Stakeholder mapping for peatland fire management in Indonesia: The case of Kayu Labu and Tumbang Nusa Villages

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SUMMARY

Catastrophic fire events in the last decade have led to policy changes regarding the permitted use of fire in cropping systems in Indonesia. This has led to a multi-stakeholder approach to fire management in the extensive peatland systems of Sumatra and Kalimantan. This study seeks to identify key stakeholders and to map and identify their roles in peat fire management at the village level. Two case study villages were used: Kayu Labu in South Sumatra and Tumbang Nusa in Central Kalimantan. The study was conducted using a Responsible-Accountable-Consulted-Informed (RACI) matrix. Data collection was carried out through in-depth interviews and a focus group discussion (FGD) in each village. Our findings showed that the Village Head was the key actor in fire management at the village level. The other stakeholders had shared roles in a largely collaborative process that included the provision of additional funding for resources and training. However, stakeholder engagement in the restoration of burnt peatland was limited, and the engagement of villagers in fire prevention and control was compromised by the threat of sanctions associated with the prohibition of burning. The findings suggest that policy commitments need to be revised in a way that ensures better engagement between external stakeholders and villagers, and focuses on the need to protect livelihoods.

KEY WORDS: Central Kalimantan, peat fire, peat swamp forest, South Sumatra, stakeholder collaboration

INTRODUCTION

Fire prevention in peatlands is a national and sub-national priority in Indonesia (GoI 2021), in part to help meet the country's commitment to reduce its greenhouse gas emissions by 32 % (on its own) or up to 43 % (with international support) by 2030 (MoEF 2022a). In this context, programmes have been enacted to improve land management practices but, to be successful, these must acknowledge the socio-economic characteristics of local communities that are reliant on peatland and embrace their inherent wisdom and knowledge regarding sustainable peatland management.

Indonesian Government Regulation No. 57/2016 describes a commitment to protect peatland ecosystems and includes provision for developing a Peatland Ecosystem Protection and Management Plan (*Rencana Perlindungan dan Pengelolaan Ekosistem Gambut*, RPPEG) at national, provincial and regency levels along with an affirmation regarding the prohibition of activities on peatlands that result in damage (BRGM 2023). A prohibition on burning has now become a serious concern at all levels of governance.

There is, inevitably, a cultural challenge to such a prohibition at village level. Smallholder farmers in Indonesia still largely practice *sonor* agriculture, which relies on prescribed burning (Hamzah *et al.* 2019, Daeli *et al.* 2021). There are two types of intervention in peatlands, namely traditional burning in historically disturbed areas and burning to control problematic plants (Taylor *et al.* 2019). An implication has been that burning can benefit peatland vegetation as well as crop production, but the benefits have been evaluated as moderate at best

and arising in only some situations (Taylor *et al.* 2019). This strengthens the case for bringing together all parties interested in better fire management which can include prohibition.

A diverse range of actors may have an interest in fire (Purnomo *et al.* 2017), which emphasises the need for understanding and harmonising the roles of multiple stakeholders in mitigating its frequency (Ekasari *et al.* 2020, Widhagdha & Dewi 2022). Effective collaboration and coordination allow stakeholders with different perspectives on fire management to exchange views and search for solutions that deliver mutual benefit (WWF 2000, Schultz & Moseley 2019). It can also help both supporters and opponents of prohibition to develop a better understanding of the issues and challenges involved in achieving goals and objectives at a variety of scales (WWF 2020). In the context of this article, a stakeholder is any individual, community, group or organisation with an interest in the outcome of a programme on peat fire management or an ability to influence any of a range of relevant activities (Dearden *et al.* 2002, Reed *et al.* 2009).

Unfortunately, the lack of clear relationships between stakeholders remains an issue (Budiningsih *et al.* 2022). While operative functions relating to fire management are in place within the public sector at national, provincial and regency levels (see Ministry of Environment and Forestry Decree No. 32/2016), peat fires occur primarily at village level (BRG 2018, Akbar 2022, Sakuntaladewi *et al.* 2024). The job descriptions and chains of authority that relate to peat fire management also remain poorly defined (Smrekar *et al.* 2020). Our study seeks to capture this situation by examining how the relevant responsibilities are currently linked to the management of fire in two villages.

Peatland is characterised by the accumulation under waterlogged conditions of partly decomposed soil organic matter (Darusman *et al.* 2022); it has a depth ≥ 50 cm, an ash content ≤ 35 %, and an organic carbon content (by weight) of at least 12 % (Osaki *et al.* 2016, Page & Hooijer 2016); it also has irreversible drying properties and can become highly flammable during the dry season (Anggraini 2023). Fires on peatlands are difficult to monitor and manage because they can spread below, as well as at, the ground surface (Yusuf *et al.* 2019). Because of the high environmental and social value of peatlands (Anda *et al.* 2021, Tarigan *et al.* 2021, Irwani *et al.* 2022, MoEF 2022b, Iqbal *et al.* 2023), fires can potentially cause high economic losses. In 2015, fire and haze resulted in losses valued at USD 857 million in Jambi, USD 3.9 billion in South Sumatra and USD 16.1 billion in total for Indonesia, while agriculture and forestry sustained estimated losses of USD 8.8 billion (World Bank 2016a). Repeated fires cause land degradation, damaging its productive potential and negatively affecting livelihoods (Lestari *et al.* 2021). Smoke and haze also compromise human health (BRG 2019).

The aim of this study is to compile a map of stakeholders that identifies their roles in peat fire management at the village level. Pertinent stakeholders at this level may differ from those at higher governance levels (Rochmayanto *et al.* 2021). Thus, the identification of stakeholders and their roles in peat fire management at the village level can result in better-coordinated responses to fire and approaches to peatland management. The study will support the development of new recommendations on fire management that better include an effective village-level contribution.

METHODS

Study sites

Kayu Labu in South Sumatra and Tumbang Nusa in Central Kalimantan were selected as the case-study villages. These villages are located in two of the seven priority provinces identified in Indonesia's national peat-fire prevention strategy (BRG 2020, BRGM 2021), and each of them met the following selection criteria:

- fire prone area;
- community living on the peatland and in surrounding areas;
- extensive interaction between villagers and peatland; and
- scheduled for restoration activities by the Peat and Mangrove Restoration Agency, known as the BRGM (*Badan Restorasi Gambut dan Mangrove*) (BRGM 2021).

Overview of Kayu Labu Village

Kayu Labu is located in the Pedamaran Timur Sub-District, Ogan Komering Ilir Regency, South Sumatra Province (Figure 1). The current population is 2,931 on an area of 171.4 km^2 (BPS Kabupaten Ogan Komering Ilir 2021). Kayu Labu consists of five sub-villages or hamlets (*Dusun* I, II, III, IV and V). The majority (approximately 80 %) of the people are of Melayu ethnic origin and the remainder are Javanese immigrants.

The landscape is generally flat lowland at an altitude of 10–20 m above sea level. Around one-quarter of the village area, mostly adjacent to the river, is peatland (BRG 2019). The range of peat

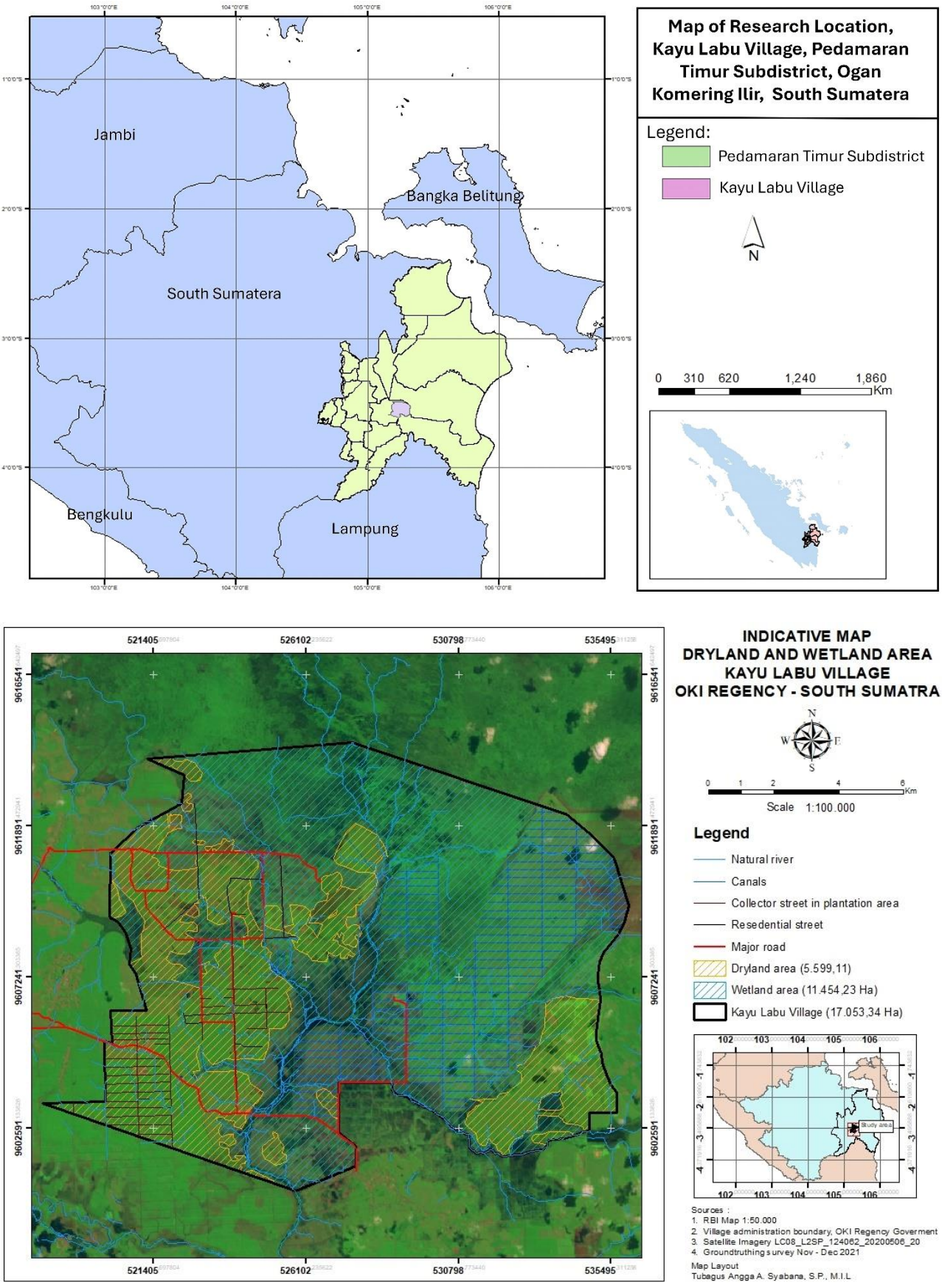

Figure 1. Kayu Labu Village. Above: map of the study site. Below: indicative map of the distribution of peatland (wetland) in the village.

depth is 1–4 m. Most of the peatland is unmanaged and vulnerable to fire, especially during the dry season. Native plants that are commonly found on the peatland are purun (the grass *Lepironia articulata*), gelam (*Melaleuca* spp.), ferns, belidang (*Scleria sumatrensis* Retz.) and kumpai (*Huperzia* sp.).

Around 40 % of the village land (6780 ha) is under oil palm plantations, typically established on both mineral soils and drained peatland, and 35 % (6161 ha) is under rubber plantations on mineral soils. Oil palm occupies areas that are managed by two companies under a partnership (plasma) model and an area that is directly managed by smallholders. Smallholders additionally grow oranges, pineapples, bananas and vegetable crops such as chillies, long beans and eggplant (Lestari *et al.* 2021); they also fish, harvest gelam wood, weave purun mats, and run export businesses based on swallow (swiftlet) houses and porang (*Amorphophallus muelleri*).

Fires burned 135.1 ha in 2015, 7.9 ha in 2016, 100.2 ha in 2017 and 156.2 ha in 2018 (BRG 2019). These fires occurred mainly on peatland.

Overview of Tumbang Nusa Village

Tumbang Nusa is located in the Jabiren Raya Sub District, Pulang Pisau Regency, Central Kalimantan Province (Figure 2). The current population is 1,004 within an area of 200 km^2 (BPS Kabupaten Pulang Pisau 2021). Tumbang Nusa consists of five hamlets. The majority of the people are of Dayak, Banjar and Javanese ethnicity.

The landscape is flat lowland at an altitude of 30 m above sea level and slope < 2º (BRG 2018). Most (> 90 %) of the land is covered by shallow and deep (> 6 m depth) peat but there is a small area of alluvial mineral soil along the riverbank (BRG 2018, Sakuntaladewi *et al.* 2024). Extensive fires affecting 7,500 ha in 2015 and 4,269 ha in 2019 (BRG 2019) have led to a decline in peatland quality and losses of floral and faunal diversity (Wijedasa *et al.* 2020).

Land with mineral soils beside the river is used for rubber (*Hevea brasiliensis*) plantations while the peatlands are used for planting native peat swamp tree species such as *Shorea balangeran* and *Dyera polyphylla* (jelutong). Jelutong was previously used as a source of latex but this has been discontinued because of the low price and it is used nowadays only as a source of seed for peatland rehabilitation around the village. Agroforestry is also carried out on peatland, combining fruit-producing woody plants such as rambutan (*Nephelium lappaceum*) with pineapple and vegetables. Additionally, a small part of the community uses peatland for chicken and duck farming. Another livelihood source is fishing but this is affected by season, the catch being smaller in the dry season than in the rainy season. The livelihoods directly impacted by fires are trading, nursery production and swallow nests (Sakuntaladewi *et al.* 2024). The development of canals by plantation companies has affected the hydrology of the peatland and exacerbated its vulnerability to fire. This has prompted the construction of canal blocks and boreholes by the BRG (the Peat Restoration Agency, predecessor of the BGRM) and the Provincial Environment Office to improve hydrological conditions during the dry season. All land management is carried out independently by individuals or farmer groups, some facilitated by the BRGM or NGOs. No commercial companies are directly involved in land management.

Data collection and analysis

Stakeholder mapping (Daerden *et al.* 2002, Reed *et al.* 2009, World Bank 2016b) was combined with role analysis using a Responsible-Accountable-Consulted-Informed (RACI) matrix where 'I' refers to knowledge transfer (Graffius 2020).

Data collection was carried out through in-depth interviews and a focus group discussion (FGD) in each village. Researchers conducted interviews with key stakeholders at the village level such as village heads and facilitators, fire-care community leaders, farmer groups, and district-level representatives of the Environment Office, Village Development Office and Forest Management Units. Interviews were conducted in Kayu Labu in October 2018, March 2021 and November 2021; and in Tumbang Nusa in March 2019 and June 2021. Semi-open guiding questions were used to elicit the following information about stakeholder relationships with fire in the peatland ecosystem:

- Identities of the people and institutions dealing with fire and its prevention.
- Specific stakeholder groups based on similarities in their work and responsibilities.
- The most influential and important actors in peat fire management.
- Definitions of stakeholder roles in preventing and managing fire, based on RACI.
- How the stakeholders are connected and how they influence one another.

In Kayu Labu, eleven informants were interviewed as key stakeholders. These were the Village Head and secretary, the heads of Hamlets I, II and III, the Chairmen of the Fire Care Farmer Group (*Kelompok Tani Peduli Api*, KTPA) and the Village Consultative Body (BPD), the section head of public service at the village office, and three

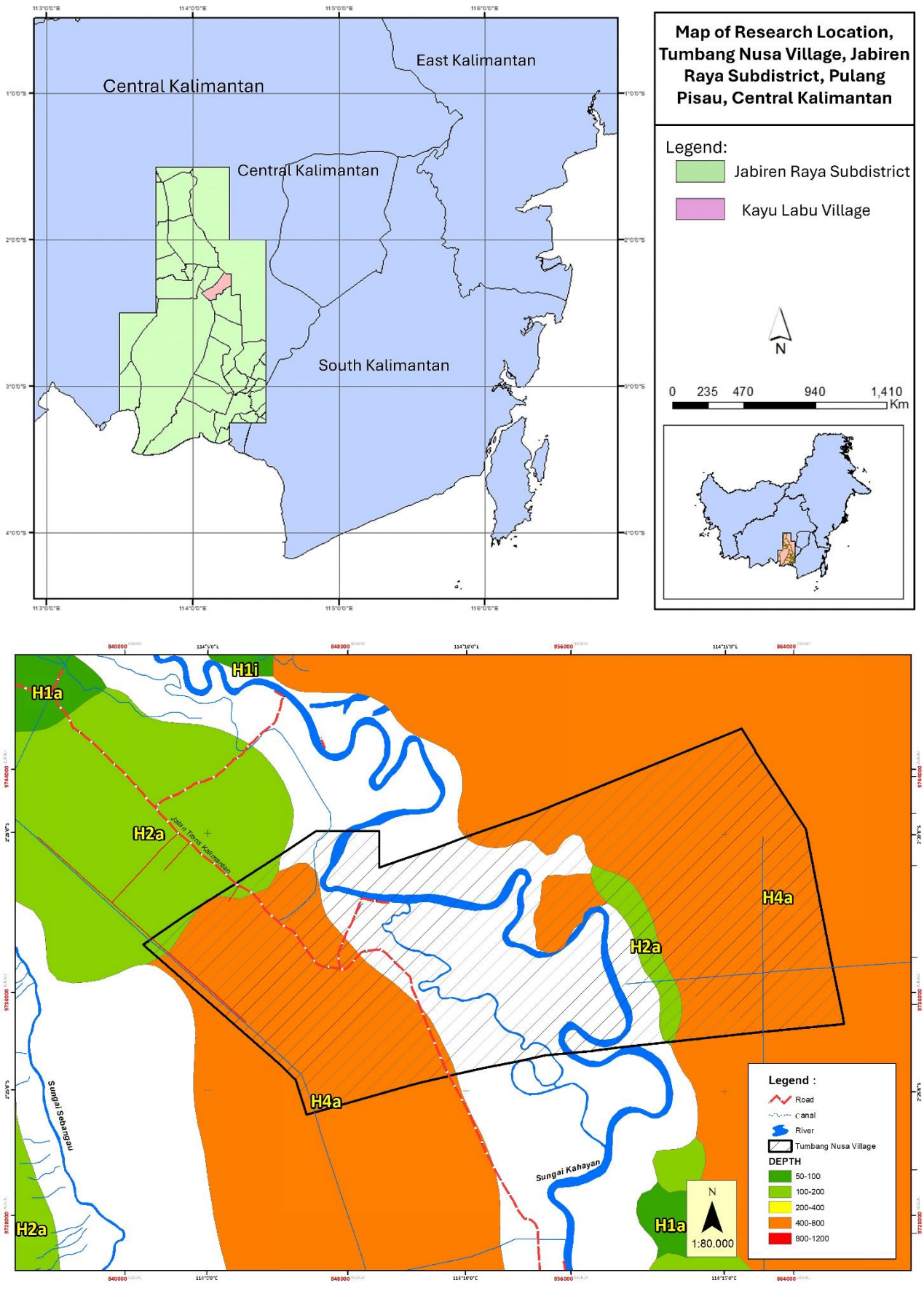

Figure 2. Tumbang Nusa Village. Above: map of the study site. Below: indicative map of the distribution of peatland (wetland) in the village.

villagers from the fire-prone area in Hamlet V. In Tumbang Nusa the (27) key informants were the Village Head, four village officers, the religious and Care Community Group leaders, three members of the Village Consultative Body, 14 farmers and three purun artisans.

The FGDs were used to deepen and triangulate data and information. These were held in October 2018 and November 2021 at Kayu Labu and in March 2019 at Tumbang Nusa. The FGDs involved representatives from the South Sumatra office of FOERDIA (Forest and Environment Research Development and Innovation Agency) and the village at Kayu Labu; and representatives from the South Kalimantan office of FOERDIA, the University of Palangka Raya (UPR) and the village at Tumbang Nusa. Ethical permissions were sought from key informants prior to all interviews and FGDs.

Data from the interviews and FGDs were transcribed and organised into categories according to the research questions, described and arranged into certain patterns, then synthesised in the form of illustrative charts, tables and descriptive explanations. Other qualitative results were analysed descriptively to capture particular phenomena, show relationships or interactions between variables, and build understanding of the study context.

An RACI matrix was constructed to describe the involvement of each stakeholder and relationships between stakeholder duties, roles and responsibilities (Watters 2013, Yogantara *et al.* 2022). For this, each stakeholder's involvement with a particular task was classified according to a four-point scoring system:

- **R**esponsible (for execution of the task);
- **A**ccountable (ultimately responsible for sign-off of the work or for decisions made);
- **C**onsulted (i.e. is consulted - through two-way communication - before deciding to undertake or before carrying out a task); or
- **I**nformed (receives information when the task has been completed, usually through one-way communication) (Graffius 2020).

RESULTS

Kayu Labu

The relationships between stakeholders identified as contributors to the prevention and control of peatland and forest fires are shown in Figure 3, and Table 1 summarises the role of each actor in a RACI matrix.

Peatland and Forest Fire Management was carried out primarily by the Fire Care Farmer Group (KTPA) as their main task and responsibility (Table 1). The KTPA was initiated by the Plantation and Animal Husbandry Office (OIC) of the OKI Regency. Its 14 members, selected from Hamlets I and II only, had been appointed and were coordinated by the Village Head, with each member receiving an incentive payment of USD 60 per month. The importance of the KTPA in facilitating fire prevention and control was recognised by most stakeholders in the village but, ironically, some villagers in Hamlet V - which had a large area of unused peatland and thus the highest fire risk - were not aware of the KTPA or its role. Operating resources for the KTPA were derived from village funds and allocated annually. Despite its central role, the KTPA was not fully effective because of insufficient funding, which limited its activities to the 3–4 most fire-prone months of the year, and its equipment was poorly maintained.

Two oil palm companies - PT. Sampoerna Agro and PT. Sentosa Agri Prima - also bore responsibility for fire control on land within and surrounding their concession areas, which included peatland. They possessed their own equipment. They had also funded the original procurement of fire-fighting equipment for the KTPA and provided training in its use. Training, as one of the knowledge improvement pathways, was also facilitated by the National Police and the BRGM. Using its own equipment, the Village Cooperation Unit (KUD) played a role in fire management through a 'nucleus-plasma' system linked to the oil palm plantations that were owned collectively by smallholder farmers within the village.

The village military representative (Babinsa) from the Indonesian National Army and the police conducted routine patrols to ensure that villagers were not starting fires. This discouraged farmers from clearing land by burning, for fear of sanctions. In addition, all stakeholders were responsible for reporting any fires. The Village Head was responsible for inviting all stakeholders to cooperate in fire-fighting. The villagers were required to work together to fight fires, especially fires that threatened their own land. All of these processes were intended to contribute to a reduction in fire frequency.

Each stakeholder had different imperatives that aligned with their personal motivations for participating in fire management. The villagers managed fires for social (helping relatives and neighbours) and economic (protecting their land and crops) reasons. Economic considerations were the main drivers for involvement of the oil palm companies and the KUD, as the main threat to their interests was fire on community and unmanaged land bordering their plantations. The work of the KTPA, Babinsa and police was monitored by superiors, so their failure to respond to fires as required could lead to disciplinary action.

Figure 3. Diagram of the relationships between stakeholders engaged in fire management in Kayu Labu. Internal village stakeholders (grey) were all answerable to the Village Head. Regency (blue) and national (orange) stakeholders facilitated and helped with fire management, also under the coordination of the Village Head. Babinsa: *Bintara Pembina Desa* (Village Development Officer from the Indonesia National Army); BRGM: *Badan Restorasi Gambut dan Mangrove* (Peat and Mangrove Restoration Agency); KTPA: *Kelompok Tani Peduli Api* (Fire Care Farmer Group); KUD: *Koperasi Unit Desa* (Village Cooperation Unit).

There was no specific planning for fire prevention and management, and discussions on this topic were usually a minor part of the agenda for village meetings. This was because fire control was centralised under the Village Head as the highest authority and decision maker, controller of the fire-management budget, and responsible person for liaison between the village and actors outside the village. All activities relating to fire management had to be reported to the Village Head, who carried sole responsibility for coordinating stakeholders and any other persons or agencies that were required to implement the response.

Before the dry season, the Village Head coordinated meetings to ensure readiness for fire prevention. Due to its highly fire-prone nature, Kayu Labu received regular visits at this time from representatives of the South Sumatran provincial government, army and police. This increased attention had worked to ensure that the Village Head was well-organised for the necessary fire-management preparations. The community of Kayu Labu and KTPA members were highly compliant, in part because the Village Head wielded a significant informal influence, supported by his family's high social status and being from the majority ethnic group.

In summary, all stakeholders had some role in fire prevention and control (Table 1) but, except for the BRGM, none had a role in the recovery process.

Tumbang Nusa

Several stakeholders contributed to the prevention and control of peatland and forest fires, and the major fires in 2015 and 2019 had resulted in an increase in their number (Figure 4). The role of each can be seen through the RACI matrix (Table 2).

As at Kayu Labu, the BRGM had no direct role in fire management but, in coordination with the District Environmental Office and Village Head, played a significant role in peatland restoration through facilitation and training of the MPA. The District Environment Office allocated funds for community empowerment, fire control training and maintenance of fire-fighting facilities and infrastructure.

Table 1. RACI matrix for the prevention and control of forest and land fires in Kayu Labu Village. R = Responsible, A = Accountable, C = Consultation, I = Information), * = if located at the fire site.

Stakeholder level	village				national			regency	
Stakeholder(s) / Tasks	Village Head	Farmer Group	KTPA	KUD	Babinsa	Police	BRGM	Agriculture & Livestock Office	Palm Oil Company
Establishment of the KTPA	R, A	I	-	I	I	I	I	C	I
Legalisation of the KTPA	C	I	-	I	I	I	I	R, A	I
Fire patrol	A	I	R	I	R	R	I	I	R
Informing if there is a peat forest fire (including coordination with other actors)	R, A	R	R	R	R	R	R, I *	R, I *	R, I *
Fire fighting	R, A	R	R	R	R	R	R, I*	I	R
Providing budget	R, A	I	I	I	I	I	R	I	R (voluntary)
Providing facilities and infrastructure	R, A	I	I	I	I	I	R	I	R (voluntary)
Maintenance of facilities and infrastructure	A	I	R	R	I	I	I	I	I
Knowledge improvement on fire management and prevention	R, A	R	R	R	R	R	R	R	R

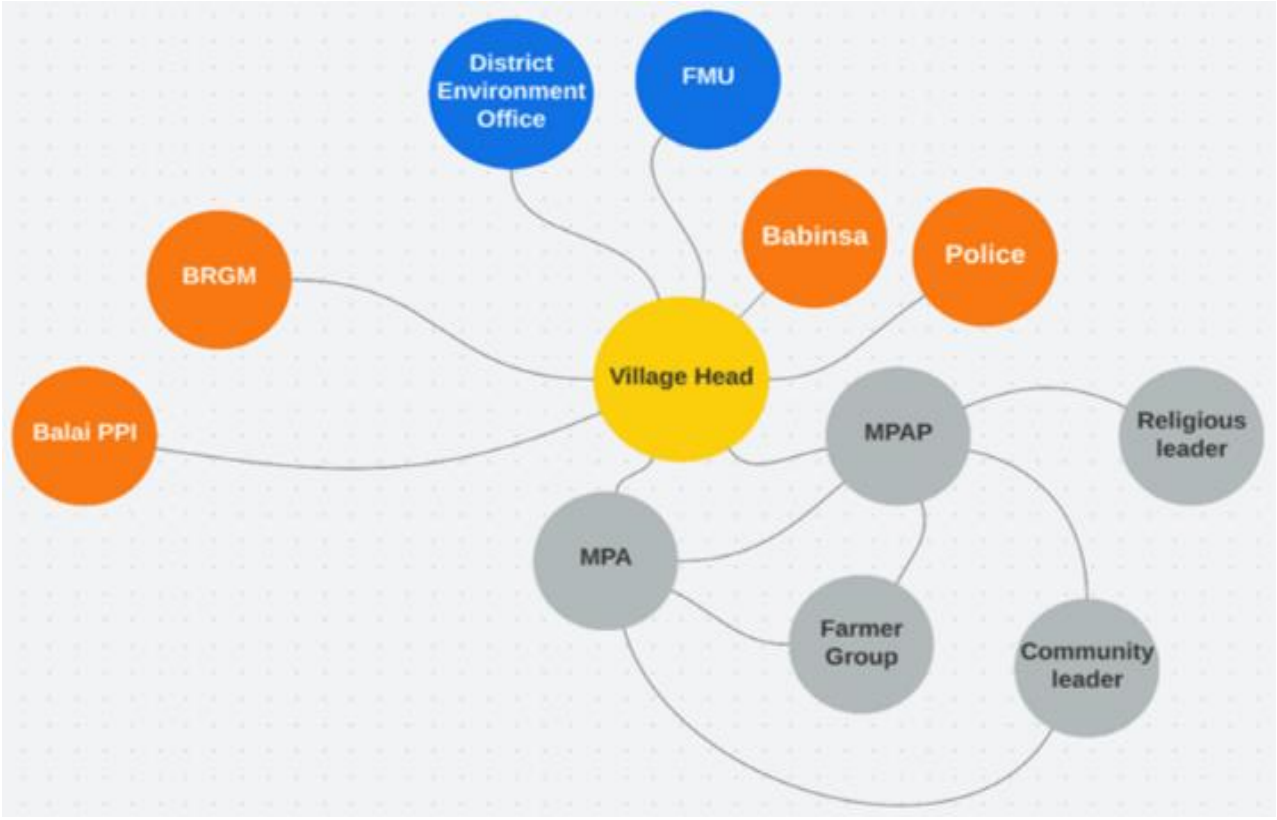

Figure 4. Diagram of the relationships between stakeholders engaged in fire management in Tumbang Nusa. For interpretation of the colour codes and stakeholders in common, see the caption to Figure 3. MPA: *Masyarakat Peduli Api* (Fire Care Community); MPAP: *Masyarakat Peduli Api Paralegal* (Paralegal Fire Care Community); Balai PPI: *Balai Pengendalian Perubahan Iklim* (Climate Change Office of the Kalimantan Region); FMU: Forest Management Unit.

The MPA was a group of volunteer villagers who wanted to be actively involved in efforts to prevent and suppress fires. They received regular training from authorised agencies along with financial incentives to carry out their duties. Their primary function was to facilitate fire prevention and control. This took the form of promoting the prohibition of burning for land clearing, conducting regular patrols, and extinguishing fires. The MPAP, which had a paralegal status, was a village entity that was formed by the Climate Change and Fire Control Office (*Balai Pengendalian Perubahan Iklim*; Balai PPI) of Kalimantan. In consultation with the Village Head, police, Babinsa, MPA and informal community leaders, the MPAP proposed fire prevention and control programmes to be considered by the FMU, District Environment Office, MoEF and BRGM. The FMU and Balai PPI trained MPA and MPAP members in the procurement and maintenance of fire control facilities and infrastructure, and in the socialisation of new regulations. The Balai PPI also contributed to the provision of information about hotspots and fire incidents. The BRGM provided equipment and training for fire-fighting and this was also supported by the village fund and the Balai PPI.

As at Kayu Labu, the Village Head was the key actor in fire prevention and control, and responsible for inviting external stakeholders - with whom he had extensive links - to manage and fight fires. At village level and through his responsibility for the MPA and MPAP, the Village Head directed these human resources. He also allocated budgets for these groups, but not for the purchase of fire-related equipment and infrastructure.

The community and religious leaders played a role in promoting fire prevention, and villagers responded to their suggestions. The police and Babinsa disseminated regulations on land clearing without burning and enforced the laws relating to land burning. They also functioned as hotspot informants for the MPAP.

Community participation in fire prevention and control was for economic rather than social reasons (such as helping relatives and neighbours), as each

Table 2. RACI matrix for the prevention and control of forest and land fires in Tumbang Nusa Village. R = Responsible, A = Accountable, C = Consultation, I = Information), * = if located at the fire site.

Stakeholder level	village						national				regency	
Tasks / Stakeholder(s)	Village Head	Farmer Group	MPA	MPAP	Religious Leader	Community Leader	Babinsa	Police	BRGM	Balai PPI	District Environment Office	FMU
Establishment and legalisation of the MPA	R, A	I	-	-	-	-	I	I	I	I	I	I
Establishment and legalisation of the MPAP	R, A	I	-	-	-	-	I	I	I	C	I	I
Fire patrol	A	I	R	R	-	-	I	I	I	C, I	I	I
Informing if there is a peat forest fire (including coordination with other actors)	R, A	R	R	R	R, I*	R, I*	R	R	R, I*	R, I*	R, I*	R, I*
Fire fighting	R, A	R	R	R	-	-	R	R	I	I	I	I
Providing budget	R, A	I	I	I	-	-	I	I	R	I	I	R
Providing facilities and infrastructure	R, A	I	I	I	-	-	I	I	R	I	R	R
Maintenance of facilities and infrastructure	A	I	I	I	-	-	I	I	R	I	I	I
Knowledge improvement on fire management and prevention	R, A	I	R	R	R	R	R	R	R	R	R	R

farmer's priority was to protect their own land and crops from fire damage. This lack of wider concern was because villagers considered that fire management was exclusively a matter for the MPA and MPAP. As stated by one of the key informants, "*Memadamkan api itu tugas MPA"* or "fire-fighting is the MPA's responsibility" and "*Masyarakat malah takut untuk memadamkan api duluan, takut disangka sebagai orang yang membakar lahan"* or "The villagers are even afraid to be seen fighting fires, as they are worried about being mistaken for arsonists".

There was no specific long-term plan for fire prevention and control at the village level. Planning was for one year only following the meeting to discuss the state of readiness. Besides the Provincial Environment Office, funding for training in fire management was provided by the Village Fund, the Balai PPI, the FMU and the local District (within the Regency) government.

In summary, the primary role of most stakeholders in Tumbang Nusa was fire prevention and control (Table 2). The BRGM, FMU and District Environment Office were also involved in restoration of fire-affected peatlands. However, as at Kayu Labu, this was not linked directly to fire management.

DISCUSSION

This study has shown how stakeholder mapping can be applied to clarify the effectiveness of fire management in villages that are dependent on peatland. Importantly, the Village Head was the crucial actor with the highest authority, whose position enabled oversight of the decision-making system linked to operational fire-fighting and prevention, the budget, internal and external coordination, and social participation. The Village Head was facilitated in discharging these responsibilities by having privileged access to (and control over) all natural resources in the village (Ekasari *et al.* 2020, Nugroho *et al.* 2021).

As the central figure, the Village Head was obliged to work with and synchronise the inputs of many, sometimes interrelated, stakeholders - at least eight actors at Kayu Labu and at least eleven at Tumbang Nusa - at village, regency and national levels. Even though stakeholder complexity at the village level is less than at the national level (Rochmayanto *et al.* 2021), this is inevitably a big challenge for the Village Head who, for successful fire management, must be competent, highly respected and in possession of the necessary leadership skills. For fire prevention at both villages, the Village Head was greatly assisted by the Babinsa and the Police enforcing the laws relating to land burning. At Tumbang Nusa but not at Kayu Labu, a select group of villagers supported this process by promoting the prohibition of burning.

The degree to which stakeholders are involved in a collaborative process can vary from a limited consultative role in which they have little say in decisions, to shared management and decision-making responsibilities (WWF 2000). In a previous study on peatland in South Sumatra, lack of coordination between some stakeholders, excessive bureaucracy and conflicting priorities worked against successful fire management (Budiman *et al.* 2021). In this study, the results indicated a largely collaborative approach at village level. In part, this was linked to the nature of the stakeholder involvement - either through government policy mandates or the need to protect plantation and agricultural assets - as well as respect for government policy. Together, these motivations contributed to overcoming some of the challenges of peat fire management at village level.

Insufficient funding for the operational needs of fire-fighting is a problem that is common in communities that are reliant on peatland (Nurhidayah *et al.* 2023). Hence, a positive outcome from the broad engagement of many stakeholders was the availability of additional funding to help meet the costs of material resources required for fire management. At Kayu Labu the main source was a Corporate Social Responsibility Fund set aside by the oil palm companies, and at Tumbang Nusa there were three sources, two national (*Anggaran Pendapatan dan Belanja Negara* or APBN through the Balai PPI, along with BRGM) and one of local government origin (*Anggaran Pendapatan dan Belanja Daerah*; APBD) through the Provincial Environment Office. These funds were used to provide equipment and training for the KTPA (Kayu Labu), MPA and MPAP (Tumbang Nusa), the training being of particular importance because villagers generally have limited skills in fire prevention and management (Widuri *et al.* 2023). This is a good example of an approach that delivers both private and public investment in fire management at village level (Clavet *et al.* 2021). These partnerships also help to overcome financial barriers to effective fire management in the FMUs (Budiningsih *et al.* 2020, KLHK 2020). Nevertheless, at Kayu Labu funding remained inadequate to support year-round fire management and to deliver the necessary skills for equipment maintenance.

Most stakeholders contributed to knowledge transfer. The practices taught were those being promoted at higher government levels. Within this approach, the traditional and social norms of fire management that villagers have applied for

generations were actively discouraged (Yamamoto & Takeuchi 2016, Fajarwati & Masruri 2019, Siombo 2021). If the intention of government directives is to achieve zero fire in a way that enhances the incomes and welfare of villagers, the stakeholders responsible need to leverage the villagers' collective knowledge into these new approaches to fire management in a way that leads visibly to improved outcomes (Li *et al*. 2015).

Stakeholder engagement in disaster management ideally incorporates prevention, mitigation, preparedness, emergency response and recovery (Widhagdha & Dewi 2022). In this study, stakeholder engagement ended when a fire was extinguished and was largely lacking during the recovery stage. This is a widespread problem in relation to burnt peatland in Indonesia (Carter 2008, Scheper *et al.* 2021, Cyr *et al.* 2022). Burnt peatland is an important criterion in determining which sites are prioritised for restoration (Lestari *et al.* 2023). At Kayu Labu and Tumbang Nusa, three stakeholders - the BRGM, the District Environmental Service and the FMU - had responsibilities for peat restoration, but these were not formally linked to fire management. A formal system for assessing damage levels and setting in place appropriate recovery measures would better service the needs of villages affected by fire.

At Kayu Labu, some villagers were unaware of the existence and role of the KTPA; and in Tumbang Nusa, those not recruited into the MPA chose to take no responsibility for fire control. An approach to resolving both problems might involve an institutional arrangement encouraging villagers to take responsibility by advancing participatory communication (Waluyo *et al.* 2024). However, to ensure that stakeholder engagement in this activity results in self-reliance and whole-community empowerment in extinguishing fires (Widhagdha & Dewi 2022), the uncertainty in villagers' minds about whether penalties might apply needs to be addressed.

The villagers' fear of sanctions at Kayu Labu and of being accused of arson at Tumbang Nusa if they became involved with fire illustrates an outcome of the underlying conflict of interests between national stakeholders and the villagers. Based on the view that burning biomass results in nutrient losses (Wildayana *et al.* 2017) and creates a risk of catastrophic fire (Hamzah *et al.* 2019, Mulyanto 2019), the key message delivered by national stakeholders was that the practice of *sonor* farming was no longer acceptable. Other stakeholders supporting this view, for example academics and NGOs, regard peatlands as fragile ecosystems that must be protected and may also argue that the fires which formed the basis of this study are an outcome of mismanagement by the villagers (Syahza *et al.* 2020, Safitri 2021). Government directives supporting these views, as well as the fear of prosecution and sanctions (Carmenta *et al.* 2021), have led to a retreat from *sonor* farming and subsistence-oriented agriculture involving fire (Smith *et al.* 2022). Historically, villagers have regarded peatlands as natural assets that are used to support livelihoods, so their main concern is inevitably that enforcement of the government's no-burn policy will compromise their livelihoods. Whether this is correct or otherwise, it remains necessary for all stakeholders to unravel the problems associated with continued livelihood dependency on peatland resources (Purnomo *et al.* 2017), albeit in an environment associated with a much-reduced fire risk. This process should incorporate respect for the villagers' own knowledge of fire management (Nikolakis & Roberts 2020, Rochmayanto *et al.* 2021).

In conclusion, mapping the key stakeholders and their role in peat-fire management has shown that multiple stakeholder groups can potentially leverage the required outcomes at village level (Caggiano 2019). Importantly, the central role of the Village Head was crucial to establishing, at least in part, a role for the villagers in fire prevention and control. The two outstanding issues identified were a failure to fully engage villagers because of the threat of sanctions, and a lack of attention to peatland restoration and recovery following a fire. These shortcomings raise concerns that the current system, which focuses solely on fire control, does not fully recognise the need to protect the livelihoods of villagers. Therefore, our findings support the view that policy settings and resources for fire management need to be better adapted to the longer-term requirements of the villagers (Schultz & Moseley 2019) in a way that fully engages them in what should be a more comprehensive, integrated and sustainable approach to fire management.

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AUTHOR CONTRIBUTIONS

YR, NS, LvK and LR conceived and designed the research. YR, NS, MI, MAQ, MAA and AA performed the data acquisition in Tumbang Nusa; and BW, SL LREM, RA and TY performed the data acquisition in Kayu Labu. YR, NS, MI, BW, SL, MAQ, MAA, LREM, RA, TY and AA analysed and interpreted the data and wrote the manuscript, which was revised and finalised by YR and DM. DM, LvK, LR and NS contributed to conceptualisation of the initial proposal and the acquisition of funding, and supervised the project.

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