Exploring community perceptions of peatland restoration in West Kalimantan, Indonesia

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SUMMARY

The Indonesian government has increasingly prioritised addressing the environmental impacts of peatland degradation through extensive restoration initiatives. However, research on the social dimensions of these efforts, particularly regarding community knowledge and perceptions, remains limited. This study examines community awareness and perceptions of peatland restoration programmes, assessing both direct and indirect involvement. The research was conducted in 32 villages across three targeted peatland restoration districts: Sambas Regency, Mempawah Regency and Kubu Raya Regency. The findings indicate that local communities generally recognise the ecological functions and benefits of peatland restoration, particularly rewetting implemented through canal blocking systems. Likert-scale analysis reveals that most participants expressed positive perceptions of peatland restoration efforts. To enhance community participation, it is crucial to integrate local involvement at all stages of the restoration process including planning, implementation and evaluation. Furthermore, increasing educational outreach on peatland restoration is essential for fostering a shared understanding between local communities and government authorities, thereby strengthening collaborative conservation efforts.

KEY WORDS: canal blocking, participation, rewetting, revegetation, tropical peatland

INTRODUCTION

Indonesia hosts approximately 20.9 million hectares of peatland, which is the fifth-largest national peatland area globally (UNEP 2022). However, according to the Ministry of Environment and Forestry, the estimated total peatland area in Indonesia is 24.7 million hectares (Osaki & Tsuji 2015, Nursyamsi *et al.* 2016, Directorate of Peatland Degradation Control 2021). The variation in results arises from differences in the definitions of peatland used in mapping (Anda *et al*. 2021). Peatland ecosystems play a crucial role in climate regulation by serving as significant carbon sinks. Undisturbed peatland forests store an average of 2,772 tons of carbon per hectare, with an additional 186–306 tons per hectare sequestered in biomass (Verwer & van der Meer 2010). Collectively, Indonesia's peatlands hold an estimated 13.6 to 55 gigatons of carbon, underscoring their global ecological significance (Jaenicke *et al*. 2011, Warren *et al*. 2017), and peat swamp ecosystems exhibit an average carbon sequestration capacity of approximately 0.74 tons per hectare annually (Agus *et al*. 2020). Given the critical role of these ecosystems in mitigating climate change, the Indonesian government has prioritised emission reduction strategies and the promotion of sustainable development to ensure the long-term preservation of its peatlands.

Peatland degradation in Indonesia remains a critical environmental challenge, primarily driven by fires and land-use changes (Uda *et al*. 2017). This degradation has resulted in severe ecological consequences including increased carbon emissions, loss of biodiversity and heightened flood risk (Dohong *et al*. 2018, Puspitaloka *et al*. 2020). These impacts pose a significant obstacle to the country's efforts to achieve its emission reduction targets. Despite ongoing restoration initiatives, several challenges persist, including the large extent of degraded peatlands, high rehabilitation cost per unit area, and limited community engagement and awareness (Yuwati *et al*. 2021). Overcoming these barriers necessitates the implementation of strategic, multidisciplinary and community-inclusive peatland restoration programmes to ensure long-term environmental sustainability and climate resilience.

The Indonesian government has adopted the 3R approach - Rewetting, Revegetation and Revitalisation - as a framework for peatland restoration efforts, which are coordinated by the Peatland and Mangrove Restoration Agency (BRGM). The rewetting process is implemented through canal blocking to prevent excessive drainage

and retain water in peatlands, ensuring that the ecosystem remains wet or moist, thereby reducing the risk of peat fires. The revegetation programme involves replanting degraded peatland areas, particularly in rewetted locations, to accelerate land cover restoration. Meanwhile, the revitalisation programme aims to enhance alternative economic opportunities for local communities, reducing dependence on unsustainable peatland utilisation practices (Gunawan 2018, Budiman *et al.* 2020, Puspitaloka *et al.* 2020, Fleming *et al.* 2024).

Despite these initiatives, peatlands continue to degrade owing to unsustainable human activities including canal excavation, illegal logging and slash-and-burn practices for agricultural expansion (Yuwati *et al.* 2021). Consequently, peatland restoration programmes implemented across several provinces in Indonesia have yet to achieve their intended objectives (Wicaksono & Zainal 2022). Addressing these challenges requires stronger community engagement, policy enforcement and the development of sustainable livelihood alternatives that align with conservation goals.

West Kalimantan Province contains approximately 1,547,876 hectares of peatland (Anda *et al.* 2021). However, only 2,556 hectares have remained intact, with the majority experiencing extensive ecosystem degradation (Direktur Pengendalian Kerusakan Ekosistem Gambut 2022). Given the severity of this environmental decline, immediate restoration efforts are required to rehabilitate the region's peatland ecosystems. While peatland restoration has demonstrable ecological benefits, its direct impact on improving local livelihoods remains limited due to the scale and scope of current restoration initiatives (Ziegler 2020, Merten *et al.* 2021, Ward *et al.* 2021, Wiesner & Dargusch 2022). Therefore, ensuring active community participation is essential, as local stakeholders play a critical role in the success and sustainability of peatland rehabilitation programmes.

Between 2016 and 2023 the BRGM, in collaboration with various stakeholders including local governments, universities, non-governmental organisations (NGOs) and local communities, successfully restored approximately 207,000 hectares of peatland in West Kalimantan. These restoration efforts included the construction of 925 canal blockings and the revegetation of 200 hectares. Additionally, economic assistance aimed at promoting zero-burning agricultural practices was provided to 219 community groups residing in or near peatland areas (MoEF 2024). To enhance community awareness and encourage participation in peatland restoration, BRGM implemented the Peatland Stewardship Village initiative, which integrates peatland restoration efforts into village development planning.

Enhancing public understanding and awareness of peatland restoration is essential for ensuring the success of restoration initiatives in Indonesia, particularly given the limited research on community exposure to such programmes (Yanarita *et al.* 2014, Nurhayati *et al.* 2020). Greater awareness facilitates the implementation of restoration activities including canal blocking and peatland revegetation. Therefore, this study aims to: (1) assess community knowledge of peatland ecosystems and conservation efforts; (2) examine the level of community participation in restoration initiatives; and (3) analyse public perceptions of peatland restoration efforts. Understanding these factors is crucial for evaluating public awareness of peatland ecosystems and their ecological significance. The findings of this study can serve as a basis for developing government policies and strategies aimed at promoting sustainable peatland conservation.

METHODS

Research location

The study was conducted during July and August 2022 in the Kubu Raya, Sambas and Mempawah districts of West Kalimantan Province (Figure 1). According to official data from the BRGM, these districts were designated as priority areas for peatland restoration, alongside seven other districts in West Kalimantan Province (BRGM 2020). As of 2021, a total of 53 peatland stewardship villages had been established in Kubu Raya District, 14 in Sambas District, and nine in Mempawah District. This reflects the active engagement of local communities in peatland restoration initiatives.

Data collection

Our study employed both primary and secondary data sources. Primary data were collected through field observations, questionnaires and interviews (Creswell & Creswell 2018). Field observations were conducted to assess the environmental conditions of the study area, while questionnaires and interviews were used to examine community characteristics, perceptions and insights from key local stakeholders (Fontana & Frey 2005). Secondary data were obtained from relevant publications, official documents and literature on peatland restoration (Bryman 2016). The integration of primary and secondary data aimed to enhance the comprehensiveness and accuracy of the findings (Morgan 1997).

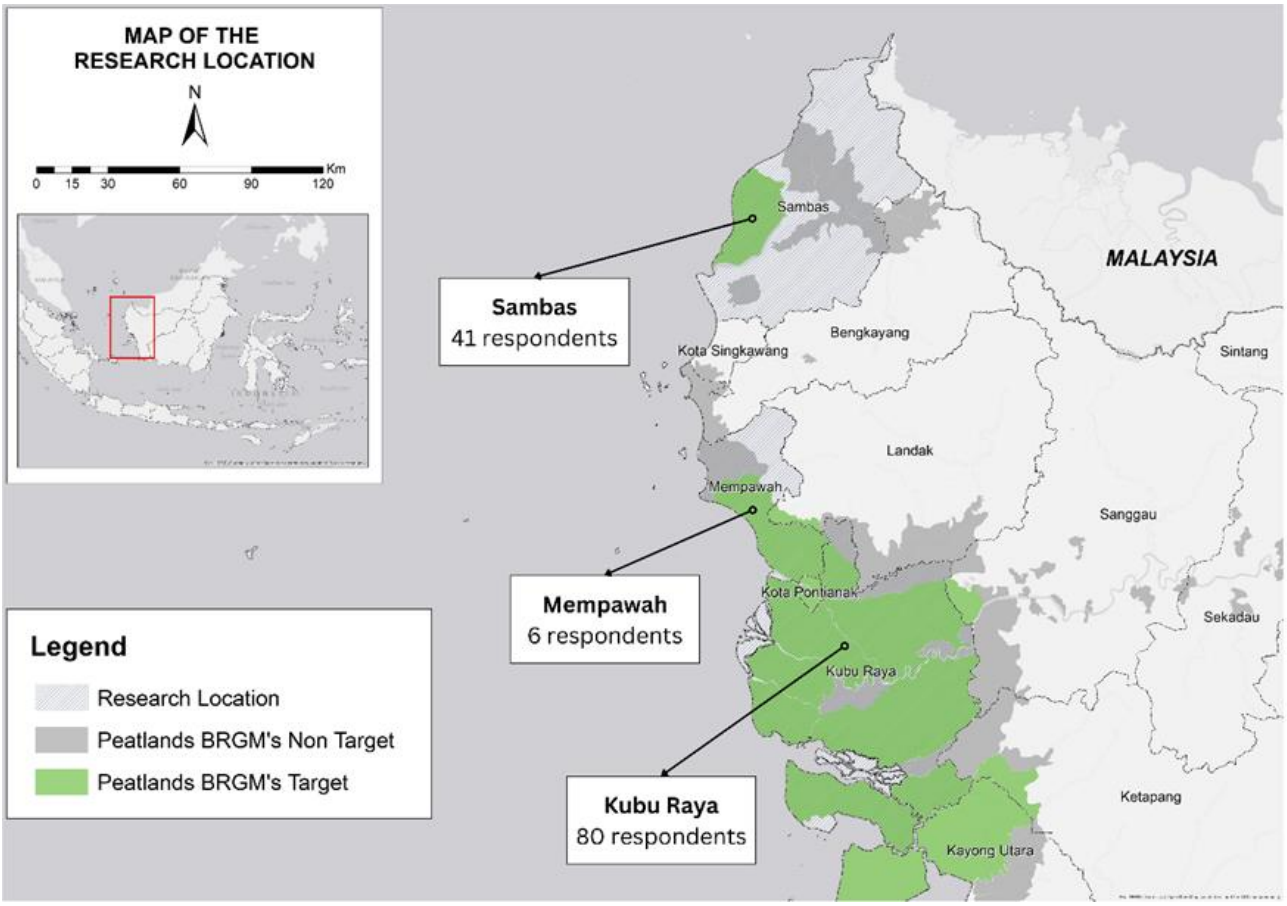

Figure 1. Map of research locations in the three districts of West Kalimantan Province, showing the distribution of respondents in relation to BRGM peatland management target areas.

Participants were categorised into two groups: individuals actively engaged in peatland restoration projects and those who, while not directly involved, resided or worked in peatland areas. Respondents were selected purposively to reflect the diversity of the population, particularly communities living within or adjacent to peatland ecosystems.

The survey instrument consisted of both open-ended and closed-ended questions. In addition to structured questionnaire responses, the study incorporated open-ended questions to capture respondents' qualitative feedback and suggestions regarding the implementation of restoration programmes. These qualitative inputs were collected through interviews, providing deeper insights into community perspectives on the effectiveness and challenges of restoration initiatives. Thematic analysis was applied to these responses to complement the quantitative findings, enabling a more comprehensive understanding of community perceptions and recommendations. Closed-ended questions, on the other hand, were used to systematically explore specific information and assess response consistency (Fontana & Frey 2005). The combined use of both open- and closed-ended questions facilitated a more robust and accurate assessment of community engagement in peatland restoration efforts (Sudman & Bradburn 1973, Morgan 1997).

Data analysis

The analysis employed both the Likert scale and a scoring method to assess community participation in peatland restoration activities. The Likert scale was used to measure the degree of community involvement in restoration efforts (Likert 1932, Agussabti *et al.* 2022) and to evaluate respondents' perceptions of peatland restoration initiatives including those that have been implemented, are currently in progress, and are planned for the future (Antriyandarti *et al.* 2019, Boca & Saraçlı 2019). This approach enabled respondents to assign a numerical value to statements regarding peatland restoration. Specifically, participants rated statements

such as: "Peatland restoration activities that have been carried out have succeeded in improving peatland conditions" on a five-point scale, where a score of 1 indicated 'strongly disagree' and a score of 5 indicated 'strongly agree'. The Likert scale was instrumental in assessing community perceptions of restoration initiatives and determining the extent to which these efforts met local expectations.

To mitigate potential bias in question framing, the study incorporated open-ended questions alongside the closed-ended questionnaire. The open-ended questions allowed respondents to elaborate on their perspectives, providing additional insights into the perceived benefits, challenges and unintended consequences of the restoration programme. The surveyors documented this qualitative feedback during interviews, ensuring that even subtle or unexpected concerns were captured.

The responses from the open-ended questions were analysed thematically to identify key patterns and unique insights that could inform future programme improvements. The qualitative data enriched the quantitative findings, offering a more comprehensive understanding of community perceptions and experiences. Overall, combining the Likert scale with qualitative analysis provided a robust framework for evaluating community engagement and perceptions of peatland restoration.

Additionally, a scoring method was employed to quantify the extent of community participation and identify key factors influencing engagement in restoration activities (Dewi *et al.* 2021). Questionnaire responses were assigned scores to determine participation levels, with the highest engagement receiving a score of 5 and the lowest engagement receiving a score of 1 (Elida 2008). This approach facilitated a systematic assessment of community involvement, enabling a clearer understanding of participation patterns and their influencing factors.

The questionnaire data were systematically scored and analysed to ensure accuracy in data interpretation and thus facilitate a structured assessment of community participation levels. The maximum and minimum scores were first determined, based on the total number of questions included in the questionnaire. For example, if there were six questions, the maximum score (V. Max; $5 \times 6 = 30$) represents the highest possible score per respondent, while the minimum score (V. Min; $1 \times 6 = 6$) denotes the lowest possible score that a respondent could attain. The interval value (IS) was calculated as:

$$\text{IS} = \frac{Maximum\ Score - Minimum\ Score}{3} \quad [1]$$

The interval value was then used to categorise the score for each participant. The following formulae were applied to classify participation levels (Lutpi 2016, Fauzi *et al.* 2019):

Low involvement = (V. Min) to (V. Min + IS)

Modest involvement = (V. Min+IS+1) to (V. Min + 2IS)

Substantial involvement = (V. Min+2IS+1) to (V. Max)

Thus, in the six-question example, the participation categories would be:

1. Low involvement: score = 6–14;
2. Moderate/modest involvement: score = 15–22; and
3. High/substantial involvement: score = 23−30.

RESULTS

Description of the respondents

The demographic characteristics of the study respondents are presented in Table 1. Participants were categorised based on six variables: gender, age, educational background, income level, number of family members, and length of residence in their current location. A total of 142 individuals returned questionnaires; however, only 127 responses were deemed valid and sufficiently complete for further analysis (Golafshani 2003, Roberts *et al*. 2006).

The majority of respondents in this study were male (85.8 %), with the largest age group ranging from 31 to 50 years (44.9 %). Most respondents had completed high school education (40.2 %). In terms of monthly income, 38.6 % of respondents reported earning between USD 133.33 and USD 200, which aligns with the average minimum wage in West Kalimantan Province for 2023, recorded at USD 173.91 (Annur 2023).

Household composition among respondents was predominantly characterised by families with 3–4 members (42.52 %), typically consisting of a husband, wife and one or two children. Additionally, 74.80 % of respondents had resided in the study area for more than 20 years, with some being native to the region, indicating a strong connection to the local environment,.

The survey results revealed that 51 respondents (40 %) had not participated in peatland restoration efforts, whereas 76 respondents (60 %) were actively engaged in various restoration activities (Table 2). Community involvement in peatland restoration included participation in workshops, planning and implementation of field surveys for canal blocking, training sessions on canal-blocking construction, and free prior informed consent (FPIC) processes; as well as implementation, monitoring and evaluation.

Table 1. Socio-demographic characteristics of respondents participating in the peatland management study in West Kalimantan Province, Indonesia. n.d. = no data.

Variable	Category	Frequency	Percentage
Gender	male	109	85.8
	female	18	14.2
Age	18–30	19	15.0
	31–50	57	44.9
	51–70	45	35.4
	> 70	2	1.6
	n.d.	4	3.2
Education	Elementary school	30	23.6
	High school	51	40.2
	Junior High school	18	14.2
	Diploma	2	1.6
	Bachelor degree	19	15.0
	Master degree	1	0.8
	No school	2	1.6
	n.d.	4	3.2
Monthly income (USD)*	< 7	16	12.6
	7–133	30	23.6
	133–200	49	38.6
	200–267	19	15.0
	267–333	5	3.9
	> 333	3	2.4
	n.d.	5	3.9
Number of family members	1–2	31	24.4
	3–4	54	42.5
	5–6	33	26.0
	> 6	5	3.9
	n.d.	4	3.2
Period of residence (years)	< 5	12	9.5
	6–20	15	11.8
	> 20	95	74.8
	n.d.	5	3.9

*USD 1 = IDR 15,000

Table 2. Distribution of respondents by village and regency of origin, categorised by engagement status in peatland management activities in West Kalimantan Province, Indonesia.

Regency	Villages	Engaged	Not engaged	Amount
Kubu Raya (14 villages)	Arang Limbung	10	8	18
	Limbung	10	8	18
	Mekarsari	1	1	2
	Muara Tiga	1	1	2
	Parit Baru	6	11	17
	Puguk	1	1	2
	Rasau Jaya Tiga		1	1
	Rasau Jaya Umum	7	4	11
	Sumber Agung	2		2
	Sungai Asam		1	1
	Sungai Enau		1	1
	Pal 9	1	1	2
	Sungai Raya Dalam		1	1
	Teluk Kapuas	1	1	2
Mempawah (3 villages)	Peniti Besar	1	1	2
	Sungai Purun Besar	1	1	2
	Sungai Purun Kecil	2		2
Sambas (15 villages)	Berlimang	3	2	5
	Lela	2		2
	Parit Setia	2		2
	Pelimpaan	1		1
	Perlimpaan	1		1
	Sarang Burung Danau		1	1
	Sarang Burung Kolam	1	1	2
	Sarang Burung Kuala	2		2
	Sarang Burung Usrat	2		2
	Sakura	2	2	4
	Sengawang	3		3
	Sungai Baru	3	2	5
	Sungai Kumpai	4		4
	Teluk Kaseh	4		4
	Tri Mandayan	2	1	3
Total		76	51	127

Public knowledge about peatland conservation

This study examines community knowledge and understanding of peatland restoration activities based on survey responses collected through structured questionnaires. The results of the analysis are presented in Table 3.

The findings indicate that the majority of respondents demonstrated an understanding of the definition of peatlands and were aware of the presence of peatland areas in their vicinity. Additionally, most respondents reported experiencing peat fires in or around their communities. These results align with the demographic characteristics of the respondents, as a significant proportion had resided in their villages for an extended period. Specifically, 74.8 % of respondents had lived in the area for over 20 years, while 11.8 % had resided there for 6 to 20 years. This prolonged duration of residence suggests that respondents have developed familiarity with the local environmental conditions. Some respondents were transmigrants from Java Island or descendants of migrant families, yet they also reported awareness of past peat fire incidents in their neighbourhoods (79.5 %).

Furthermore, 79.5 % of respondents indicated an understanding of peatland restoration programmes, suggesting that only approximately 20 % had limited knowledge of such initiatives. Among the surveyed individuals, 60 % actively participated in peatland restoration efforts, implying that even those not directly engaged in these programmes possessed a fundamental awareness of restoration practices.

With regard to the BRGM, 75.6 % of respondents were aware that this institution was responsible for implementing peatland and mangrove restoration initiatives. However, nearly 25 % of respondents were unfamiliar with BRGM's role. This was predominantly observed among those who had not been directly involved in the agency's peatland restoration programmes.

Public perception of restoration efforts

Analysis of the Likert-scale data indicates that respondents predominantly expressed agreement or strong agreement regarding peatland restoration efforts. The assessment was based on nine structured questions with multiple response levels. A detailed presentation of the Likert-scale results is provided in Table 4.

The majority of respondents strongly agreed that canal blocking effectively maintains peatland moisture and reduces the risk of fire, as indicated by a Likert scale score of 88.0. Furthermore, canal

Table 3. Respondents' knowledge of peatland, land fire incidents and peatland restoration activities in West Kalimantan Province, Indonesia. n.d. = no data.

Respondent knowledge indicators	Response	Frequency	Percentage
Knowledge of the definition of peatland	No	6	4.7
	Yes	121	95.3
Knowledge of the location of peatland around the residence	No	4	3.2
	Yes	123	96.9
Knowledge of land fire incidents around the residence	No	3	2.4
	Yes	124	97.6
Knowledge of peatland restoration (rewetting, revegetation, revitalisation)	No	25	19.7
	Yes	101	79.5
	n.d.	1	0.8
Knowledge of the National Institution, namely the Peatland and Mangrove Restoration Agency (BRGM)	No	30	23.6
	Yes	96	75.6
	n.d.	1	0.8

blocking was perceived to sustain the peatland water table during the dry season, with a Likert score of 91.5, categorised as strong agreement. Respondents also acknowledged that canal blocking facilitates fire control by ensuring water availability, as reflected in a Likert score of 92.3. Additionally, the perception of canal blocking as a measure to mitigate flooding was positive, with a Likert score of 72.5, categorised as agreement.

From a conservation perspective, canal blocking was widely recognised for its role in reducing peatland degradation, receiving a Likert score of 84.0, categorised as strong agreement. Respondents also agreed that canal blocking promotes vegetation growth, as indicated by a Likert score of 79.5. The contribution of canal blocking to environmental health was similarly perceived positively, with a Likert score of 85.8. Moreover, its role in maintaining water availability for agricultural and plantation activities was strongly endorsed, with a Likert score of 86.5. Lastly, respondents strongly agreed that canal blocking facilitates peatland cultivation, as evidenced by a Likert score of 84.0.

The positive perceptions surrounding canal blocking highlight its potential to enhance effective peatland management. As an integral component of peatland restoration efforts, canal blocking not only supports conservation but also presents economic opportunities for local communities without necessitating peatland destruction. Therefore, strengthening the capacity of local stakeholders is essential to ensuring the long-term success and sustainability of peatland restoration initiatives.

Participation in restoration activities

The survey respondents consisted of individuals who had either directly or indirectly participated in peatland restoration programmes. To assess the extent of community involvement, participation levels were measured quantitatively and categorised into three distinct levels. Community engagement in restoration initiatives serves as a form of social licence, reflecting local acceptance and support for these programmes (Wiesner & Dargusch 2022).

The results indicate that the majority of respondents in this study demonstrated a moderate level of participation in peatland restoration programmes (Figure 2). Community participation was classified into three categories: low, moderate and substantial involvement. These classifications

Table 4. Respondents' perceptions of the effectiveness of canal blocking as a peatland restoration measure in West Kalimantan Province, based on a Likert Scale assessment. Likert scores in this Table are presented as weighted averages expressed as percentages, based on the responses to each statement.

No.	Question	Likert Scale (%)	Category
1	Canal blocking has made peatlands moister, which prevents them from burning.	88.0	Strongly agree
2	Canal blocking maintained peatland's water table, especially during the dry season.	91.5	Strongly agree
3	Canal blocking could make it easier to extinguish fires when a fire occurred.	92.3	Strongly agree
4	Canal blocking could prevent flooding.	72.5	Agree
5	Canal blocking could reduce rate of peat degradation.	84.0	Strongly agree
6	Canal blocking caused vegetation to grow faster.	79.5	Agree
7	Canal blocking prevented peatlands from burning so that public health can be maintained.	85.8	Strongly agree
8	Canal blocking improved water availability for agriculture or plantations so that land productivity increased.	86.5	Strongly agree
9	Canal blocking made peatland utilisation easier.	84.0	Strongly agree

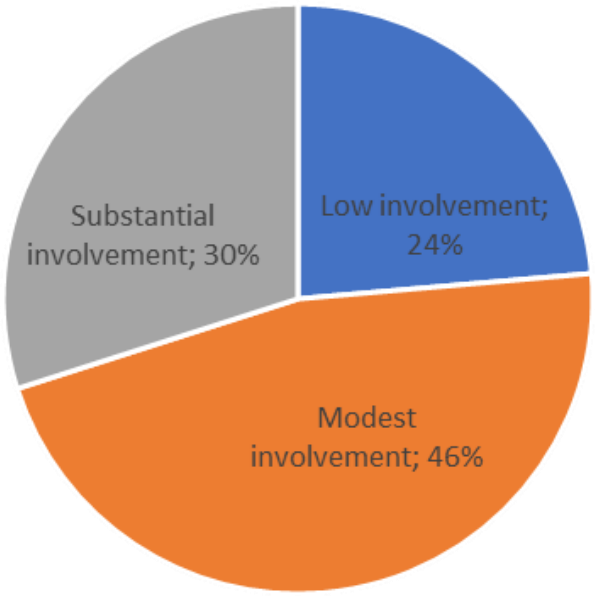

Figure 2. Classification of respondents by level of participation in peatland restoration programmes in West Kalimantan Province, Indonesia.

were determined based on questionnaire scores ranging from 6 to 30. Respondents who scored between 6 and 14 were categorised as having low involvement, characterised by minimal engagement such as limited awareness or attendance at meetings. Scores between 15 and 22 signified moderate involvement, in which respondents occasionally participated in restoration programmes including attending workshops or contributing to planning stages. Lastly, scores from 23 to 30 indicated substantial involvement, representing active participation across various stages of the restoration process including implementation, monitoring and evaluation.

The data presented in Table 5 indicate that local communities exhibit varying levels of involvement in peatland restoration initiatives. Among these, participation in the peatland stewardship village programme is the lowest. While a majority of community members have attended meetings or socialisation sessions related to the peatland stewardship programme, only a limited number have been engaged in the FPIC process preceding the construction of canal blockings.

Table 5. Respondents' involvement and awareness in various peatland restoration activities facilitated by BRGM in West Kalimantan Province, Indonesia.

Question	Response (%)		
	Involved	Know	Do not know
Are you involved with or do you know about *Desa Mandiri Peduli Gambut* (peatland stewardship)?	28	36	36
Are you involved with or aware of the construction of a canal blocking near your residence?	32	59	10
Are you involved with or aware of the FPIC process before construction of the canal blockings in your residential area?	31	32	37
Are you involved with or aware of the community group that built the canal blockings where you live?	31	53	17
Are you involved with or do you know of any Community Groups that carry out social revitalisation activities?	44	35	21
Have you ever been involved with or heard about any meetings or socialisation activities carried out by BRGM where you live?	62	22	16

DISCUSSION

The findings of this study regarding the construction of canal blockings align with those of previous research. Sopha *et al.* (2021) reported that local communities in Sebangau National Park, Central Kalimantan, generally held positive perceptions of canal blocking initiatives. Among the 100 respondents surveyed in their study, over 80 % either agreed or strongly agreed that canal blocking provided multiple benefits including improved water management, fire prevention, enhanced vegetation and peatland ecosystems, and increased fish populations. However, despite the predominantly positive perceptions of government-led peatland restoration programmes observed in the present study, there remains a limited understanding among local communities regarding the broader ecological functions and environmental significance of peatland ecosystems. Several studies have indicated that local communities primarily support peatland restoration programmes due to their direct economic benefits, particularly programmes facilitated through revitalisation initiatives. However, these programmes have not been entirely effective in fostering an understanding of peatland conservation and its role in environmental sustainability (Puspitaloka *et al.* 2020*,* Susanto *et al.* 2020).

The results of this study indicate that respondents who supported the construction of canal blockings perceived them as beneficial for fire prevention, improved irrigation and reduced forest fire risk due to increased soil moisture. Conversely, respondents who opposed canal blocking initiatives expressed concerns that the programme would be ineffective and might result in farmland inundation. These findings suggest that farmers who were sceptical about the canal blocking programme lacked confidence in the potential benefits of rewetting initiatives. Several previous studies have demonstrated that canal blockings implemented as part of peatland rewetting programmes can contribute significantly to forest fire prevention (Ritzema *et al.* 2014, Ward *et al.* 2021). In certain cases, however, community responses to these programmes have been less favourable, probably due to a lack of awareness regarding the functions and benefits of canal blockings. Therefore, effective community engagement and targeted outreach efforts are necessary to ensure that local residents understand that peatland restoration initiatives do not pose a threat to their livelihoods but can instead provide long-term ecological and economic benefits. The limited success of some peatland restoration programmes has been attributed to insufficient community participation in their design and implementation. This issue is exemplified by the restoration efforts in Tumbang Nusa Village, Pulang Pisau Regency, Central Kalimantan, where the lack of community involvement in selecting programme sites and insufficient understanding of the benefits of restoration initiatives have hindered programme effectiveness (Fleming *et al.* 2024).

The government has sought to enhance community involvement in peatland restoration activities by appointing village-level facilitators. These facilitators play a crucial role in disseminating information, providing educational outreach, and strengthening local community institutions including religious organisations, community leaders, and youth groups. Additionally, the government has introduced incentive-based mechanisms to encourage greater community participation and maximise the positive effects of restoration initiatives (BRGM 2023). Although comprehensive before-and-after evaluations have not yet been conducted, analysis using Likert-scale measurements suggests that these efforts have contributed to improving public perceptions of restoration activities.

The analysis of open-ended survey responses further revealed that, while respondents acknowledged the benefits of peatland restoration, such as improved water availability and reduced fire risk, they also expressed concerns regarding potential negative consequences including disruptions to agricultural activities. Some respondents emphasised the need for additional training and community outreach to enhance public acceptance of the programme. These findings highlight the importance of strengthening communication between programme implementers and local communities to ensure the long-term success and sustainability of peatland restoration efforts.

Survey data (Table 1) also indicate that men are predominant amongst the participants in restoration activities across the three study locations. This trend is largely attributed to the physical nature of tasks such as constructing canal blockings, carrying out rewetting operations during the dry season, and conducting maintenance and repair work. However, women have played an important role in the early stages of restoration efforts, particularly in mobilising materials for canal blocking. In later stages they have been involved in agricultural processes including preparing planting beds, applying fertilisers, watering, planting, crop maintenance and harvesting. Evaluations suggest that women's participation in peatland restoration is constrained to the field level and requires enhancement. Expanding opportunities for women's

involvement in restoration activities is essential, provided that programme objectives remain feasible. Additionally, gender mainstreaming at the village level should be strengthened to ensure women's active participation in all aspects of peatland restoration. Since 2022, the BRGM has taken steps to address this issue by establishing the Gender Mainstreaming Task Force for Peatland Restoration, aimed at increasing women's engagement in restoration initiatives (UNDP Indonesia 2024).

The classifications presented offer a nuanced framework for understanding the varying levels of community engagement, indicating that individuals with substantial involvement were instrumental in the success of peatland restoration initiatives. These engagement levels - categorised as low, moderate, and substantial - were derived from a scoring system based on questionnaire responses, as depicted in Figure 2. These highly engaged respondents can be considered programme drivers, as their active participation contributes significantly to programme implementation. Government initiatives focused on local community empowerment are more likely to succeed when they involve individuals with high levels of engagement. This aligns with the peatland restoration programme in Tumbang Nusa Village, where full community involvement has been instrumental in achieving positive programme outcomes (Fleming *et al.* 2024).

As shown in Table 5, the considerable variation in respondents' levels of involvement and awareness across various peatland restoration activities facilitated by BRGM underscores the critical need for enhanced outreach and consultation efforts. Insufficient involvement in the planning stages of canal blocking can lead to community resistance and a limited understanding of the objectives of peatland restoration (Wiesner & Dargusch 2022). Although the 3R programme serves as a social license for government-led peatland restoration initiatives (Fleming *et al.* 2024*,* Wiesner & Dargusch 2022), significant gaps remain in the dissemination of key information regarding peatland restoration in West Kalimantan.

Despite shortcomings in the FPIC process, the construction of canal blockings remains one of the most widely recognised and accepted restoration programmes, surpassing both the peatland stewardship and economic revitalisation initiatives. It is likely that this can be attributed to the active involvement of local communities at various stages including planning, site selection, training and infrastructure development, as well as the direct benefits these blocking structures provide to residents in and around peatland areas. Several studies have demonstrated that canal blockings effectively maintain peatland groundwater levels at a minimum of 0.4 metres, a critical threshold for peatland sustainability (Sutikno *et al.* 2019, Yananto *et al.* 2021, Putra *et al.* 2022, Hikouei *et al.* 2023).

Effective dissemination of programme-related information is a key determinant of the success of peatland restoration efforts. One of the primary challenges in peatland restoration stems from inadequate communication between stakeholders including the central government, local governments and local communities (Susanto *et al.* 2020). In many instances, poor communication has been a major factor contributing to the ineffective implementation of restoration programmes. Additionally, public education plays a crucial role in enhancing community understanding of peatland restoration initiatives and fostering awareness of the importance of conserving peatland ecosystems. Strengthening these aspects is essential to ensuring the long-term success and sustainability of peatland restoration efforts.

To enhance public awareness of peatland conservation, the establishment of community-based organisations dedicated to preventing and mitigating peat fires is essential. Engaging local communities in such initiatives, including the Fire Care Community (*Masyarakat Peduli Api* or MPA), the Fire Care Peatland Community Group (*Kelompok Masyarakat Gambut Peduli Kebakaran* or KMGPK), and the Disaster Resilient Village (*Desa Tangguh Bencana* or DESTANA), is a strategic approach to increasing participation in peatland fire prevention efforts (Nurhayati *et al.* 2020). These initiatives are expected to foster positive public perceptions of peatland restoration programmes while simultaneously raising awareness of the importance of peat conservation. Furthermore, local residents actively collaborate with various institutions such as *Manggala Agni* (the forest fire response team of the Ministry of Environment and Forestry), the Regional Disaster Management Agency (*Badan Penanggulangan Bencana Daerah* or BPBD) and the Peatland and Mangrove Restoration Agency (BRGM), in conducting fire patrols and monitoring activities.

Although community perceptions generally reflect positive attitudes toward canal blocking, further empirical studies are necessary to assess the effectiveness of these restoration measures. Such research should focus on evaluating the tangible ecological, economic and social outcomes of peatland restoration to ensure the long-term sustainability of these interventions. A comprehensive assessment framework would enable policymakers to align restoration programmes with

community expectations and improve their overall effectiveness.

Raising awareness of the adverse impacts of peat fires among communities living in peatland areas is also crucial. Studies indicate that public concern for peatland protection tends to increase after individuals directly experience the consequences of peat fires, such as agricultural losses and health problems (Nurhayati *et al.* 2020, Lestari *et al.* 2021). Therefore, targeted education and outreach programmes are needed to proactively inform communities about the risks associated with peatland degradation and promote sustainable land management practices.

One of the primary challenges for peatland restoration efforts in Indonesia is reducing the dependence of local communities on peatland resources. Widespread poverty has driven many individuals to exploit peatlands as a means of livelihood, with peat burning being the most cost-effective method for land clearing (Dohong *et al.* 2018*,* Raharjo *et al.* 2023). To address this issue, economic revitalisation programmes should be implemented to offer viable and sustainable alternatives to peatland exploitation.

The success of economic revitalisation efforts in peatland restoration depends on shifting community practices from environmentally harmful activities to more sustainable approaches. Although human disturbance has affected peatland ecosystems for centuries, these ecosystems can recover under specific conditions, for example if hydrological functions are preserved and appropriate seed sources are available. Research has shown that peatlands degraded by up to 30 % by human activities still possess a capacity for natural regeneration (Hapsari *et al.* 2018). The restoration process is facilitated by the presence of intact peat forest fragments and seed dispersal agents including wind and wildlife (e.g., birds, mammals and insects) (Blackham *et al.* 2014). However, recurring peat fires significantly hinder the natural regeneration of peatland ecosystems, underscoring the need for effective fire prevention strategies.

In the context of economic revitalisation within peatland restoration efforts, transitioning agricultural practices from unsustainable methods to environmentally responsible approaches is a critical factor. Agroforestry has been proposed as a viable solution, allowing farmers to cultivate peatlands without causing further environmental degradation while maintaining financial benefits (Applegate *et al.* 2022). Additionally, paludiculture techniques - which involve cultivating native wetland vegetation - can help maintain peatland integrity and ecosystem functions. This approach has the potential to support the growth of at least 534 plant species that thrive in wet environments such as hydrologically intact peatlands (Budiman *et al.* 2020). The integration of paludiculture and agroforestry into peatland management offers a sustainable economic pathway for local communities, particularly through the production of non-timber forest products and commercially valuable wetland crops (Dharmawan *et al.* 2024).

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AUTHOR CONTRIBUTIONS

JTR handled conceptualisation of the initial proposal, the acquisition of funding, and project supervision. Drafting of the initial proposal and data analyses were conducted by JTR, FSR, AWN and RF. RF was responsible for final review and editing of the manuscript.

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