



RESEARCH ARTICLE

Enhancing the sustainability of oil palm plantations through the application of principles and adaptive management of high conservation value areas in Central Kalimantan

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Abstract

The rapid development of oil palm plantations raises environmental issues related to biodiversity and conservation. Thus, a holistic and integrated approach is needed to manage high conservation values (HCV). This holistic and integrated approach involves various stakeholders in implementing sustainability principles. This study aims to analyze the effectiveness of applying the principles and evaluating the adaptive management practices of HCV areas applied to oil palm plantations. The research was conducted on an oil palm plantation in Seruyan District, Central Kalimantan Province, Indonesia, with HCV 1 – 5 criteria covering an area of 5,379 ha. Employing an observational method, the data were collected via field observations and interviews with relevant stakeholders, including oil palm plantation management, environmental organizations, and local communities. The findings show that by protecting HCV, oil palm plantations can operate sustainably and reduce environmental negative impacts. The application of the principles of HCV areas in the company involves identifying, assessing, and protecting areas with high ecological, social, and cultural values. These are then used as the basis for recommendations for adaptive management in oil palm plantations. Through adaptive management, oil palm plantations can adapt their practices to local conditions, reduce negative impacts, assess impacts, and take appropriate steps according to the conditions. The success of adaptive management carried out by the company can be seen based on data on the decline in HCV openings and the maintenance of HCV 1 - 5 areas. Thus, by applying adaptive principles and management, oil palm plantations in Central Kalimantan can increase sustainability, protect the environment, and provide sustainable social and economic benefits. Having important implications for the palm oil industry, this research can be used as a guide in policy-making that supports the development of environmentally responsible oil palm plantations.

Keywords

Adaptive Management; High Conservation Value Areas; Oil Palm; Principles, Sustainability .

Introduction

The palm oil industry is currently experiencing rapid growth in several countries, emerging as one of the primary agricultural commodities that

significantly contribute to the global economy (1,2). However, the development of oil palm plantations raises various environmental issues, particularly those related to biodiversity and conservation (3). High Conservation Value Areas (HCV) are characterized by high flora and fauna richness, playing a crucial role in maintaining a balanced and sustainable ecosystem (4,5).

Management analysis of HCV areas is critical for the sustainability of oil palm plantations (6). Effective HCV management can help maintain biodiversity, minimize adverse impacts, and provide long-term benefits for environmental and social sustainability (7,8). It plays a vital role in maintaining environmental sustainability and mitigating the negative impacts that may arise from oil palm plantation activities (9). Furthermore, HCV management can have positive social impacts by considering local community participation and fulfilling community rights (10,11). A comprehensive analysis of HCV management in sustainable oil palm plantations is necessary to provide valuable insights for sustainable decision-making and policy-making in the palm oil industry (12).

Despite various efforts made to manage HCV in oil palm plantations, challenges and deficiencies still exist in optimizing these practices. Issues requiring attention include the maintenance of biodiversity, sustainable management of natural resources, mitigation of environmental impacts, and the well-being of local communities (13). In this regard, a holistic and integrated approach to HCV management is essential, involving various stakeholders and applying sustainability principles (14). The principle of implementing HCV is an approach to managing areas with high biodiversity, and community participation, and sustainable management for long-term sustainability (15). This includes developing a comprehensive strategy to ensure the maintenance of biodiversity and habitats, sustainable management of natural resources, protection against negative environmental impacts, and increased participation and well-being of local communities (16).

To address these challenges, the concept of sustainable oil palm plantations, including the management of HCV areas, has been proposed. These principles aim to preserve biodiversity, ecosystem function, and overall environmental sustainability. However, few studies have comprehensively analyzed the application of adaptive management principles and procedures to HCV areas in sustainable oil palm plantations. This study aimed to investigate the effectiveness of applying these principles and evaluate the adaptive management practices of HCV areas in oil palm plantations in Central Kalimantan.

Materials and Methods

Study Site/Location and/or materials

This research was conducted for six months, from January to June 2023, in an HCV area of 5,379 ha on an oil palm plantation in Seruyan District, Central Kalimantan Province, Indonesia (Fig. 1). The research location was in a flat to slightly undulating topography with elevations ranging from 5-32 meters above sea level (m asl) (Fig. 1).

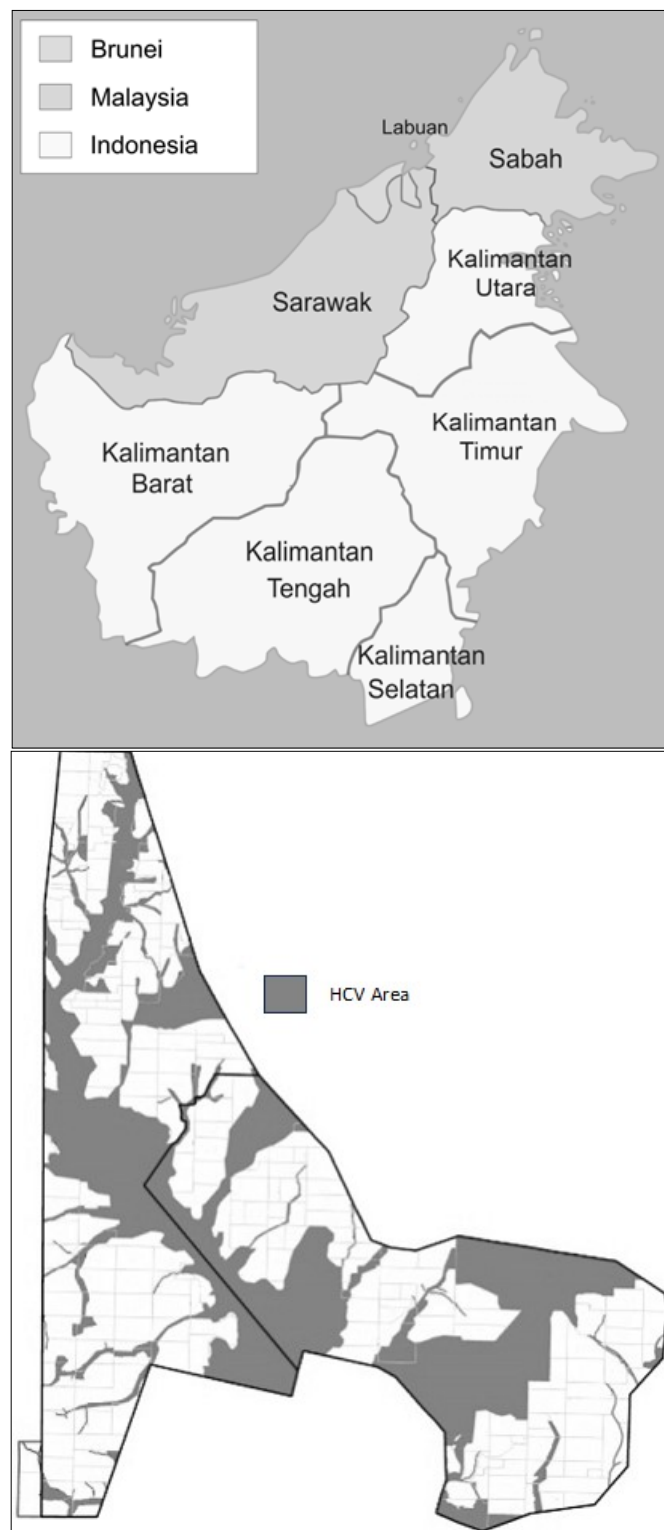


Fig 1. Map of Locations of Oil Palm Plantations in Central Kalimantan

Methods

This research employed both qualitative and quantitative approaches to gain a comprehensive understanding of the application of the principles of HCV areas in sustainable oil palm plantations. The research method used field observations in HCV areas. Literature studies and interviews were also conducted to understand the principal concept of HCV areas in sustainable oil palm plantations and to view relevant previous studies. The literature study was carried out by reviewing related scientific literature and publications, including previous studies conducted in relevant contexts. Interviews were conducted with relevant

experts and practitioners, including oil palm plantation management, environmental organizations, and local communities. Through these interviews, valuable information was collected about best practices, challenges faced, and their views regarding the application of the HCV principles to sustainable oil palm plantations in Central Kalimantan.

Data Sources

This study used two types of data, namely secondary data and primary data. The secondary data were obtained by collecting information from literature sources, policy documents, and reports related to HCV management in the oil palm plantations in the study locations. Meanwhile, the primary data were obtained through conducting field surveys to gather information on the site of HCVs, biodiversity, management practices, HCV land openings, and stakeholder participation around the oil palm plantations where the research was conducted.

Data Analysis

Descriptive analysis was used to analyze the application of the principles of HCV areas, and their impact on the environment, and the sustainability of oil palm plantations. This approach could give this research a holistic understanding of the principle of high conservation value areas in oil palm plantations. The results of this analysis could provide an overview of the implementation of the principles of HCV areas, and their impact on the environment, and the sustainability of oil palm plantations. Recommendations can be prepared based on the analysis results to increase the application of the principles of HCV areas in sustainable oil palm plantations. The proposals aimed to provide practical inputs for oil palm plantation management and related stakeholders. Thus, management practices and sustainability can be promoted.

Results and discussion

Workforce and Supporting Facilities of HCV Management

The workforce plays a crucial role in managing and monitoring HCV areas in oil palm plantations. The field officer (1 person) is responsible for ensuring that work programs are achieved, coordinating activities in the field, and monitoring overall environmental conditions. The Field Conductor (2 people) ensures that the work is carried out according to plan, collaborates with the field team, and monitors the work's progress. In addition, the KHT nursery (1 person) is responsible for caring for seedlings in the nursery before planting them in the HCV, including growth monitoring, maintenance, and protection against pests

and diseases. Meanwhile, the Field KHT (6 people) plays a crucial role in carrying out patrols, conducting flora and fauna surveys, and maintaining the continuity of HCVs by maintaining and updating information signs and providing information to visitors and the surrounding community. In total, ten workers are involved in the management and monitoring of the HCV area, each playing a complementary role in maintaining sustainability and environmental conservation in the context of oil palm plantations in the research location.

Various important facilities and infrastructures are needed to manage and preserve HCV areas effectively. These facilities include field notebooks to record observations and monitoring activities. Additionally, field manuals provide instructions to field officers in carrying out their duties. Simultaneously, cameras are used for visual documentation of environmental conditions, flora, fauna, and threats in HCV areas. Furthermore, GPS is an important tool for accurately mapping HCV locations. Camera traps play a special role in recording wildlife movements for further monitoring and analysis. Monitoring towers are placed strategically placed to observe real-time field activities.

Water facilities such as reservoirs and drilled wells are crucial for meeting the water needs to manage HCV areas. Signboards are installed to inform the public and employees about the importance of protecting riparian ecosystems and animals in the area. The nursery serves as breeding ground for plants, playing a significant role in conservation purposes. Meanwhile, the use of a water pump helps regulate water distribution in areas where it is needed. By using these various facilities and infrastructure, the monitoring of HCV areas can be carried out more effectively and efficiently. Information and data obtained from these facilities serve as a vital basis for making informed decisions in managing and conserving HCV areas.

Attention to monitoring facilities and infrastructure is crucial in managing HCV areas. An effective and integrated monitoring system, using advanced technology such as sensors, remote sensing (drones), and geographic information systems, is necessary for real-time monitoring of HCV areas. Sustainability and reliability of monitoring facilities are also essential and can be achieved through regular maintenance of equipment and investment in human resources. Clear standards and protocols in data collection and analysis must be established to ensure that the collected data can be used to make informed decisions (Table 1).

Table 1. Facilities and infrastructure used in monitoring HCV areas

No	Types of Tools	Total	Function
1	Field Notebook	6	Record findings in the field during daily HCV patrols and monitoring
2	Field Guidebook:	7	Identification of flora and fauna species
	a. Mammals of Borneo (Series of field guidebooks), covering all types of mammals (including primates) in Kalimantan	1	
	b. Birds of Sumatra, Java, Bali and Kalimantan	1	

	c. Wildlife identification guide series in oil palm plantations	1	
	d. Snake of Borneo Series	1	
	e. Frog and Lizard of Borneo Series	1	
	f. Kalimantan Tree Species Guide	1	
	g. Amphibious on Borneo	1	
3	Binocular	2	Observing in more detail animals that are quite far away
4	Operational Motorcycle	2	Transportation during field activities
5	GPS	3	Retrieval of coordinates
6	DSLR Camera	1	Documentation of the types of animals encountered
7	Powershot Camera	2	Documenting animals that are far away or moving slowly
8	Camera Trap	4	Documenting animals that are hard to find
9	PC Computer	2	Report generation
10	Laptop	1	Report generation
11	Monitoring Tower	5	Monitoring field conditions related to karhutla
12	Reservoir	31	Providing water supply during the dry season
13	Karhutla Drilled Well	21	Availability of water in water-critical areas
14	HCV Signboard	25	Information and prohibition boards in HCV areas
15	Riparian Signboard	13	Information and prohibition boards in the Riparian area
16	Protected Wildlife Poster Signboard	17	Protected wildlife information boards
17	Nursery	2	Forest plant nurseries with a maximum capacity of 25,000 seedlings
18	Waterpump	13	Pumping water from a drilled well
19	Drone	2	Monitoring vegetation and hotspots

Application of HCV Principles by Oil Palm Plantation Company

The oil palm plantation company in the study locations plays a significant role in managing the HCV areas. The company is actively engaged in maintaining environmental sustainability and natural resource conservation through its operational activities. It adheres to sustainability principles and implements best practices to minimize negative impacts while maximizing positive environmental benefits. The applied HCV management principles also align with relevant best management regulations and Standard Operating Procedures (SOP). Through these SOPs, the company ensures the protection of wildlife and plants in all Cultivation Rights (HGU) areas, safeguarding them from potential threats. The company is also involved in managing watersheds and riparian belts within the HGU, preserving the functions of water bodies such as rivers, reservoirs, and swamps by adhering to regulations and best management practices.

The company is committed to preventing and addressing human-wildlife conflicts in HGU through established SOPs. Additionally, the company applies HCV principles in watershed management, wildlife protection, and the conservation of endangered plants. Moreover, the company employs adaptive management strategies to address changes in HCV management. Through the protection and enhancement of environmental and social values in the HGU, coupled with the implementation of SOPs, the

company aims to achieve a harmonious balance between plantation activities and environmental preservation. Overall, the oil palm plantation company in the study locations plays an important role in managing the HCV areas by maintaining environmental sustainability and conserving natural resources. Below are some of the SOPs implemented by the company for effective management and monitoring in HCV areas:

1. SOP for management of high conservation value areas aims to protect, maintain, and enhance significant environmental and social values as part of responsible management of identified high conservation value areas within the company environment.
2. The SOP for protecting protected wild animals and plants aims to protect and minimize threats to the lives of protected wild animals and plants throughout the company's HGU area.
3. SOP for the management of watersheds and riparian zones (riparian belt) within the company's HGU aims to protect and maintain the carrying capacity of the watersheds in the company's permits and guarantee the preservation of the functions of water bodies (rivers, reservoirs, and swamps) within the activity location in the form of the management of riparian zones, referring to applicable laws and regulations and referring to Best Management Practices.
4. SOP for preventing and overcoming conflicts

between humans and wild animals in company HGUs aims to prevent and minimize conflicts between humans and wild animals with understanding, perceptions, and steps and commitments in handling them within company HGUs in a timely, fast, effective, and efficient manner.

5. The SOP for protecting monkeys' habitat and actions for monkeys found within HGU aims to protect monkeys living within HGU and HCV areas and ensure that encounters with these species can be treated appropriately and can be accepted by conservation agencies. In addition, it does not conflict with applicable government regulations.
6. SOP for identification of flora and fauna aims to assist in collecting data on the types of flora and fauna that exist in the plantation location permit area in the framework of protecting flora and fauna.
7. SOP for mitigating and managing forest and land fires aims to monitor, prevent, detect, suppress, and report land and forest fires.

One indicator of a company's success in managing HCVs is the absence of disruptions to the integrity of the HCV area itself. When an HCV area is managed properly, activities such as illegal land clearing, illegal logging, or other destructive practices can be effectively avoided or controlled. This ensures that habitats and ecosystems within HCV areas are preserved, allowing for the maintenance of high biodiversity. Shielding HCVs from disturbance creates opportunities for endemic flora and fauna to thrive, sustaining a balanced ecosystem and protecting species that may be threatened with extinction. Such success underscores the commitment and serious efforts of relevant stakeholders, including the government, local communities, and other involved parties, in safeguarding and preserving HCV areas as valuable assets for biodiversity and the general welfare.

2020 - 2022 it was 53.60 ha. This indicates that there has been a 75% reduction in the intensity of HCV exposures after implementing adaptive management. Based on the annual trends in Fig. 1, the decrease in the openings of HCVs following the implementation of adaptive management can be considered a positive achievement in managing the area. This decrease is very important for maintaining the sustainability of HCV areas, protecting biodiversity, and ensuring that natural ecosystems are preserved. This success can be compared to the old management, where there was an increase in the clearing of HCVs, which indicates a problem in managing the area. Increased openings of HCVs can threaten sensitive ecosystems, accelerate habitat loss, and disrupt environmental sustainability.

The reduction in the opening of the HCV area indicates a positive outcome resulting from the collaborative efforts of the company and the community in environmental preservation. This gives hope that the conservation and management measures carried out by the oil palm plantations in the research locations have positively impacted and changed people's behavior to become more environmentally conscious. However, continued monitoring and conservation efforts in this area are still needed to ensure this decline continues and bring long-term benefits to the area and the biodiversity contained therein. Table 2 highlights some distinctions between the traditional management approach and adaptive management.

In Table 2, the core activities involved in managing HCVs in oil palm plantations are displayed. HCV patrols are very important as they ensure regular surveillance and monitoring of HCV areas to protect the biodiversity and high conservation value they contain. The promotion of HCV management is pivotal in educating the community, stakeholders, and oil palm plantation workers about the significance of preserving conservation values in the area. The HCV survey is essential for identifying and thoroughly

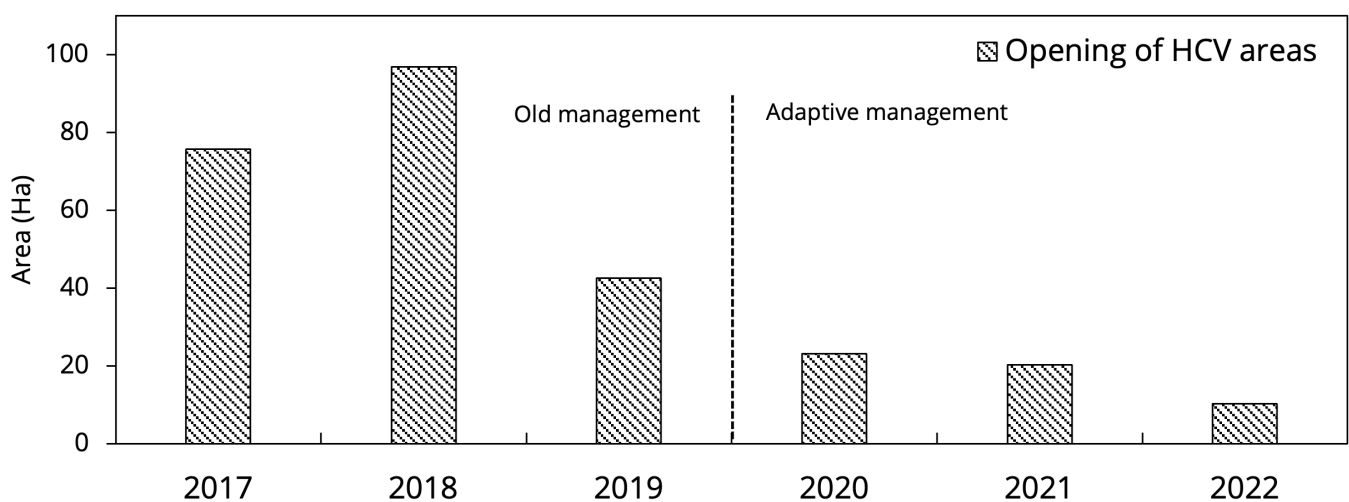


Fig. 2. Comparison of the intensity of opening of HCV areas by the community during the old management and after applying adaptive management.

Fig. 2 above compares the intensity of HCV exposure by the community during the old management (2017 – 2019) and after implementing adaptive management (2020 – 2022). The total HCV land cleared by the community during 2017 – 2019 was 215.00 ha, while in

assessing the existence of ecosystems, rare species, and important habitats that need to be protected in HCV areas. Riparian monitoring is essential for overseeing and preserving the quality of water resources, safeguarding river ecosystems, which play a pivotal role in the environmental

Table 2. The difference between old management and adaptive management

No	Old Management	Adaptive Management
1	HCV patrol Daily HCV patrols	Daily patrols and analysis of potential threats and disturbances according to the HCV value. Patrols are also carried out on fire lookout towers.
2	HCV Management Socialization HCV socialization in the community is carried out in the local village. HCV socialization to employees and staff once a year	HCV socialization in the community is carried out in the local village. Socialization to all residents who do activities around the HGU during HCV patrol activities HCV socialization and training to employees and staff 2x a year
3	HCV surveys Survey of monkeys monitoring transect lines every three months. A rapid survey once a year	Survey of monkeys monitoring transect lines along the Pukun River every three months. A rapid survey once a year Update the types of fauna and flora survey results in the HCV database. The list of animals and plants is reported to the Department of Environmental Service at the District level.
4	Riparian Monitoring Monitoring riparian flows and ensuring water conditions are not polluted. A sampling of water every six months	Monitoring of riparian flows and ensuring that the condition of the water is not polluted. Ensuring that the riparian flows are clear from oil palm fruits and other wastes. Records the findings of the riparian biodiversity. A sampling of water every six months
5	Monitoring of HCV Boundary Marks Maintenance of boundary signs, boundary markers, and installed signboards Maintenance of installed Wildlife posters	Maintenance of attached boundary signs, boundary markers, and signboards Additional signboards in HCV areas have been compensated. Maintenance of wildlife posters that have been installed in strategic places in the HCV area and the housing environment of employees and staff.

sustainability surrounding HCV areas.

The monitoring of HCV boundary markers is carried out regularly to maintain the area's integrity and prevent land misuse, which can be detrimental. Related to this, field officers check and verify the boundary marks set, such as land markers, tree markers, or other physical construction. Monitoring also involves visual monitoring and documentation of changes around the HCV boundary using technologies such as GPS mapping, aerial surveys, or satellite imagery. This helps identify acts of violation or threats that could undermine the integrity of HCV areas. Close monitoring of HCV boundary markers can detect violations early. Thus, appropriate law enforcement and correction steps can be taken promptly.

Nonetheless, additional efforts are required to enhance public awareness regarding the importance of conserving forests and adopting sustainable practices (17,18). Moreover, heightened supervision and the enforcement of stringent policies are essential to curb illegal land clearing and prevent further environmental damage (19). Fig. 3 also serves as a warning for stakeholders and the general public urging collectively action in managing HCV 2 areas through strong collaboration between the government, communities, and other stakeholders. This collaborative effort aims to reverse the trend of increasing forest clearing and instead achieve a significant decrease (20,21). The HCV managers in Area 2 also need to discuss with the managers of this area to exchange information for improvement in the HCV 2 area. Several steps are necessary to address the challenge of overlapping land, including land restoration, increased supervision and law enforcement, collaboration between related parties including the

government, and sustainable farming practices (7, 22).

HCV Adaptive Management Efforts by Oil Palm Plantation Company



Fig. 3. Results of a survey on the presence of proboscis monkeys in the HCV 1 area

The HCV management efforts undertaken by the oil palm plantation company represent a crucial strategy in mitigating environmental negative impacts and promoting sustainability. The company, situated in the study locations, adopts an adaptive management approach to ensure the sustainable cultivation of oil palm plantations. This strategic approach involves continual adjustments based on monitoring, collaboration with stakeholders, implementation of corrective actions, utilization of innovative technologies, capacity building for managers, effective communication, and cooperation with research institutions. These measures are geared toward enhancing

the effectiveness of adaptive management for HCVs, with a primary focus on protecting biodiversity and disseminating crucial information about their goals and benefits.

An illustrative example of this commitment is the implementation of a rehabilitation program, which involves replanting native vegetation, including cover crops that aid in preventing erosion and restoring soil quality. The company has also minimized the use of pesticides by introducing environmentally friendly organic control methods, such as employing natural predators to manage pests and diseases. Furthermore, the company actively engages with local communities to raise awareness about the importance of sustainability and involves them in conservation activities. This includes counseling on sustainable practices and waste management. Through these adaptive management efforts, the oil palm plantation company demonstrates a steadfast commitment to balancing palm oil production with environmental preservation and addressing the social impacts within their surroundings. HCV 1 Adaptive Management (Presence of Endemic or Endangered Species)

There are HCV criteria 1 in this area because there is a landscape of monkey habitat. In addition, there is also a swamp forest which is part of the habitat landscape of threatened wetland species, including the Senyulong Crocodile (*Tomistoma shelgelii*), and includes areas that function as seasonal breeding grounds. The results of the 2022 monitoring survey show that proboscis monkeys (*Nasalis larvatus*) can still be found in the area. Both species are key species included in the RTE (rare, threatened, or endangered) category, so protection and moni-

HCV areas and prevent individual numbers from decreasing or becoming extinct. Based on this, the management efforts carried out by the oil palm plantation company in the HCV 1 area can be said to be successful. It is important to protect species that are dependent on the HCV area and cannot be found elsewhere. To achieve this parameter of success, the oil palm plantation company has undertaken effective conservation efforts such as protecting suitable habitats and monitoring threats such as illegal hunting, wildlife trade, and habitat degradation. In addition, monitoring populations of endemic or endangered species is also important to understand population trends, obtain accurate data, and design appropriate protection measures.

These activities are detailed in the HCV 1 management program, which includes HCV monitoring, monkey surveys, socialization to communities living around HCV areas, installation of camera traps, annual surveys, surveys of proboscis monkeys around the Pukun River (Fig. 3), and socialization accompanied by government agencies or company partners if needed. Following are the efforts (Fig. 4) made for the adaptive management of HCVs based on criteria 1 – 5 found at the research location. This activity follows the objectives of the oil palm plantation company in the research location for HCV 1, namely 1) maintaining the presence of populations of RTE species, and proboscis monkeys in the HCV area, and 2) maintaining the habitat of RTE species. The company efforts to maintain HCV 1 can be seen in Fig. 4.

The success of the oil palm plantation company in maintaining populations of endemic or endangered spe-



Fig. 4. Efforts by the oil palm plantation company to maintain HCV 1 (A. Monitoring HCV 1 biodiversity, B. Installing signboard posters of wild animals in the HCV 1 area, C. Class C nests, D. Socialization to the community, E. Camera trap results: Pelanduk napu or *Tragulus napu*, F. Monitoring the presence of proboscis monkeys in the Pukun River)

toring efforts are needed to maintain their populations and habitat.

The success parameter for HCV 1 is being able to maintain populations of endemic or endangered species in

cies in HCV areas significantly impacts biodiversity and ecosystem integrity (23,24). These species play important ecological roles, such as pollinating plants and natural predators and providing resources for other organisms

(25,26). Maintaining populations of these species also involves cultural heritage and aesthetic value associated with their uniqueness and beauty. Failure to meet HCV 1 criteria means failing to maintain endemic or endangered species populations and preventing individual numbers from decreasing or becoming (27,28). Habitat loss, environmental degradation, illegal hunting, climate change, and interactions with invasive species can cause population decline (29). Effective conservation measures, such as population monitoring, habitat restoration, protection measures, public education, and stakeholder collaboration, are necessary to ensure the success of HCV 1 criteria and maintain ecological sustainability and biodiversity in the area(30,31).

HCV 2 Adaptive Management (Ecosystem Representative)

The presence of HCV 2 in the research location is a wetland ecosystem landscape (Fig. 5) that functions as part of a regional ecological community. This area as a whole is an ecosystem landscape consisting of a mosaic of wetlands, freshwater swamp forests, and heath forests that form the landscape of the Pukun River riparian corridor, which



Fig. 5. The existence of HCV 2 as a wetland ecosystem landscape

connects with the Pukun Besar River riparian to the

Seruyan River. The middle of the landscape corridor of the Pukun River riparian is cut off by a small road made by plantation operations. It is the only access road connecting oil palm plantation operations at the research location. The wetland ecosystem landscape of HCV 2 can be seen in the Fig. 5.

The results of the 2022 monitoring survey show that ecosystems and mosaics with surviving populations are well managed. In addition to this, its large size and connectivity can be maintained. The existing landscape is not fragmented, and no species are lost due to management activities. These results demonstrate the success of HCV 2 management by the oil palm plantation company that can maintain the completeness and diversity of ecosystems within HCV areas, including the representation of various types of habitat and landscape structures. To achieve this parameter of success, an in-depth understanding by oil palm plantation managers is needed about the types of habitats within HCV areas and conservation efforts that involve protecting and restoring threatened or degraded habitats. Some of the efforts made by the oil palm plantation company at the research location (Fig.6) include HCV monitoring, monkey surveys, socialization with communities living around HCV areas, installation of camera traps, annual surveys, drone surveys, and socialization accompanied by government agencies and company partners. The company efforts to maintain HCV 2 can be seen in Fig. 6.

The completeness and diversity of ecosystems in HCV areas involve various types of habitats and landscape structures, such as primary forests, secondary forests, wetlands, and grasslands (32). Each habitat provides a unique habitat for various species, and it is vital to maintain this diversity (33). Habitat diversity and landscape structure play an important role in maintaining interactions between species, energy and nutrient flows, and



Fig. 6. Efforts by the oil palm plantation company to maintain HCV 2 (A. Monitoring HCV areas in the HCV 2 area, B. Surveying nests, C. Socialization to communities around the HGU, D. Installing camera traps (CT results from Beruk (*Macaca nemestrina*), E. Annual survey activities, F. Remote sensing survey of HCV areas

species reproduction and distribution within HCV areas (34). Failure to meet HCV 2 criteria is often caused by a lack of efforts to maintain the completeness and diversity of ecosystems, such as land conversion, habitat degradation, and fragmentation of HCV ecosystems (35). To succeed in HCV 2 criteria, it is necessary to monitor habitats, protect threatened habitats, restore damaged ecosystems, and consider the representation of various habitats in land use planning (36,37). By maintaining the completeness and diversity of ecosystems in the HCV 2 area, the sustainability of ecosystem functions and increasing biodiversity in the long term can be ensured.

HCV 3 Adaptive Management (Ecological Sustainability)

The presence of the HCV 3 area in the research location includes an area of a threatened ecosystem with forest cover as a freshwater swamp forest. MEC (2007) stated that

diversity within HCV areas. The oil palm plantation company carries out several management efforts (Fig. 8) in the research location to maintain freshwater swamp forest ecosystems, heath forests, and wetlands, namely HCV monitoring or patrols, monkey surveys, socialization to communities living around HCV areas, annual surveys, socialization accompanied by government agencies or corporate partners if necessary. The company efforts to maintain HCV 3 can be seen in Fig. 8.

The success parameter for HCV 3 involves maintaining balanced ecosystem interactions, where interactions between various ecosystem components must be maintained so that the ecological functions of HCV areas can continue to run well (4). Failure to meet HCV 3 criteria can be caused by disturbances in the nutrient cycle, such as excessive use of fertilizers or pollution, as well as by reductions in biodiversity and disturbances in balanced



Fig. 8. Efforts by the oil palm plantation company to maintain HCV 3 (A. Monitoring biodiversity in HCV areas, B. Patrols in HCV 3 areas, C. Rapid surveys on vegetation plots)

these areas were unsustainable. A mosaic of forest with shrubs, vegetation, and ponds on both sides of the Pukun River was identified as a mosaic of threatened wetland ecosystems. The monitoring results also identified the presence of a heath forest dominated by gerunggang (*Cratogeomys arborescens*) and belangeran (*Shorea balangerana*) trees. Based on the IUCN status, the belangeran species is included in the RTE or Critically Endangered (CR) category, so its existence must be protected and its population maintained. The results of the 2022 monitoring survey show that the heath forest (Fig. 7) as a whole is in good condition and there is no disturbance in the area. The heath forest as the presence of HCV 3 can be seen in the Fig. 7.

In achieving the success of HCV 3, the oil palm plantation company focuses on ensuring the continuity of the ecological functions of HCV areas. Ecological functions cover various important aspects of maintaining ecosystem sustainability. The success of HCV 3 also involves maintaining bio-



Fig. 7. Heath forest as the presence of HCV 3

ecosystem interactions, such as the presence of invasive species or loss of mutual dependence between species (38,39). To succeed in HCV 3 criteria, there should be balanced nutrient cycling, protection of biodiversity, and a good understanding of ecosystem interactions within HCV areas and long-term ecological sustainability(40,41).

HCV 4 Adaptive Management (Regional Ecological Importance)

The presence of HCV 4 is a vegetated area along the Pukun River which functions as a protective buffer against soil erosion. All natural water bodies/streams have riparian belts to ensure water quality within the oil palm plantation company's activity locations. The results of the 2022 monitoring survey showed that, as a protective buffer against soil erosion, the areas along the Pukun River are still in good condition and maintained (Fig. 9). This shows the success of the oil palm plantation company in managing HCV 4 toward regional ecological sustainability. It also involves understanding how HCV areas interact and relate to other conservation areas. One of the important aspects is the ecological connectivity between HCV areas and other conservation areas, bearing in mind that these areas contain HCVs 1 - 5. HCV areas with good connectivity with other conservation areas can form a strong ecological network and allow wildlife to move between these areas. The vegetation along the Pukun River as a protective buffer against soil erosion can be seen in Fig. 9.

The success parameter for HCV 4 focuses on identi-

ifying the importance of HCV areas as migration habitats. HCV areas that provide protection and good conditions for migratory species have a key role in maintaining the conti-



Fig. 9. The vegetation along the Pukun River as a protective buffer against soil erosion

nunity of these species' life cycles and populations. Through the success parameter of HCV 4, it is possible to identify and provide important value to this HCV area as part of an important migration route for regional ecological sustainability and to take the necessary actions to ensure the continuity and sustainability of the migratory habitat. The following are the efforts made by the oil palm plantations in the research location to maintain HCV 4 (Fig. 10): patrolling and monitoring, water samples, annual surveys, maintenance of stakes, borders, rejuvenation of stakes, maintenance of signboards, and riparian. The company efforts to maintain HCV 4 can be seen in Fig. 10.

Failure to meet HCV 4 criteria is caused by an inability to identify and understand the contribution of HCV areas to regional ecological sustainability(42,43). These factors include a lack of studies on the connectivity of HCV areas with other conservation areas, which hinders synergy in maintaining regional ecological sustainability,

and a lack of understanding of the role of HCV areas as migratory habitats for certain species (44). To achieve success in the HCV 4 criteria, a comprehensive identification of the contribution of HCV areas is required, including research related to connectivity with other conservation areas and understanding the importance of HCV areas as migration habitats (45). It is necessary to take steps to protect and make decisions that consider the contribution of HCV areas to regional ecological sustainability.

HCV 5 Adaptive Management (Function of Ecology for Human Sustainability)

The Pukun River is identified as HCV 5, an area where local people seek fish (Fig. 11) to meet their protein requirement. Monitoring results from the oil palm plantation company indicates the presence of Pondok Haur Village, where most of the people's livelihoods in the village are fishing in the Pukun River using fish cages and fishing nets. Fish catches obtained by the community are usually sold to employees of the oil palm plantation company in the research site as their source of income. The Pukun River still has a wealth of valuable fish species, such as tapah fish (*Wallago leeri*), baung (*Hemibagrus nemurus*), kelabau (*Osteochilus melanopleuora*), kerandang (*Channa pleurophthalma*), and lais (*Kryptopterus* sp.) which are local species favored by residents and become a local commodity. The area along the Pukun River where local people catch fish can be seen in Fig. 11.

The results of the 2022 monitoring survey reveal that areas along the Pukun River remain in good condition and are still utilized by the local people for fishing. The success of the oil palm plantation company in managing HCV 5 is primarily attributed to optimizing the ecological benefits of HCV areas for the welfare and sustainability of local communities. This includes recognizing and utilizing

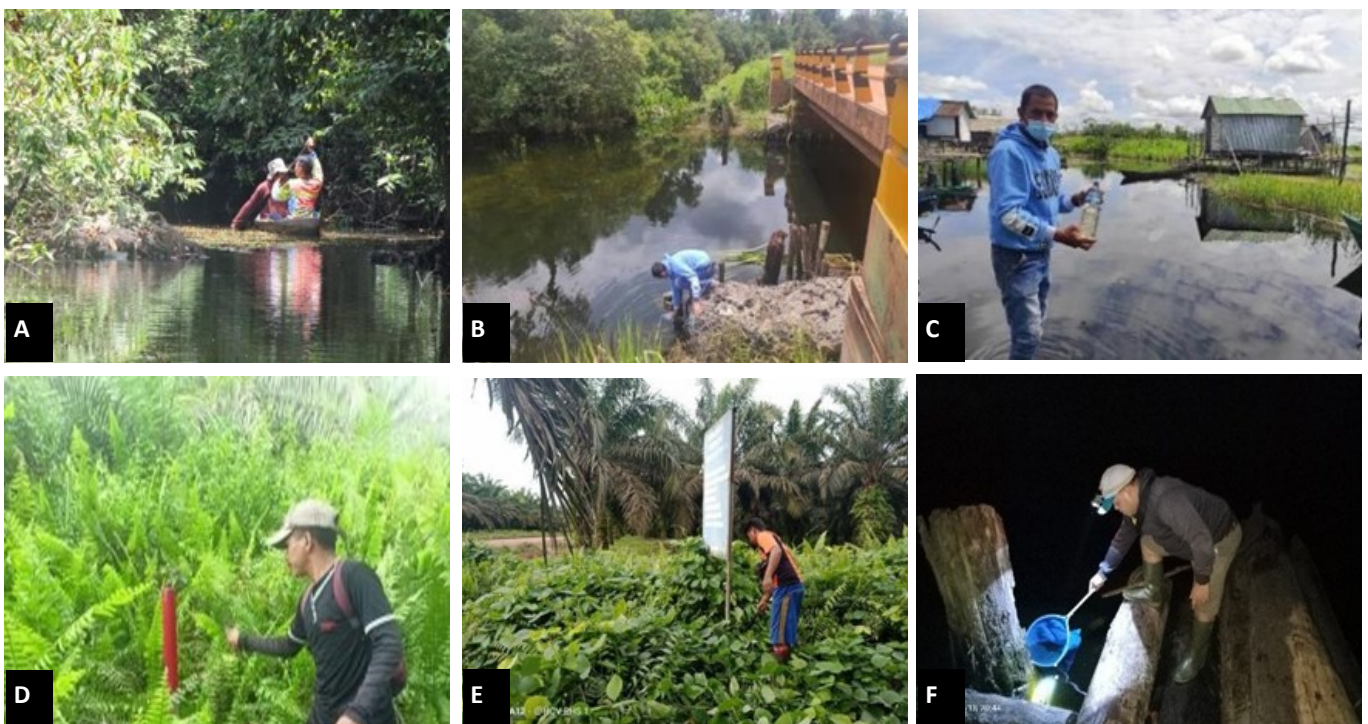


Fig.10. Efforts by the oil palm plantation company to maintain HCV 4 in the Pukun River (A. Monitoring of HCV 4 areas; B. Sampling of water in the Pukun River; C. Sampling of water downstream of the Pukun River; D. Maintenance of riparian stakes; E. Maintenance of riparian signboards F. Identification of the types of fish in the Pukun River)



Fig. 11. Along the Pukun River as an area where local people catch fish

the ecosystem services provided by HCV areas. In addition to supporting the livelihoods of local communities, the HCV5 areas in this research location also have the potential to be used for ecotourism, traditional knowledge, or sustainable management of natural resources. The company efforts to maintain HCV 5 can be seen in Fig. 12.

The success in managing HCV 5 involves empowering local communities (46). Through their participation, communities can have fair access and a sense of responsibility for the area (47). This empowerment includes enhancing participation in management, conducting environmental education, and improving social and economic welfare through sustainable activities (48). Failure to meet

their practices according to local conditions, mitigate adverse impacts, assess impacts, and take appropriate steps according to HCV criteria. The success of adaptive management by a company can be observed based on data on the decline in HCV exposure and the maintenance of HCV 1 - 5 areas.

This research shows that the application of principles and adaptive management of HCV areas in oil palm plantations has long-term benefits. In addition to preserving important biodiversity and habitats, it enhances the image of oil palm plantations, strengthens relationships with local communities, and meets international sustainability standards. Thus, by applying such operations, oil palm plantations can be increased in a sustainable manner, protect the environment, and provide sustainable social and economic benefits. This research has important implications for the palm oil industry. It can be used as a guide in policy-making that supports the development of environmentally responsible oil palm plantations.

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Fig. 12. Efforts by the oil palm plantation company to maintain HCV 5 (A. Monitoring biodiversity areas of HCV 5; B. Socialization to fishermen on the Pukun River; C. Toman fish (*Channa micropeltes*))

HCV 5 criteria is caused by an inability to optimize the ecological benefits of HCV areas for the welfare and sustainability of local communities (49). Achieving success requires a holistic approach that involves local communities in decision-making and area management, coupled with a profound understanding of the ecosystem services provided by HCV areas (50, 51). Consequently, the ecological benefits of HCV areas can be optimized to improve the welfare and sustainability of local communities, thereby preventing the failure to meet HCV 5 criteria (52).

Conclusion

The application of HCV principles is crucial for a sustainable oil palm plantations in Central Kalimantan. The application of the principles of HCV areas involves identifying, assessing, and protecting areas with high ecological, social, and cultural values, which can be recommended for adaptive management in oil palm plantations. By paying attention HCVs, oil palm plantations can operate sustainably and reduce environmental impacts. Through adaptive management, oil palm plantations can adapt

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Authors contributions

Conceptualization, EDN, ARS, BJP, H; methodology, EDN, ARS, BJP, H; and S; validation, EDN, ARS, and S; formal analysis, EDN, ARS, RJ, and S; investigation, EDN, ARS, S, and H; SW; resources, EDN, SW; data curation, EDN, ARS, RJ, S, MD; writing—original draft preparation, S, RJ, and HUA; writing—review and editing, ARS, S, and RJ; supervision, BJP, and H; project administration, EDN, RJ, and S; funding acquisition, EDN. All authors have read and agreed to the published version of the manuscript.

Compliance with ethical standards

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