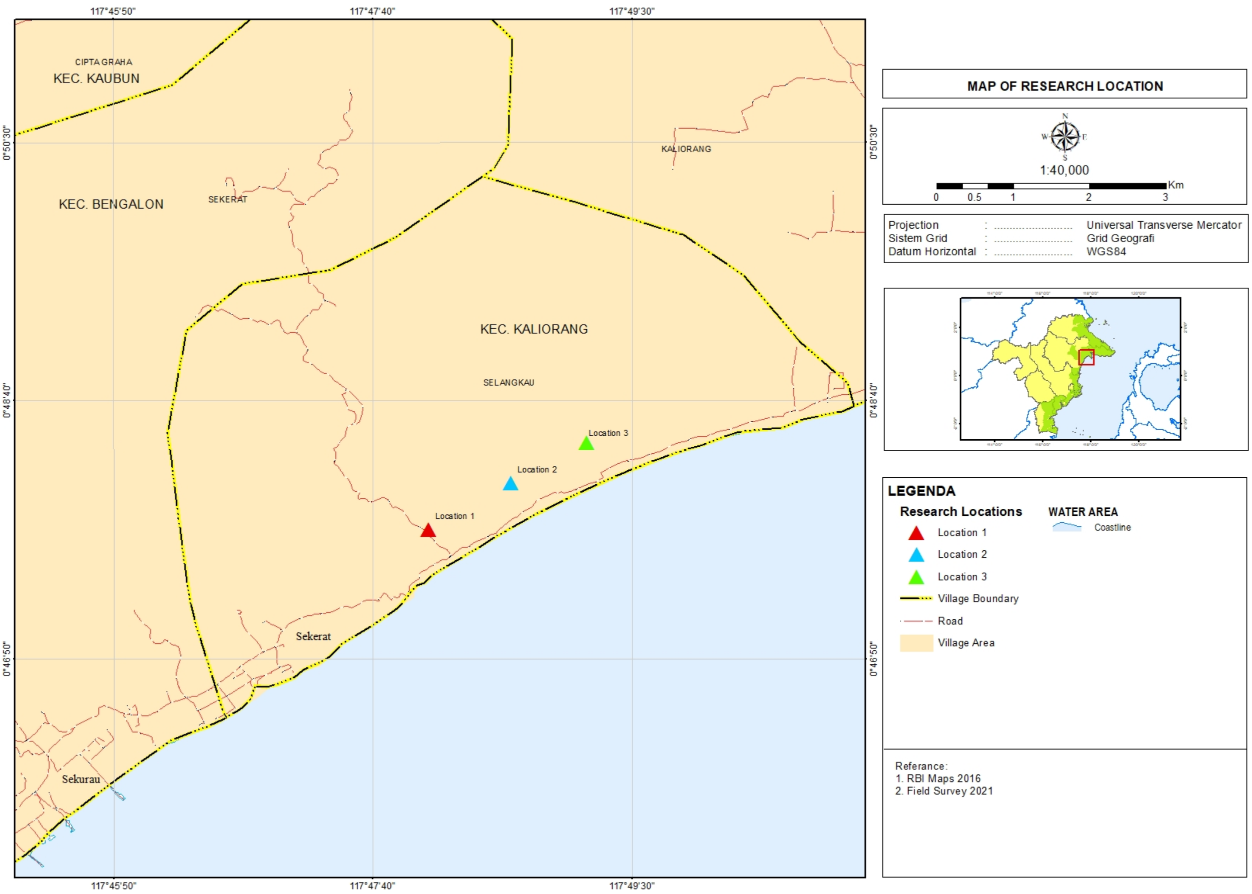

Figure 1. Three locations of sampling in Kaliorang Sub-district, East Kutai District, East Kalimantan Province, Indonesia

Figure 2. Vegetation coverage in limestone hill forest in which cement factory complex and its supporting facilities will be constructed. This area is densely covered by small sized trees

Vegetation study

The sampled plots for vegetation study were determined by purposive sampling method using 3 points distributed across the construction site of the new cement factory plan. The vegetation data were collected by combining the transect and multiple plots methods with each point had one transect, and each transect had five plots.

Each plot had the sub-plots to collect data for each growth stage as follows: (a) Seedlings (from sprouts to shoots with less than 1.5 m tall) and ground vegetation (plants other than tree/woody species such as shrubs, herbs, and lianas) with sub-plot size of 2x2 m^2; (b) Saplings (woody plants with a height of more than 1.5 m and maximum 10 cm in diameter) with sub-plot size of 5x5 m^2; and (c) Poles (woody plants with stem diameter at breast height of 10-20 cm) with sub-plot size of 10x10 m^2; (d) Trees (woody plants with stem diameter more than 20 cm) with sub-plot size of 20x20 m^2. In all plots, the species names (local name and scientific name), and the number of individuals for each species were recorded.

Fauna/wildlife study

In general, observations on animals were also done in the transects as well as the riverbanks and seaside. The observation methods are described below.

Sign searching

This method refers to the observation of signs left by animals. The presence of mammal species was identified by the signs left in certain places, such as droppings, footprints, scratch marks, sounds, smells, and nests.

Observation with binoculars

Observation with binoculars was done along the transects, although the dense jungle condition highly affected the identification work. Normally, a successful observation relies on the sun rays in the edges of the forest or in the area where the trees fall. Observation with binoculars was especially aimed at birds. During this research, observation was done all day from morning to afternoon. The types of observed birds were recorded and identified based on the morphological features, and sounds, if recognized.

Public information

Information from the local community also provided data on the fauna present in the research location. Ecological data and information for each species were obtained from various literature and previous ecological studies of the species. Considering that there were still many species that might not be identified in the field survey, the collected information and compiled study concerned not only the species observed directly in the field but also the large terrestrial mammal species of which the distribution area might include the research location. In addition, it was also based on the theory of species distribution and habitat similarity.

Trap camera

There were relatively hard to find for nocturnal animals through direct observation, so identification was made by installing trap cameras in locations where the animals might be encountered.

Data analysis

The following analyses were done.

Species Importance Value Index (IVI)

IVI was calculated using the following formula:

IVI = RD + RF + RDm (for poles and trees) or
IVI = RD + RF (for seedlings and saplings)
with
Density (D) and Relative Density (RD)

$$D = \frac{\sum \text{individual species}}{\text{Size of area sampled}}$$

$$RD = \frac{\text{D of a species}}{\text{D of all species}} \times 100\%$$

Frequency (F) and Relative Frequency (RF)

$$F = \frac{\sum \text{Sub-plot of observed species}}{\sum \text{All sub-plots sampled}}$$

$$RF = \frac{\text{F of a species}}{\text{F of all species}} \times 100\%$$

Dominance (Dm) and Relative Dominance (RDm), which was calculated only for the pole and tree stages

LBD = ¼ π d2, d = stem diameter (m)

$$Dm = \frac{\text{Size of the plot of a species}}{\text{Size of the plot sampled}}$$

$$RDm = \frac{\text{Dm of a species}}{\text{Dm of all species}} \times 100\%$$

Species Richness Index (R)

The species richness index was calculated using Margalef's formula (Wijana 2014) as below:

$$R = \frac{S-1}{\ln (N)}$$

Where: R refers to the species richness index, S is the number of species, N is the number of individuals in all species, and ln is the natural logarithm.

Diversity Index (H')

The diversity index was calculated using a formula by Shannon and Wiener (1949) as stated in Magurran and McGill (2011)

$$H' = -\sum_{i=1}^{S} (Pi \times \ln(Pi))$$

Where: H' is the species diversity index, S is the species forming a community, Pi is (ni/N) or the ratio between the number of individuals in a species i (ni) and the total number of individuals of all species within a community, and ln is the natural logarithm.

Dominance Index (C)

In order to determine whether vegetation community is more dominated by one or several species, the dominance index by Simpson (1949) as described in Magurran and McGill (2011) was used,

$$C = \sum_{i=1}^{S} Pi^2$$

Where: C is Simpson dominance index, S is the number of species, ni is the total individuals of species i, N is the total number of individuals of all species, and Pi is ni/N as the species proportion of species number-i.

Evenness index

According to Pielou (1966) in Magurran and McGill (2011), the evenness index (E) was calculated using the following formula,

$$E = \frac{H'}{\ln(S)}$$

Where: E is the species evenness index, H' is the species diversity index, S is the number of species, and ln is the natural logarithm.

The species importance value index (IVI), the diversity index (H'), the species dominance index (C), the species richness index (R), and the species evenness index (E) were classified based on criteria by Fachrul (2007) for the species importance value, as well as by Barbour et al. (1987) for the diversity index, Krebs (1985) for the dominance index, and Magurran and McGill 2011 for the species richness index as described below.

For animal/fauna, successfully identified mammal species were subsequently tabulated based on the family, genus dan species. The list also presented the source of data for each identified species, such as direct observation, droppings, footprints, other signs (nests, tree bark peels, scratch marks, soaking area, and sounds), as well as information from the community.

A list of species was then made both for the plants and wild animals identified along with their conservation status, referring to the existing laws (Indonesia Government 2018), the CITES Appendices for international trade, and the IUCN Red List for the conservation status. Information on the endemism of plants was also collated.

RESULTS AND DISCUSSION

Diversity of vegetation community

The research location, which consists of almost entirely limestone hill forest, is located in Selangkau Village, Kaliorang Sub-district, East Kutai District, East Kalimantan. The vegetation was dominated by small-sized, but dense trees. In general, 29 species were recorded, six included in the IUCN Red List, and one with an Endangered (EN) status, namely *Shorea glauca* King (Dipterocarpaceae). *Buchanania arborescens* Blume or the sparrow's mango was found to dominate the vegetation. Further, four species that are endemic (limited distribution) to Kalimantan were also identified (Table 3).

The structure of the vegetation community becomes an important parameter in monitoring the ecological condition of an ecosystem (Trodd and Dougill 1998). In addition, species density, dominance and biomass also provide useful insight regarding vegetation community (Mendonca et al. 2017). Table 4 shows that at all growth stages, *Buchanania arborescens* Blume (Anacardiaceae Family) had the highest importance values with 60.55% at the seedling stage, 149.19% at the sapling stage, 197.22% at the pole stage, and 225.90% at the tree stage. Based on the criteria stated by Fachrul (2007) in Table 1, *B. arborescens* has a high importance value. The plant has small fruits, which can serve as feeds for birds in the forest, as well as herbivore mammals. Seeds abundance and diversity has an important influence on the vegetation community structure in a landscape (Shiflett et al. 2010). The abundance of the seeds of *B. arborescens* can be referred from the highest importance value at the seedling stage compared to other species, which indicates the domination of the vegetation community structure in the research area.

The analyses on the richness index (R), the diversity index (H'), evenness index (E) and dominance index (C) of the vegetation in the research location are presented in Table 5 below. Depicted in Table 5, the species richness index (R) at all growth stages are classified as low with an R value were lower than 3.5 based on criteria by Magurran and McGill (2011) stated in Table 1. The biodiversity index (H') at seedlings and ground vegetation according to the criteria by Barbour et al. (1987) is moderate with an H' value between 2-3, whereas at other growth stages, it is low with an H value between 0 and 2. When a seedling grows into a tree as a result of succession there will be a change of the species composition (Dalmaso et al. 2020). Not all seedlings will grow and become trees, so the diversity index at the tree stage is lower than at the seedling stage.

The dominance index (C) indicates dominating species based on the number of individuals present in the observation plot in which if C is closer to 0 there are no dominating species, while if C is closer to 1, there is a domination of a species (Krebs 1985). From calculations and data analysis, the tree stage had a high level of species dominance with a value of $0.75 < C < 1$, while the pole stage had a moderate species dominance level with a value of $0.5 < C < 0.75$, and the sapling and seedling/ground vegetation had a relatively low level of species dominance with a value of $0 < C < 0.5$.

The evenness index (E) that is higher or closer to 1 means that the number of individual vegetation is evenly distributed in each type, and vice versa. From the results of calculations and data analysis, based on the criteria by Magurran and McGill (2011) in Table 2, it is known that at the growth stages of sapling and seedling/ground vegetation, the vegetation is somewhat evenly distributed with an E value between 0.51-0.75, while at the poles and trees are classified as uneven with an E value between 0.26 and 0.50.

Based on the analysis, it was found that the vegetation community at the seedling and sapling stages had the highest species diversity index (H'), species richness index (R), and species evenness index (E) compared to the vegetation community at the pole and tree stages, whereas the dominance index (C) was the lowest. This shows that the vegetation community in the research location had a balanced growth which tends to be stable, based on the vegetation diversity index value of 2.09 at the seedling stage (moderate). The decreased diversity and richness values at the tree stage suggest there might be some disturbances within the vegetation community which might be caused by natural factors, such as competition and predation, or external factors, such as human activities/logging.

Table 2. Classification of Species Evenness Index (E)

Criteria	Evenness Index (E)
Not even	0.00-0.25
Less even	0.26-0.50
Somewhat even	0.51-0.75
Nearly even	0.76-0.95
Even	0.96-1.00

Note: Magurran and McGill (2011)

Table 1. Classification of the Species Importance Value Index (IVI), Diversity Index (H'), Species Dominance Index (C), and Species Richness Index (R).

Criteria	IVI (Fachrul, 2007)	H' (Barbour et al. 1987)	C (Krebs, 1985)	R Magurran and McGill (2011)
High	>42.66	>3	$0.75 < C < 1$	$R > 5.0$
Moderate	21.96-42.66	2-3	$0.5 < C < 0.75$	3.5-5.0
Low	<21.96	0-2	$0 < C < 0.5$	R<3.5

Note: For the Species Evenness Index (E), the classification is as follows (Magurran and McGill, 2011)

Table 3. List of species of recorded in the studied area in Selangkau Village, Kaliorang Sub-district, East Kutai District, East Kalimantan, Indonesia and its conservation status.

Family	Species	IUCN	CITES	UURI	End
Anacardiaceae	*Buchanania arborescens* (Blume) Blume				
Annonaceae	*Miliusa macropoda* Miq.				√
Dipterocarpaceae	*Shorea glauca* King	EN		√	
Euphorbiaceae	*Cephalomappa malloticarpa* J.J.Sm.				
Fabaceae	*Fordia brachybotrys* Merr.				√
Hypericaceae	*Cratoxylum sumatranum* (Jack) Blume	LC			
Lamiaceae	*Vitex pinnata* L.	LC			
Lygodiaceae	*Lygodium circinatum* (Burm. f.) Sw.				
Malvaceae	*Pterospermum diversifolium* Blume				
Moraceae	*Artocarpus lakoocha* Roxb.				
Myrtaceae	*Syzygium grande* (Wight) Walp.				
Nephrolepidaceae	*Nephrolepis biserrata* (Sw.) Schott				
Pentaphylacaceae	*Ternstroemia hosei* Ridl.				√
Phyllanthaceae	*Cephalomappa malloticarpa* J.J.Sm.				
Phyllanthaceae	*Glochidion lutescens* Blume	LC			
Picrodendraceae	*Austrobuxus nitidus* Miq.				
Poaceae	*Imperata cylindrica* (L.) Raeusch.				
Primulaceae	*Ardisia elliptica* Thunb.				
Primulaceae	*Ardisia pachysandra* (Wall.) Mez				
Rubiaceae	*Psychotria polytricha* Miq.				√
Sapindaceae	*Guioa diplopetala* (Hassk.) Radlk.				
Sapindaceae	*Paranephelium xestophyllum* Miq.				
Sapotaceae	*Planchonella maingayi* (C.B.Clarke) P.Royen	NT			
Simaroubaceae	*Ailanthus triphysa* (Dennst.) Alston				
Simaroubaceae	*Quassia* sp.				
Symplocaceae	*Symplocos cerasifolia* Wall.				
Thelypteridaceae	*Cyclosorus polycarpus* Holttum				
Violaceae	*Rinorea* sp.				
Vitaceae	*Leea indica* (Burm. f.) Merr.	LC			

Note: IUCN: International Union for the Conservation of Nature and Natural Resources. CITES: Convention on International Trade in Endangered Species of Wild Fauna and Flora. UU RI:Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number P.106/MENLHK/SETJEN/KUM.1/12/2018 (√ = protected status). End: Endemic or plants with limited distribution. EN: Endangered, NT: Near Threatened, LC: Least Concern

A case study in the Philippines, a country with rich biodiversity and a high level of species endemism, found that shifting cultivation has become the primary threat to the rainforest's diversity and structure in the region (Mukul et al. 2020). On the abandoned lands, species density is significantly higher in the oldest site, whereas the diversity index, species evenness, number of stems, size of the basal area and the leaf size index are higher in forests with no disturbance of shifting cultivation (Mukul et al. 2020).

It is important to note that the ecosystem in the research location is the habitat of one protected species based on the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia, namely the Meranti plant (*Shorea glauca* King) (Indonesia Government 2018). The species is also classified as endangered according to IUCN Red List, as supported by the study finding of the plant's population in which only three individuals were found in the research location at the pole stage and none at other stages. The absence of this Meranti plant at the seedling and sapling stages suggests that the local population of this species is endangered. Therefore, regulations and laws are necessary to protect endangered species and their habitats. In order to succeed in such a program, incentives may be required for participants (Ward et al. 2018). The impact of the new cement factory development plan in the research location on the existence of Meranti as an endangered species must be considered. Some conservation efforts are needed, for example, by planting the species in the green open space or preserve its habitat outside the factory area through the Corporate Social Responsibility (CSR) scheme by involving the participation of the local community.

The forest vegetation also provided food resources for the local community. In various regions, wild plants consumption has become a long-standing tradition, involving a great range of plant families. Some plants must be cooked, while others are safe to consume raw. The parts of plants which can be consumed are fruits, tubers, leaves, and stems. Therefore, the high diversity of wild plants can serve as a food source all year long (Ojelel et al. 2019). Local wisdom or indigenous knowledge practices from the local community continually offers support for the conservation of biodiversity with the cultural landscape that it forms (Aziz et al. 2018).

Table 4. Species importance value index (IVI) at seedling, sapling, pole and tree stages in the studied area in Selangkau Village, Kaliorang Sub-district, East Kutai District, East Kalimantan.

Family	Species	Indonesian name	IVI Seedling	IVI Sapling	IVI Pole	IVI Tree
Anacardiaceae	*Buchanania arborescens* (Blume)	*Mangga burung pipit, rawa-rawa pipit*	60.55	149.19	197.22	225.90
Sapindaceae	*Guioa diplopetala* (Hassk.) Radlk.	*Pohon aras*	25.87	5.45	-	-
Hypericaceae	*Cratoxylum sumatranum* (Jack) Blume	*Irat, geranggang, manding, mentialing, serungan, serungan mampat*	15.45	26.89	11.06	8.74
Myrtaceae	*Syzygium grande* (Wight) Walp.	*Apel laut*	14.52	18.72	5.50	21.84
Phyllanthaceae	*Glochidion lutescens* Blume	*Mareme, manyam, obah nasi timbau, timbau*	14.27	49.15	27.66	8.67
Simaroubaceae	*Ailanthus triphysa* (Dennst.) Alston	-	10.15	-	3.17	8.22
Fabaceae	*Fordia brachybotrys* Merr.	-	9.20	5.58	-	-
Euphorbiaceae	*Cephalomappa malloticarpa* J.J.Sm.	-	7.72	5.34	-	-
Vitaceae	*Leea indica* (Burm. f.) Merr.	*Ki tuwa, girang merah*	6.53	6.85	-	-
Poaceae	*Imperata cylindrica* (L.) Raeusch.	*Ilalang, alang-alang*	6.28	-	-	-
Lygodiaceae	*Lygodium circinatum* (Burm. f.) Sw.	*Paku hata*	6.03	-	-	-
Nephrolepidaceae	*Nephrolepis biserrata* (Sw.) Schott	*Paku harupat*	5.32	-	-	-
Sapindaceae	*Paranephelium xestophyllum* Miq.	-	3.38	2.36	5.75	9.25
Symplocaceae	*Symplocos cerasifolia* Wall.	-	3.38	-	2.66	8.45
Thelypteridaceae	Cyclosorus polycarpus Holttum	*Tumbuhan paku*	3.14	-	-	-
Picrodendraceae	*Austrobuxus nitidus* Miq.	-	2.18	3.38	-	-
Malvaceae	*Pterospermum diversifolium* Blume	*Bayur jantan, cerlang, balangkoras, balang*	1.69	4.23	3.45	-
Rubiaceae	*Psychotria polytricha* Miq.	-	1.45	-	-	-
Simaroubaceae	*Quassia* sp.	*Kayu pahit*	1.45	-	-	-
Pentaphylacaceae	*Ternstroemia hosei* Ridl.	*Buwa dawat/ papar bubu*	1.45	-	-	-
Annonaceae	*Miliusa macropoda* Miq.	-	-	9.12	-	-
Primulaceae	*Ardisia elliptica* Thunb.	*Lempeni*	-	4.17	-	-
Lamiacea	*Vitex pinnata* L.	*Laban, leban, amola, agil, humulawan, kalapapa, kulimpapa batu, kulimpapa*	-	4.18	10.18	-
Sapotaceae	*Planchonella maingayi* (C.B. Clarke) P.Royen	-	-	2.59	-	-
Primulaceae	*Ardisia pachysandra (*Wall.) Mez	-	-	2.79	-	-
Violaceae	*Rinorea* sp	*Kokosan monyet*	-	-	18.16	-
Phyllanthaceae	*Chephalomoppa malloticarpa* J.J.Sm.	-	-	-	6.22	-
Dipterocarpaceae	*Shorea glauca* King	*Meranti, tengkawang*	-	-	5.87	-
Moraceae	*Artocarpus lakoocha* Roxb.	*Buah monyet*	-	-	3.11	8.93
	Total		200	300	300	300

Table 5. The analyses on Richness Index (R), Diversity Index (H'), Evenness Index (E) and Dominance Index (C) of the vegetation in the research location.

Diversity Index	Seedling	Sapling	Pole	Tree
R	3.16	2.56	2.18	1.68
H'	2.09	1.43	0.83	0.71
C	0.22	0.40	0.69	0.72
E	0.70	0.51	0.32	0.34

The local wisdom practice of the traditional community has effectively managed the forest ecosystem through the zonation system, in which the areas are divided into zones for food and remedies, hunting zone, land cultivation and residence, bird habitat, taboo, and the river area. This is a form of biodiversity conservation practice that maintains local tradition (Tamalene and Almudhar 2017).

Diversity of wildlife

According to direct observation on the field, as well as the information from company workers and the local community, a list of species of fauna is presented in Table 6. Some of them are protected animals based on the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia (Indonesia Government 2018), IUCN Red List and CITES. From the result of the fauna study in the research location, there were 67 animal species consisting of 42 species of birds, 14 mammals, and 11 amphibians and reptiles. Of 67 recorded species, 12 are protected by the Indonesian Government laws, 63 are included in the IUCN Red List, and 10 species are regulated in CITES.

Table 6. Species of fauna in the research location Selangkau Village, Kaliorang Sub-district, East Kutai District, East Kalimantan, Indonesia

Family	Species	Indonesian name	Conservation status	Note
Aves				
Accipitridae	*Elanus caeruleus*	*Elang tikus*	D, LC, II	Interview
Accipitridae	*Haliastur indus*	*Elang bondol*	D, LC, II	Interview
Accipitridae	*Pernis ptilorhynchus*	*Sikep madu asia*	D, LC, II	Observation
Alcedinidae	*Ceyx erithaca*	*Udang api*	D, LC	Observation
Alcedinidae	*Pelargopsis capensis*	*Pekaka emas*	D, LC	Observation
Artamidae	*Artamus leucorynchus*	*Kekep babi*	LC	Observation
Ardeidae	*Egretta sacra*	*Kuntul karang*	LC	Observation
Bucerotidae	*Buceros rhinoceros*	*Rangkong badak*	D, NT, II	Interview
Chloropseidae	*Chloropsis sonnerati*	*Cica daun kecil besar*	LC	Observation
Columbidae	*Streptopelia chinensis*	*Tekukur biasa*	LC	Observation
Columbidae	*Treron capellei*	*Punai besar*	VU	Observation
Columbidae	*Delimukan zamrud*	*Punai tanah*	LC	Observation
Corvidae	*Corvus enca*	*Gagak hutan*	LC	Observation
Corvidae	*Corvus macrorhynchos*	*Gagak kampung*	LC	Observation
Cuculidae	*Centropus bengalensis*	*Bubut Alang-alang*	LC	Observation
Cuculidae	*Centropus sinensis*	*Bubut Besar*	LC	Observation
Dicruridae	*Dicrurus paradiseus*	*Srigunting batu*	LC	Observation
Estrildidae	*Lonchura fuscans*	*Bondol Kalimantan*	LC	Observation
Eurylaimidae	*Eurylaimus ochromalus*	*Sempur hujan darat*	NT	Observation
Hemiprocnidae	*Hemiprocne comata*	*Tepekong rangkang*	LC	Observation
Megalaimidae	*Caloramphus fuliginosus*	*Takur ampis*	LC	Observation
Megalaimidae	*Megalaima mystacrophanus*	*Takur warna-warni*	NT	Observation
Meropidae	*Merops viridus*	*Kirik-kirik biru*	LC	Observation
Motacillidae	*Anthus novaeseelandiae*	*Apung tanah*	LC	Observation
Nectariniidae	*Anthreptes malacensis*	*Burungmadu kelapa*	D, LC	Observation
Passeridae	*Passer montanus*	*Burung gereja erasia*	LC	Observation
Phasianidae	*Lophura bulweri*	*Sempidan biru*	VU	Interview
Picidae	*Picoides moluccensis*	*Caladi tilik*	LC	Observation
Picidae	*Dinopium javanense*	*Pelatuk besi*	LC	Observation
Pycnonotidae	*Amphoixus phaeocephalus*	*Empuloh Irang*	LC	Observation
Pycnonotidae	*Pycnonotus aurigaster*	*Cucak kutilang*	LC	Observation
Pycnonotidae	*Pycnonotus goiavier*	*Merebah cerukcuk*	LC	Observation
Pynonotidae	*Pynonotus erythropthalmus*	*Merbah kacamata*	LC	Observation
Rallidae	*Amaurornis phoenicurus*	*Kareo padi*	LC	Observation
Rhipuduridae	*Rhipudura javanica*	*Kipasan belang*	LC	Observation
Sturnidae	*Acridotheres cristatellus*	*Kerak jambul*	LC	Observation
Sturnidae	*Acridotheres javanicus*	*Kerak kerbau*	LC	Observation
Sturnidae	*Aplonis panayensis*	*Perling kumbang*	LC	Observation
Sturnidae	*Gracula religiosa*	*Tiong emas*	D, LC, II	Observation
Sylviidae	*Orthotomus ruficeps*	*Cinenen kelabu*	LC	Observation
Timaliidae	*Stachyris maculata*	*Tapus tungir merah*	NT	Observation
Vangidae	*Hemipus hirundinaceus*	*Jing-jing batu*	LC	Observation
Mammals				
Cercopithecidae	*Macaca fascicularis*	*Monyet ekor panjang*	LC	Observation
Cercopithecidae	*Macaca nemestrina*	*Monyet beruk*	VU	Observation
Cercophitecidae	*Trachypithecus cristatus*	*Lutung kelabu*	D, NT	Observation
Cervidae	*Muntiacus muntjak*	*Kijang muncak*	LC	Interview
Cervidae	*Rusa unicolor*	*Rusa sambar*	VU	Interview
Felidae	*Felis bengalensis*	*Kucing kuwuk*	D, II	Interview
Hystricidae	*Hystrix brachyura*	*Landak raya*	D, LC, I	Interview
Sciuridae	*Callosciurus notatus*	*Bajing kelapa*	LC	Observation
Suidae	*Sus barbatus*	*Babi*	VU	Interview
Tragulidae	*Tragulus kanchil*	*Pelanduk kancil*	LC	Interview
Tupaiidae	*Tupaia tana*	*Tupai tanah*	LC	Interview
Ursidae	*Helarctos malayanus*	*Beruang madu*	D, VU, I	Interview
Viverridae	*Viverra tangalunga*	*Musang Tenggalung*	LC	Interview
Viverridae	*Cynogale bennettii*	*Musang air*	D, EN	Observation

Amphibians and reptiles				
Ranidae	*Amnirana nicobariensis*	*Kongkang jangkrik*	LC	Observation
Ranidae	*Hylarana erythraea*	*Kongkang gading*	LC	Observation
Rhacophoridae	*Polypedates leucomystax*	*Katak pohon bergaris*	LC	Observation
Agamidae	*Bronchocela cristatella*	*Bunglon jambul hijau*	LC	Observation
Agamidae	*Bronchocela jubata*	*Bunglon surai*	LC	Observation
Agamidae	*Draco volans*	*Kadal terbang*	LC	Observation
Colubridae	*Dendrelaphis pictus*	*Ular tambang*		Observation
Elapidae	*Ophiophagus hannah*	*Ular kobra*	VU, II	Interview
Pythonidae	*Python reticulatus*	*Ular sanca*	II	Interview
Scincidae	*Eutropis multifasciata*	*Kadal*	LC	Observation
Varanidae	*Varanus salvator*	*Biawak*	LC, II	Observation

Note: D: Protected by Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number P.106/MENLHK/SETJEN/KUM.1/12/2018. LC/LR: Least Concern/Lower Risk. NT: Near Threatened. VU: Vulrenable. EN: Endangered. I, II: Apendix I or II CITES

Habitat types in a forest in Ketapang, West Kalimantan found eight species of diurnal mammals across six families (Putra et al. 2020), although the amphibians have a lower number. Another case study in the conservation forest of Gunung Semahung in the Landak District of West Kalimantan identified 18 species from 6 families with a total number of 357 individuals (Yani et al. 2015).

According to Table 6, the biodiversity in the research location can be classified as good, with 42 bird species, 7 of which are protected. The distinctive characteristics of birds make them a natural indicator of the biodiversity richness of a region. In other words, the diversity of birds represents a high level of wildlife biodiversity because birds have a niche or diverse habitats, and their communities are affected by the vegetation community structure in the forest (McNeely et al.1990; Hino 2000).

Because the existence of the 42 bird species is affected by the vegetation community structure in the research location, the plan to develop a construction in the area will change the vegetation community structure, which will further affect the diversity and population of birds in the area. Change in the vegetation structure caused by long-term logging can significantly decrease the population and richness of the bird species that rely heavily on the forest (Sekercioglu 2002; Ocampo-Peñuela 2020). Therefore, bird conservation must maintain the structure and diversity of vegetation in the forest.

In addition, there is also a range of protected mammals classified as endangered species, such as sun bears, otter civets, leopard cats, and silvery lutung. This shows that the research area had important types of animals. For this reason, in response to the plan to develop a new cement factory in the research location, conservation efforts are crucial to be done; for example, by transferring the animals into a new habitat that resembles the original one. The efforts are important as the threatened animals will instinctively attempt to seek a new habitat to continue their regeneration (Kloskowski and Frączek 2017). The habitat transfer may be done by setting up a corridor that connects the old habitat and the new one to guide the animals (Aars and Ims 1999).

Threats toward the wildlife habitat in the research location are begun at the first stage of the new factory construction preparation where the land will be cleared and the topsoil layer will be removed. Naturally, this involves removing all the vegetation in the topsoil. This removal will eventually lead to negative impacts on the vegetation and wildlife diversity which rely on the land as their habitats. The loss of pristine and undisturbed forest and habitat fragmentation may result in loss of species diversity, mainly vertebrates (Ocampo-Peñuela 2020). The expansion of mining activities, especially in the mountain area (>750 m) also becomes a severe threat toward biodiversity sustainability. Much of the area is the habitat for endangered species. Therefore, a management plan is necessary and must involve *in situ* and *ex situ* conservation to reduce the potential threat of mining activities in the future (Droissart et al. 2019; Pratiwi et al. 2021).

Environment management can also be done with a technological approach, as follows: (1) logging can only be done on the specific area where the factory and its supporting facilities will be built, and letting the plants/trees outside the area remain as a green belt or a green open space; and (2) making a green open space with plants with multiple functions for the aesthetics, conservation, as well as habitat for the wildlife. The types of plants to be selected should include the local species with a high importance value in the ecosystem such as sparrow's mango (*Buchanania arborescens*), meranti (*Shorea glauca*), or non-invasive non-local plants which are suitable for the land such as teak (*Tectona grandis*), weeping fig (*Ficus benjamina*), Japanese bamboo (*Pseudosasa japonica*) and *kersen/kerukup siam/talok* (*Muntingia calabura*) trees.

Likewise, after the mining activities are completed and the factory operations stop, land reclamation and revegetation can be carried out with local plants that are easy to grow and adapt with the land condition in the former mining area (Anderson et al. 2016). Reforestation should be considered to repair the loss of habitat that might happen during the mining process. Trees to be planted should be chosen not only based on the historical past of the land but also related to the quality of the soil, ecological function of species and also closely related phylogenetic groups of former species that grow in cleared areas (Chechina and Hamman 2015; Gastauer et al. 2018; Pietrzykowski 2019) Vegetation density and diversity become important factors which determine the density and diversity of birds. Therefore, revegetation primarily works with species that can invite wild animals, e.g., trees with seeds that feed birds, or flower plants that offer nectars for insects and nectar-eating birds.

The reclamation of ex-mining land can improve carbon stocks in the soil and plant biomass in the form of forests to benefit the surrounding community (Hirons et al. 2013). Further, there are a set of criteria and indicators in the success of sustainable forest management. Five principles that can be used as a reference in the forest biodiversity conservation are (1) the maintenance of connectivity; (2) the maintenance of landscape heterogeneity; (3) the maintenance of stand structural complexity; (4) the maintenance of aquatic ecosystem integrity; and (5) the use of natural disturbance regimes to guide human disturbance regimes (Lindenmayer et al. 2006). The substrate difference and types of disturbance affect the recovery of the endangered plant species population. The plant habitat interrupted by humans may be recovered as long as there is a natural ecosystem process, as well as the vegetation community structure and the habitat heterogeneity (Robinson and Hermanutz 2015).

Based on the above elaboration, it can be concluded that the vegetation community structure in the forest ecosystem of Selangkau Village, Kaliorang Sub-district, East Kutai District, East Kalimantan Province was quite diverse and tends to be stable, based on the diversity index value. *B. arborescens* (Blume) had the highest importance value at all growth stages. One protected species was identified, namely *Shorea glauca* King (Meranti), meaning it is imperative to make management efforts toward the impacts of the new cement factory development plan in the future on this plant. One of the efforts can be made by growing the plant species in the green open space area or by preserving its habitat outside the factory area through the Corporate Social Responsibility (CSR) scheme. On the other hand, the study findings on fauna show that many protected species are identified based on the regulations and laws with endangered status. Therefore, conservation efforts of the protected species must be made regarding the new cement factory in the research location, namely by transferring the species into a new habitat that resembles the original one. Moreover, it is also imperative to have a green open space that can serve as the new habitat for the protected species.

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