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Institutional dynamics of collaborative governance for forest fire mitigation in large scale palm oil enclaves in West Kalimantan Indonesia

Rijal Ramdani

rijalramdani@umy.ac.id

Universitas Muhammadiyah Yogyakarta

Agam Fatchurrochman

Bumitama Biodiversity & Community Program

Eko Priyo Purnomo

Universitas Muhammadiyah Yogyakarta

Andi Muhammad Amin

Bumitama Biodiversity & Community Program

Hefi Al Hifdhi

Datar Luhur - Environmental Governance Research Group

Reza Ariesca

The Coordinating Ministry for Economic Affairs

Obed Asamoah

Université du Québec en Outaouais

Susilo Nur Aji Cokro Darsono

Universitas Muhammadiyah Yogyakarta

Dian Indra Praja

Bumitama Biodiversity & Community Program

Bagus Ali Imron

Bumitama Biodiversity & Community Program

Nasrulhaq Nasrulhaq

Universitas Muhammadiyah Makassar

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Abstract

Forest and land fires remain a persistent sustainability challenge in Indonesia's palm oil landscapes, particularly within enclave areas, community-managed lands located inside large-scale corporate concessions that are highly fire-prone during the dry season due to slash-and-burn practices. This study examines how collaborative governance among palm oil companies, local communities, village authorities, and government agencies contributes to sustainable fire mitigation in these complex socio-ecological systems. Drawing on qualitative case studies from two villages surrounding a major oil palm concession in Ketapang, West Kalimantan, the research integrates in-depth interviews, focus group discussions, field observations, document analysis, and GIS mapping. The findings show that collaborative arrangements, implemented through fire awareness campaigns, preparedness activities, joint monitoring, and coordinated firefighting, have reduced high-risk burning and limited fire spread across community lands and adjacent plantations. These processes were enabled by structured coordination, knowledge exchange, and resource sharing, while shaped by tensions between customary land-use practices and evolving environmental and regulatory conditions. Collaboration was further driven by interdependence in funding, equipment, legitimacy, and personnel, alongside external pressures such as market-based sustainability certification and state enforcement. The study highlights how collaborative governance can strengthen fire resilience and support more sustainable palm oil governance in the Global South.

Introduction

Forest and land fires in Indonesia's palm oil frontiers represent a persistent sustainability challenge at the intersection of agrarian change, corporate expansion, and community land use. A particularly complex setting within these landscapes is the enclave—areas geographically surrounded by large-scale plantations such as oil palm or timber concessions but fully managed by local communities (Toumbourou & Dressler, 2021, 2024). In Indonesia, enclaves typically emerge when concession rights are granted to companies in territories where communities have long been present and have managed land across generations (Li, 2017). Although these areas remain under community control, they are embedded within industrial production systems, creating overlapping ecological risks and governance tensions.

Satellite-based analyses frequently attribute fire occurrences to oil palm concessions (Carlson et al., 2018), and advocacy organizations such as Greenpeace often identify companies as responsible actors for burning within concession boundaries. However, emerging empirical evidence complicates this narrative. Research in West Kalimantan shows that fires within enclaves are often associated with community-based land clearing for oil palm, rice paddies, and horticultural crops (Ramdani et al., forthcoming). Burning is widely perceived as a rapid and low-cost technique, rooted in long-standing agrarian traditions dating back to the seventeenth century (Dauvergne, 1998; Idhom, 2019; Syaufina, 2018). Fires may also originate outside plantations and subsequently spread into concession areas (Cattau et al., 2016). Similarly, Purnomo et al. (2019) found that multiple burned areas in Sumatra were

managed by local communities and potentially extended into company concessions. These findings suggest that fire governance in palm oil landscapes cannot be reduced to a simple corporate-versus-community dichotomy but instead reflects intertwined socio-ecological dynamics.

Addressing fire risk in such hybrid landscapes, like enclaves, requires engagement among multiple actors, including companies, communities, village authorities, and government institutions. Collaborative governance has been widely discussed as a shift from hierarchical, top-down arrangements toward multi-actor engagement in addressing complex environmental problems (Barton et al., 2015; Brink & Wamsler, 2018; Few et al., 2007; Hamilton & Lubell, 2018). It has been applied in contexts of social learning, knowledge co-creation, and participatory decision-making (Bates et al., 2013; Kvamsås et al., 2021; Morris, 2020), and increasingly as a pathway to mitigate human-made disasters such as forest fires (Baird et al., 2016; Kalesnikaite, 2019). Empirical studies show that intergovernmental cooperation and cross-sector communication can reduce fire risks and enhance prevention and restoration efforts (Urgenson et al., 2017; Böhling, 2019).

However, collaboration does not emerge automatically. It is often driven by interdependence, collective action needs, and resource asymmetries (Purdy, 2012). In Indonesia, for example, a Fire Care Community (FCC) collaborated with timber companies, district fire brigades, and military institutions due to limited local capacity to manage fires independently (Ramdani & Mustalahti, 2023). Similar dynamics of adaptive learning, mutual dependence, and external support have fostered collaboration in Nepal (Ojha et al., 2019; Chaudhary et al., 2015). Stakeholder interdependence—where actors hold complementary resources, expertise, and influence—has also been identified as a key driver of collaborative arrangements (Ran & Qi, 2019). Yet power relations remain uneven and dynamic, shaping how collaboration unfolds (Orth & Cheng, 2018; Choi & Robertson, 2014). Trust-building, shared incentives, and joint learning are essential but often contested processes (Levesque et al., 2017; Robertson & Choi, 2012). Despite these insights, limited research has examined how collaborative governance operates specifically within enclave settings embedded in industrial agricultural concessions, where community autonomy, corporate liability, and regulatory pressures intersect.

Drawing on case studies from enclave areas within a large-scale palm oil company's concession in Ketapang, West Kalimantan, this study critically examines the forms of collaborative governance developed to mitigate forest and land fires and the motivations driving actors to engage in such arrangements. These enclaves experience recurrent dry-season fires. While communities have retained control over their lands and continue to use fire for agricultural clearing (Ramdani et al., forthcoming), provincial and municipal regulations permit controlled burning under certain conditions, adding further governance complexity. At the same time, companies face reputational, market-based, and regulatory risks when fires occur within concession boundaries. This creates a setting characterized by shared vulnerability yet differentiated responsibilities. By analysing how collaborative mechanisms are structured, enacted, and negotiated in this context, the study contributes to broader debates on sustainability governance in socio-ecological systems and offers insights for strengthening fire resilience in palm oil landscapes of the Global South.

Theoretical framework

Collaborative governance in sustainability and mitigation contexts

This study draws on the collaborative governance framework developed by Emerson et al. (2012) and Emerson and Nabatchi (2014). Collaborative governance is defined as “the processes and structures of public policy decision-making and management that constructively engage a wide range of parties from public institutions, government, communities and the private sector, to implement a public good that cannot be achieved by other means” (Emerson et al., 2012: 1). Importantly, collaborative governance encompasses both formal state-led arrangements and informal, participatory, and community-based processes (Emerson et al., 2012). This broader understanding is particularly relevant in socio-ecological systems where authority, responsibility, and risk are distributed across actors.

Within environmental governance, collaborative approaches are increasingly viewed as necessary to address complex and cross-scale sustainability challenges (Armitage et al., 2012; Bodin, 2017). Yet collaboration is neither inherently transformative nor automatically effective. While it may generate better outcomes than fragmented or unilateral action (Lee, 2023), collaborative environmental governance does not guarantee equitable or sustainable results (Kimani, 2010). Institutional asymmetries, power imbalances, and divergent interests may limit its effectiveness. Nevertheless, given the limited capacity of individual organizations to address multifaceted environmental problems (Mah & Hills, 2012), collaboration is often presented as a pragmatic governance response to shared ecological risks.

We situate collaborative governance within the broader concept of mitigation. Nelson et al. (2007) define mitigation as activities undertaken to reduce exposure to adverse changes through regulation, programs, or technological interventions. Similarly, the United Nations Office for Disaster Risk Reduction defines mitigation as “the lessening or minimizing of the adverse impacts of hazards and related disasters” (UNDRR, 2007). In climate governance, the Intergovernmental Panel on Climate Change conceptualizes mitigation as human intervention to reduce the sources of greenhouse gases (IPCC, 2014).

In this study, forest fire mitigation is understood as coordinated actions aimed at reducing fire occurrence, spread, and impact within enclave landscapes. Collaborative governance becomes a mechanism through which diverse actors attempt to manage fire risk collectively. Empirical evidence from Indonesia supports this linkage. Ramdani & Purnomo (2022) show that rewetting degraded peatlands, fire monitoring, and cross-actor knowledge exchange reduced fire incidents in community forestry areas in Sumatra. Prayoga & Koestoer (2021) similarly demonstrate that collaborative, science-based land assessments contributed to reducing fire accidents. These studies suggest that mitigation outcomes are shaped not only by technical measures but by the quality and configuration of inter-actor collaboration.

Collaborative approaches in forest fire mitigation

Building on Emerson and Nabatchi (2015) and Ramdani & Mustalahti (2023), we analyse collaborative governance approaches through three interrelated dimensions: structural arrangements, knowledge and learning, and resource sharing (Fig. 1).

Structural arrangements refer to inclusive and deliberative decision-making processes in which actors voluntarily engage to pursue shared goals (Emerson et al., 2012). Inclusion is normatively central, as it allows diverse interests and perspectives to inform collective decisions (Emerson & Nabatchi, 2015). However, collaboration unfolds within unequal power structures. Actors with greater financial resources, technical expertise, or legal authority may dominate agenda-setting and decision-making (Purdy, 2012). Empirical studies show that government institutions frequently exercise disproportionate influence due to their regulatory mandate (Arai et al., 2021; Orth & Cheng, 2018), while local communities—despite possessing contextual and traditional knowledge—often hold less formal power (Orth & Cheng, 2018). Power asymmetries are dynamic and may shape whose knowledge counts and whose risks are prioritised.

Knowledge and learning represent processes through which diverse actors exchange information and develop shared understandings (Emerson et al., 2012). Social learning occurs when actors integrate insights from interaction and knowledge sharing (Emerson & Gerlak, 2014). Collaborative governance thus depends on mechanisms that facilitate dialogue and mutual reflection (Van Buuren, 2009), whether through formal training or informal exchange (Sellmann & Bogner, 2013). In fire mitigation contexts, such learning has enabled local actors to acquire technical skills from professional fire squads and environmental organizations (Ramdani & Mustalahti, 2023; Ramdani, 2023). Yet learning processes may also privilege scientific or corporate expertise over local practices, raising questions about epistemic justice within collaboration.

Resource sharing refers to the pooling of financial, technical, human, and institutional resources among actors (Emerson et al., 2012; Emerson & Gerlak, 2014). Because no single actor possesses sufficient resources to manage complex environmental risks (Thomson & Perry, 2006), collaboration enables access to complementary capacities (Emerson et al., 2012). In Sumatra, donor-funded initiatives such as WWF and the Japan Partnership Program through the Tropical Peatland Society Project supported community fire patrols and peatland restoration (Ramdani & Mustalahti, 2023; Ramdani, 2023). However, resource dependence may also reinforce hierarchical relations, where actors controlling funding or equipment exert greater influence over collaborative priorities.

Drivers of collaborative governance in forest fires' mitigation

According to Emerson et al., (2012), four main drivers can encourage parties to collaborate, namely: uncertainty, interdependence, consequential incentives, and leadership. However, there can be one or more key drivers to initiate collaboration depending on the case study to (Emerson et al., 2012). For

example,Ramdani & Purnomo (2022) identified that three of the four key drivers of collaborationinterdependence, consequential incentives, and uncertainty—play a pivotal role in shifting conflict over peatland water sharing into collaboration. In this study, we also critically analyze how uncertainty, interdependence, and consequential incentives have brought multiple parties to collaborate to mitigate the forest and land fires in the enclaves.

Uncertainty emerges when different parties lack sufficient understanding of the complex issues they encounter or the appropriate solutions to address them (Hossu et al., 2018). The parties are also unsure about the outcomes of their efforts to solve the problems (Ulibarri, 2019). This uncertain condition can lead groups to collaborate to share and reduce risks (Emerson et al., 2012). Many problems are not fully understood, and because of limited information, each party struggles to come up with solutions (Whyte & Thompson, 2012). Through collaboration, parties can share information and knowledge, helping to turn uncertainties into clear, understood, and meaningful challenges (Walker et al., 2017). For example, Ramdani and Purnomo (2023) found that uncertainty regarding the amount of water the local community needs from the timber concessions in Sumatra to restore degraded peatlands has led multiple parties, such as universities, timber companies, and local communities, to collaborate in measuring the water volume.

Interdependence arises in situations where conflicting parties feel the need to cooperate (Hossu et al., 2018). Existing research has shown the reasons why parties are interdependent. For example, the problem at hand may be beyond the capabilities of one party (Emerson et al., 2012). Due to the unique distribution of resources, each party needs to share resources such as knowledge, authority, and legitimacy (Zachrisson & Lindahl, 2013). Neither party has sufficient resources to tackle a complex problem independently, and they are interdependent in determining and implementing joint efforts (Raitio, 2012). They rely on one another for efforts and gain support (Thomson & Perry, 2006). If parties or organizations had sufficient information about a problem and its solution, they could act independently to pursue their interests or manage risks (Emerson et al., 2012).

Consequential incentives are internal and external pressures, both positive and negative, and opportunities that encourage conflicting parties to take collaborative actions (Hossu et al., 2018). These incentives can have many consequences. For example, internal pressures could be mandatory government regulations, while external pressures could be unforeseen conditions of natural or human-caused disasters (Emerson & Nabatchi, 2015). Previous research has shown how long-term EU funding in Romania and national higher education goals in Papua New Guinea have encouraged different parties to engage in collaborative action (Eldridge et al., 2018; Hossu et al., 2018).

Research Methods

This research used a case study method. According to Creswell & Clark (2018), the case study method is relevant for the focus of the study if the study is a current phenomenon instead of a historical event. In this study, we focus on the approaches and drivers of collaboration among multiple actors in the

mitigation of forest and land fires in the enclave areas. This research was conducted in the subdistrict (Kecamatan) of Nanga Tayap, Ketapang District, West Kalimantan particularly in the enclaves of large-scale oil palm plantations (Fig. 2). The enclaves have frequently burned since 2015, particularly during the dry seasons from June until September.

The data was collected through interviews, questionnaires, Focus Group Discussions (FGD), document analysis, and Geographic Information System (GIS) mapping.

In-depth interviews are a key method in qualitative research, allowing researchers to gather accurate information through face-to-face or online interactions (Irvine, 2011). In this research, we conducted in-depth interviews with key informants—individuals who were directly involved in the event being studied (Muhoza et al., 2021). In our case the key informants refer to palm oil company managers, local farmers, local communities, indigenous community leaders, local government institutions, and environmental organizations (Table 1) who were involved in the collaboration process. The in-dept interview with 12 palm oil company managers, NGOs, and experts were carried out through online platform (Zoom). Meanwhile, the rest of the in-depth interviews were carried out through face-to-face interviews. Each interview was taken about an hour using Bahasa Indonesia with the help of an interview guide developed based on the literature review.

Table 1. List of Informants interviewed during the fieldwork.

No	Institutions	Method of interviews	N Informants
1	Oil palm company sustainability and fire supervisors	Online interview	8
2	Oil palm company CSR and sustainable manager	Face-to-face interview	2
3	Oil palm company fire squads	Face-to-face interview	4
4	Non-Government Organizations (NGOs)	Online interview	1
5	Local Government representative	Online interview	1
6	Experts of forest and land fires in Indonesia	Online interview	1
7	Expert of the enclave in the oil palm plantation	Online interview	1
8	Leader of Dayak Kayong community	Face-to-face interview	1
9	Leader of Malay People	Face-to-face interview	1
10	Villagers	Face-to-face interview	2
11	Fire Care Community (FCC)	Face-to-face interview	3
12	Village office leaders	Face-to-face interview	2
13	Head of the subdistrict office	Face-to-face interview	1
14	Subdistrict military command	Face-to-face interview	1
15	Subdistrict police station	Face-to-face interview	1
N Total			30

Focus Group Discussion (FGD) is a form of semi-structured interview with a focus on a predetermined topic and guided by an expert moderator (Denzin & Lincoln, 2011). The process begins with questions

from the moderator, followed by responses and discussion between participants. In this research, FGD were carried out in two locations of villages around the enclaves. FGDs were carried out to find out the perspectives of the fire factors from various parties, namely company managers, local farmers, local communities, indigenous community leaders, local government institutions, and environmental organizations.

Document analysis refers to the review of documents that are relevant to the issue and context of the research (Bowen, 2009) such as legal regulations, proposals, progress reports, meeting minutes, magazines, newspapers and official websites (Yin, 1981). The documents collected can help researchers to 1) correctly name actors and locations, 2) carry out triangulation to check the validity of the information, and 3) provide detailed information from other sources (Bowen, 2009; Gorsky & Mold, 2020). In this research, we collected documents from several sources, namely 1) legal regulations at national, province, and district levels, 2) power points and reports from the large-scale palm oil company group, and 3) fire distributions and records from the village office.

To map hotspot distribution in the enclaves, we utilized the Quantum Geographic Information System (QGIS). Hotspot data were obtained from NASA-MODIS satellites for 2015–2019 and 2020–2024, accessed through the Indonesian Ministry of Environment and Forestry (MoEF) website (http://webgis.menlhk.go.id). Once all data were collected, we integrated them into QGIS, including the SHP file of the two villages of the research location and the two large-scale oil palm plantation concessions (Figs. 3 and 4). This mapping enables us to visualize hotspot conditions before and after collaborative activities.

In this research, we begin data analysis by transcribing the recorded interview and FGD material into written text. Next, we transferred all the data into the NVivo 14 Plus software. NVivo 14 Plus is a tool that researchers can use to carry out qualitative data analysis (Edwards-Jones, 2014). In Nvivo, data is classified based on 1) interview transcriptions, 2) FGD transcripts, and 3) archives/documents. Next, every information and statement from the data will be coded in Codes and Cases. In Codes adaptation, coding is based on variables from the literature review. Meanwhile, in Cases, we code it based on informants, namely: palm oil company representatives, local farmers, local communities, indigenous community leaders, local government institutions, and environmental organizations.

Findings

Collaborative activities in mitigating forest and land fires in the enclaves

To mitigate forest and land fires, palm oil companies, village offices, local communities, and government institutions at the subdistrict level collaborate in fire awareness campaigns, preparedness drills, and joint firefighting activities aimed at minimizing slash-and-burn practices and preventing fire spread in enclave areas. Satellite data show that 65 hotspots were detected in enclave areas between 2015 and 2019

(Fig. 3). Following strengthened collaborative efforts from 2020 to 2024, the number of detected hotspots declined (Fig. 4).

Fire awareness campaigns to prevent the spread of fires.

Palm oil companies, government institutions, and village offices conduct fire awareness campaigns to prevent forest and land fires. The company installs signboards warning against slash-and-burn practices and encouraging the public to report fire incidents (Interview 1b). These signboards are placed along public roads within plantation areas and distributed to the subdistrict military command (Koramil), subdistrict police station (Kapolsek), subdistrict office, and village offices for installation in publicly accessible locations. The company also conducts direct awareness activities through firefighters and Corporate Social Responsibility (CSR) programs. The CSR manager stated that although CSR primarily focuses on economic empowerment, it also includes information about fire risks (Interview 2a).

The company and village offices of Sungai Kelik and Kayong Utara signed a Memorandum of Understanding (MoU). Sungai Kelik Village became a priority area after the 2019 mega-fire, which burned approximately 1,000 hectares of peatland within High Conservation Value (HCV) and High Carbon Stock (HCS) areas. Under the MoU: (1) the village establishes a Fire Care Community (FCC) and Farmer Fire Awareness Groups (FFAG) responsible for fire awareness and monitoring; (2) the company provides training and financial support; and (3) the company rewards the village if no hotspots are detected in the enclave area within one year (Interview 1c). The company allocates USD 1105 annually for FFAG operations in Sungai Kelik, which consists of six members (Interview 1b). FCC groups (5–10 members) remain under village responsibility (Government Decree No. 60/2009), while FFAG establishment reflects company obligations under Law No. 39/2014, which requires corporate involvement in fire mitigation. In 2023, the company awarded USD 3690 to Kayong Utara Village for achieving zero hotspots despite ongoing slash-and-burn land clearing (Interview 1d). The funds supported a community farming program that included mango and durian cultivation and fishpond development.

Joint fire awareness dissemination events are conducted in villages with participation from customary leaders of the Dayak and Malay communities. The subdistrict office reiterated that slash-and-burn is permitted only up to two hectares and prohibited on peatland areas (Governor Decree No. 1/2022). Military and police representatives emphasized the need to inform neighboring landowners before burning to reduce social conflict (Interviews 14 and 15). Burning activities require notification through the village office, which submits formal communication to the company and subdistrict government institutions. Customary leaders stressed cooperative fire management and reminded communities of customary sanctions if fires spread to neighboring land (Interviews 8 and 9). The company finances honoraria for speakers, while village offices provide venues and refreshments (Interview 1e).

Preparedness for the prolonged dry season

After the major fire in 2019, the palm oil company initiated an annual fire preparedness drill held every July. The drill aims to ensure the readiness of all responsible parties, including the company firefighters, village offices, FCC and FFAG members, the military, and the police, to face the risks of forest and land fires during the dry season. The drill also aims to check the readiness of personnel, equipment, and emergency response mechanisms (Interview 1a). The company decided on the timing and location of the drill, which will take place at the company soccer field. Subdistrict military institutions lead the drill, while company firefighters, FCC and FFAG members from the villages, and members of the district police and military participate as attendees. The company also invited the head of the Regional Disaster Management Agency (RDMA) of Ketapang District and Mangga Agni—a firefighter squad under the Ministry of Forestry (MoF), to attend the event.

Regarding the preparedness drill, the first purpose is to remind people that we have entered the dry season. The community tends to take it lightly if fire awareness dissemination is conducted only at the village and subdistrict levels. However, when a semi-military drill is held, and the head of RDMA is present to announce that we have entered the dry season, everyone must be alert. The presence of the military district command and RDMA in the drill serves as a strong reminder that the dry season has arrived. (A Company Sustainability and Fire Supervisor)

During the fire preparedness drill, the head of RDMA, the subdistrict military commander, and the police chief emphasized the need to stay alert to the threat of forest and land fires as the dry season had begun. Manggala Agni provided training to all firefighting units on how to extinguish fires in both mineral and peatland areas. The Manggala Agni also conducted training on self-rescue techniques when trapped by fire, creating firebreaks, and identifying early signs of fire. The company showcased all its firefighting equipment, including fire trucks, water pumps, hoses, and safety gear such as fire-resistant suits, boots, helmets, and gloves, allowing all participants to test them. The company covered all expenses, including the event venue, honorariums, transportation, and refreshments (Interview 1h).

Entering the dry season, the subdistrict military command, subdistrict police station, and subdistrict office also established an emergency response post for forest and land fires. The emergency post was set up following the responsibility orders from higher authorities, such as the military district command (Dandim), police district (Polres), and the regent of Ketapang, respectively. Members of the subdistrict military and police, as well as members of the subdistrict office, take turns in the daily shift at the post. The company provided funding for the establishment of the post and the monthly operational costs as well as supplies firefighting equipment such as water pumps. Every two to three weeks, the emergency post conducted joint patrols involving the company's firefighters, FCC, FFAG, and subdistrict military command, led by the subdistrict police chief, who was responsible for public order in the subdistrict territory.

We use the company's 4x4 vehicles during joint patrols because the terrain is difficult for our vehicles or motorcycles. At the emergency response post, the company also lent us water pumps and spraying equipment since we do not have them, and some of what we do have is broken. We have also learned

how to extinguish fires and use the equipment during the company's fire preparedness rally. We have never received this kind of training before—what we learn as soldiers is combat. (Member of the Subdistrict military command)

Fighting against the fires during the slash-and-burn and mega-fires

In Kayong Utara and Sungai Kelik villages, the Dayak Kayong and Malay communities practice traditional slash-and-burn for rice cultivation. For the Dayak Kayong, rice planting is a vital life custom, providing daily food from one to two hectares of land. This knowledge has been passed down through generations. Communities reject using excavators for rice farming, viewing them as harmful to soil fertility. Instead, slash-and-burn is believed to enrich the soil through biochar from the burning (Interview 10 a). This traditional practice is legitimized by West Kalimantan Governor Regulation No. 1 of 2022, allowing each family to clear up to two hectares for rice and vegetable cultivation. This regulation aims to accommodate long-standing traditional practices among indigenous communities while setting manageable limits to prevent uncontrolled large-scale fires.

In traditional slash-and-burn practices, the village office holds meaningful power and is crucial in approving or rejecting slash-and-burn permit requests from the community. This power stems from the village office's recognition as a government representative, the direct election of the village head by the community, and the community's daily interaction with the village office. Besides, village office heads in Kayong Utara and Sungai Kelik have traditional authorities. For example, in Kayong Utara, where most of the population is Dayak, the village office head also serves as a Dayak customary leader. In Sungai Kelik, the village administrators are Malay customary leaders. The village offices approve or reject slash-and-burn permit requests based on customary considerations, such as the number of farmers planning to conduct slash-and-burn on the same day, the readiness of firebreaks to prevent the spread of fire, and weather conditions, particularly wind direction (Interview 12a).

In traditional slash-and-burn practices, all collaborating parties—community members, the village through FCC and FFAG, the company, police, military, and subdistrict office—are involved. Farmers, along with relatives and neighbours, help extinguish the fire (Interview 10a). A company firefighting unit with full equipment, including fire trucks, water pumps, and hoses, assists, while FCC, FFAG, military, and police use company-provided firefighting tools. The community relies on basic equipment like water-filled sprayers. Slash-and-burn is usually done in the afternoon to avoid satellite detection of hotspots based on the knowledge from the company firefighters (Interview 10b). Each party brings their own food, but the company covers meals for FCC, FFAG, military, and police members.

In 2019, when a fire burned approximately 1,000 hectares of peatland in Sungai Kelik, the firefighting efforts involved RDMA Ketapang and Manggala Agni. The firefighting process lasted a month, with teams rotating in shifts (Interview 3a). The fire was suspected to have been caused by the drying of the peatland and sparks from community activities in the area. As the fire grew uncontrollable, the company requested assistance from RDMA and Manggala Agni, leading to a joint firefighting operation led by

RDMA Ketapang. The RDMA could lead the joint effort due to its position to represent the Regence that is elected by the population. The fire was eventually extinguished after rainfall, with the company covering daily meal costs and providing firefighting equipment along with RDMA (Interview 3b).

During the FGDs in Sungai Kelik, the community emphasized the importance of maintaining canals and ditches in the peatland area, which is part of the company's HCV and HCS areas. Unmaintained ditches can potentially cause fires, as people often fish and start fires there. Additionally, firefighting becomes difficult due to the lack of water in the ditches. The community believes that the widespread fire in 2019, which burned approximately 1,000 hectares, was partly caused by the dry, uncleaned ditches that failed to prevent the fire from spreading. The company representative acknowledged that the company had prioritized the rewetting peatland management and cleaning ditches in HCV and HCS areas that were directly in border with the company's plantation areas to prevent flooding and drought.

Drivers of collaboration in mitigating forest and land fires in enclaves

Uncertainty in dealing with the traditional slash-and-burn practices

For the local community and villages, uncertainty arises from the tension between traditional practices and the changing biophysical and non-biophysical environmental landscape. The slash-and-burn method is considered efficient and produces biochar-fertilizer for rice cultivation, a practice that cannot be abandoned as it preserves local wisdom and rice varieties (Interview 8 and 9). However, the landscape where they traditionally farm has changed into enclaves, as the government designated it as palm oil plantation concessions. Their farming areas are now directly bordering the company's palm oil plantations. Uncontrolled fires could damage the company's palm oil crops, and the community fears that a prolonged dry season with strong winds could lead to large-scale forest and land fires.

The palm oil company faces uncertainty regarding their responsibilities over the enclaves within concession areas. The burned community farmland is legally situated within the company's concession, making the company liable for any slash-and-burn activities. If hotspots are detected via satellite imagery of the MoF, the government will hold the company accountable. The company may face sanctions from the Roundtable on Sustainable Palm Oil (RSPO) if found negligent in managing fires within its concession (Interview 2a). However, in practice, these areas are fully controlled and managed by local communities who refuse to sell the land to the company and deliberately carry out slash-and-burn. The company is also concerned that fires from community slash-and-burn activities could spread to its oil palm plantations. The heat from the fires can stress or kill the palm trees, causing financial losses for the company (Interview 1a).

Village and subdistrict offices face concerns about fires spreading to forests, potentially causing large-scale disasters like the 2015 fire that burned around 50,000 hectares in Ketapang, severely impacting the

economy and creating health risks (Interview 13). Meanwhile, the police station and military command worry about social conflicts if fires from traditional slash-and-burn practices spread to neighbouring lands. In Dayak Kayong and Malay customs, damaging another's land results in customary sanctions, which can trigger conflicts if disputes involve different customary laws. Therefore, government institutions must ensure that slash-and-burn is limited to a maximum of two hectares and controlled with firebreaks to prevent the spread of fires (Interview 15).

Interdependence and consequential incentives of the forest and land fires' mitigation

Communities and village offices rely on the company due to their limited firefighting equipment. Without the company's support, they fear they cannot control fires that could spread into company oil palm plantations or forests. Besides, village offices have limited funds to disseminate the governor decree No. 1/2022 and raise awareness about the dangers of forest and land fires without financial assistance from the company, including signboards and community engagement activities. Village offices also depend on the company's financial support for FFAG operations and firefighting training for FCC members. They hope no hotspots are detected in their areas so they can receive company rewards, such as the USD 3690 awarded to Kayong Utara in 2023.

The company relies on the legitimacy of village offices as the lowest level of the government institution that directly engages with the community's daily activities. Without the village office's legitimacy, the company cannot conduct community engagement activities or assist in fighting against the fires during traditional slash-and-burn practices (Interview 1d). The company also faces personnel limitations for both fire patrols and firefighting. The establishment of FCC and FFAG by the villagers significantly eases the company's burden. The financial costs for supporting FFAG are much lower than hiring professional firefighters, while FCC members are not paid by the company at all (Interview 1c).

The subdistrict office also relied on the company for equipment, training, and financial support for fire awareness campaigns, emergency response posts, and fighting against the fires (Interview 13). Government institutions at the subdistrict level face pressure from higher authorities— such as the district military command and district police, respectively. Presidential directives have bound both military and police institutions since 2018, which mandate the dismissal of territorial commanders if fires occur in their jurisdictions (Interview 14 and 15). This creates a chain of command pressure within military structures. At the same time, the company relies on the legitimacy of these military institutions as state witnesses to verify that fires within the company's concession areas are caused by community activities, not the company itself (Interview 1d). The company also gains incentives from subdistrict military command and sector police to conduct fire awareness campaigns in enclaves under the legitimation of state institutions (Interview 1f).

Discussions

This study demonstrates that collaborative governance in enclave palm oil landscapes can contribute to forest fire mitigation when diverse actors coordinate risk reduction strategies across institutional and jurisdictional boundaries. The decline in hotspot detections after the intensification of collaborative measures suggests that joint awareness campaigns, preparedness drills, and coordinated patrols enhanced collective capacity to manage fire risks. These findings reinforce arguments that collaborative governance is particularly relevant in complex socio-ecological systems where authority and responsibility are distributed (Emerson et al., 2012; Emerson & Nabatchi, 2014). The enclave setting reveals governance dynamics that were previously underexplored, especially the coexistence of corporate concession rights and community land management within the same spatial boundaries. Mitigation outcomes appear to depend not solely on technical interventions, but on negotiated legitimacy among companies, village authorities, customary leaders, and state security institutions operating under overlapping mandates.

The findings indicate that collaboration is shaped by pragmatic risk management rather than purely deliberative consensus. Actors engage in collective action due to shared exposure to ecological uncertainty and regulatory liability. This aligns with the proposition that collaborative governance often emerges in response to complex and cross-scale sustainability challenges that exceed the capacity of individual actors (Armitage et al., 2012; Mah & Hills, 2012). Nevertheless, collaboration does not automatically eliminate structural asymmetries. Corporate actors retain significant influence through control of funding, equipment, and organisational capacity, while village authorities contribute contextual knowledge and social legitimacy. Such asymmetries confirm that power relations condition collaborative processes and may shape whose knowledge is prioritised (Purdy, 2012; Orth & Cheng, 2018). Fire mitigation gains therefore coexist with unequal resource distribution and differentiated decision-making authority.

Collaborative Governance in Enclave Fire Mitigation: Structures, Learning, and Resource Politics

Structural arrangements in this case combine formal Memoranda of Understanding with customary approval mechanisms embedded in village governance. This hybrid configuration supports the broader conceptualisation of collaborative governance as encompassing both formal state-led and informal participatory processes (Emerson et al., 2012). Empirically, the palm oil company plays a dominant role in fire awareness campaigns and preparedness drills because it controls financial resources. Initiatives such as signboard development and drill organization were designed and funded primarily by the company, with other actors performing supportive or symbolic roles. This confirms Purdy's (2012) argument that actors controlling critical resources shape collaborative agendas. In contrast, village offices exercise significant authority in regulating community burning practices due to their formal governmental mandate and customary legitimacy within Dayak and Malay communities, supporting findings by Arai et al. (2021) and Orth & Cheng (2018) regarding state dominance in collaborative settings. Similarly, subdistrict military and police commands retain hierarchical authority in establishing

emergency response posts and coordinating large-scale fire suppression. Thus, collaboration reflects a hybrid governance arrangement that blends horizontal coordination with vertical command structures.

Knowledge and learning processes occur through both formal and informal mechanisms (Emerson & Gerlak, 2014; Sellmann & Bogner, 2013). Fire awareness campaigns and preparedness drills function as formal arenas for disseminating technical knowledge, including satellite hotspot monitoring and fire response protocols. Training of FFAG members institutionalizes shared learning. Informally, firefighters and community members exchange experiential knowledge on wind direction, firebreak construction, and local land conditions. However, the prominence of corporate and state firefighting expertise raises questions about epistemic balance, as local ecological practices may be subordinated to technocratic approaches. It also notices that these interactions support operational risk reduction, yet learning remains largely technical and compliance-oriented rather than transformative. Moreover, structural ecological drivers—particularly peatland hydrology and drainage management—receive comparatively less attention,

Resource sharing expands collective capacity beyond individual organizational limits (Emerson et al., 2012; Thomson & Perry, 2006). The palm oil company contributes funding, equipment, drones, and logistical support, while village offices, community groups, and government agencies provide personnel, facilities, and legitimacy. However, ecological gaps persist. Community concerns regarding insufficient peatland rewetting and drainage canal maintenance indicate that preventive ecosystem restoration is underprioritized. As highlighted by Ramdani & Mustalahti (2023), peatland rewetting is critical for sustained fire mitigation. The emphasis on suppression over restoration reveals a structural imbalance in current collaborative arrangements. This situation illustrates how collaboration compensates for limited state and community capacity (Thomson & Perry, 2006), yet financial dependence on corporate funding may reinforce agenda-setting power. Collaborative governance in fire mitigation should therefore be conceptualised as adaptive but not inherently emancipatory.

Uncertainty, Interdependence, and Consequential Incentives in Enclave Fire Governance

The study also refines understanding of collaborative drivers by demonstrating the interaction of uncertainty, interdependence, and consequential incentives within enclave fire mitigation. Uncertainty is a central driver of collaboration (Emerson et al., 2012; Hossu et al., 2018; Ulibarri, 2019). Enclaves represent transformed socio-ecological landscapes where customary farming areas are embedded within corporate concessions, intensifying tenure ambiguities and risk exposure. Prolonged dry seasons heighten fears of uncontrollable fires damaging plantations and forests. The palm oil company faces regulatory uncertainty, as satellite-detected hotspots may trigger government sanctions and certification penalties regardless of direct responsibility. Military and police authorities operate under strict command systems, facing institutional consequences if fires occur within their jurisdictions. These overlapping uncertainties generate shared vulnerability, encouraging coordinated action.

Interdependence further consolidates collaboration (Zachrisson & Lindahl, 2013). It arises because no single actor possesses sufficient authority, legitimacy, and resources to address fire risks independently (Emerson et al., 2012; Zachrisson & Lindahl, 2013). Communities and village institutions depend on corporate funding and equipment, while the company relies on local legitimacy and human resources to operate effectively within enclaves. No single actor possesses sufficient capacity to manage large-scale fires independently, reinforcing Emerson et al.'s (2012) proposition that complex socio-ecological challenges necessitate inter-organizational cooperation.

Consequential incentives, particularly external regulatory and market pressures, play a decisive role. Companies face potential sanctions from the Roundtable on Sustainable Palm Oil and legal liability under Indonesian regulations. This market based and state enforcement mechanisms create strong motivations for hotspot prevention. At the same time military and police officers operate under presidential directives that threaten dismissal if fires occur in their jurisdictions. Moreover, Financial rewards for hotspot-free villages provide additional inducements for participation. These layered pressures generate compliance-based collaboration in which actors align efforts to avoid sanctions and reputational damage. Collaboration thus emerges from converging risk calculations rather than solely from shared environmental values, broadening the analytical lens on drivers of environmental governance. Similar patterns in Romania and Papua New Guinea (Eldridge et al., 2018; Hossu et al., 2018) demonstrate how sanctions and funding influences collaborative durability. However, reliance on incentives risks promoting compliance-driven behavior rather than deeper ecological transformation.

Conclusion

Our study demonstrates that collaborative governance in palm oil enclave areas of West Kalimantan has reduced the risks and exposure associated with forest and land fires through coordinated fire awareness campaigns, preparedness drills, and joint suppression efforts. In line with Nelson et al. (2007), these initiatives are best understood as mitigation measures that lower vulnerability rather than fully transforming underlying land-use systems. Drawing on Emerson and Nabatchi (2015), we show that structural arrangements, knowledge and learning processes, and resource sharing constitute the core collaborative dynamics shaping these outcomes. However, decision-making is marked by asymmetry: the palm oil company exerts strong agenda-setting influence due to its financial capacity, while village offices retain authority over slash-and-burn permits through formal and customary legitimacy. Although this configuration limits deliberative inclusiveness and constrains deeper knowledge co-production, resource pooling—particularly funding, equipment, and personnel—has enhanced operational capacity and reduced immediate fire risks. These findings highlight both the potential and the structural limits of cross-sectoral collaboration in advancing sustainable fire governance.

Consistent with Emerson et al. (2012), uncertainty, interdependence, and consequential incentives are decisive in sustaining collaboration within this socio-ecological landscape. Communities confront shifting tenure arrangements and intensifying drought conditions, while companies face regulatory and certification pressures linked to hotspot detection. Subdistrict authorities operate under strict

administrative mandates that heighten accountability for fire incidents. These intersecting vulnerabilities create shared risk exposure and functional interdependence, as no actor can manage fire threats alone. External pressures—from state enforcement to market-based sustainability standards—further reinforce coordinated action. Theoretically, this case refines collaborative governance scholarship by demonstrating how sustainability-oriented collaboration in contested landscapes is structured by hybrid authority systems, power asymmetries, and compliance-driven risk management rather than purely horizontal consensus. From a policy perspective, strengthening long-term fire resilience requires rebalancing decision-making power, embedding ecosystem restoration—particularly peatland hydrological management—into collaborative mandates, and reducing reliance on short-term financial incentives in favor of institutionalized, landscape-level prevention strategies.

Declarations

Data availability

The data supporting the findings of this study are available from the corresponding author upon reasonable request. Due to confidentiality agreements with research participants, some data may be made publicly accessible. A preprint version of this article is available on *Research Square* (URL: https://www.researchsquare.com/article/rs-6282160/v1; DOI: https://doi.org/10.21203/rs.3.rs-6282160/v1.

Conflicts of interest

The authors declare that they have no conflicts of interest.

Ethical Approval and accordance

The study received ethical approval from Universitas Muhammadiyah Yogyakarta Ethics Committee (Approval Number: 050/C.6-III/FS-IP/I/2014). All research procedures were performed in accordance with the ethical guidelines and regulations of Universitas Muhammadiyah Yogyakarta and the principles outlined in the Declaration of Helsinki. All participants involved in interviews, Focus Group Discussions FGDs, and observations were fully informed about the study and provided informed consent prior to participation. Participants also consented to the use and publication of anonymized data.

Consent to publish and Consent to Participate

Informed consent to participate in the study and for the publication of anonymized data was obtained from all participants. All participants were aged 18 years or older and provided their consent voluntarily.

References

1. Arai Y, Oktoriana S, Suharyani A, Inoue M. How can we mitigate power imbalances in collaborative environmental governance? Examining the role of the village facilitation team approach observed in

West Kalimantan. Indonesia Sustainability. 2021;13(7):3972.

2. Armitage D, De Loë R, Plummer R. Environmental governance and its implications for conservation practice. Conserv Lett. 2012;5(4):245–55.
3. Baird J, Plummer R, Bodin Ö. Collaborative governance for climate change adaptation in Canada: experimenting with adaptive co-management. Reg Envriron Chang. 2016;16(3):747–58. https://doi.org/10.1007/s10113-015-0790-5.
4. Barton JR, Krellenberg K, Harris JM. Collaborative governance and the challenges of participatory climate change adaptation planning in Santiago de Chile. Climate Dev. 2015;7(2):175–84. https://doi.org/10.1080/17565529.2014.934773.
5. Bates LE, Green M, Leonard R, Walker I. The Influence of Forums and Multilevel Governance on the Climate Adaptation Practices of Australian Organizations. Ecol Soc. 2013;18(4):art62. https://doi.org/10.5751/ES-06120-180462.
6. Bodin Ö. Collaborative environmental governance: achieving collective action in social-ecological systems. Science. 2017;357(6352):eaan1114.
7. Böhling K. (2019). *Land Use Policy Collaborative governance in the making: Implementation of a new forest management regime in an old-growth conflict region of British Columbia*. *86*(February), 43–53. https://doi.org/10.1016/j.landusepol.2019.04.019
8. Bowen GA. Document analysis as a qualitative research method. Qualitative Res J. 2009;9(2):27–40.
9. Brink E, Wamsler C. Collaborative Governance for Climate Change Adaptation: Mapping citizen–municipality interactions. Environ Policy Gov. 2018;28(2):82–97. https://doi.org/10.1002/eet.1795.
10. Carlson KM, Heilmayr R, Gibbs HK, Noojipady P, Burns DN, Morton DC, Walker NF, Paoli GD, Kremen C. (2018). Effect of oil palm sustainability certification on deforestation and fire in Indonesia. *Proceedings of the National Academy of Sciences*, *115*(1), 121–126.
11. Cattau ME, Harrison ME, Shinyo I, Tungau S, Uriarte M, DeFries R. Sources of anthropogenic fire ignitions on the peat-swamp landscape in Kalimantan, Indonesia. Glob Environ Change. 2016;39:205–19. https://doi.org/10.1016/j.gloenvcha.2016.05.005.
12. Chaudhary P, Chhetri NB, Dorman B, Gegg T, Rana RB, Shrestha M, Thapa K, Lamsal K, Thapa S. Turning conflict into collaboration in managing commons: A case of Rupa Lake Watershed, Nepal. Int J Commons. 2015;9(2):744. https://doi.org/10.18352/ijc.561.
13. Choi T, Robertson PJ. Deliberation and decision in collaborative governance: A simulation of approaches to mitigate power imbalance. J Public Adm Res Theor. 2014;24(2):495–518. https://doi.org/10.1093/jopart/mut003.
14. Creswell, Clark P. (2018). *The Sage Handbook of Mixed Methods Research Design*.
15. Dauvergne P. The political economy of Indonesia's 1997 forest fires. Australian J Int Affairs. 1998;52(1):13–7. https://doi.org/10.1080/10357719808445234.
16. Denzin N, Lincoln Y. (2011). *The SAGE Handbook of Qualitative Research*.

17. Edwards-Jones A. Qualitative data analysis with NVIVO. J Educ Teach. 2014;40(2):193–5. https://doi.org/10.1080/02607476.2013.866724.
18. Eldridge A, Guyot P, Moscoso P, Johnston A, Eyre-Walker Y, Peck M. Sounding out ecoacoustic metrics: Avian species richness is predicted by acoustic indices in temperate but not tropical habitats. Ecol Ind. 2018;95:939–52. https://doi.org/10.1016/j.ecolind.2018.06.012.
19. Emerson K, Gerlak AK. Adaptation in collaborative governance regimes. Environ Manage. 2014;54(4):768–81. https://doi.org/10.1007/s00267-014-0334-7.
20. Emerson K, Nabatchi T. Evaluating the productivity of collaborative governance regimes: A performance matrix. Public Perform Manage Rev. 2015;38(4):717–47. https://doi.org/10.1080/15309576.2015.1031016.
21. Emerson K, Nabatchi T, Balogh S. An integrative framework for collaborative governance. J Public Adm Res Theor. 2012;22(1):1–29. https://doi.org/10.1093/jopart/mur011.
22. Few R, Brown K, Tomkins EL. Public participation and climate change adaptation: avoiding the illusion of inclusion. Clim Policy. 2007;7(1):46–59. https://doi.org/10.1080/14693062.2007.9685637.
23. Gorsky M, Mold A. (2020). *Qualitative Research in Health Care, Fourth Edition*.
24. Hamilton M, Lubell M. Collaborative Governance of Climate Change Adaptation Across Spatial and Institutional Scales. Policy Stud J. 2018;46(2):222–47. https://doi.org/10.1111/psj.12224.
25. Hossu CA, Ioja IC, Susskind LE, Badiu DL, Hersperger AM. Factors driving collaboration in natural resource conflict management: Evidence from Romania. Ambio. 2018;47(7):816–30. https://doi.org/10.1007/s13280-018-1016-0.
26. Idhom AM. (2019, October 23). Penyebab dan akibat kebakaran hutan di Kalimantan hingga Sumatera. *Tirto.Id*. https://tirto.id/penyebab-dan-akibat-kebakaran-hutan-di-kalimantan-hingga-sumatera-eic3#google_vignette
27. IPCC. (2014). Mitigation of climate change. *Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, *1454*, 147.
28. Irvine A. Duration, Dominance and Depth in Telephone and Face-to-Face Interviews: A Comparative Exploration. Int J Qualitative Methods. 2011;10(3):202–20. https://doi.org/10.1177/160940691101000302.
29. Kalesnikaite V. Keeping Cities Afloat: Climate Change Adaptation and Collaborative Governance at the Local Level. Public Perform Manage Rev. 2019;42(4):864–88. https://doi.org/10.1080/15309576.2018.1526091.
30. Kimani N. A Collaborative Approach to Environmental Governance in East Africa. J Environ Law. 2010;22(1):27–57. https://doi.org/10.1093/jel/eqp031.
31. Kvamsås H, Neby S, Haarstad H, Stiller-Reeve M, Schrage J. Using collaborative hackathons to coproduce knowledge on local climate adaptation governance. Curr Res Environ Sustain. 2021;3. https://doi.org/10.1016/j.crsust.2020.100023.

32. Lee H. Collaborative governance platforms and outcomes: An analysis of Clean Cities coalitions. Governance. 2023;36(3):805–25. https://doi.org/10.1111/gove.12702.
33. Levesque VR, Calhoun AJK, Bell KP, Johnson TR. Turning Contention into Collaboration: Engaging Power, Trust, and Learning in Collaborative Networks. Soc Nat Resour. 2017;30(2):245–60. https://doi.org/10.1080/08941920.2016.1180726.
34. Li TM. Intergenerational displacement in Indonesia's oil palm plantation zone. J Peasant Stud. 2017;44(6):1160–78. https://doi.org/10.1080/03066150.2017.1308353.
35. Mah DN, Hills P. Collaborative governance for sustainable development: wind resource assessment in Xinjiang and Guangdong Provinces, China. Sustain Dev. 2012;20(2):85–97. https://doi.org/10.1002/sd.466.
36. Morris LL. Stakeholder collaboration as a pathway to climate adaptation at coastal ports. Marit Policy Manage. 2020;47(7):953–67. https://doi.org/10.1080/03088839.2020.1729435.
37. Muhoza P, Koffi AK, Anglewicz P, Gichangi P, Guiella G, Olaolorun F, Omoluabi E, Sodani PR, Thiongo M, Akilimali P, Tsui A, Radloff S. Modern contraceptive availability and stockouts: A multi-country analysis of trends in supply and consumption. Health Policy Plann. 2021;36(3):273–87. https://doi.org/10.1093/heapol/czaa197.
38. Nelson DR, Adger WN, Brown K. Adaptation to environmental change: contributions of a resilience framework. Annu Rev Environ Resour. 2007;32:395–419.
39. Ojha HR, Bhusal P, Paudel NS, Thompson PM, Sultana P. Turning conflicts into cooperation? The role of adaptive learning and deliberation in managing natural resources conflicts in Nepal. Clim Policy. 2019;19(sup1):S107–20. https://doi.org/10.1080/14693062.2018.1556240.
40. Orth PB, Cheng AS. Who's in Charge? The Role of Power in Collaborative Governance and Forest Management. Humboldt J Social Relations. 2018;1(40):191–210. https://doi.org/10.55671/0160-4341.1068.
41. Prayoga MBR, Koestoer RH. Improving forest fire mitigation in Indonesia: A lesson from Canada. Jurnal Wilayah Dan Lingkungan. 2021;9(3):293–305.
42. Purdy JM. A framework for assessing power in collaborative governance processes. Public Adm Rev. 2012a;72(3):409–17.
43. Purdy JM. Power in Collaborative Governance. Public Adm Rev. 2012b;72(3):409–17. https://doi.org/10.111/j.1540-6210.2012.02525.x.A.
44. Purnomo EP, Ramdani R, Agustiyara, Tomaro QPV, Samidjo GS. Land ownership transformation before and after forest fires in Indonesian palm oil plantation areas. J Land Use Sci. 2019;14(1):37–51. https://doi.org/10.1080/1747423X.2019.1614686.
45. Raitio K. New institutional approach to collaborative forest planning on public land: Methods for analysis and lessons for policy. Land Use Policy. 2012;29(2):309–16. https://doi.org/10.1016/j.landusepol.2011.07.001.
46. Ramdani R. Governing Fires in the Tropics: Peatland Fires and Oil Palm Expansions in Sumatra, Indonesia. Itä-Suomen yliopisto; 2023.

47. Ramdani R, Fatchurrochman A, Purnomo EP, Amin AM, Al-Hifdhi H, Ariesca R, Asamoah O, Darsono SNAC, Praja DI, Imron BA. Nasrulhaq, & [Forthcoming]. (n.d.). Is slash-and-burn for oil palm plantations truly the main driver of forest and land fires in Indonesia? Evidence from enclaves in Ketapang, West Kalimantan. *Forest Policy and Economics*.
48. Ramdani R, Mustalahti I. Collaborative everyday adaptation to deal with peatland fires: a case study on the east coast of Sumatra, Indonesia. Ecol Soc. 2023;28(3). https://doi.org/10.5751/ES-14263-280312.
49. Ramdani R, Purnomo EP. Shifting conflict into collaboration: peatland fires mitigation in the biosphere conservation transition zone in Sumatra, Indonesia. Int J Wildland Fire. 2022;31(12):1103–13.
50. Ran B, Qi H. The Entangled Twins: Power and Trust in Collaborative Governance. Adm Soc. 2019;51(4):607–36. https://doi.org/10.1177/0095399718801000.
51. Robertson PJ, Choi T. Deliberation, Consensus, and Stakeholder Satisfaction: A simulation of collaborative governance. Public Manage Rev. 2012;14(1):83–103. https://doi.org/10.1080/14719037.2011.589619.
52. Sellmann D, Bogner FX. Climate change education: Quantitatively assessing the impact of a botanical garden as an informal learning environment. Environ Educ Res. 2013;19(4):415–29. https://doi.org/10.1080/13504622.2012.700696.
53. Syaufina L. (2018). Forest and Land Fires in Indonesia: Assessment and Mitigation. In *Integrating Disaster Science and Management: Global Case Studies in Mitigation and Recovery* (pp. 109–121). Elsevier. https://doi.org/10.1016/B978-0-12-812056-9.00008-7
54. Thomson AM, Perry JL. (2006). Collaboration processes: Inside the black box. Public Adm Rev.
55. Toumbourou TD, Dressler WH. Sustaining livelihoods in a palm oil enclave: differentiated gendered responses in East Kalimantan, Indonesia. Asia Pac Viewp. 2021;62(1):40–55.
56. Toumbourou TD, Dressler WH. The politics of misalignment: NGO livelihood interventions and exclusionary land claims in an Indonesian oil palm enclave. Crit Asian Stud. 2024;56(1):89–114.
57. Ulibarri N. Collaborative governance: A tool to manage scientific, administrative, and strategic uncertainties in environmental management? Ecol Soc. 2019;24(2). https://doi.org/10.5751/ES-10962-240215.
58. UNDRR. (2007). *Terminology*. https://www.undrr.org/terminology/mitigation
59. Urgenson LS, Ryan CM, Halpern CB, Bakker JD, Belote RT, Franklin JF, Haugo RD, Nelson CR, Waltz AEM. Visions of Restoration in Fire-Adapted Forest Landscapes: Lessons from the Collaborative Forest Landscape Restoration Program. Environ Manage. 2017;59(2):338–53. https://doi.org/10.1007/s00267-016-0791-2.
60. Van Buuren A. Knowledge for governance, governance of knowledge: Inclusive knowledge management in collaborative governance processes. Int Public Manage J. 2009;12(2):208–35. https://doi.org/10.1080/10967490902868523.

61. Walker MF, Hoffmann TC, Brady MC, Dean CM, Eng JJ, Farrin AJ, Felix C, Forster A, Langhorne P, Lynch EA, Radford KA, Sunnerhagen KS, Watkins CL. Improving the development, monitoring and reporting of stroke rehabilitation research: Consensus-based core recommendations from the Stroke Recovery and Rehabilitation Roundtable. Int J Stroke. 2017;12(5):472–9. https://doi.org/10.1177/1747493017711815.
62. Whyte KP, Thompson PB. Ideas for How to Take Wicked Problems Seriously. J Agric Environ Ethics. 2012;25(4):441–5. https://doi.org/10.1007/s10806-011-9348-9.
63. Yin RK. The case study strategy, a serious research. Knowledge: Creation Diffus Utilization. 1981;3(1):97–114.
64. Zachrisson A, Lindahl KB. Conflict resolution through collaboration: Preconditions and limitations in forest and nature conservation controversies. For Policy Econ. 2013;33:39–46. https://doi.org/10.1016/j.forpol.2013.04.008.

Figures

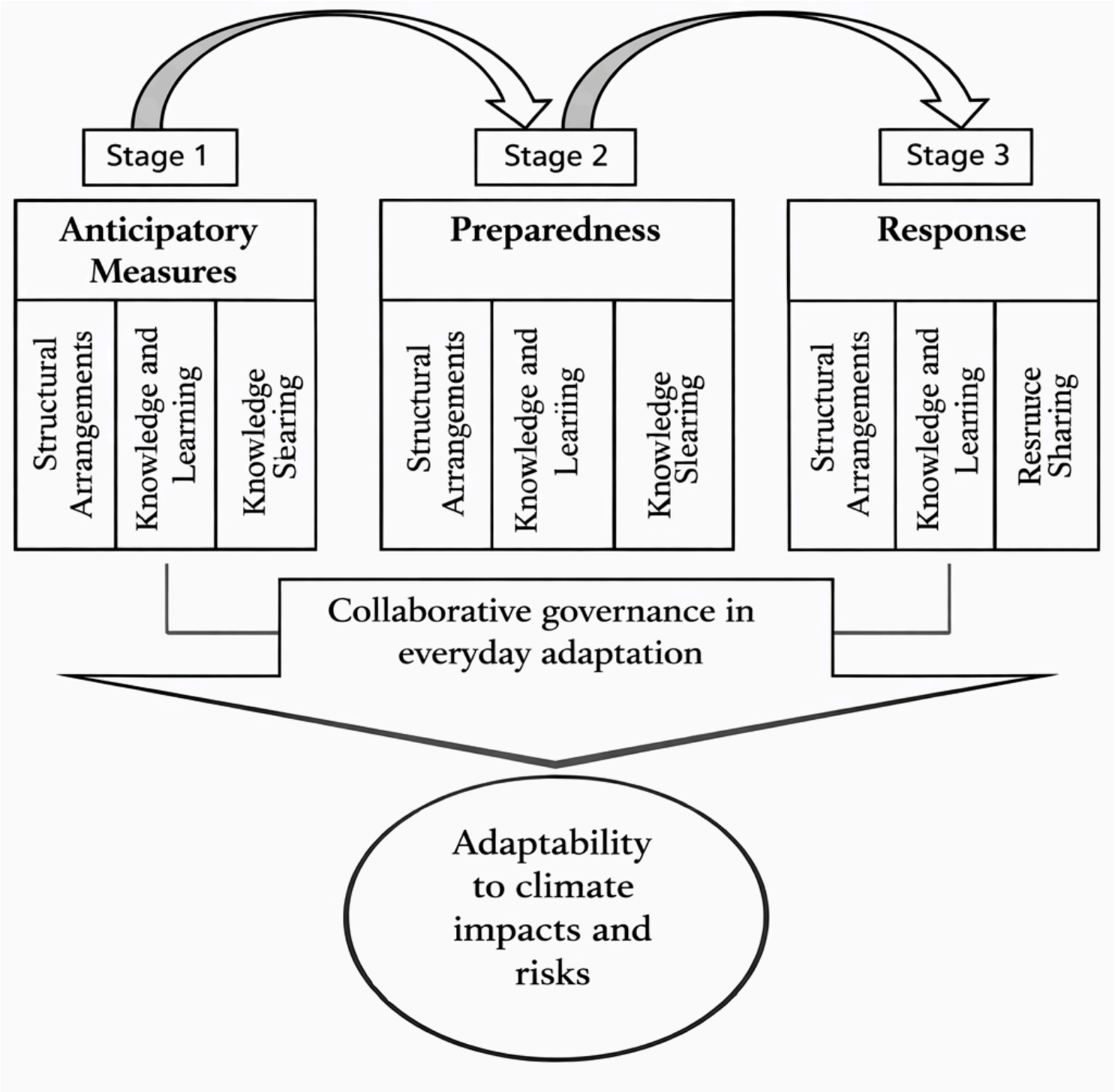


Figure 1

Collaboration in mitigating the impacts of Climate change Framework introduced by Ramdani & Mustalahti, (2023).

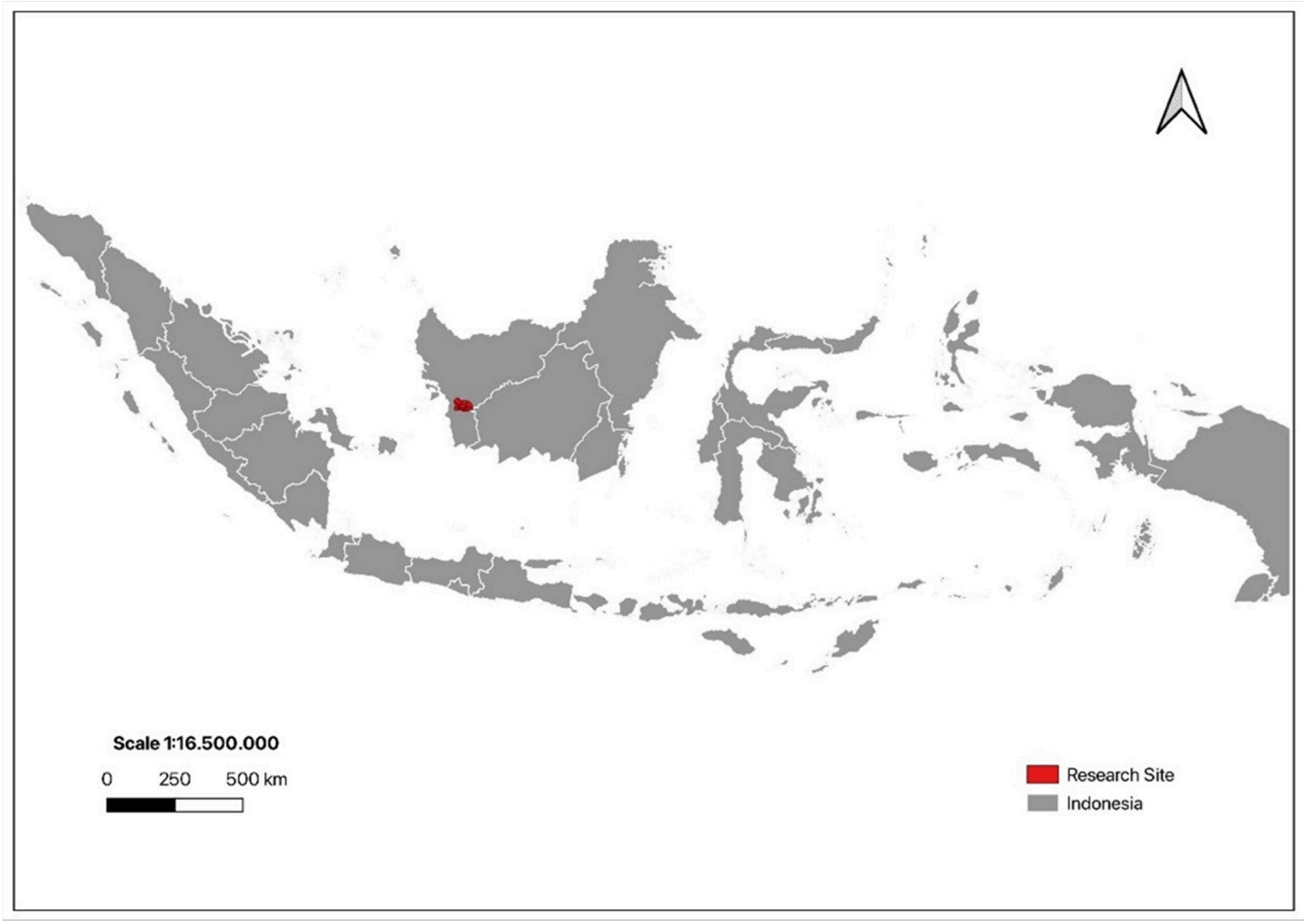


Figure 2

Map of the research site in West Kalimantan, Indonesia, within enclaves in a large-scale palm oil company group.

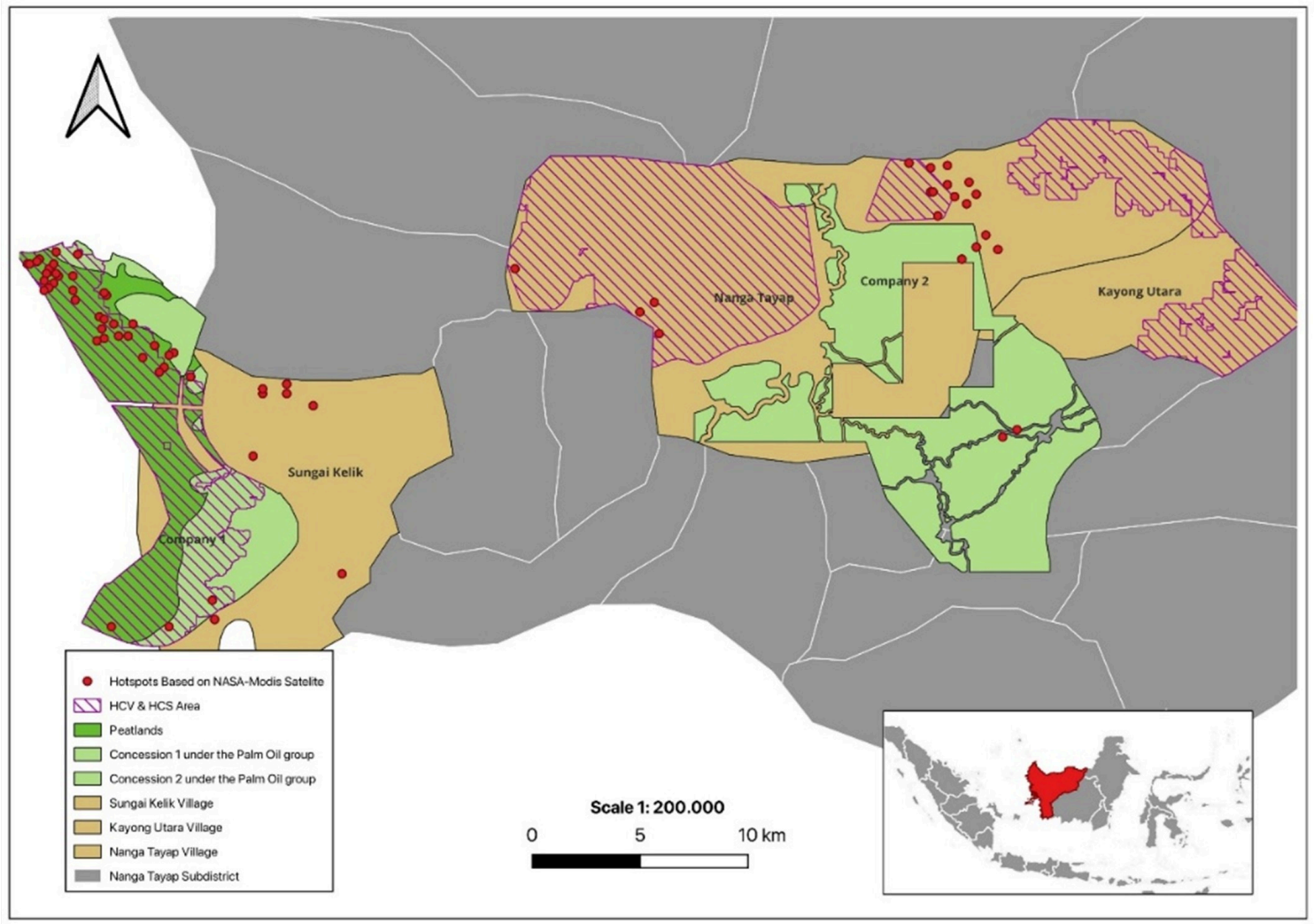


Figure 3

Hotspots captured by the Satellite in the enclaves between 2015 and 2019 before the collaboration initiated.

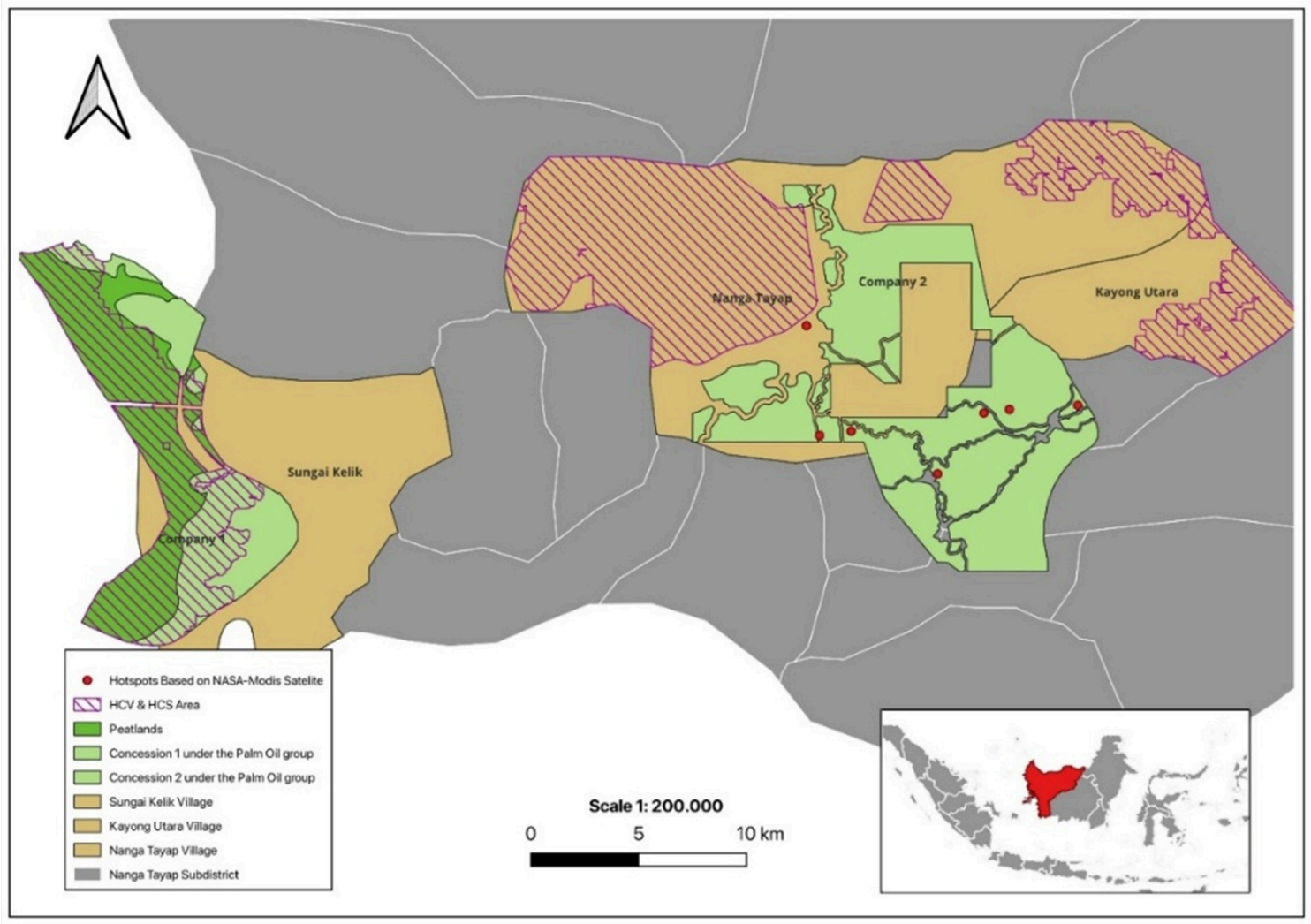


Figure 4

Hotspots captured by the Satellite in the enclaves between 2020 and 2024 after the collaboration initiated.