Biodiversity of Nusantara

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April of 2024

INTRODUCTION

The Indonesian province of East Kalimantan is a biodiversity hotspot, home to a diverse range of flora and fauna species (Encyclopedia Britannica, 1998). The unique rainforest ecosystem supports endemic species to the island of Borneo, many of which are endangered due to human interference (Encyclopedia Britannica, 1998). Despite the region's ecological importance, the threat of habitat degradation and destruction to biodiversity remains and is likely to escalate with the Indonesian capital relocation from Jakarta on the island of Java to Ibu Kota Nusantara in East Kalimantan on the island of Borneo.

Environmental degradation in Borneo began with the colonization of Indonesia in the early 17th century (Encyclopedia Britannica, 1998). With colonization came widespread rainforest deforestation, poaching of native species, changes in land use, pollution, habitat destruction, degradation, and fragmentation, resulting in biodiversity decline. Simultaneously, environmental justice issues arose; local communities became disadvantaged due to inequitable treatment, the destruction and decline of natural resources, and forced relocation (Encyclopedia Britannica, 1998), (Ocampo-Penuela et al., 2020). Environmental justice issues increased slowly through a process known as "slow violence" (Nixon, 2011). When applied to Indonesia, this process represents the incremental, increasing severity of environmental degradation, the decline in biodiversity, and the consequent negative implications for local people. Some communities in Nusantara rely on the environment for food, as a source of income, ingredients for traditional medicines, cultural and spiritual value, and ecotourism (Ariani et al., 2012). As the environment is degraded and destroyed, local people bear the implications economically, culturally, and environmentally.

Borneo's biodiversity is currently affected by the palm oil industry, where transnational companies create monoculture palm oil plantations involving the deforestation of large swaths of land (Meijaard et al., 2020). In addition to the damage caused by the palm oil industry, mining, quarrying, logging, hunting, and human-wildlife interactions threaten regional biodiversity (Encyclopedia Britannica, 1998; Peatland et al., 2016). Further environmental damage will ensue due to the capital relocation and city construction (Normile, 2022). With the capital relocation and the formation of urban areas, biodiversity declines, triggering a domino effect: natural resources dwindle, pollution escalates, exploited labor becomes commonplace, and local communities face a complete upheaval in their way of life. However, the capital relocation plan considers and plans to mitigate the environmental impact (Azizah, 2023). To do this, the city development plan includes creating conservation areas, relocating threatened and endangered species, and developing green corridors to maintain habitat connectivity (Ramadhani & Djuyandi, 2022). Despite these efforts, the new capital creation will significantly affect biodiversity and, as a result, local populations.

Previous research on this topic focuses on historical and current threats to biodiversity in Indonesia. However, there is a distinct lack of literature and quantitative data on how the creation of Nusantara will amplify these threats and affect populations of native and endemic species. Additionally, few studies or public interviews are available that outline the environmental justice implications of a loss of biodiversity in general and as a result of the capital relocation. Therefore, this paper aims to provide a qualitative overview of how capital relocation and city creation will affect species biodiversity and to contextualize these findings through the scope of environmental justice. This analysis can provide insight into this issue, informing conservation efforts to mitigate biodiversity decline in the Nusantara planning and construction practices and policies.

This study will evaluate the biodiversity implications of the capital relocation to Nusantara, Borneo through the analysis of two species case studies: the helmeted hornbill (*Rhinoplax vigil*)

and the Bornean orangutan (*Pongo pygmaeus*).

RESEARCH QUESTION

This study aims to provide insight into the question: How will the creation of Nusantara in Indonesia affect species biodiversity? To do this, we evaluated two species case studies: the Bornean orangutan and the helmeted hornbill. These case studies focus on the biological and ecological aspects of these species, and how they are threatened by human inference, particularly in the form of habitat destruction. They also explore how these threats may change with the capital relocation to Nusantara and the environmental justice ramifications for local communities. From this species-level analysis, we can understand how biodiversity is affected by capital relocation and how these adverse effects on biodiversity create environmental injustice. These findings can be applied more broadly to other species in East Kalimantan.

METHODS

To answer our research question, we studied two species considered valuable to the Indonesian forest as well as native to the forest where Nusantara is planned to be constructed. The research for this paper included a qualitative analysis of data sources, including peer-reviewed scientific journal articles, first-hand accounts, and reports. Furthermore, we included a quantitative analysis of data such as species' population numbers and area of land deforested, and spatial data files for the species' range to create maps from the International Union for Conservation of Nature (IUCN) Red List. The maps for the species' ranges were made using QGIS software.

Our authors originate from the United States of America and Indonesia. All authors of this paper are university students studying environmental science and studies, or related fields, such as geography, forest management, or global environmental justice. Backgrounds in this field allied with different study focuses, allowed for a comprehensive analysis of this subject and the integration of varied knowledge and perspectives. While the American students rely on research to inform their research, the Indonesian students from East Kalimantan brought their first-hand knowledge of the issue.

RESULTS

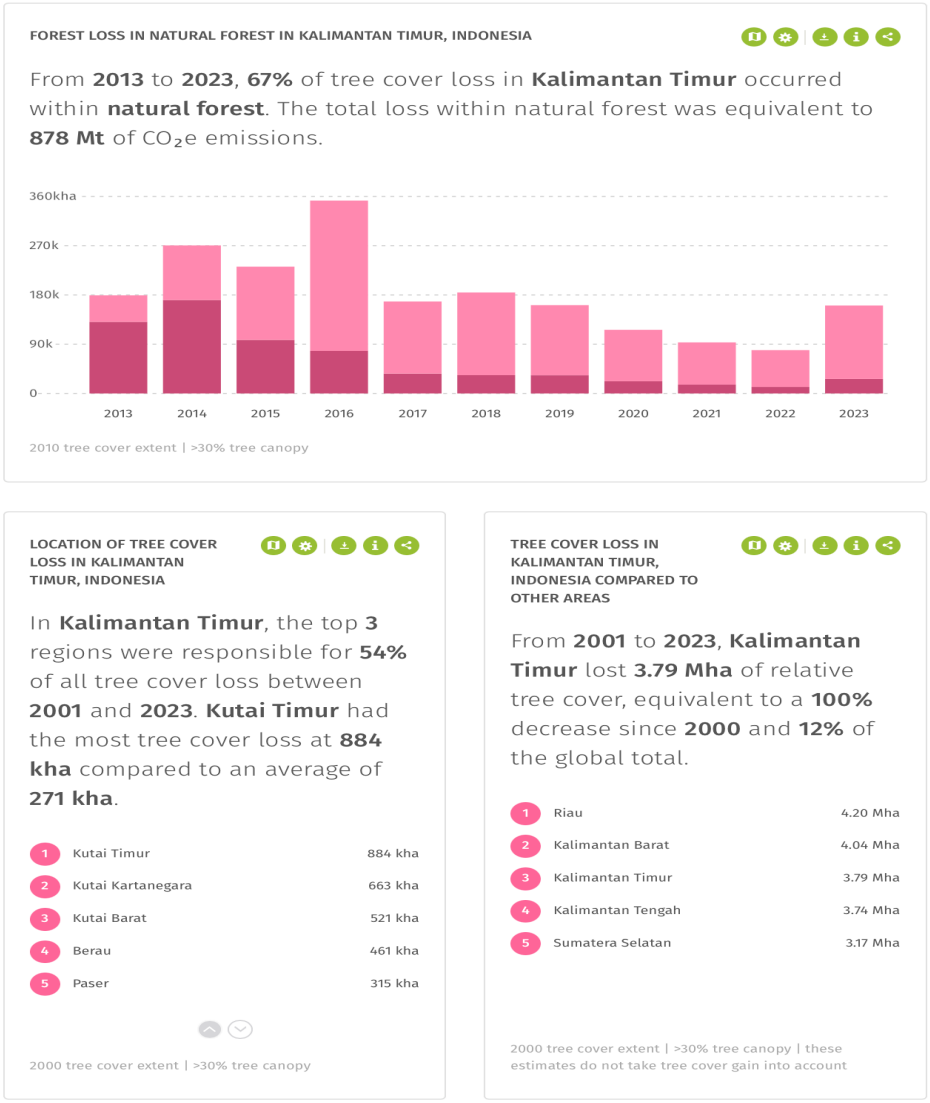

Figure 1. Rates of forest change in Kalimantan Timur, Indonesia.

Source: Global forest watch

Forest Loss and Palm Oil Expansion

Forest loss in Borneo has significantly impacted biodiversity, primarily due to palm oil plantations. From 1973 to 2015, Borneo experienced a 50% reduction in forest cover, resulting in an average habitat loss of 28% for 245 species of forest birds and mammals (Ocampo-Penuela et al., 2020). This deforestation has predominantly affected lowland areas, which naturally host higher species richness and have been targeted for agricultural expansion due to their suitability for crops like oil palm. As a result, the functional connectivity of these habit has declined 35 % over four decades, increasing the vulnerability of these species to environmental changes and human activities (Ocampo-Penuela et al., 2020).

The expansion of oil palm plantations is a significant contributor to forest loss in Borneo. Between 2001 and 2019, Indonesia saw more than doubling of land dedicated to oil palm cultivation, with a substantial portion of this growth occurring in Borneo (Austin et al., 2022).

During this period, 32% of deforestation was directly linked to converting forest into oil palm plantations (Austin et al., 2022). This expansion has not only led to habitat loss but also increased forest fragmentation, making it challenging for wildlife to survive. Efforts such as the indonesian government's moratorium on new oil palm concessions in primary forest have seen minimal success, indicating a need for stronger conservation policies and sustainable farming practices (Austin et al., 2022).

The consequences of forest loss and palm expansion are extensive, affecting both ecological balance and socio-economic conditions in the region. Fragmentation forest disrupts species movement and genetic diversity, is essential for maintaining healthy populations (Ocampo-Penuela et al., 2020). Furthermore, converting forest to plantations often leads to land use conflicts, impacting indigenous communities and local economies. Sustainable management and reforestation efforts are crucial to reducing these impacts. Promoting responsible palm oil production, enforcing stricter regulations, and investing in conservation programs are essential to preserving Borneo's biodiversity (Austin et al., 2022).

Orangutan Kalimantan Case Study

Figure 2: Photo of the Bornean orangutan (*Pongo pygmaeus*)
Photo Source: Galdikas, 1999

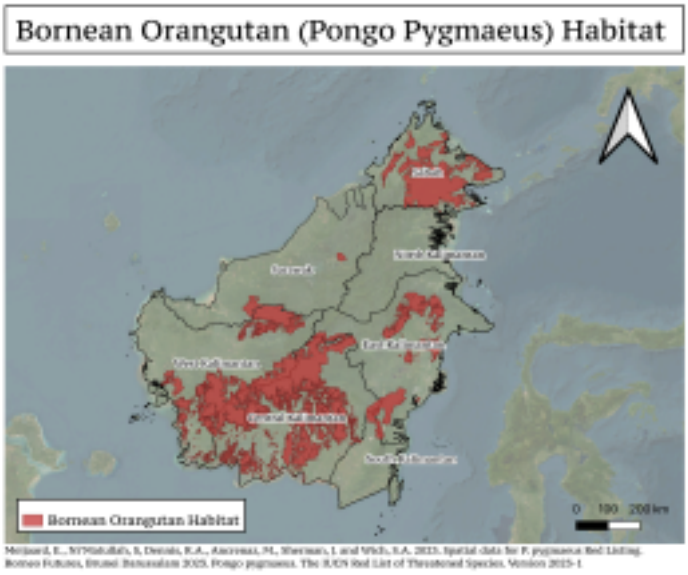

Figure 3: Map of Bornean orangutan (*Pongo Pygmaeus*) habitat in Borneo Data from the IUCN Red List of Threatened Species, map made by authors.

One of three species of orangutan lives across the island of Borneo. This critically endangered orangutan is aptly named the Bornean orangutan (IUCN, 2023). The Bornean orangutan showcases a short stature, broad build, and red fur, as seen in Figure 1. Such a look makes them the target for many hunting escapades, to be described later (Downey, 2022). The relocation of Jakarta to Nusantara stands to further the threats to the orangutans, which in turn enhances their current label of being critically endangered. The potential for further endangerment is not only detrimental to the species as a whole but also poses a looming threat to the biodiversity of Borneo.

To understand why such threats, hold significant potential for destruction, the lifestyle of the orangutans must first be established. Bornean orangutans can live over 40 years and are often swinging from tree to tree. The Bornean orangutans' range is 740,000 km^2. Over such a large geographic area, the orangutans tend to live in fragmented groups, as the island has no single, connected population. The population fragments can be seen in Figure 2, which depicts different areas that the various orangutan populations have been known to inhabit (these are bound to change as the populations move). Within the populations exist subspecies including the Northwest Bornean orangutan, the Northeast Bornean orangutan, and the Southeast Bornean orangutan (United Nations Environment Programme & World Conservation Monitoring Centre, 2005).

The role that this species plays in environmental functions is paramount to the success of biodiversity in Borneo. The Bornean orangutans' frugivorous diet consists of hundreds of plants, with fruits contributing to over half of their intake (Russon et al., 2009). This diet enables orangutans to play a crucial role in seed dispersal across Borneo, as they defecate and spread various plant through their feces. The long-life span and constant mobility of the orangutans mean each individual contributes significantly to Bornean rainforest biodiversity (WWF, 2024). Unfortunately, anthropogenic impacts are slowly creeping in to change the narrative of the Bornean orangutan's successful seed spreading.

Indonesia's rainforests are irreplaceable as they host and protect a vast number of endangered species, including the orangutan. Currently, a highly dangerous threat to the orangutan as well as the biodiversity of Indonesia is deforestation. Overall, the world's most biodiverse areas are rapidly shrinking. These Indonesian forests that once hosted a myriad of species comprising 12% of the world's biodiversity, now only contain 1.4% (Brooks, 2002). This severe biodiversity

loss is a result of deforestation and other threats to the great number of rare plants and animals that are unable to leave their habitats such as the orangutan, which depend on the Indonesian forests to survive.

Over the past two decades, in Indonesian New Guinea, over 75 million acres of forest were deforested, and habitat destroyed (Gaveau, 2021). With the limited land area in Indonesia, people destroyed the forest to create plantations that could generate more oil palm and pulpwood. Projects were even implemented to add roads and ports to Indonesian New Guinea to promote infrastructure and improve the economy (Gaveau, 2021). To this day, a remaining threat to the forest and orangutan of Indonesia is the massive amounts of land people want to turn into industrial projects. What happened in Indonesian New Guinea is expected to occur on the island of Borneo with the creation of Nusantara. Similarly, deforestation will occur to clear the land at the site of the new capital, leading to a decline of habitat for orangutans in the region.

While deforestation is a leading cause of why the Bornean orangutan is critically endangered, it is not its sole cause. The killing of orangutans is another large contributor to why they have become so close to extinction (Meijaard, 2011). Over time as agriculture increases in the villages of Indonesia, the orangutan's mortality rates are also increasing. With more farms appearing where forests once were here, orangutans are not only losing their habitat but are also hunted (Peatland et al., 2016). Members of villages will hunt them if they think it is creating a problem for the harvest (Meijaard, 2011). To those in the village, these orangutans are like pests or vermin, harming their crops (Meijaard, 2011). But the orangutans see these farms as still a natural part of their home in which they can eat whatever they want. Researchers did a study in 2011 and estimated that there were 1750 orangutans killed in that year alone, and according to their data, the death rates were only ever increasing (Meijaard, 2011).

Rangkong Gading Case Study

Figure 4. Photo of the Helmeted Hornbill (*Rhinoplax vigil*)
Photo Source: Unknown

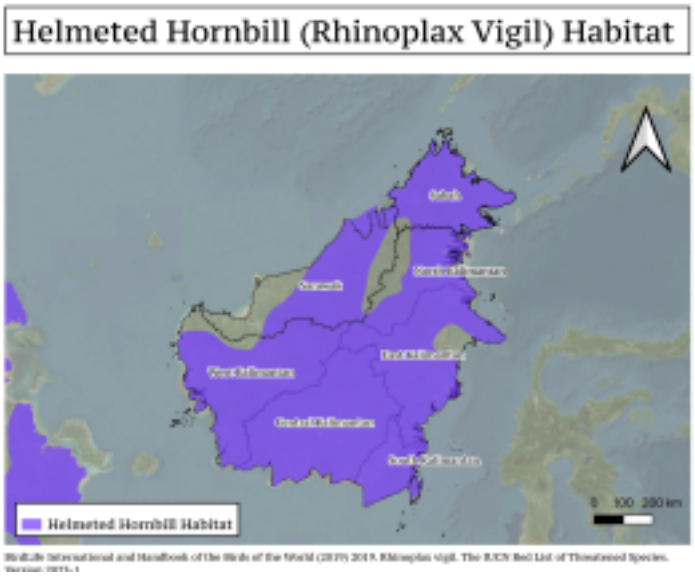

Figure 5: Helmeted hornbill (*Rhinoplax Vigil*) habitat in Borneo
Data from the IUCN Red List of Threatened Species, map made by authors

Largest of the hornbill species, with a beak that extends above its eyes, and black and white coloring, the helmeted hornbill is one of the most striking hornbill species in the world (Hidayah, 2018). As shown in Figure 3, the species's range covers a majority of Borneo — over 100km^2(Jain et al., 2018). Its ubiquity and distinguished appearance make this rare bird species prominent environmentally, economically, and culturally in Borneo.

Similar to the Bornean orangutan, the helmeted hornbill is a keystone species, playing a significant role in maintaining Borneo's biodiversity. Through their diets of various plants, coupled with migratory patterns, the birds are invaluable in the germination and growth process of rainforests (Kitamura and Poonswad, 2013; Rose, 2021). With 98% of their diet consisting of fruits, these birds are effective at ornithochory: the dispersal of seeds by birds (Mariyappan et al., 2023). Hornbills disperse high quantities of seeds through their feces across the forest within their vast geographic range (Kinnaird & O'Brien, 2007; Kitamura & Poonswad, 2013.

Mariyappan et al., 2023). As a result, hornbills are an indicator species for ecosystem health - a high number of hornbills indicates a healthy ecosystem (Mariyappan et al., 2023). In addition, to the ecosystem services provided by the hornbill, they benefit the economy. Birdwatching is a focus of Bornean ecotourism, with the hornbill as a sought-after sighting (Mariapan et al., 2017). Economic growth is generated from ecotourism, benefiting locals financially (Mariapan et al., 2017). Ecotourism is often located in rural, low-income regions, making it an important and valuable industry (Mariapan et al., 2017). Furthermore, ecotourism benefits the hornbill and other species, as revenue is reinvested in conversation efforts (Mariapan et al., 2017). Culturally, the hornbill is valued by various groups in Indonesia. In Kalimantan, the hornbill is a symbol of "purity and strength" (ProFauna, 2019). For instance, the Dayak people believe in a spirit called the "Bird

Commander", manifested in the form of a hornbill (ProFauna, 2019). In the Hindu Prambanan Temple in Indonesia, there are ancient hornbill reliefs, showing evidence of the historical importance of the hornbill (ProFauna, 2019).

Despite the hornbill's importance environmentally, economically, and culturally they are critically endangered, as classified by the IUCN Red List (IUCN BirdLife International, 2020). The helmeted hornbill is the rarest of all hornbill species, and the population continues to decline, a trend predicted for the future in the absence of robust conservation efforts (IUCN BirdLife International, 2020). Their endangerment is caused by various threats, both direct and indirect. Regarding direct threats, the "ivory" helmet of the hornbill, can comprise 10% of the bird's weight - the substantial size makes it a prime target for poaching (Rose, 2021). They are sought after for these uniquely shaped beaks, which are used for various purposes such as jewelry (Kinnaird & O'Brien, 2007). Hornbills are also used in some traditional medicinal practices, for which they are hunted (Kinnaird & O'Brien, 2007). Indirect threats contributing to the helmeted hornbills' potential extinction include deforestation and the destruction of their natural tropical forest habitats (Sodhi et al., 2004). Deforestation, habitat destruction, and degradation are the results of land-clearing efforts to make way for agriculture, resource extraction, and infrastructure development. All of these factors have ultimately led to the fragmentation and loss of habitat vital to the species' survival (Sodhi et al., 2004).

DISCUSSION

Bornean Orangutan

With the loss of orangutans, environmental injustice arises as a result for indigenous people. For instance, the Dayak tribe's culture in East Kalimantan values and recognizes the importance of biodiversity, including the orangutan (Borneo Orangutan Survival Foundation, 2020; Save the Orangutan, 2020). The continued survival of the orangutan is culturally important to the Dayak people. The death of orangutans and overall loss of biodiversity contradict the Dayak's beliefs of living sustainability and respecting the natural world (Borneo Orangutan Survival Foundation, 2020; Save the Orangutan, 2020). This tribe, and many others, experience environmental injustice as a direct result of biodiversity loss. With the creation of Nusantara, the associated destruction of rainforests, decline in biodiversity, and threats to orangutans, create environmental injustice.

The importance of the orangutan to the Dayak people is just one example of how the capital relocation and the consequent habitat destruction and biodiversity decline adversely impact people, thus raising environmental justice concerns. Countless other environmental justice issues exist and will increase in severity due to biodiversity decline. For instance, many

other endangered Bornean species hold cultural value and will decline in population with the capital relocation.

Due to this species' importance environmentally and socially, conservation efforts exist in Borneo to mitigate further population decline. These efforts include orangutan protection and area-based regional management plans, resulting in 31-40% of the population to be protected (Peatland et al., 2016). Furthermore, orangutan protection includes international legislation, dictating international population management efforts and legal restrictions on orangutan trading (Peatland et al., 2016). Despite these efforts, they are still critically endangered, so further action is needed to ensure this species' survival (Peatland et al., 2016).

Helmeted Hornbill

The relocation of Indonesia's capital to Nusantara increases the pressure on this already vulnerable species. Nusantara will require significant removal and destruction of the regional rainforest. Therefore, the relocation stands to amplify harm to the helmeted hornbills. In the absence of this keystone species, a negative feedback loop will ensue. As hornbill populations decline, so will other plant species that rely on the hornbill for seed dispersal. With a decline in these plants, hornbills will have fewer food sources, furthering the decline in hornbills. The destructive cycle continues, resulting in a decline in biodiversity and habitat degradation.

The Nusantara relocation and consequent effects on the hornbill population also hurt local people. The hornbill is culturally and spiritually important to Indonesian indigenous groups (Kinnaird & O'Brien, 2007). As hornbill populations decline, so will countless other bird species, which could have adverse impacts on the local ecotourism economy, thereby jeopardizing the income of those employed in the sector. Moreover, with a decline in this flagship species, comes a loss of this renowned physical representation and symbol of conservation.

The planning and construction of Nusantara is reminiscent of slow violence. Historically, habitat degradation and destruction occurred in East Kalimantan incrementally, slowly adding pressure on local species populations, such as the hornbill. But, people, outsiders to this ecosystem, enter and destroy the habitat and all that rely on it. Now, with the capital relocation plans, further and intensified human disturbance is planned for the foreseeable future.

Many threats exist to the helmeted hornbill in the wake of Nusantara's birth, but conservation efforts are also being implemented (IUCN, 2020). Conservation efforts include (1) an active recovery plan involving species research and population monitoring; (2) the identification of conservation sites and protected areas; and (3) international management and wildlife trade controls in international legislation (IUCN, 2020). In addition to these efforts, the cooperation of various stakeholders is needed to ensure the survival of this bird species. Additionally, further conservation efforts are possible such as a systematic population monitoring scheme, species management such as reintroduction or ex-situ conservation, and education and awareness programs (IUCN, 2020). However, cooperation to implement these additional efforts appears unlikely based on current actions that place urban development above habitat and biodiversity conservation.

Biodiversity Conservation: A Native Perspective

Traditional knowledge plays a crucial role in biodiversity conservation in the development of Nusantara. Indigenous communities possess a deep understanding of local ecosystems, which is essential for sustainable management. The convention on biological diversity emphasizes the importance of respecting, preserving, and maintaining traditional knowledge while promoting its wider application with involvement of knowledge holders (Antons, 2010). However, in Indonesia national interest often take precedence, complicating the inclusion of traditional knowledge in conservation strategies (Antons, 2010).

Indigenous tribes like the Dayaks of Kalimantan utilize practices such as shifting cultivation to manage and conserve biodiversity. This method, involves rotating fields and allowing of fallow (a field left unplanted for one growing season), maintains soil fertility, and promotes diverse ecosystems. The Dayaks also practice agroforestry, planting useful trees that benefit both diversity and community livelihoods (Dalle et al., 2011). Although traditional shifting cultivation has been criticized for causing deforestation, studies suggest it has minimal long-term impact compared to modern agricultural methods. Socio cultural changes and industrial pressure threaten these sustainable practices, emphasizing the need for policies that recognize and support traditional conservation strategies (Dalle et al., 2011).

Indonesia's biodiversity management policies reflect efforts to integrate traditional practices into broader conservation strategies. Laws such as the 1990 Law on the Conservancy of Living Earth Resources and Their Ecosystems and the 2009 Law on Environmental Protection and Management emphasize community participation and sustainable resource use (Duadij et al., 2023). Despite these legal frameworks, the effectiveness of these policies is limited by insufficient collaboration between government levels, budget constraints, and weak enforcement mechanisms. Addressing these issues requires reform to existing laws, enhancing institutional capacities, and fostering genuine community involvement in biodiversity management (Duadij et al., 2023).

Limitations and Future Study

Our ability to assess the full environmental impact of Nusantara's construction was hampered by a lack of historical data, particularly concerning the effects of past development projects on local flora and fauna. While we utilized various resources, the speculative nature of our findings necessitates further research before definitive conclusions can be drawn. Existing data on past construction projects is often outdated and does not accurately reflect current environmental conditions. Moreover, due to the limited scope of this study, the biodiversity threats evaluated do not fully represent the issue in Borneo. While the impacts discussed on the orangutan and the hornbill are applicable to a myriad of other species, there are variations in the extent and manner to which other species are affected by anthropogenic disturbance. A more comprehensive analysis is needed, to fully evaluate the scope of Nustanara's impact on biodiversity and consequently environmental injustice.

To address these limitations, we recommend a multi-pronged research approach before and after Nusantara's construction. Before completion, in-depth studies are needed to identify and document the potential impact on a broader range of species, including culturally significant animals like the orangutan and hornbill, and lesser-known, non-flagship plant and animal life. One potential area of focus could be studying unique botanical or agricultural plant species native to East Kalimantan. Following Nusantara's completion, long-term studies (spanning several years) should be conducted to monitor the populations and behavior patterns of the identified species. This will allow us to determine if construction has demonstrably impacted local biodiversity. Additionally, it is crucial to consider the potential "spillover effect" of the new city, analyzing how

it might influence further development beyond the designated construction zone. By implementing this comprehensive research plan, we can clearly understand the environmental consequences of Nusantara, which can inform biodiversity conservation efforts and, hopefully, mitigate any potential negative impacts.

CONCLUSION

To summarize, this study found that biodiversity will be affected by the capital relocation and creation of Nusantara. We focused on the Bornean orangutan and the helmeted hornbill, two endangered, keystone species, with cultural and economic value, native to East Kalimantan, the site of Nusantara. The orangutan and the hornbill are threatened due to human interference, notably habitat destruction. These species will display the adverse implications of escalated human activity in the region, before other, more resilient species that can better adapt to changes in their environment. Therefore, by analyzing the effects on these two species, we can understand how other endangered species will be affected in the short run and how species with stable populations may be affected in the long run. Moreover, we found that a loss of Bornean biodiversity will cause environmental injustices for local indigenous people, whose cultures are connected to the environment and who rely on these species to sustain the rainforest biodiversity and ecosystems. Traditional knowledge and practices, such as those of the Dayaks of Kalimantan, play a crucial role in biodiversity conservation. However, the creation of the new capital and associated pressures threaten these sustainable practices. With eth implementation of policies and laws like those emphasizing community participation and sustainable resource use, Indonesia aims to integrate traditional practices into broader conservation strategies. Despite these legal frameworks, challenges persist. Therefore, the creation of the new capital is expected intensify threats to biodiversity, resulting in further population decline of the orangutan and hornbill and countless other vulnerable, rare, or endemic species, while simultaneously evoking environmental injustice.

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