

Tropical peatland village communities' self-perceived attitude and behaviour changes regarding fire usage

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SUMMARY

Indonesia has the world's second largest national extent of tropical peat deposits, after Brazil. Forest and land fires cause serious disturbance to these peatlands. Whereas more than two million hectares of peatlands burned during 2015, there was an overall decrease in the incidence of fires between 2016 and 2019. This raises the question of whether the decline was due to a change in the behaviour of human communities with regard to their use of fire. This study investigated self-perceived attitudes and behaviour changes amongst communities living in peatlands. Two villages in each of three districts (Pulang Pisau, Kapuas, OKI) within two provinces (Central Kalimantan, South Sumatra) were included. In-depth semi-structured interviews based on a questionnaire were conducted with 90 respondents (15 people per village). The results showed the perception that nearly all fires were caused by people using fire on small-to-medium pieces of land. Post-2015, social conditions were influenced by the creation of new regulations prohibiting burning, innovations in technology, and developing knowledge of the negative effects of fires on the economy. Thus, communities had been made more aware of the importance of preventing fires. This led to reduced interest in burning land and a willingness to start applying modern technology to the preparation of land for various uses. Most community members had actively participated in fire prevention activities. People felt that community landowners carry the greatest share of responsibility for managing their land. The dominant perception was that the ban on burning, socialised at village level, was one of the main reasons for the reduced incidence of fires. The existence of village fire control teams (MPAs), which provide fire-fighting equipment and knowledge, was perceived to strongly support changes in community attitudes to reducing fires. We emphasise that this study presents self-perceived changes in community attitudes and behaviour in using fire

KEY WORDS: burning, Indonesia, land preparation, livelihood, peat swamp forest

INTRODUCTION

Peat swamp forest ecosystems have an important function in stabilising the climate by mitigating global warming (Gaveau *et al.* 2014, Applegate *et al.* 2016). From a utilisation aspect, peat swamp forests are a source of germplasm (Bellamy 2017, Bappenas 2009); and from a social perspective they act as a source of livelihoods (Dinomika *et al.* 2024). Indonesia has about 14.9 million hectares of peat swamp forests (Wahyunto *et al.* 2014) which are spread across the islands of Sumatra, Papua, Kalimantan (Borneo) and Sulawesi as well as the Nusa Tenggara Islands. Previously, it was thought that Indonesia hosted 50 % of the world's total tropical peatland area, but recent discoveries of additional peat deposits in the Congo Basin and

South America mean that Indonesia now ranks as the country with the second largest known area of tropical peatland after Brazil (Page *et al.* 2010, CIFOR 2023).

In recent years, the condition of Indonesian peat swamp forests has changed dramatically through unsustainable use (Wahyunto *et al.* 2016). The vertical structure of the forest has been degraded such that many areas now have open-canopy forest, resulting in the development of large amounts of fuel in the form of ferns and shrubs which burn easily when dry (Hoscilo *et al.* 2011). If ignition occurs, the fire will easily spread to consume the available fuel through the processes of convection, conduction and radiation, then may enter the soil and develop into a peat fire (Graham *et al.* 2022). Forest and land fires have become almost annual events in Indonesia, and

are now becoming a further cause of damage to peat swamp forests as well as a strong source of carbon emissions with implications for climate change (Ballhorn *et al.* 2009, Bappenas 2009, Applegate *et al.* 2016).

Almost all forest and land fires in Indonesia originate from land clearing and other human activities related to the livelihoods of communities living around the forest (Page & Hooijer 2016, Purnomo *et al.* 2017, Goldstein *et al.* 2020). There are also instances of companies deliberately burning to clear land for planting crops (Dennis 1999, Couwenberg *et al.* 2010). This shows that cultural influences and community habits can influence the nature and occurrence of fire throughout the districts of Indonesia, meaning that the insights and perspectives of both indigenous communities and transmigrant settlers are needed to better understand the characteristics of forest and land fires that commonly occur in each locality (Gellert 2005, Doğan 2017). Knowledge of forest and land fire dynamics must be contextualised by local wisdom, traditional knowledge and practice; as well as by the education and training received by the community, existing infrastructure, economic conditions, and the government and private institutions that are actively involved in fire management efforts.

One important influence on change within a community is innovation from outside institutions that can improve land use habits and also support transitions of community practice (Loarback *et al.* 2017). Examples of success would be communities that have been able to move away from management methods which are not environmentally sound, such as using uncontrolled fires as part of their livelihood activities, and instead adopt practices which can minimise unwanted fire on community land. Therefore, research on behavioural changes in the use of fire at community level is urgently needed to determine to what extent communities across a range of districts have made progress towards reducing the incidence of wildfires. This study aimed to:

- explore how communities' attitudes and behaviour towards fire usage has changed in recent years, notably since the 2015 wildfires;
- determine how efforts in the form of education, training, infrastructure and law enforcement provided to communities influenced changes in community behaviour, particularly after the 2015 wildfires; and
- assess how any changes related to the social characteristics of the communities.

We emphasise that the findings presented in this article focus on the communities' self-perceived

attitude and behavioural changes and the causes of the self-perceived changes, without testing whether the self-perceived changes translate into actual changes on the ground, measured quantitatively in terms of the number of hotspots and the area burned in each village. However, the results will be used to develop more effective and efficient fire prevention solutions that can benefit communities living on peatlands throughout Indonesia.

METHODS

Study site and duration

The research was carried out in three districts of Indonesia, namely Pulang Pisau and Kapuas districts in Central Kalimantan Province and Ogan Kemering Ilir (OKI) district in South Sumatra Province. Fire incidence was high in these two provinces during 2015. Two villages situated adjacent to peat domes were selected in each district. The villages were: Tumbang Nusa (2° 24' 21" S, 114° 15' 36" E) and Tanjung Taruna (2° 11' 22" S, 114° 02' 48" E) in Pulang Pisau district; Mentangai Hulu (2° 29' 20" S, 114° 29' 48" E) and Sei Ahas (2° 22' 05" S, 114° 24' 30" E) in Kapuas district; and Kayu Labu (3° 35' 29" S, 105° 13' 01" E) and Pulau Geronggang (3° 36' 36" S, 105° 07' 54" E) in OKI district. These villages were chosen because they had all experienced severe fires. The data were collected from October to December 2021.

Data collection

Data were collected using two methods, namely:

- conducting a census by direct interviews with village government officials and community and customary leaders in the village, to explore the efforts invested in each village aiming to bring about change (5–6 participants); and
- conducting structured in-depth interviews with villagers arranged within a questionnaire format (15 participants per village). The questions explored self-perceived changes in attitude and behaviour towards fire usage. Informal conversations with participants and small groups were also undertaken where necessary to improve understanding and reduce confusion across and between participants.

Census methods

The collection of census data was used to discover the extent of efforts from government, private and NGO sectors in relation to reducing forest and land fires. The categories included: capacity building activities through education and training of local

communities including work in schools; facilitation of physical resources such as canal blocking and wells; facilitation and application of equipment in the field such as pumps and hoses; and implementation of law enforcement to provide a deterrent to arson offenders. For each category, the questions (see Appendix) addressed the number of events held, the number of people involved, and the cost.

The census was aimed at community leaders including village heads, village secretaries, village officials, traditional leaders, village councils associated with village planning and development, and village fire-fighting chairmen/members. All participants were willing to be interviewed; they were mainly local indigenous people who were known to the community as figures who had sound knowledge about village history as well as various village events focusing on fire prevention and community empowerment.

Interview methods

Structured in-depth interviews, arranged in the form of a questionnaire (see Appendix), were conducted to obtain information about the community's direct experience of forest and land fires and what their perceptions were as a result of these events (Greenhill *et al.* 2019). Our questionnaire allowed for in-depth discussion with local community members, while providing a structured format and quantitatively ranked responses in addition to qualitative descriptions. This enabled a deeper dialogue and understanding between researchers and participants, whilst also allowing consistent quantitative analysis to be carried out between and across the three districts.

In order to understand how far the perceptions of the communities living around the forest had changed with regard to forest and peatland fires, a number of questions were asked on topics including: social behaviour related to burning land; participation in fire prevention activities; opinions on fire prevention methods; opinions on the obligations of different parties in relation to fire control; knowledge about forest fire prevention programmes and their benefits; experience regarding the frequency of burning in the community before the forest and land fires of 2015 and 2020; and the likelihood of fires in the future (2025). Questions of a technical nature included: the proportion of the community using fire; the causes of forest and land fires; what happened after the regulation prohibiting burning of land by the community was issued; the reasons for some community members still burning; the attitudes and perceptions of the community after 2015; how government and the private sector intervened in their efforts to prevent fires; how the socialisation of fire

prevention was carried out by the government; and how the community felt about the government's efforts to prevent fires. The final questions probed the community's feelings and views about a scenario in which there was no more burning. These included: the views and actions of the village community if they saw someone carrying out land preparation without burning; estimates of the percentage of the farming community that no longer burned; and why non-farmers no longer burned.

Fifteen respondents consisting of a balanced mix of men and women were selected from each village, based on the following conditions: more than 18 years old; agreed to be interviewed; and had lived in the village for more than six years. In addition, respondents were prioritised to meet a range of the following criteria: frequent participants in forest and land fire-fighting training, restoration or community development activities; active collectors of natural resources from peatlands such as fishermen, swiftlet bird house owners, forest wood or log collectors, hunters, and collectors of other non-timber forest products; a range of all the religions in the village; women who were heads of households; people with low economic status; people with high school education and higher education; people who work or have worked for oil palm or timber companies; members of the Family Welfare Programme; and members of village farmer groups.

Ethics

We received ethical clearance from CSIRO before starting to collect data in the field. The code of ethics for social research, specifically regarding permits from village heads and related service institutions, was followed to uphold the honour and confidentiality of respondents, local village officials and related institutions. The research was carried out during the COVID-19 pandemic, so we conducted one-to-one interviews rather than focus group discussions. The health protocols were also followed, to minimise risk to participants and researchers.

Positionality

We acknowledge that, as with all social science research, those conducting the interviews and their relationships with the interviewees will influence the degree of trust and accurate knowledge sharing that is provided. All researchers who carried out the questionnaire surveys were long-term Indonesian residents of the same district. They were all from known local government or non-government organisations (NGOs), and the scope of this work had been socialised and active within each village since 2018 (i.e. for at least three years). Community

members were able to review and discuss the consent form and withdraw from participating at any point. The researchers invested time and sat with respondents, also conducting informal discussions and meetings, to build trust and answer questions. The respondents' anonymity and the fact that only averaged data would be reported or shared was made clear. Given these elements, we believe that most of the information provided was honest and accurate.

Data analysis

Data analysis involved descriptive and quantitative testing. Qualitative data were analysed descriptively by grouping the data, then tabulating and narrating the themes that arose by looking at strengths, weaknesses, opportunities and challenges. To help describe the qualitative data through quantitative analysis, many of the interview questions were presented with a ranking system such that averages, standard deviations and percentages could be calculated. Qualitative analysis was mainly used to capture differences in the communities between the different districts and provinces.

RESULTS

The results are grouped into three sections, namely:

- how the habits of communities in the research area relate to the occurrence of peatland fires;
- what preventive measures at village level were taken by the government and other parties after the 2015 forest and land fires; and
- changes in the community's views that have occurred since these interventions were implemented.

Socio-economic conditions, behaviour and perceptions of communities

The people living in each district largely belonged to indigenous communities. Pulau Pisau was dominated by Dayak (93.3 %) and Banjar (6.7 %) ethnicities while Kapuas was mainly Dayak (93.3 %), Banjar (3.3 %) and Javanese (3.4 %). There were eight ethnic groups living in the OKI research area, namely Ogan (46.7 %), Javanese (23.3 %), Pangkalan Lampam (10 %), Kayu Labu (6.7 %), Sundanese (3.3 %), Malay (3.3 %), Seri Pulau (3.3 %) and Gerunggang Island (3.4 %) (Table 1). Land management approaches and traditions may vary across and within ethnicities.

Most community members had received education to elementary or secondary level, although a small proportion had undergraduate qualifications.

The main source of livelihood in Pulau Pisau was fishing, followed by government or private employment, then agricultural farmers, breeders and traders. In contrast, Kapuas was dominated by farmers, followed by government employees, fishermen and traders. Likewise, the community in OKI were mainly farmers and employees, followed by craftsmen, non-timber forest product harvesters and traders. The dominance of smallholders, non-timber forest product harvesters and fishermen around the forest areas in all three districts reflects the high dependence of these communities on forested peatlands (Greenhill *et al.* 2019, Dinomika *et al.* 2024). Across all three districts, community members largely owned their agricultural land and only a small portion rented land for their livelihood activities.

Crops planted by community members on their land included thirteen species in Pulau Pisau, seventeen in Kapuas and seven in OKI. These consisted of annual plants and seasonal food plants. Seven types of annually-fruited trees, rattan and five seasonal crops were cultivated by the community in Pulau Pisau, while nine species of annually-fruited trees, rattan and seven food crops were grown in Kapuas. Only three annually-fruited tree species and four seasonal food crop species were cultivated in OKI (Table 1). The crops planted showed evidence of culture related to the use of fire. Across all three districts, most landowners (60–80 %) cultivated the land themselves. A smaller fraction (20–40 %) of the community used labourers to cultivate their land. In other words, most of the community worked their own land and, therefore, had direct experience of managing their fields.

Prior to the 2015 forest fires, the community used to practise burning for various purposes including shifting cultivation and opening access to the forest. Our results show that people in Pulau Pisau felt they could burn land as there were no rules to prevent them from lighting fires, so they would follow traditions passed down from generation to generation. They believed this would make the land more fertile, it was an effective way of opening access to land, and they did not yet feel any negative effects (Table 2). In Kapuas, soil quality was the primary motivator, as burning was believed to make the land more fertile and this related to longstanding land-management traditions. Other reasons included: they knew of no other techniques for clearing land; burning would clear large logs; and it was a practical way to clear land. Land burning in OKI was motivated by the belief that it made the land more fertile, reduced labour inputs and was a practical way to clear land, as well as by traditional practices (Table 2).

Table 1. Socio-demographic profile of the participants. NTFP = non-timber forest production.

Variable		Pulang Pisau (n = 30)	Kapuas (n = 30)	OKI (n = 30)
Average age (years; $\pm$ SD)		43.8 $\pm$ 7.6	43.6 $\pm$ 13.6	44.9 $\pm$ 10.2
Ethnicity (%)	Dayak	93.3	93.3	
	Banjar	6.7	3.3	
	Jawa		3.4	23.3
	Ogan			46.7
	others (6)			26.7
Highest level of education (% of sample)	Primary	30.6	40.0	36.7
	Secondary	63.3	46.7	60.0
	Bachelors	6.6	13.3	3.3
Livelihood strategy (% of sample)	Fishing	70.0	13.3	
	Agriculture	10.7	46.7	46.7
	Livestock	3.3		
	Shopkeeper	3.3	10.0	6.6
	Crafts			10.0
	NTFP			10.0
	Employee	13.3	30.0	26.7
Hired labour (% of sample)		20.0	33.3	40.0
Land tenure	Owned	96.7	73.3	70.0
	Rented	3.3	26.7	30.0
Mean area of land managed (ha; $\pm$ SD)	Total	4.4 $\pm$ 0.7	7.8 $\pm$ 1.6	4.2 $\pm$ 0.8
	On peat	2.3 $\pm$ 0.4	2.0 $\pm$ 0.3	5.6 $\pm$ 0.9
Types of crops grown	Acacia		•	
	Banana		•	
	Belangeran	•	•	
	Buah asam		•	
	Cashew	•		
	Cempedak		•	
	Chilli	•	•	•
	Corn	•		
	Eggplant		•	
	Gelam	•		•
	Guava		•	
	Jelutung	•		
	Mango		•	
	Oil palm	•	•	•
	Peanut	•	•	
	Pepper		•	
	Pineapple	•		
	Rattan	•	•	
	Rice	•	•	•
	Rubber	•	•	•
	Sengon	•	•	
	Tomato		•	•
	Watermelon			•

Government investment in fire prevention

Education and training, provision of physical and technological resources and law enforcement have been implemented to a greater or lesser extent in all villages in the study areas. These investments can be categorised as follows:

- fire control training for MPAs, which are village community fire teams (*'Masyarakat Peduli Api'*, literal translation 'Fire-Care Community');
- field schools on peatland farming without burning;
- building canal blocks installing dipwells, providing fire extinguishers and constructing drilled wells;
- workshops in schools and in the community; and
- law enforcement and punishment in relation to the use of fire.

All villages received forest and land fire training except for one of the villages in Kapuas district. Three villages (two in Pulang Pisau and one in OKI) carried out fire patrols and received a monthly fee when conducting patrols. Participation in field schools for farmers (organised by the Ministry of Environment and Forestry) was reported in Pulang Pisau district only. In these field schools, participants were taught how to clear land for agricultural purposes without fire and practised it for several days. Participants could see directly the practice of clearing agricultural land without burning and experience its positive effect on the environment. Canal blocking was carried out in the Pulang Pisau and Kapuas villages. Canal blocking aimed to raise the overall water table, so that the peat soil around the

canal would not dry out during the dry season. The dams were sometimes made of wood or had concrete walls. In the villages in Pulang Pisau and Kapuas, workshops were held several times in school buildings and community meeting halls. These workshops discussed existing regulations regarding forest and land fires and environmentally friendly livelihood options, as well as the negative effects of forest and land fires and ways to prevent large and widespread fires. In all villages except one in Pulang Pisau, there were almost no reported incidents of fire violations resulting in punishment. The most costly of these interventions was the implementation of community fire control training.

Changes in community perceptions

In this section we consider how the perceptions and understanding of village communities regarding fire management have changed, including:

- community progress towards not burning;
- who is still burning their land, and why;
- the effectiveness of government and other initiatives to prevent fires;
- institutional responsibility for preventing fires; and
- the community's reasons for stopping burning.

First, we outline the views of people living around the peat forest regarding community behaviour towards burning. Community members of all villages in Pulang Pisau, Kapuas and OKI stated that, prior to 2015 when there were no rules relating to burning, almost every resident had a tradition of burning when land was cleared for various purposes and they

Table 2. Reasons given for historical burning by the community. The percentage of respondents providing each reason per district is shown.

Reason	Pulang Pisau	Kapuas	OKI
Saves labour	0.0	0.0	26.1
Tradition from long time ago/ancestors	6.7	29.2	8.7
There was no fire ban	73.3	4.2	0.0
Burning makes the land more fertile	6.7	33.3	34.8
Practical way to open up access to land	6.7	4.2	21.7
To clear big logs	0.0	8.3	0.0
No other way	0.0	16.6	4.3
No need for heavy equipment	0.0	4.2	0.0
Impact is not significant	6.7	0.0	0.0

almost always used burning to clear forested land. However, by 2020 they burned only occasionally, and their predictions for 2025 indicated they may never burn again for land preparation (Figure 1). Overall, the percentage of respondents from all six villages who said they still use fire to clear land for various purposes was small, at less than 6.1 %.

For the small portion of the community who are still burning, the motivations given by respondents can be outlined as follows: they know how to burn; other people also burn; they are satisfied with the results of burning; burning has become a tradition handed down by their ancestors; burning is the best way; there is no other way; and burning is an easy and cheap method. These reasons were similar and present across all villages and districts.

The specific reasons given by respondents in Pulang Pisau as to why they still use fire for land clearing were as follows: opening access to *beje* (natural fishponds); construction of buildings; maintaining rubber gardens; and continuing with local wisdom and cultural practice. In Kapuas, the reasons given for continuing to burn included making the land fertile and growing crops, but most respondents said they did not know why. In OKI the reasons included planting trees, so that the land becomes fertile, and to avoid the capital costs of clearing the land manually (Table 3).

The respondents were also asked whether they thought forestry companies, oil palm companies or other nearby villages (locally considered to be the main players) were the main cause of fires that did not originate from people within their own village.

Community members in Pulang Pisau were of the view that individual forestry companies still occasionally burn land, followed by oil palm companies. The village communities in Kapuas and OKI thought that all three of these stakeholder categories still occasionally burn (Figure 2).

The knowledge of community members in relation to fire management has been increasing, with many people being able to identify specific activities that have led to forest and land fires; for example, slashing and stacking slash with subsequent burning of the debris piles has occasionally resulted in fires in Pulang Pisau and Kapuas. When not managed properly, the use of flammable fuel in application of chemicals such as herbicides during the dry season has also resulted in land fires in Pulang Pisau, Kapuas and occasionally OKI. The sale of land was also noted to have resulted in burning of idle and unmanaged land, to demonstrate land ownership and/or remove unwanted debris, that initiated much bigger fires. It was said that changes in cropping patterns such as strip cropping has also occasionally caused fires in Pulang Pisau, Kapuas, and rarely in OKI. Fishing activities in peat swamps also occasionally cause fires in all three regions. Clearing for road access can occasionally cause forest and land fires in Pulang Pisau, and almost always results in fires in Kapuas. Hunting activities in forests and thickets can occasionally cause forest fires in Pulang Pisau and OKI, and sometimes in Kapuas. It is worth noting that field cooking fires have been allowed to escape in Pulang Pisau, and sometimes also in Kapuas and OKI.

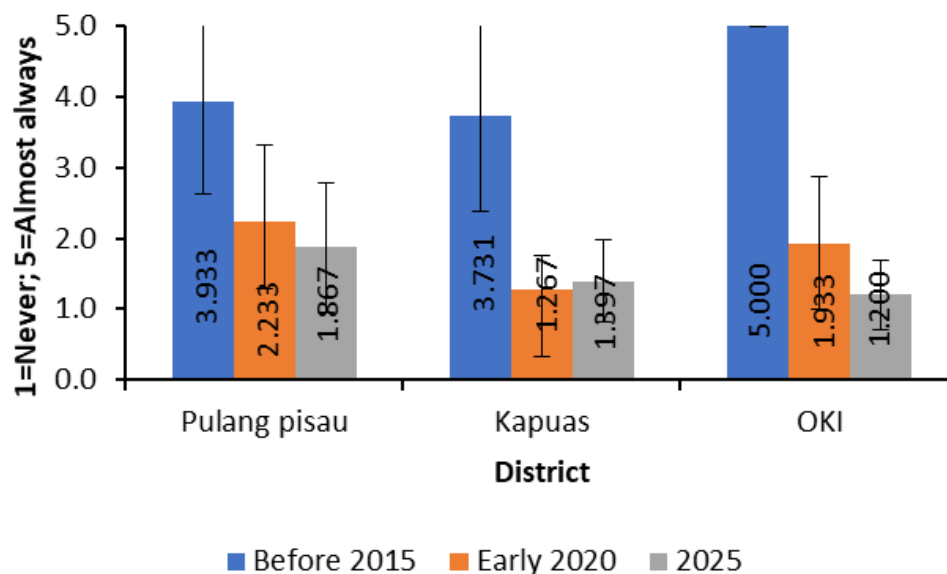


Figure 1. Average rankings ($\pm$ SD) for community perceptions of the frequency of burning by the community before and after the prohibition of 2015.

The communities' perceptions of the provision of guidance and outreach by government and the private sector can be summarised by stating that all villages stood between agreement and neutral on the question of whether they had been given sufficient understanding and knowledge to manage their land without burning. Almost all respondents agreed that they were able to carry out land preparation without burning. Communities in the six villages shared the same view that they wanted government assistance with land clearing, especially for agricultural activities and to open up access to fishing. They felt that they had not received assistance with carrying out land preparation without burning, but that some land clearing without burning had been carried out independently. All respondents said that fires occur only during the dry season and are the result of human activity (Figure 3).

The level of community knowledge regarding village-level programmes aiming to prevent forest and land fires was fairly high in OKI, well known amongst the people of Pulang Pisau and somewhat known for the villagers in Kapuas (Figure 4). The existence of the MPA was well known in Pulang Pisau and OKI, and to some extent known in Kapuas. However, there were other programmes in Kapuas such as farmer groups and fishery groups and, as a whole, the communities felt they knew quite a lot about fire prevention. There was environmental socialisation from the private sector, which was also somewhat known to respondents with the exception of those living in Kapuas. The government prohibition on burning land was one of the best-known programmes amongst all respondents across all districts. The village communities in OKI were very familiar with the fire prevention programme,

Table 3. Reasons given for present-day burning by the community. The percentage of respondents providing each reason per district is shown.

Reason	Pulang Pisau	Kapuas	OKI
Planting vegetation	25.9	3.3	17.2
To make the land fertile	0.0	6.7	3.4
To open access to <i>beje</i> (fish ponds)	55.5	0.0	0.0
Don't know	3.7	86.7	62.1
Tending rubber plantation	11.1	0.0	0.0
No capital to open up land	0.0	0.0	10.3
Local wisdom continuation	3.7	0.0	0.0
I know I should burn but cannot give a reason	0.0	3.3	0.0

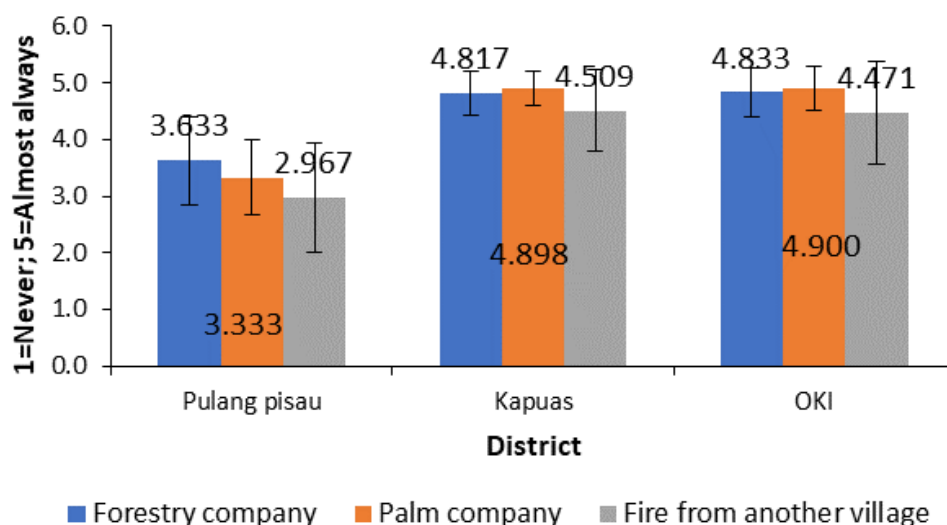


Figure 2. Average rankings ($\pm$ SD) for community perceptions of actors outside the community who are linked with land clearing using fire.

while the communities in Pulang Pisau and Kapuas knew quite a lot about it. The socialisation of land and forest fire information effected by government through the MPAs (*Manggala Agni DAOPS*) was well known to the villagers in OKI and Pulang Pisau, while those in Kapuas said they knew only a little but also had information relating to fines for arsonists.

We now turn to the community's views on the institutions responsible for fire prevention. In both OKI and Kapuas it was felt that the primary

responsibility for preventing fires lies with the local community and local land owners, closely followed by district and then provincial government, whilst the lowest responsibility was assigned to NGOs and researchers. Likewise, in Pulang Pisau it was felt that the community owning the land has the highest responsibility for preventing forest fires, but also that individual forestry companies and land occupiers have the second highest responsibility, followed by district and provincial governments.

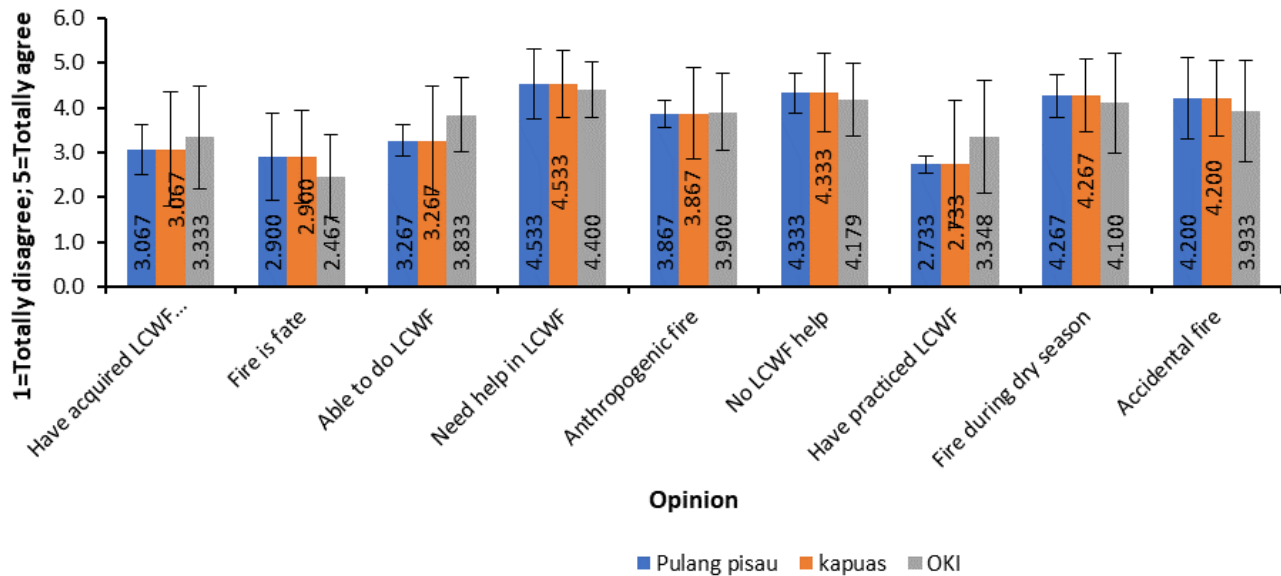


Figure 3. Average rankings ($\pm$ SD) for perceptions of the level of community preparedness for fire prevention (LCWF = land clearing without fire).

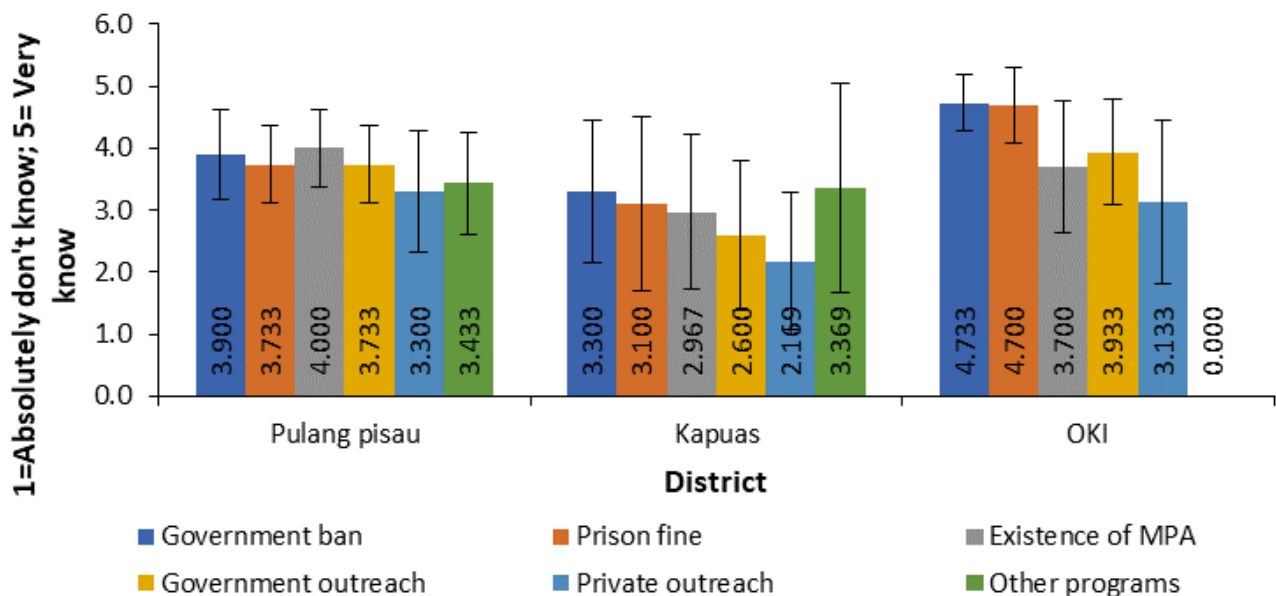


Figure 4. Average rankings ($\pm$ SD) for the level of community knowledge of six government programmes that aim to prevent forest and land fires in the village.

In Pulang Pisau the government programmes which were felt to be most beneficial by community members were the government ban on burning and the fines for offenders, as well as the existence of the MPAs. The response was similar in OKI, but government outreach (dissemination of regulations and livelihood training) was felt to be more helpful than the MPA. However, in Kapuas, it was the MPA, government outreach and other programmes such as fishery and plantation farmer groups, that were most helpful in preventing fires (Figure 5). In general, community opinion was that most of the community

has stopped burning. Not burning due to fear of legal sanctions was the primary reason given by all respondents. Other important reasons included their wish to avoid the negative effects of smoke. They also mentioned that they want to try not burning when clearing land because they do not want to disturb neighbouring landowners, and it is important to them that they should be well-perceived socially within the community. Only one statement was generally disagreed with by all respondents; they had not stopped burning because they wanted gifts or rewards (Figure 6).

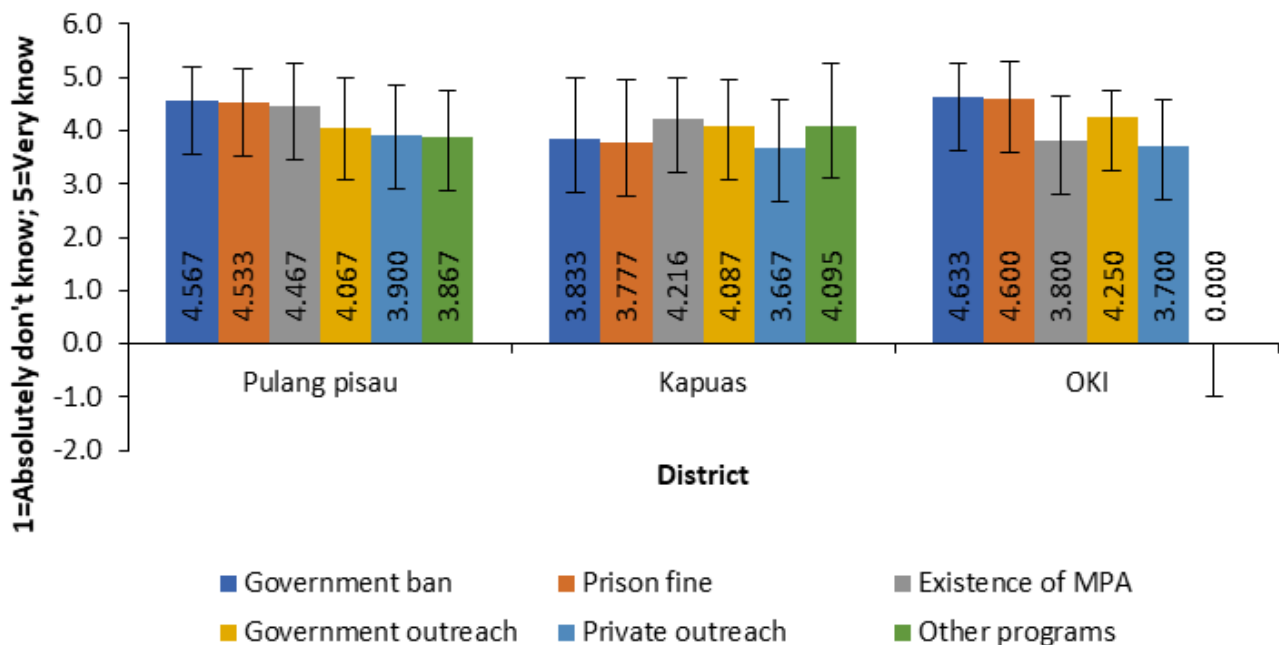


Figure 5. Average rankings ($\pm$ SD) for government programmes in terms of how beneficial they were at village level.

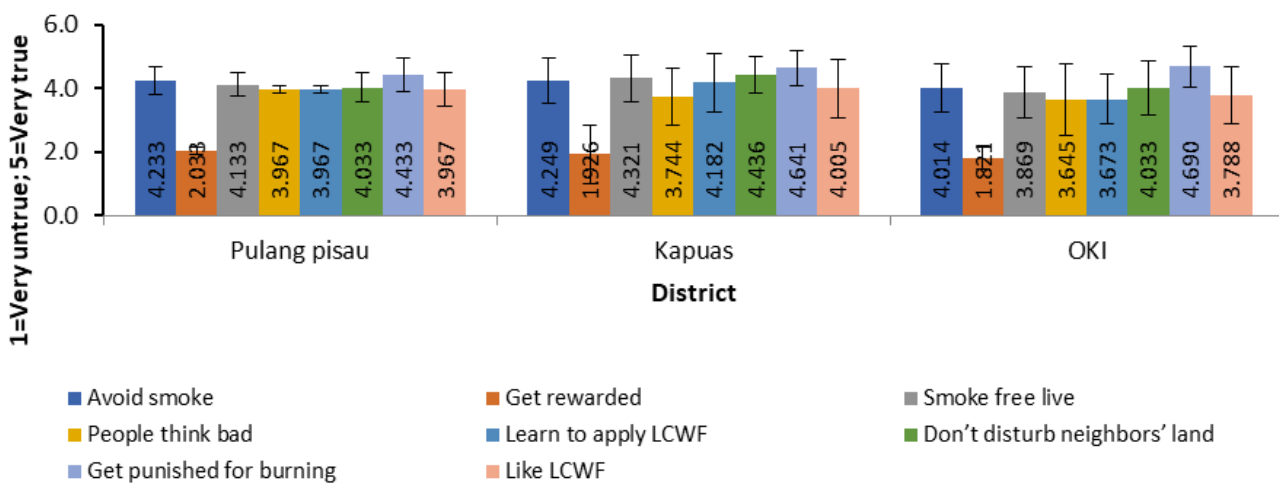


Figure 6. Average rankings ($\pm$ SD) for different reasons provided by community members for stopping burning (LCWF = land clearing without fire).

DISCUSSION

The ecology and effects of burning peatlands

Burning to prepare agricultural land has been practised for thousands of years in Indonesia (Goldammer 1990); but only recently on peatlands, which do not burn in their natural wet state. In recent years Indonesian peatlands have become highly vulnerable to fires, producing toxic smoke haze and large amounts of greenhouse gas emissions (Glover & Jessup 1999, Page & Hooijer 2016). This has occurred because it has become increasingly popular to clear and drain peatlands for agriculture and forestry, which often results in peat soils drying out and becoming prone to fire (Dohong *et al.* 2017). Fire-prone conditions occur during the dry season and are exacerbated when the weather remains dry for several months as a result of the natural weather phenomenon known as El Niño. Prior to land clearing and drainage, peatlands were fire-resistant owing to their often-waterlogged condition and closed canopy of peat swamp forest (Applegate *et al.* 2012). When a surface fire enters the peat soil, it becomes difficult to extinguish (Graham *et al.* 2022). Peat fire suppression is expensive and the most appropriate strategy is to encourage a commitment from local communities not to start surface fires (fire prevention).

Changing human behaviour

The factors that influence perception may be classified as internal and external (Mifta 2014). Internal factors include feelings, attitudes and individual personalities, prejudices, motivations and expectations (Gillard *et al.* 2016, Loarback *et al.* 2017); while external factors include family background, information obtained, and living needs (Kashima *et al.* 2009). The living needs are usually defined at community level, with individuals being influenced by society and societal availability regarding these needs.

The key to controlling burning behaviour is changing social norms (Greenhill *et al.* 2019). There is common knowledge among all stakeholders that burning for land clearing has become an accepted norm for communities living around peatlands and this norm should change in view of the dry peatland conditions that now prevail. How the normative beliefs can be changed, and how different fire prevention policies and programmes can be strengthened so that they actually change these norms, has not been fully explored as yet. Changing social norms has been successfully applied to change individual behaviour in various situations including cigarette smoking; and changing land burning norms

may be the best way to create sustainable changes in burning behaviour (Greenhill *et al.* 2019). One route to changing these norms involves increasing knowledge exchange with the community regarding the dangers of forest fires (Shove 2010, Kashima *et al.* 2011).

All communities agreed that land fires occur due to people's activities in using fire on the land and fires occur only in the dry season. They equally believed that the pre-2015 tradition of burning has changed such that more people were reluctant to burn land after 2020 and, in 2025, there will be fewer people interested in burning for land clearing. Based on the responses of the participants, fear of punishment seems to be the current dominant reason for change. However, various additional factors were also emerging as influential, such as increased knowledge about land clearing techniques using fire and the harmful effects of smoke. This may have been helped by rural community empowerment programmes in all development sectors (Marlier *et al.* 2013, Elbaar & Meilantina 2020). Finally, the cultural transformation that is formed and applies in each village community is greatly influenced by shared awareness and mutual respect between community individuals (Rosul 2015). As a norm begins to undergo community-wide transformative change, it builds momentum and people become concerned about being perceived badly by others if they do not follow the new cultural norm (i.e. not burning) or damage a neighbour's property, as was shown in our results.

Causes of fire

The village community provided insight into which activities they believed can lead to and trigger forest and land fires. These activities included slashing and piling up the slash, using herbicides to eradicate grasses, leaving idle land unused, burning unused land with the aim of maintaining and marking land ownership, fishing, burning to access roads, driving away mosquitoes, cooking, and hunting or extracting natural resources by opening access.

Negative effects of fire and community change

Whilst human actors are the usual cause of ignition for peatland fires, these actors do not usually intend to start big wildfires. Rather, it is often lack of care, negligence, or an inability to successfully put out a fire once it has been started that results in large wildfires (Goldstein *et al.* 2020). Therefore, the community can play a key role in altering the sequence of events (Akbar *et al.* 2021). Our results show that various government efforts have been able to increase public awareness about the importance of

preventing unwanted fires by not burning to clear land. Furthermore, in addition to releasing greenhouse gases, peatland forest fires produce local smoke that has disrupted human health as well as economic and social activities in the village (Hirano *et al.* 2009, Hoscilo *et al.* 2011). The community realises that peat fires have become the main source of the haze that occurs during the dry season. As a result of the negative effects of smoke and haze on health and economy being felt directly, a decrease in the number of people in the villages who habitually burn could occur even without regulations. However, some people still feel they need help to carry out livelihood activities without using fire on the land. If this is not addressed, a small percentage of the community may still burn because of their economic situation.

Ways to bring about change

Community motivation and awareness are determined primarily by values that have been built in the community itself so as to create conditions for a safe, just and prosperous community (Singh *et al.* 2018). Outsider interventions do not necessarily change old habits that have been in existence for a long time and passed from generation to generation. However, interventions such as the construction of sample demonstration plots whose benefits can be felt directly by the community can be more quickly adopted than other interventions (Kaskaya *et al.* 2017). Our results also show that aspects of law enforcement can be effective in quickly changing the perceptions and behaviour of people whose actions have negatively affected the environment to become more environmentally friendly without reducing economic productivity. Educational aspects, in the form of various kinds of community skills training and increasing knowledge of losses due to forest and land fires can also tend to transform negative habits into positive ones (Kaskaya *et al.* 2017).

Many participants hoped that efforts to reduce the risk of forest and land fire could be achieved by increasing the role of the MPAs towards developing skills in the early detection of fires and subsequently extinguishing them, accompanied by increasing infrastructure facilities, covering field operational costs, and developing village regulations regarding fire management. The regulations would encompass law enforcement, increasing community prevention programmes (e.g. by regulating against discarding cigarette butts that are still burning), and training the community in utilising the village's natural resources in an environmentally friendly manner (e.g. the use of purun grass (*Eleocharis dulcis*) for making mats, bags, baskets, etc. and kalakai (*Stenochlaena palustris*) as an alternative food source to replace

vegetables, tea and chips).

Facilitating the introduction of new technologies, especially firefighting equipment, was also observed to bring about perceived changes in behaviour. However, it needs to be accompanied by capacity building in maintenance techniques along with the provision of maintenance funds. Currently, much equipment has been provided to the Pulang Pisau communities through village government, although there is still a lack of maintenance (Akbar 2022). These efforts will be more effective if accompanied by well-designed and well-managed demonstration plots in villages (Altenbuchner *et al.* 2018).

Our results show the community felt that much information has been provided by the government, such as knowledge for managing land without burning and utilising cut grass species for organic fertiliser. Respondents generally did not agree that fires are predestined. They also believed that the community had capacity to pursue non-burning livelihoods. There was agreement that nobody in the villages wanted extensive peatland fires, so when fires actually spread this was usually considered to be due to negligence. The community hoped that the government would continue to increase equipment facilitation and operational costs for fire prevention, and increase training for village communities in the use of local natural resources without burning.

The success of forest and land fire prevention campaigns can be measured by the extent to which the educational aspect of law enforcement and technological approaches have been adopted by the community (Akbar 2022). It was noted that there was now widespread awareness of the fire prevention efforts from government and law enforcement agents in the form of outreach about the prohibition of burning such as banners and billboards posted along roadsides, which have influenced the community by causing people to be fearful of violating the regulations. Further studies are needed to determine whether it is fear of punishment or increased awareness and capacity - or a combination of the two working in parallel or in tandem - that is leading to changes in perceptions and behaviour towards fire.

Perceptions about the obligations of relevant institutions and individual stakeholders with regard to fire prevention was similar across the three regencies. The communities largely felt that those with the greatest responsibility are landowners followed by the provincial and district governments. Overall, NGOs and researchers were considered to carry the least responsibility.

The community's obligation to participate in controlling fires has existed since 1990, as stipulated in: Law number 5 of 1990 concerning the

conservation of living natural resources and their ecosystems; Joint Decree of the Minister of Forestry, Minister of Home Affairs and Minister of Transmigration no. 480/Kpts-II/1993 concerning handling of forest encroachers and shifting cultivation; and Decree of the Minister of Forestry no. 523/Kpts-II/1993 concerning guidelines for protection in forest concession areas. The government also created Forest Fire Handling Procedures in 1997 (Glover & Jessup 1999). Socialisation of these rules was not well understood at the village level and not been strictly enforced, which was one of the reasons why the community tradition of burning land continued up to 2015.

From a political point of view, the most complete legislation for forest fire control is due to the OKI government, which has a regional regulation made together with the regional people's representative council, as well as a regent's regulation. Kapuas has only regional regulations on controlling forest fire and Pulang Pisau has only a regent's regulation on controlling forest and land fires. OKI has the largest area (19.023 km²) followed by Kapuas (14.999 km²) and Pulang Pisau (9.650 km²). OKI has the highest population density (44 people km⁻²), followed by Kapuas (27 people km⁻²) and Pulang Pisau district (14 people km⁻²). The more complete the regulations, the greater the guarantee that the fire prevention programme will be implemented.

Awareness of the efforts for change

Amongst the communities there was variation in the knowledge level about the government programmes for fire prevention. Importantly, all participants said they had heard of and knew at least something about them. These programmes included the government's ban on burning, the existence of fines or imprisonment by the state for arsonists, the existence of MPAs and farmer groups, plus counselling and outreach programmes from the government and the private sector. In general, the villagers felt the government's ban on burning, enforced by fines or imprisonment, was a helpful way to bring about change. They also felt the MPAs, guidance programmes and various socialisation efforts from government and the private sector were beneficial.

The relationship between social aspects of the community and their vulnerability to peat fires has started to become apparent in some villages. During the onset of the dry season, communities clear ferns and grasses from the plantation forests to prevent fire from entering so the plantations do not burn. Intensive guidance provided by government agencies to village communities around the forest has enabled an increase in community responsiveness in putting

out fires in their early stages and thus preventing them from encroaching onto community land, although difficulty regarding the operational costs was also reported.

Why people have stopped burning

Participants felt that those who have stopped burning have done so because they are aware that smoke has negatively affected human health and they would prefer to live in a smoke-free environment. Peer pressure in the form of not wanting to be thought of badly by other people and not wanting to disturb neighbours' land was also important. The participants said the communities were largely interested in learning new ways to manage their land other than by burning. All of the communities felt that payment for not burning was an appropriate route. These responses indicate that people's views on burning have changed in concert with their own awareness, and the prohibition of burning from government has begun to complement the process.

The current smoke-free living conditions have provided a more comfortable situation for the communities and this has opened up possibilities for sharing views and changing attitudes in villages where the tradition of land management through fire is a legacy from the time of their ancestors. The knowledge and practice of the community's old burning traditions has altered since 2015, moving from the habit of burning freely to the emergence of a more disciplined approach as people's perceptions changed, then not burning anymore due to government and private interventions towards preventing fires. Many people stated that they would not use fire again in the future.

What cannot be ignored is that there is still a small fraction of the population who burn land because they are satisfied with the results of burning, because it is a tradition passed down from previous generations, because they believe that burning is the best way, because they do not know any other way, and because fire is a cheap and easy tool. Some people still use fire for land preparation and opening access to the forest for economic reasons, as they lack the capital to obtain goods to satisfy their primary needs. The pressure of economic or financial needs for human daily life is often the reason for violations (Shove 2010). The village community is dominated by people with low incomes (< Rp. 3,000,000 per year). This will result in inability of the community to send their children into higher education (Shove 2010, Kashima *et al.* 2011). Low levels of education in rural communities will result in continuing difficulties for both government and external parties in providing and introducing innovations to improve their

livelihoods (Biggs & Gory 2012, Sujakhu *et al.* 2018). In this study it was found that there is a small percentage of people who still burn for the same reasons. In fact, the view of some people (5 %) with low to medium education in rural areas is that the cheapest form of land clearing is by burning (Akbar 2022). These community members do not usually think about the negative effects of their burning activities, as the most important thing for them is to get daily cash income without having to make a big investment (Tatariyanto 2018). However, it is predicted that with training efforts in addition to field farming and equipment facilitation, this minority will decrease further, as is the case in developing countries such as Kenya and Cambodia (Matiku *et al.* 2013, Kry *et al.* 2020).

Concluding remarks and recommendations

The change in burning habits identified in this article has, to some extent, been brought about by the various fire prevention efforts of the government and private companies empowering people at village level to become knowledgeable, skilled, aware and motivated. However, differences in political, social and economic conditions between regions have led to some differences in habits and interest regarding fire usage and knowledge of the negative effects of fire. All of the factors that cause fires - both biophysical and social - need to be continuously identified everywhere, because the causal factors or triggers follow the development of human activities and are thus dynamic in nature.

Fire prevention needs to be carried out through three integrated components, namely education and training for communities living around the forest, technology facilitation, and law enforcement against arson offenders. Educational efforts that can be undertaken include training in the use of local natural resources, especially the grasses and ferns that readily fuel the spread of wildfires, so as to minimise standing crop during the dry season. Technological facilitation efforts that are needed would be directed towards early detection and suppression of fires using tools such as drones in and around the forest; while law enforcement efforts should have a deterrent effect to minimise the causes of criminal fires.

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AUTHOR CONTRIBUTIONS

AA and GBA conceptualised the study; AA, AK, EEWH and NII collected and prepared field data together with many other people including VA. AA, AK, EEWH and NII contributed to drafting the questionnaire and census forms. AA and EEWH conducted data analysis, created the Figures and Tables and wrote the first draft of the manuscript with input from all authors. GBA provided supervisory advice and critical comments during the research and improved the manuscript. All authors contributed to interpretation of the results, discussion, and associated improvements of the article.

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Appendix

Stakeholders Effort Census

Village: _____

Contributors (including position):

Please give numbers for the following in your village between 2016 and 2019:

Effort topic	Effort sub-topic	Total number	Total cost (IDR)
Capacity building	Firefighting training events		
	Number of funded firefighters (individuals)		
	No-burn farmer field schools conducted		
Physical resources	Canal blocks		
	Water table level monitoring implements installed		
	Firefighting equipment sets purchased		
	Deep wells installed		
Education - on improved fire management	Workshops in schools		
	Workshops in the community		
Enforcement	Fire cases reported		
	Fire cases brought to trial/punishment		

Community Questionnaire

No	Questions	Answers
1	Year of your birth	_____
2	What tribe are you from?	_____
3	What was your last education?	_____
4	What is your main job?	_____
5	What is your main source of income? (in order of importance)	_____
6	Your marital status	_____
7	Are you a member (officially or not) of a farmer group? (only one answer is allowed)	☐ Yes ☐ No ☐ Not sure
8	What is your standing / status in the community?	☐ Village head ☐ Community leader ☐ Community members
9	How many people in your household? (including you)	a. Children (< 18 years old) people b. Adult people
10	Compared to other families in your village, how much is your household income? (only one answer is allowed)	☐ High (more than 10 million rupiah per month) ☐ Rather high (6–10 million) ☐ Medium (3–6 million) ☐ Low (below 3 million)
11	a. Do you own land and/or rent land?	☐ Owned ☐ Rented ☐ Do not own/rent land (skip questions 12 and 13)
	b. How many plots of land do you own/lease?	_____
	c. What is your total land area?	_____ (ha)
	d. How much of your land is in the peat area?	_____ (ha)
	e. What agricultural crops do you grow on peatland? (select/tick all answers that apply)	☐ Oil palm ☐ Annual crops (for example: vegetable, chilli, groundnut, corn ☐ Sago ☐ Rice ☐ Rubber ☐ Other woody plants (for example: jelutung, gelam, gemor, meranti) ☐ Others (please list)
12	Do you and/or your family members work your own land?	☐ Yes ☐ No
13	Do you hire labour to work your land?	☐ Yes ☐ No
14	a. Have you or any family members previously burned to prepare land for other activities (or hired someone to do it)?	☐ Yes ☐ No

- b. If yes, which activity? _____
- c. If yes, why did you burn? (write down as much information as you can provide) _____
- 15 a. Do you know of anyone/parties who are still burning to prepare their land for other activities? ☐ Yes ☐ No
- b. If yes, which activity? _____
- c. If yes, which sector? (for example: farmers, communities or companies) _____
- d. If yes, why do you think they burned? _____
- 16 a. Are you still preparing land for other activities by burning? ☐ Yes ☐ No
- b. If yes, which activity? _____
- c. If yes, why do you burn? (there may be more than one reason) _____
- d. If not, how did you prepare the land for this activity? _____
- e. If not, what caused you to stop/avoid burning? (there may be more than one reason) _____
- 17 a. Do you know any other way (besides burning) to prepare land for your other activities? ☐ Yes ☐ No
- b. If yes, what is another way? _____
- 18 How did you learn about (the) other way(s) (without burning)? _____
- 19 Have you or your village ever participated in efforts to prevent fires? ☐ Yes ☐ No

If yes, what are the efforts? Are they government efforts or something else? How useful were the efforts (please rate the reason based on the rating scale immediately below the grid)

Types of efforts	Who implements	How useful do you think they are?	Reason for your score

Scale *: 1 = useless 2 = not so useful 3 = useful enough 4 = useful 5 = very useful

- 20 In your village area, are there any people/parties who intentionally burn large areas of land (over 2 ha)? Was there a fire that broke out accidentally? _____
- 21 In your village area, were there any people/parties who burned less land than before (for example, compare 2015 and 2020)? Why do you think they burn less widely? _____

- 22 In your estimation, what percentage or share of people in your village are still preparing land for other activities by burning? Why do you think that is? _____
- 23 In your opinion, are there other efforts that can reduce the incidence of fires _____
- 24 Using the scale below, who should be responsible for preventing fires in your village, and why? (write numbers based on the scale in the spaces provided for answers)
1 = completely irresponsible 2 = quite responsible
3 = a bit more responsible 4 = responsible
- Central/provincial government _____
Local government _____
NGO (Non-Governmental-Organization) _____
Local forestry company _____
Local people including me _____
Researchers in higher education _____
Extension officers _____
Media (TV, radio) _____
- 25 Using the scale below, how often do you or people in your village start fires? (write numbers based on the scale in the spaces provided for answers)
1 = almost always 2 = sometimes 3 = occasionally 4 = seldom 5 = never
- Before the 2015 fire? _____
Early 2020? _____
The coming years (in 2025)? _____
- 26 How often would you or people in your village start fires if there were no burning restrictions? (write numbers based on the scale in the spaces provided for answers)
1 = almost always 2 = sometimes 3 = occasionally 4 = seldom 5 = never
- Before the 2015 fire? _____
Early 2020? _____
The coming years (2025)? _____
- 27 How often do the following community groups or companies use fire to clear land at this time? (write numbers based on the scale in the spaces provided for answers)
1 = almost always 2 = sometimes 3 = occasionally 4 = seldom 5 = never
- Forestry company _____
Oil palm company _____
People from other villages _____
- 28 How much do you agree or disagree with the following statements (please give reasons)
1 = totally disagree 2 = don't agree 3 = neutral 4 = agree 5 = totally agree
- I have been given the understanding/knowledge to be able to manage my land without burning _____
Land fires occur because it is destiny _____
I am confident that I can manage land without burning _____
I need help to manage land without burning _____
Land fires occur due to people using fire as part of their activities (e.g. for land clearing) _____

I'm not getting the help I need to manage my land
or other field activities without burning _____
I have practised and followed the instructions on _____
how to manage land without burning _____
Land fires occur only during the dry season _____
Land fires occur because people start them _____
accidentally (e.g. throwing away cigarette butts) _____

- 29 Several fire prevention programmes have been carried out by government and private companies. I will read you a list of programmes. Please rate how knowledgeable you are about each one.
1 = absolutely do not know 2 = don't know 3 = know enough 4 = know 5 = absolutely know

Government ban on burning _____

Fines and/or imprisonment by the state _____

Fire care community (MPA) _____

Extension or outreach programmes from the
government _____

Extension or outreach programmes from private
companies _____

Other programmes, state their names: _____

- 30 How useful are these programmes in helping fire prevention?
1 = completely useless 2 = of little use 3 = quite useful 4 = useful 5 = very useful

Government ban on burning _____

Fines and/or imprisonment by the state _____

Fire care community (MPA) _____

Extension or outreach programmes from the
government _____

Extension or outreach programmes from private
companies _____

Other programmes, state their names: _____

- 31 Currently, how often do people in your village carry out the following operations in managing their land and other activities, so as to cause or potentially cause fires?
1 = almost never 2 = sometimes 3 = occasionally 4 = seldom 5 = never

Slashing and stacking/hoarding slashed material _____

Using chemicals to eradicate weeds _____

Leaving the land unused/unmanaged _____

Proving land ownership _____

Changing to a planting method that does not
require burning _____

Managing e.g. oil palm or annual crops _____

Fishing _____

Cleaning road/river access _____

Hunting/gathering natural resources _____

Cooking in the field _____

Others, be specific _____

- 32 How do you and the people in your village feel after there is no burning?
☐ very happy ☐ unhappy ☐ neutral ☐ quite happy ☐ very happy

- 33 What would the people in your village think if they saw someone clearing their land or implementing other field activities without burning?
☐ very unacceptable ☐ not acceptable ☐ neutral ☐ quite acceptable ☐ very acceptable

- 34 Currently, how many farmers in your village are managing their land without burning?
☐ very few ☐ about 25 % ☐ about 50 % ☐ about 75 % ☐ almost everyone
- 35 At this time, how many people in your village - other than farmers - are active in the field/forest without burning?
☐ very few ☐ about 25 % ☐ about 50 % ☐ about 75 % ☐ almost everyone
- 36 If you or people around you have stopped burning, please answer the following questions (if still burning, please proceed to the next question)
- Why have you or those around you stopped burning?
 1 = very untrue 2 = untrue 3 = neutral 4 = true 5 = very true
- Because I want to avoid the negative impact of fire smoke _____
- Because I get 'reward' if I don't burn _____
- Because I enjoy living in a smoke-free environment _____
- Because other people will think badly about me _____
- Because I want to learn a new way to manage my land without burning _____
- Because I don't want burning to affect my neighbour's land _____
- Because I will be punished if I burn _____
- Because I enjoy working on my land without any fires _____
- 37 If you or people around you are still burning, please answer the following questions (if you/they don't burn, please proceed to the next question)
- Why are people around you still burning?
 1 = very untrue 2 = untrue 3 = neutral 4 = true 5 = very true
- They know how to burn properly _____
- Other people also burn _____
- They are satisfied with the result of burning for land preparation or other activities _____
- It is hereditary tradition from their ancestors _____
- They believe burning is the best way to clean land _____
- They don't know any other way to manage land _____
- Burning is a cheap and easy method _____
- 38 How much do you agree or disagree with the following statements?
 1 = totally disagree 2 = disagree 3 = neutral 4 = agree 5 = totally agree
- I feel comfortable with my current living conditions _____
- I feel that my relationship with the people in the village is not close _____
- I do not share my views with other people in this village _____
- Land fires occur naturally throughout the year _____
- 39 Do you have other comments regarding forest and land fires that have not been included in this questionnaire? (please list your comments/questions) _____