ITERA Botanical Garden Development Recommendation as a Feeding and Roaming Habitat for the Black-Winged Kite (*Elanus caeruleus*)

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ABSTRACT

Indonesia ranks fourth globally in bird species diversity. The Sumatera Institute of Technology (ITERA) Campus, with its diverse vegetation, supports at least 28 avian species, including the black-winged kite (*E.caeruleus*), a protected diurnal bird of prey. This species is protected in Indonesia and listed as Appendix II under CITES. One prominent area for these birds is the ITERA Botanical Garden, which has potential as a suitable habitat. This study aims to (1) analyze habitat suitability for the black-winged kite and (2) propose a landscape plan to support the species conservation in the ITERA Botanical Garden. Using mixed methods and a modified Gold landscape planning framework which includes inventory, landscape analysis, and synthesis, the research identifies the garden as a critical feeding and roaming area for the species. Results show that the ITERA Botanical Garden provides essential feeding and roaming areas for black-winged kites. The proposed concept, "JEJAKENUI: Exploring the Black-winged Kite Path," enhances connectivity among landscape elements through three zones: feeding habitat, roaming zone 1, and roaming zone 2. The findings emphasize the garden's role in conserving biodiversity while balancing visitor activities.

Keywords: ecological planning, habitat suitability, land cover, landscape metrics, wildlife

INTRODUCTION

Birds are key bioindicators of environmental health. Indonesia, with approximately 1,791 bird species, ranks fourth globally in avian diversity (Butler, 2023). This substantial diversity indicates that Indonesia offers favourable environmental conditions for birds survival (Qulub, S *et al*., 2023). The ITERA Campus, rich in vegetation, hosts diverse bird populations, including the black-winged kite (*Elanus caeruleus*) (Tohir *et al.,* 2021). The ITERA environment showcases significant biodiversity, particularly among its bird populations. Previous research has identified at least 19 bird species within ITERA,

exhibiting a moderate diversity index and relatively stable species evenness (Oktaviani *et al.*, 2021). Moreover, Mardiyanto and Prasetio (2020) reported 26 bird species, while Tohir *et al.* (2021) documented 28 species in the same area. Despite variations in the number of species recorded, all three studies consistently identified the black-winged kite (*Elanus caeruleus*) among the diverse bird species found in the ITERA environment.

The black-winged kite is a diurnal bird of prey that plays a vital role in maintaining the ecological balance as a top predator in its environment (Oktaviani *et al.*, 2021). This species, protected under Indonesian law and it has been categorized under Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). This classification reflects the urgent need for conservation efforts, especially in Indonesia, where illegal trade in birds of prey is prevalent. Studies by Iqbal (2016) and Gunawan *et al*. (2017) have highlighted the black-winged kite as one of the most frequently traded species. In response, the Indonesia government has taken proactive measures by designating the black-winged kite as a protected species under Government Regulation (PP) Number 7 of 1999 concerning the Preservation of Plant and Animal Species. Therefore, it is essential to safeguard the presence of the black-winged kite within the ITERA campus. One of the distribution of black-winged kite on the ITERA Campus is in the ITERA Botanical Garden (Tohir *et al.*, 2021).

ITERA Botanical Garden is an important flora conservation institution located within ITERA Campus. This location offers tremendous potential as a conservation area for the black-winged kite due to its diverse plant species and accessible food sources, such as mammals (Tohir *et al.,* 2020). The rich vegetation in this area could provide essential habitat for birds, allowing foraging, nesting, resting, and breeding opportunities (Hasibuan *et al*., 2018). Given that the black-winged kite is a protected species under Government Regulation No. 7 of 1999, it is crucial to leverage the role of botanical gardens in breeding and conserving both plants and animals. The potential of ITERA Botanical Garden as a conservation institution and the presence of black-winged kite in the ITERA Botanical Garden area make it necessary to plan the habitat of black-winged kite to carry out the main function of a conservation institution by Government Regulation Number 1999, as well as to conserve the black-winged kite. Despite prior studies documenting bird diversity at ITERA (Oktaviani *et al*., 2021; Mardiyanto and Prasetio., 2020), gaps remain in habitat-specific planning for the black-winged kite. This study addresses this by evaluating habitat suitability and proposing a landscape plan to support the species' conservation.

METHODS

Study area

The research was conducted at ITERA Botanical Garden (50.8 ha) in South Lampung Regency, Lampung Province. Data collection and landscape planning stages occurred from May to November 2024. The map of the research location can be seen in Figure 1.

Data collection and analysis

The study employed mixed methods, combining quantitative landscape metrics analysis (using FRAGSTATS 4.2) and qualitative descriptive analysis. The modified Gold (1980) framework guided the stages: preparation, inventory, analysis, synthesis, and planning. An illustration of these research stages can be found in Figure 2 below.

Figure 1. Research location

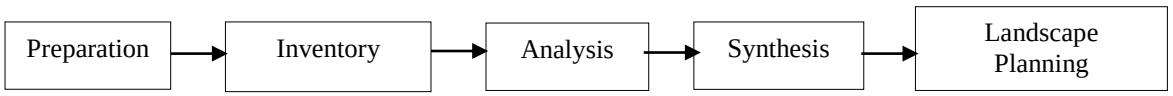

Figure 2. Modified Gold's (1980) planning stages

1. Preparation: The initial stage of selecting ITERA Botanical Garden as the site and formulating the problem, objectives, and research potential. The stage of conducting a literature study related to the approach used and administrative preparation for research permits.
2. Inventory: The stage of collecting data or information related to the characteristics/existing conditions of the site through primary data and secondary data. The primary data collection technique is carried out using field survey and interview.
3. Analysis: The stage of identifying problems and potentials in the ITERA Botanical Garden to be developed into a conservation area based on the results of the inventory. The analysis methods used in this study are landscape metrics analysis and qualitative descriptive analysis.
   a. Landscape Metrics Analysis
      Landscape metrics analysis utilizes an ecological approach aimed at conserving animal habitats within a specific landscape (Muhaimin *et al*., 2022). This analysis quantifies the structure of landscapes, which is then represented through landscape indices related to biodiversity, form, structure, and fragmentation levels (Prasetyo, 2017). It is applied to evaluate land cover characteristics at a given site. The landscape metrics analysis using 10 landscape metrics indices considered: CA (Total Class Area); PLAND (Percentage of Landscape); NP (Number of Patch); PD (Patch Density); LPI (Large Patch Index); TE (Total Edge); ED (Edge Density); LSI (Landscape Shape Index); AREA_AM (Area-weighted mean patch area); IJI (Interspersion and Juxtaposition Index) (Hutriani, 2024). The stages of landscape metrics analysis are depicted in Figure 3.

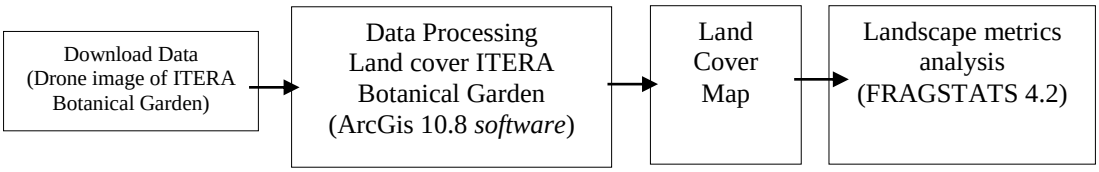

Figure 3. The stages of landscape metrics

b. Descriptive Analysis
   Descriptive analysis aims to explain and describe a problem or potential clearly and in detail using words and images (Sugiyono, 2015). Descriptive analysis evaluated physical, biophysical, and socio-cultural attributes.

4. Synthesis: follow-up of analysis results to develop solutions that align with the objectives of site development. These solutions are formulated based on the problems identified during the analysis stage. The outcomes of the synthesis will guide the principles of site planning and integrated findings to develop habitat solutions.
5. Landscape Planning: the final stage produced masterplan, zoning, and visualization outputs.

RESULTS AND DISCUSSION

Inventory

The research location of ITERA Botanical Garden is located in the ITERA Campus, precisely in Way Hui Village, Jati Agung District, South Lampung Regency, Lampung Province. The area of the planning site is 50,8 hectares. ITERA Botanical Garden is located in the western part of the ITERA Campus and can be accessed through the main gate or the west gate of the ITERA Campus. ITERA Botanical Garden has a reservoir for groundwater reserves. ITERA Botanical Garden has a high level of biodiversity with a dominant land cover in the form of grasslands. At least 15 species of birds have been identified, including the black-winged kite and 10 species of herpetofauna found in ITERA Botanical Garden (Tohir *et al.,* 2020; Tohir *et al.,* 2021). ITERA Botanical Garden as a flora conservation institution has the theme of lowland plant conservation in Sumatra with existing zones including the welcoming zone, tourism zone, management zone, and collection zone.

Landscape metrics

The analysis of landscape metrics related to land cover is valuable in identifying area within the ITERA Botanical Garden that serve as preferred habitats for the black-winged kite, based on the prevailing land cover types. The land cover map for the ITERA Botanical Garden is depicted in Figure 4. Examining land cover patterns (Rifaie *et al.,* 2023) is crucial for supporting wildlife conservation initiatives, particularly in identifying suitable habitats for bird species (Hutriani, 2024). This study employs ten landscape indices, including CA (Class of area), PLAND (Percentage of Landscape), NP (Number of Patch), PD (Patch Density), LPI (Large Patch Index), TE (Total Edge), ED (Edge Density), LSI (Large Shape Index), AREA_AM (Area-weighted Mean Patch Area), and IJI (Interspersion and Juxtaposition Index). The results of landscape metrics analysis are provided in Table 1 below.

Table 1. Results of landscape metrics analysis

Land Cover Type	CA	PLAND	NP	PD	LPI	TE	ED	LSI	AREA_AM	IJI
Waterbodies	2.1	4.1	27194	53714	3.1	53512	1056	92.8	1.17	82.5
Grasslands	21.8	43.1	241486	476989	15.8	762675	15064	408.9	3.14	30.4
Forest	23.8	46.9	186849	369069	25.7	736204	14541	378.6	7.53	25.0
Built-up area	3	5.9	43317	85560	2.5	121413	2398	175.9	0.54	90.3
Total	50.6	100.0	498846	985332	47.1	1673804	33059	1056.2	12.38	228.2

The results of the landscape metrics analysis for the habitat suitability of black-winged kite are based on four key indices, which are (1) CA or Class Area index indicates that forest land cover is the dominant type, followed closely by grassland; (2) PLAND or Percentage of Landscape index shows that grassland land cover constitutes a significant proportion after forest; (3) LPI or Largest Patch Index reveals the forest land cover is the most prominent in terms of the size of patches; (4) AREA_AM index suggests that areas with forest and grassland land cover types consist of larger patches, which are more valuable as habitats compared to other land covers. Forest (46.9%) and grassland (43.1%) dominated land cover, with forests showing the largest patches (LPI: 25.7).

Meanwhile, the analysis of landscape metrics regarding habitat fragmentation and edge effects is based on four other indices, which including (1) TE or Total Edge and (2) ED (Edge Density) show that grassland land cover has the highest value, indicating that the grassland on the site is fragmented and may lead to isolated habitats. The highest IJI (Interspersion/Juxtaposition Index) value, which reflects patch isolation levels, is found in bult-up areas. The highest LSI (Landscape Shape Index) value is also found ini grassland land cover, indicating a potential increase in edge length and the associated edge effects. Grasslands, though fragmented (high ED, TE), provided ideal hunting grounds. Built-up areas had the highest IJI (90.3), indicating patch isolation. The results of the landscape metrics synthesis can be visualized in Figure 4 below.

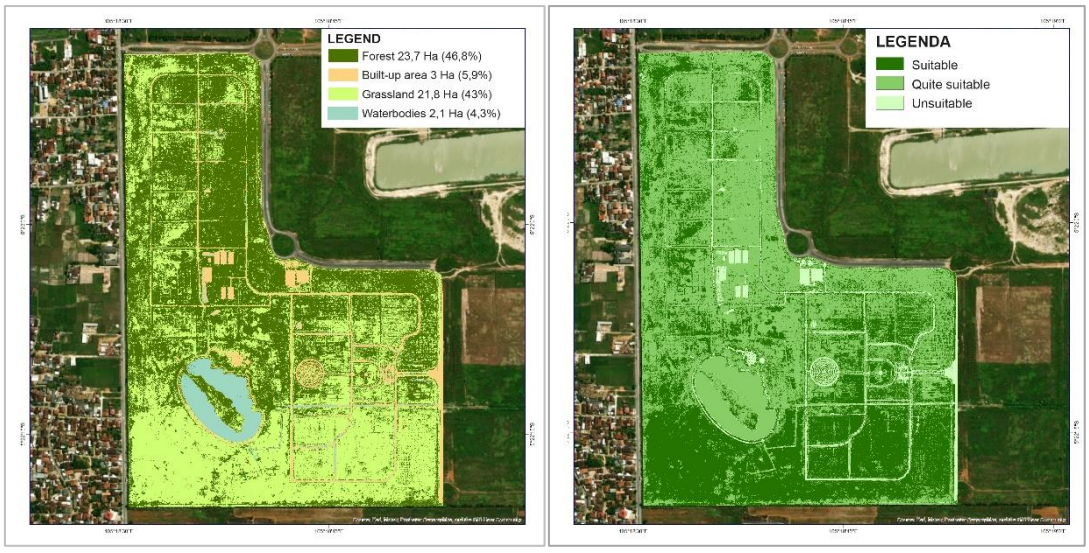

Figure 4. ITERA botanical garden land cover map (left) and habitat suitability map (right)

Descriptive analysis and synthesis

Descriptive analysis used in the analysis of physical attributes, biophysical attributes (vegetation and fauna), and socio-cultural attributes. The analysis and synthesis can be seen in Table 2.

Table 2. Descriptive analysis and synthesis

Aspect	Analysis	Synthesis
Physical	Topographic	
	The slope of the ITERA Botanical Garden is classified as gentle, making it an ideal habitat for the black-winged kite. This type of landscape also has the potential to support the movement of the black-winged kite as it hunts for prey (Wu *et al.*, 2023).	The topographic conditions of the Botanical Gardens should be preserved to facilitate the hunting activities of the black-winged kite.
		Maintaining the slope of the land as it has a high bearing capacity that can support various type of buildings and vegetations.
	Hydrology	
	Drainage on the site tends to be shallow, which potentially supporting the growth of rodent, reptile and amphibian populations (Wu *et al.*, 2023).	Maintain effective drainage and establish wetlands to meet the drinking needs of the black-winged kite and to ensure the availability of its prey.
	The Sumatera reservoir could serve as a valuable water supply for the ITERA Botanical Garden area.	Maintain the reservoir to meet the drinking water needs of the black-winged kite and to provide water for irrigation purposes.
	Climate	
	ITERA Botanical Garden is classified under climate group D2 (Oldeman classification), which means it relies on a consistent water supply for irrigation.	Maintain the existing reservoir, as it serves as a reserve for irrigation water and drinking water for the black-winged kite.
Biophysical	Land cover	
	The grassland area of ITERA Botanical Garden covers 21.8 hectares and has the potential to serve as a feeding habitat, as black-winged kite are commonly found in open grasslands, reeds, and swamps with scattered trees (Wu *et al.*, 2023).	Maintain the grassland habitat to support the feeding habitat of black-winged kite.
	Grasslands typically exhibit a high number of patches leading to fragmented conditions.	Avoiding fragmented grassland areas as habitat for black-winged kite.
	Vegetation	
	Low-density vegetation in the ITERA Botanical Garden has the potential to be a habitat for the black-winged kite because it is in accordance with the feeding area preferences of the black-winged kite (Wu *et al.*, 2023).	Maintaining areas with low vegetation density to accommodate the black-winged kite's feeding habitat and making areas with medium and high vegetation density as perching and sheltering areas.
	Fauna	
	ITERA Botanical Garden has the potential to serve as a habitat for the black-winged kite, as these birds are commonly seen around the reservoir and maze during the morning and	Maintain the habitat and the land cover characteristic in areas where the black-winged kite present.
		Creating feeding and roaming habitats for the black-winged kite by planting tall

Aspect	Analysis	Synthesis
	evening hours.	vegetation or installing poles that can be used as perches.
Socio-culture	Accessibility and circulation	
	The accessibility measures at the ITERA Botanical Garden are not currently adequate.	Improving the access restrictions on the site to effectively support the conservation efforts for the black-winged kite, including separating general visitor access from that of managers and researchers by implementing different level of access: limited access, controlled access, and unrestricted access.
	Facilities and Utilities	
	There are no supporting facilities for animal conservation, especially for birds.	Develop informative signage focused on the conservation of the black-winged kite, as well as birdwatching trails and viewing towers.
	Activity	
	The dominant activities are tourism and conservation activities. Black-winged kite tends to prefer areas with low intensity of human activity (Wu *et al.*, 2023; Supratman *et al.,* 2023).	Creating and separating zones with more specific activities for visitors and black-winged kite.

Planning vision

The vision for the planning of the ITERA Botanical Garden is "to become a leading botanical garden in the fields of conservation, research, and education, focusing on the preservation and sustainable use of Sumatran flora and local fauna." The planning concept aims to create connectivity among landscape elements using a landscape ecology approach. This concept is named "JEJAKENUI" derived from the Lampung word for eagle, "Kenui", which translates to "*Jelajah Jalur Elang Tikus*" or "Explore the Black-winged kite route." As a flora conservation institution, the ITERA Botanical Garden plays a vital role in the surrounding ecosystem and biodiversity. Therefore, the concept emphasizes the importance of harmonizing flora conservation with the needs of local birds, particularly the black-winged kite.

Planning principles

The development of the ITERA Botanical Garden as a habitat for the black-winged kite incorporates ecological principles aimed at wildlife conservation planning. Key principles in this planning include: (1) Creating interconnected and adjacent habitat patches to prevent habitat fragmentation, (2) Optimizing existing land cover while preserving local biodiversity, (3) Establishing habitats that support the prey of the black-winged kite, and (4) Defining clear spatial boundaries to minimize external interference or disturbance.

Spatial structure plan

The spatial structure plan for the ITERA Botanical Gardens, designed to meet the needs of the black-winged kite is organized into three activity centers including black-winged

kite foraging habitat, black-winged kite sheltered habitat, and visitor activity center. The spatial structure plan map can be seen in Figure 5 below.

Zoning plan

The zoning plan for the ITERA Botanical Garden area is divided based on the needs of the black-winged kite on the site, which consists of three zones, namely the feeding habitat zone, roaming zone 1, and roaming zone 2. Feeding habitat zone are core conservation area with restricted access; Roaming zone 1 are controlled access for conservation and research; and Roaming zone 2 are unrestricted access for tourism and education. The zoning plan map for the area can be seen in Figure 6 below.

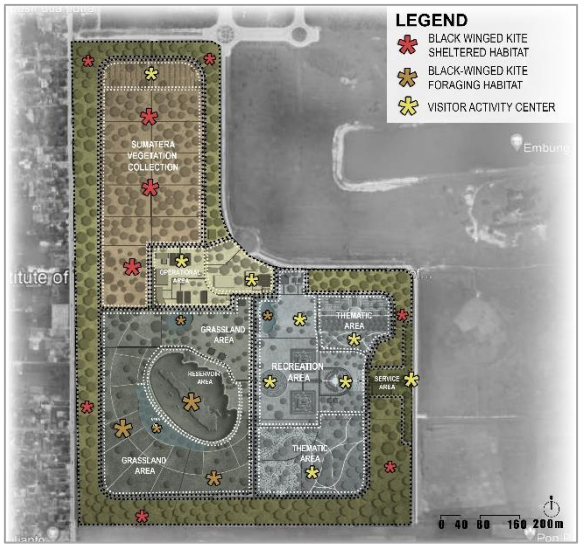

Figure 5. Spatial structure plan

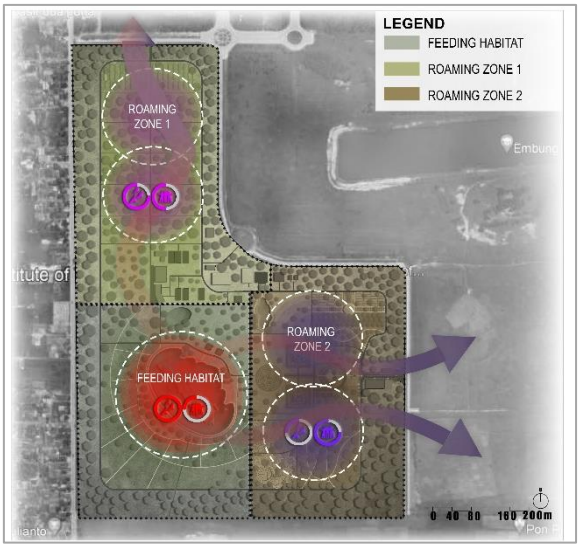

Figure 6. Zoning plan

Circulation and accessibility plan

The site features three types of circulation, which consists of primary circulation, secondary circulation, and tertiary circulation. Access to the site is categorized as limited access, controlled access, and free access in each zona to ensure conservation activities be conducted effectively. The circulation and accessibility plan map can be seen in Figure 7 below.

Vegetation plan

The vegetation plan of ITERA Botanical Garden is divided into three different types of vegetation to accommodate the needs of the black-winged kite, including vegetation for nesting, vegetation for perching, and vegetation for shelter. The vegetation plan map can be seen in Figure 8 below.

Ecological structure plan

The ecological structure plan is a plan that shows the relationship between the structural elements of the landscape that are arranged in various patches. In the ecological structure plan, there are six different patches that include forest patches, water body patches,

grassland patches, fruit plant patches, collection plant patches, and barrier patches. The ecological structure plan map can be seen in Figure 9 below.

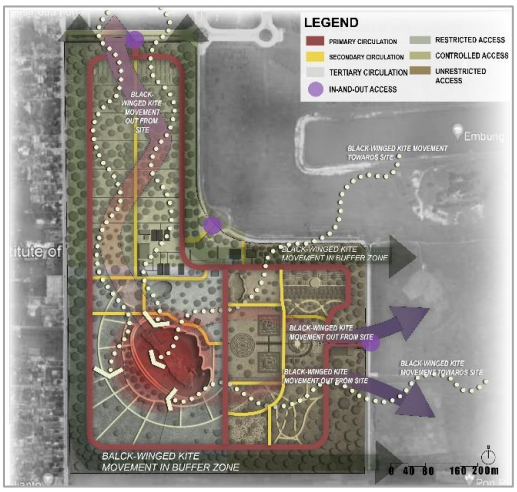

Figure 7. Circulation and accesibility plan

Figure 8. Vegetation plan

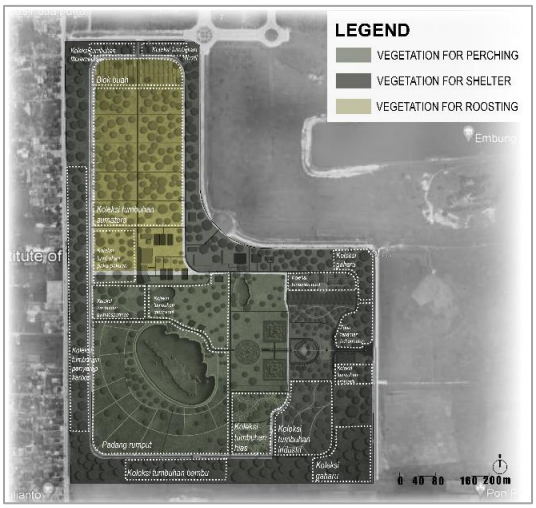

Figure 9. Ecological structure plan

Development phase plan

The development plan for the ITERA Botanical Garden is divided into three stages, (1) Stage one spans the first to the third year (3 years) and focuses on feeding habitat zone. (2) Stage two covers the fourth to the seven year (4 years) and emphasizes the development of the roaming habitat 1 zone. (3) Stage three is the final stage that extends from eighth to tenth year, will center on the transition zone or buffer area.

Space utilization and control plan

The ITERA Botanical Garden spatial utilization control plan refers to the Regional Regulation of south Lampung Regency Number 15 of 2012 concerning the Spatial Planning of South Lampung Regency for 2011-2031 where ITERA Botanical Gardens is included in the natural tourism park area which is a conservation area for the purpose of collecting plants or animals. In addition, the spatial utilization control plan also refers to the Regulation of the Director General of Natural Resources and Ecosystem Conservation which discusses the Guidelines for Determining Wildlife Corridors as Essential Ecosystem.

Blow-up and 3D visualizations

Blow-up of the masterplan is divided based on the zoning plan, namely the feeding habitat zone, roaming zone 1, and the roaming zone 2. The blow-ups and 3D visualizations effectively illustrate the landscape planning of the ITERA Botanical Garden, as shown in the following images.

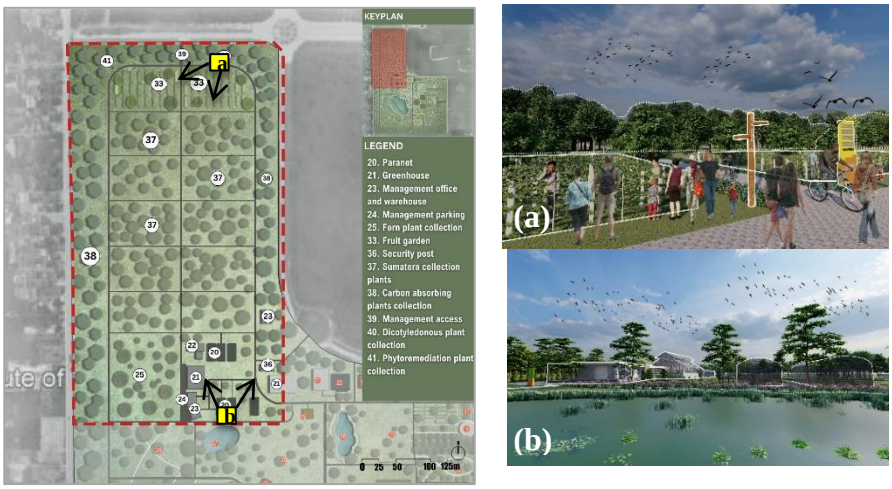

Figure 10. Roaming Zone 1 blow-up plan (a) fruit garden, (b) management office

Roaming Zone 1 is designated as an exploration area for black-winged kite. This zone primarily focuses on conservation and research rather than tourism and education, ensuring that visitor access is carefully controlled. The activities of black-winged kite in this area include perching, roosting, and hunting. Additionally, fruit gardens can attract prey for black-winged kite, such as small insects and mammals like rodents, because fruits are typically sweet and rich in water. This abundance of fruit can draw more wildlife, which serves as potential prey for the black-winged kite.

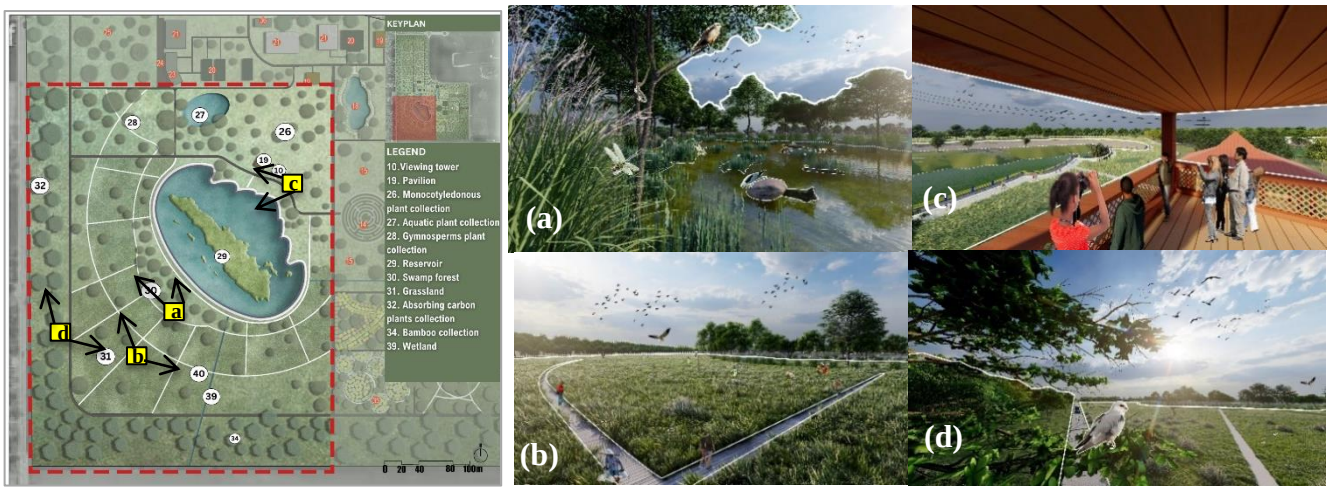

Figure 11. Feeding habitat zone blow-up plan (a) swamp forest, (b) grassland, (c) viewing tower, (d) buffer area

Masterplan

The conservation landscape planning for the black-winged kite habitat in the ITERA Botanical Garden includes a masterplan that consists of three designated zones, along with supporting facilities to enhance visitor activities and promote the conservation of the black-winged kite and other fauna within. The masterplan of ITERA Botanical Garden is illustrated in Figure 12 below.

Figure 12. Masterplan ITERA botanical garden for the black-winged kite habitat

The feeding habitat zone is specifically designated as core area for the black-winged kite, focusing on conservation and research activities, which limits visitor access. Within this zone, the black-winged kite engages in various activities such as eating, drinking, perching, roosting, and hunting for prey. The swamp forest area is particulary important as it meets the drinking needs of the black-winged kite and serves as an additional source of prey. Grassland areas function as hunting zones due to their wide visibility, allowing the black-winged kite to effectively search for food. These grasslands can also be accesed by humans for birdwatching and observing the black-winged kite alongside other bird species. Buffer areas play a critical role in providing shelter and perching spots, while also serving to separate the core habitat from the surrounding environment. These areas offer the black-winged kite convenient access to monitor and hunt prey effectively.

Roaming zone 2 has a stronger emphasis on tourism and educational purposes rather than conservation and research, allowing visitors full access to the area. In this zone, the black-winged kite engages in activites such as flying and perching. There is a welcoming area that includes plaza and main gate. Additionally, a fountain pool serves as one of the water sources for the drinking needs of wildlife, including the black-winged kite. The maze area, which is relatively high, create microhabitats for small insects and provides shelter for small mammals. This maze can also serve as a source of prey in roaming Zone 2

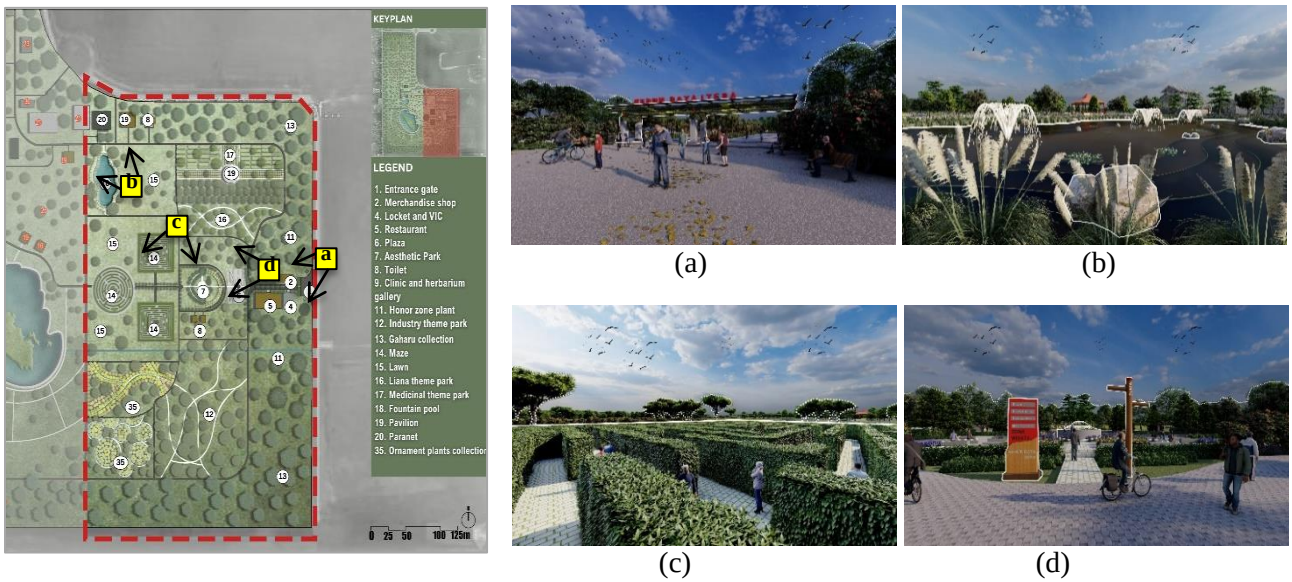

Figure 13. Roaming Zone 2 blow-up (a) entrance gate, (b) fountain pool, (c) maze, (d) plaza

CONCLUSION

The ITERA Botanical Garden serves as a vital habitat for the black-winged kite. Among these avian residents is the black-winged kite, a diurnal bird of prey that stands at the top of the food chain. With its variety of plant species and the presence of essential food sources like small mammals, reptiles, and insects, ITERA Botanical Garden holds significant potential to become a conservation area for the black-winged kite. The land cover of ITERA Botanical Garden is primarily grasslands and open areas, which are ideal habitats for the prey of the black-winged kite. These conditions allow the bird to hunt and feed effectively.

Based on the research findings, the ITERA Botanical Garden serves as both a feeding and roaming area for the black-winged kite. Therefore, the planning concept focuses on

creating connectivity between various landscape elements using a landscape ecology approach called “JEJAKENUI: Jelajah Jalur Elang Tikus”. This concept underscores the importance of the ITERA Botanical Garden as a conservation institution, which in turn influences the surrounding ecosystem and biodiversity. The black-winged kite is a species that already exists within the garden, and the development direction of ITERA Botanical Garden will impact its survival. Consequently, the planning for habitat conservation of the black-winged kite, a landscape metrics analysis was conducted to assess land cover and landscape structure within the garden. This analysis yielded three distinct zones, which are (1) Feeding habitat zone that focusing on conservation activities, this area has restricted access for human. (2) Roaming zone 1 that emphasizes both conservation and tourism activities, with controlled access and (3) Roaming zone 2 that primarily dedicated to tourism activities, this zone allows for unrestricted access. The proposed zoning plan balances conservation with human activities, ensuring species protection while enhancing the garden's ecological and educational roles. Further studies should monitor kite populations post-implementation.

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