Facilitating new livelihoods to promote peatland restoration in Indonesia - what are the challenges for ensuring sustainable and equitable livelihood transitions?

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SUMMARY

Much of the peatland in Central Kalimantan is highly degraded because it has been cleared and drained over the last 30–40 years. Degraded peatland is highly susceptible to burning and oxidation and contributes 30–60 % of the annual greenhouse gas emissions of Indonesia. To combat these problems, the Government of Indonesia has made peatland restoration a high priority, with revitalisation of livelihoods being a critical component to help communities transition to rewet peat. We sought to understand this social transition in Tumbang Nusa, one of the villages that has had a high level of intervention through the recent peatland restoration efforts. Over the last five years, several new livelihood initiatives have been deployed in Tumbang Nusa including seven capacity building programs, five government assistance programs and 18 demonstration plots, but many of these initiatives have been unsuccessful, with only a handful of farmers having adopted the outcomes. In effect, the peatland has not been rewet and the community has largely not transitioned to a more sustainable set of livelihoods. To make peatland restoration work it is critical to overcome several barriers so that communities can embrace the restoration process and can drive it autonomously, rather than needing outside input and assistance to maintain momentum. There is also a clear need for a functioning carbon market, such that peatland communities benefit from peat rewetting. Only once the community directly benefits from restoration will it actively participate in ensuring its success.

KEY WORDS: adoption, capacity building, demonstration plot, revitalisation, rewetting, Tumbang Nusa

INTRODUCTION

Indonesia has around 14.3 Mha of peatland, mainly located on Sumatra, Kalimantan and Papua (Anda *et al.* 2021). More than 70 % of this land has been degraded through logging, canal construction and drainage (Miettinen *et al.* 2016). Drained peatland in Indonesia is a globally significant source of CO_2 emissions, oxidation from dry peat being responsible for approximately 30 % of Indonesia's greenhouse gas emissions in a non-fire year, and in a bad fire year such as 2015/16, as much as 60 % (Hooijer *et al.* 2006). Peat fires are also the main source of the toxic smoke haze that has had damaging consequences for human health and the economy across South-East Asia (Stockwell *et al.* 2016). The 2015/16 fire season was reported to result in economic losses of around US $16B (Edwards *et al.* 2020) and 91,600 excess deaths across Indonesia (Koplitz *et al.* 2016). Between 2013 and 2017, Hein *et al.* (2022) estimated that exposure to particulate material ($PM_{2.5}$) from peatland fires in Indonesia caused an average of 8.9 M lost workdays each year, the deaths of 33,100 adults and 2,900 infants, and 635,000 cases of severe asthma in children. Unborn babies are also victims of this smoke haze, with an estimated 1.2 % decrease in national birth rates caused by the 1997 fires (Jayachandaran 2009).

Many dryland agricultural as well as plantation crops are grown on drained peatlands (Usup & Aguswan 2021). Two plantation crops, oil palm and rubber, are strongly preferred by communities because of their high income earning potential as well as the support that is provided by industrial partners in growing, harvesting and processing (Surahman *et al.* 2018). Oil palm companies have also brought many other benefits to the communities in the form of roads and other infrastructure (Jalilov *et al.* 2024). However, dryland crops are not a sustainable land use on peatland as they require the peat to be drained, resulting in ongoing peat soil oxidation, emissions of CO_2 and high susceptibility to fire (Adesiji *et al.* 2015). To mitigate these effects, it is recognised that livelihoods need to transition to more sustainable

options (Jewitt *et al*. 2014). A number of sustainable livelihood options have been proposed, for example paludiculture, agroforestry and rearing of livestock, but these remain unattractive compared to the current 'go-to' dryland options (Jalilov *et al*. 2024). Restoration efforts also have typically not seen any significant move away from these profitable but unsustainable options.

After the disastrous fires of 2015/16, the Government of Indonesia (GoI) established the Badan Restorasi Gambut (BRG, or Peatland Restoration Agency; in 2021 its scope was expanded to include mangrove restoration and it is now known as BRGM). This agency represents a significant investment by the GoI in raising the profile of peatland restoration, both domestically and internationally (Indrajaya *et al.* 2022). The core principles of the BRGM are the '3 Rs' - Rewetting of the peat soil, Revegetation with native species and Revitalisation of livelihoods for communities that are currently practising unsustainable land management on peatland. The key step for reducing fires and peatland oxidation is rewetting, but this will not be successful unless there are equitable and sustainable livelihood options that allow communities to attain a reasonable standard of living. Thus, revitalisation of livelihoods is critical to the success of rewetting. Note that restoration in this context refers to the restoration of ecosystem function around raised water tables and reduced carbon emissions, and not necessarily to return of the original ecosystem. Otherwise known as Forest Landscape Restoration (FLR; Erbaugh & Oldekop 2018), the approach includes people as part of the solution.

While peatland restoration is a clear priority of the GoI, and a top priority for many international concerns because of the contribution of degraded peatlands to global warming, messaging at the level of peatland communities is often mixed. The imperatives facing these communities often differ from those of national and international concerns, so initiatives such as oil palm and food production are still being promoted and adopted on peatlands at the village level, even though they are incompatible with peatland restoration.

The province of Central Kalimantan has around 2.7 Mha of peatland (DLH Kalimantan Tengah 2018), and commensurately large areas that are in need of restoration. This is especially true in the area of the former Mega Rice Project (MRP) that was established in the 1990s to develop 1 Mha of peatlands for rice production, but was unsuccessful and left a legacy of substantial areas of degraded peat (Goldstein 2016). Tumbang Nusa is a village within the ex-MRP area, most of which is on peatland. As Tumbang Nusa is at high risk of fire in the dry season (BRG 2018), it is one of the high priority villages for restoration (BRG 2019), but to date the restoration efforts at Tumbang Nusa have been largely ineffective in reducing fire risk or CO_2 emissions. Despite much effort and focus from several government and non-government organisations on restoring their peatlands, the community remains largely unaware of both the pressing need for restoration and the challenges that restoration will bring for their traditional livelihoods (Fleming *et al.* 2024). Examples of successful restoration are few in the literature and typically restricted to shallow peat, although Terzano *et al*. (2022) report on peatland restoration that is successfully community-led, with community participation in each of the restoration efforts rather than just in the 'revitalisation' step.

The aim of this study was to understand what initiatives have been implemented to facilitate livelihood transition and to rewet peat in Tumbang Nusa, and whether or not these have had any effect on the community and its journey to equitable and profitable peatland restoration. We include our own efforts through ACIAR project FST/2016/144 ("Improving community fire management and peatland restoration in Indonesia"), which commenced in December 2017, as part of the analysis. The potential opportunities for improving peatland restoration in Tumbang Nusa, implementing new restoration initiatives in this village, and for scaling up to vulnerable peatland communities across Indonesia, are discussed.

METHODS

Study site

This study was conducted at Tumbang Nusa, a fire-prone village as designated by the Ministry of Environment and Forestry (MoEF), and already subjected to a range of interventions for transitioning of livelihoods. Tumbang Nusa is located on the Kahayan River in Central Kalimantan (Figure 1), around 40 km from the provincial capital Palangka Raya, and has a population of 1027 people comprising 517 males and 510 females across 286 households (BRG 2018). Mineral soils are found adjacent to the river and peat soils farther away. Of the 20,000 ha of Tumbang Nusa, approximately 90 % is peatland with depth varying from 2 m to 8 m (BRG 2018). The village comprises part of the Sungai Kahayan and Sungai Sebagau peatland hydrological unit (PHU) and is managed by the Kahayan Hilir Forest Management Unit (FMU). Of the five neighbourhood units within Tumbang Nusa, three are

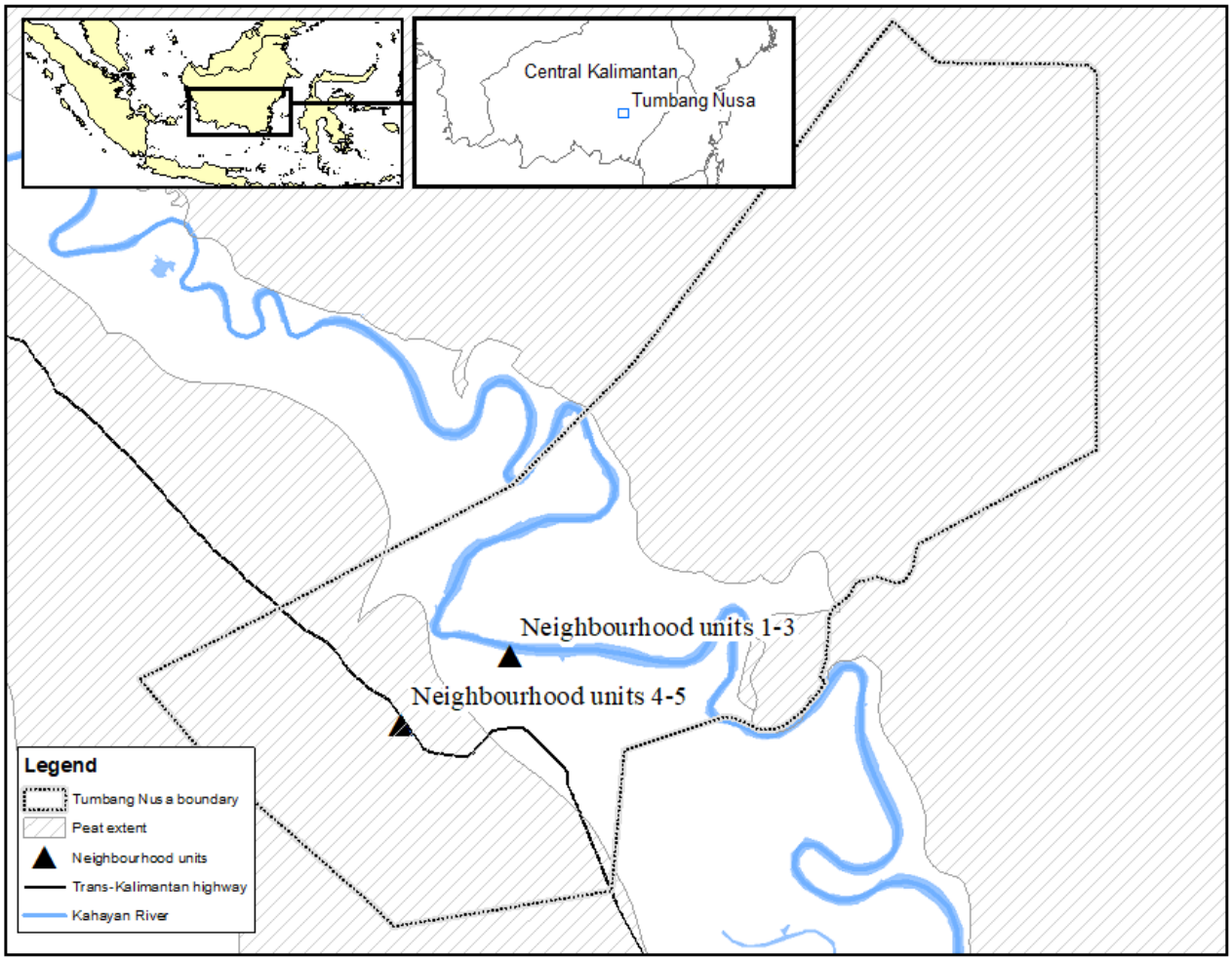

Figure 1. Map showing the location of Tumbang Nusa village, with neighbourhood units 1–3 along the Kahayan River and neighbourhood units 4–5 on peatland adjacent to the trans-Kalimantan highway.

located on mineral soils of the river bank (60 % of the population) and two are located on deep peatland adjacent to the trans-Kalimantan highway (40 % of the population).

Data collection

Data on past and current livelihoods were collected through a Community-Led Analysis and Planning (CLAP) process, conducted at Tumbang Nusa in 2019 (YTS 2019). This process was conducted as a starting point for project activities by our research team, and engaged ten key informants from the village to work with the village community on 15 analytical tools including a livelihood trend analysis.

Data on the livelihood initiatives and demonstration plots were collected through literature review, field observations and interviews (Table 1). For the interviews, respondents were selected through snowball sampling from neighbourhood units both near the river (50 %) and on peat near the highway (50 %). Around 71 % of the respondents were native/Dayak and the remaining 29 % had migrated from elsewhere. Other demographic characteristics of the respondents included that they were mostly male (67 % compared with 33 % female), mostly later age (90 % were older than 40, with 43 % in the 41–50 age group), and reasonably well educated, with 80 % having graduated from at least junior high school and 10 % holding a bachelor degree. The median landholding size of the respondents was around 2 ha, although 31 % reported owning 0.1 ha or less.

Information was collected on livelihood programmes: what programmes have been deployed, their duration, the number of members in the group, the institution carrying out the programme, the type of assistance received in the programme, the amount of funding, activities and facilities received, and the sustainability of the programme including the reasons why it stopped or why it has continued. Government assistance that has been provided to help with transition to more sustainable livelihood options was

Table 1. Sources of data collected from Tumbang Nusa.

Topic	Source of data	Data collection method	Number of respondents
Livelihood programmes	Leaders and members of groups, agriculture extension reports	Interview and literature review	31
Demonstration plots	Demoplot managers	Interview and field observation	8

also recorded. Such government assistance can come from central, provincial or regency level governments and typically requires the formation of a farmers' group to receive it. In total, 31 people representing participants in the livelihood programmes were involved in this part of the study. In each farmers' group, interviews were conducted with the leader and at least 50 % of the members. In addition to the group discussions, interviews were conducted with agriculture extension officers working in Tumbang Nusa who also provided reports from the agricultural extension office.

Information was also collected on the demonstration plots that have been established in the village. Respondents included those who were involved in the development of demonstration plots either from government programmes or established for research purposes. The data collected were as follows: the number of demonstration plots, institutions involved, whether on private or public land, budget sources and amounts, commodities developed, the current condition of the demonstration plot, whether a practice was adopted more widely in the community, and any gender aspects. Additionally, adopting a demonstration plot could imply that the farmer maintains it, expands it on his own, or that another individual has used the technology to establish their own plot. Eight enumerators were involved in collecting data on the demonstration plots, with data collection initiated in June 2020 and completed in June 2022 after COVID-19 travel restrictions were lifted. Impact of the livelihood programmes or demonstration plots was assessed quantitatively on a three-point scale, whereby a high score (***) was awarded if some members of the community have adopted some or all technology, a moderate score (**) if part or all of the livelihood programme had been maintained but there was little or no broader community adoption, and a low score (*) if the programme had been discontinued without broader adoption.

RESULTS

Livelihoods in Tumbang Nusa have traditionally focused on fishing (both river and lake) and rubber tapping (Figure 2). Between 2009 and 2019, rubber tapping declined from representing 10 % to 0.5 % of the livelihood options. With the arrival of the trans-Kalimantan highway in 2001/2 and the Tumbang Nusa Bridge (connecting Central Kalimantan and South Kalimantan Provinces) in 2013, trading started to become an important livelihood option, representing 10 % of livelihoods in 2014 and 15 % in 2019. Purun harvesting increased from 0 % in 2009 to 8 % in 2014, but then declined to 1 % by 2019. A new livelihood opportunity that appeared between 2014 and 2019 was the development of nursery businesses (3 %). Logging started in 1965 and represented a significant source of livelihood at the time, but in recent years only one or two people in the village have been earning a livelihood from logging. This was not picked up in 2009 and 2014, but in 2019 it was reported to represent 0.5 % of the livelihood options in the community, reflecting the small number of villagers who were associated with salvage of fallen trees.

While fishing remains the most important source of livelihoods, there has been substantial effort to assist the community to adopt new livelihoods. To date, 18 demonstration plots have been deployed across 15 programmes (Table 2). The effect of these demonstration plots on the community ranges from the plot not being maintained or adopted (2 programmes), the plot being maintained but with no wider adoption (10 programmes), and uptake of at least a component of the plot by community members who were not directly involved in the demonstration plot (3 programmes). Therefore, only 17 % of the demonstration plots had been adopted more broadly by the community. A key example of a programme component adopted by others has been stingless bees (in Programme 10, Table 2), which were taken up by

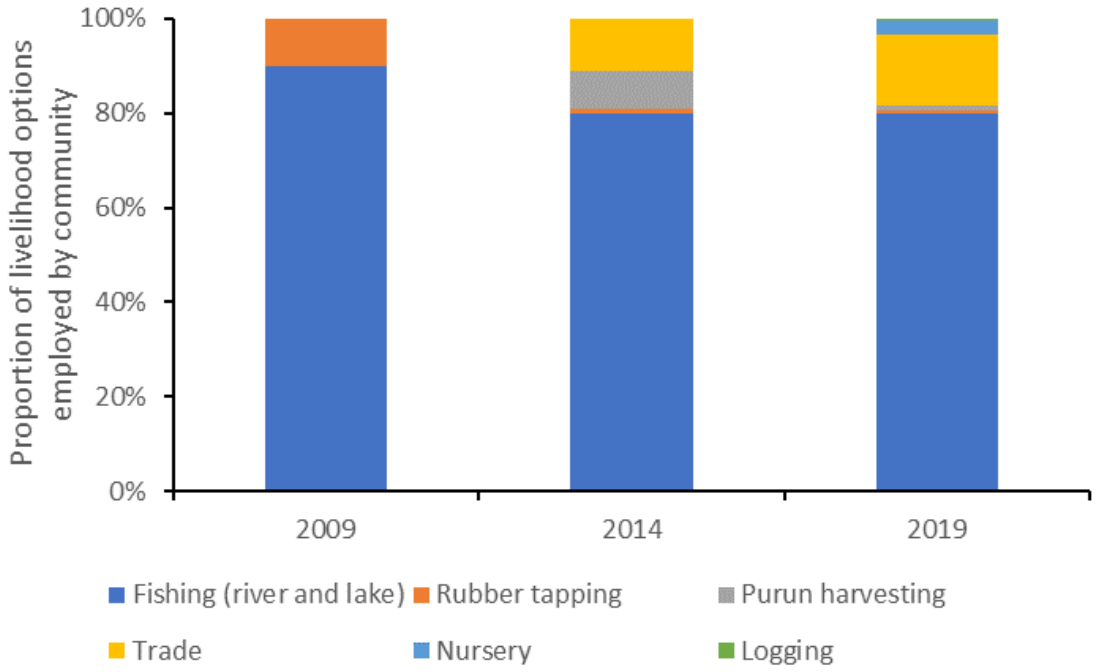

Figure 2. Tumbang Nusa livelihood trends, from YTS (2019).

the neighbours around these demonstration plots. The community interest in stingless bees has been high and they have taught themselves (using social media) how to divide the bees into additional hives.

In addition to the demonstration plots, 12 capacity building/government assistance programmes were initiated between 2015 and 2021 (Table 3). Capacity building programmes require the formation of farmers' groups. Only two of these groups are still active, and each has only one participant remaining. Similarly, only 17 % of the livelihood programmes have been continued, each by one person only. The reasons given for discontinuation of each of the livelihood programmes (Table 4) included:

(1) the group was formed solely for the purpose of receiving assistance;

(2) lack of interest in the initiative;

(3) the programme did not give sufficient returns to justify the time required;

(4) the required inputs and/or capital were difficult for the community to source; and

(5) the requirement for working together as a group requires a level of social cohesion that doesn't exist.

It is also clear that the social transition from fisherfolk to land managers/agriculturalists is a key challenge; input costs and labour are difficult to source; villagers feel a lack of agency, being told what they can do rather than coming up with the ideas from within the community; and lastly, there is a degree of livelihood programme fatigue and expectations of continuous programmes coming through the village as the main source of ongoing income, rather than adopting the initiatives themselves.

The gender balance of the training initiatives is also interesting, with fish and livestock production being heavily male dominated while fish processing and training associated with purun are heavily female dominated (Table 5).

DISCUSSION

Most of the livelihood initiatives associated with peatland restoration at Tumbang Nusa have not had the intended effect of facilitating the transition to more sustainable land-based livelihood options. Among the reasons for the lack of adoption is that most of the respondents are not accustomed to peatland-based livelihoods, as they have traditionally practised fishing and limited shifting agriculture on mineral soils. The new technologies offered through the new livelihood initiatives typically come from outside the village and consequently the community is more a passive recipient than an active driver of change. A requirement for the community to work in groups tends to go against their preferred way of working, even though local farmer institutions and groups can help individuals to overcome this constraint through training, information provision, incentive offerings and credit services. Our findings

Table 2. Demonstration plots established in Tumbang Nusa since 2003 and their impact on the community. Impact was assessed as follows: *** = community has adopted some or all technology, ** = parts of the demoplot maintained but little/no community adoption, * = plot not maintained or adopted.

ID#	Year	Programme title and (number of initiatives)	Estimated cost ($US)	Crop/commodity	Organisation and (Funder if different)	Land tenure	Impact
1	2003–2005	Mycorrhizae for rehabilitation of tropical peatland (1)	4,000	jelutung	FOERDIA	Private	**
2	2012	Agroforestry model for rehabilitation of peatland in Central Kalimantan (1)	26,000	agrosilvopasture: jelutung, rambutan, chickens, goats, vegetables	FOERDIA (Sumitomo For.)	Private	**
3	2016–2019	Capacity building and restoration of degraded peatland (1)	13,000	jelutung, belangeran, ramin, gemor	FOERDIA (AFOCO)	State	**
4	2017	Rice demonstration plot (1)	13,000	lowland rice	BRG	Private	*
5	2017, 2019	Paludiculture research in South and Central Kalimantan (2)	48,000	Liberica coffee, pineapples, rambutan, gerunggang, fish ponds, belangaran	FOERDIA (BRG)	Private	**
6	2017–2018	Restoration of peatland in Central Kalimantan (2)	39,000	jelutung, fish ponds, goats, belangeran, merapat, jelutung, gerunggang	FOERDIA (BRG)	Private and State	***
7	2018–2021	Improving community fire management and peatland restoration in Indonesia (1)	8,000	belangeran, bintangur, durian, rambutan, green pepper, chilli	FOERDIA (ACIAR)	Private	**
8	2019	The establishment of microbe-based application paludiculture demonstration plots (1)	9,000	native trees, rambutan, pinang, Liberica coffee, fish ponds, pineapple	FOERDIA	State	**
9	2019–2021	Mycorrhiza to restore degraded peatland (1)	36,000	belangeran, jelutung, gerunggang	FOERDIA (The Mushroom Init.)	State	**
10	2020	Evaluation of paludiculture after rewetting in Central Kalimantan (2)	32,000	vegetables, stingless bees,native trees, fruit trees, fish ponds, pineapples	FOERDIA	Private and State	***
11	2020	Papuyu fish cultivation (1)	3,000	papayu fish/fish ponds	FOERDIA	Private	*
12	2020	Agroforestry demonstration plot (1)	32,000	jelutung, pineapples, rambutan and fish ponds	FOERDIA (Sumitomo For.)	Private	**
13	2014	Agroforestry demonstration plot (1)	33,000	oil palm, gaharu, pigs, pineapples	FOERDIA	Private	**
14	2020	Livestock and paludiculture (1)	1,000	stingless bees	FOERDIA	Private	***
15	2020	Land use after canal blocking (1)	5,000	belangaran, fruit trees, fish ponds	FOERDIA	Private	**

Table 3. Community engagement in capacity building and government assistance programmes between 2015 and 2021. Impact was assessed as: *** = some members of community have adopted some or all technology; ** = parts of the livelihood programme maintained but little/no community adoption; * = programme discontinued.

ID	Programme	Programme date(s)	Equipment supplied	Number of participants	Current status	Impact
Capacity building						
1	Production of purun (*Lepironia articulata*) straws	2019–2020	oven, other equipment (including knife, bowl, gas stove)	20	One person remains active	***
2	Training in fish production	2015	fish ponds (tarpaulin), feed-making machine, fish eggs	10	Group disbanded	*
3	Training in fish processing	2018(–2019)	stove, pot, frying pan, blender, fridge/freezer, milling machine, cooking utensils, carpet, tray, packaging tools	10	One person remains active (if an order comes in)	**
4	Dry rubber processing	2016	no equipment; engagement in co-learning activities	4	Group disbanded	*
5	Cow feed production	2019	feed-milling machine, drums, tarpaulin	20	Group disbanded	*
6	Organic agriculture	2018	polybags, fertilizer, tomato seeds, chillies, eggplant	16	Group disbanded	*
7	Purun weaving training	2018	none	10	Some members can fulfil an order	**
Government assistance						
8	Fishing equipment	2020	boat engine, gas cylinder, traditional fishing gear (rempa)	10	Fishing equipment still in use	**
9	Goats	2018(–2019)	goats and cages	10	One person still raises goats	*
10	Cows	2018(–2019)	Rp 100,000,000 cash grant to purchase livestock	20	Cows are still maintained	**
11	Fruit crop seeds	2017	pineapple, rambutan (*Nephelium lappaceum*) and petai (*Parkia speciosa*) seeds	100	Pineapple farmers continuing; rambutan has been adopted	**
12	Gelam (*Melaleuca cajuputi*) seed	2018(–2019)	1,500 gelam seeds and a lawnmower	12	Group disbanded	*

Table 4. Key reasons cited for lack of adoption of initiatives.

Issue	Background
Demonstration plots are for cultivation on peatland. Peatland cultivation is not a traditional way of making a living.	The community of Tumbang Nusa is not accustomed to cultivating peatlands. Farmers traditionally grow rubber, rattan and vegetables on mineral soils.
Conversion from catching wild fish to cultivation of fish requires a major change in approach.	The community of Tumbang Nusa is dominated by the Dayak ethnic group whose key livelihood is focused on wild fishing.
Local people do not have any history related to peatland cultivation. In fact, some of the peatland areas are considered sacred places in the local beliefs and culture.	The Dayak ethnic group does not recognise the concept of peatland. The terms 'peatland' and 'gambut' were introduced by outsiders. The 1 Mha rice project was the first exposure to the concept for many of the Dayak people, and was associated with logging high-value timber species from their land.
Intensive cultivation of peatland areas is a big challenge for the Dayak people, culturally, socially, economically and technologically.	Dayak people traditionally use shifting cultivation and controlled slash and burn techniques to utilise the mineral land.
Intensive cultivation will have a long journey to be accepted and adapted by the Dayaks.	The traditional point of view of Dayak people is personification of the land (including peatland) as their mother. They do not exploit the land intensively but tend to apply shifting cultivation (cultivating fertile land and giving nature the opportunity to re-fertilise until it can be re-cultivated).
Cultivation on peatland requires significant capital input and specialised tools/machinery.	Smallholder farmers typically have minimal capital reserves and minimal equipment.
They do not have any knowledge or experience of planting crops on peatland.	Those who traditionally plant crops are mostly working on mineral land. Extension and training are needed to help farmers transition to new livelihood options.
Local people do not feel they have any input into what options they are given.	The species that the donor or programmes offer for planting on peatland are not based on their needs, but on market needs.
The community feel they have wasted time and money in conducting activities related to the programmes they received when they cannot sell the product.	There is no market certainty for selling their harvest from the programmes of agricultural activities they have done.
Intensive focus on one livelihood will be a big challenge for farmers or development agents.	Tumbang Nusa farmers generally have multilayered livelihoods. They know when they have to plant, go fishing, go gold prospecting, look after their cattle or conduct trade in their shop.
People have been exposed to a lot of programmes and are no longer paying attention to the contents of the programmes - only on the short-term gains that can be had from the assistance that is being provided.	Some suggestion of moral hazard as a result of too many programmes targeting the village of Tumbang Nusa - villagers are prepared to accept programmes only when the cost is borne by others.

Table 5. Gender balance of participants in training for the livelihood/capacity building initiatives. PIC = Person In Charge.

Programme/demonstration plot	Number of participants	
	women	men
Livelihood programmes		
Mycorrhizae for rehabilitation of tropical peatland		5
Agroforestry model for rehabilitation of peatland in Central Kalimantan	0	1 (PIC), 3 labourers
Rice demonstration plot	30	30
Paludiculture research in South and Central Kalimantan		1 (PIC)
Improving community fire management and peatland restoration in Indonesia	1	1 (PIC)
Papuyu fish cultivation	1	14
Agroforestry demonstration plot	1	
Livestock and paludiculture	1	1
Land use after canal blocking		10
Capacity building		
Purun straw production	17	3
Fish production	1	9
Fish processing	10	
Dry rubber processing	2	2
Cow feed production		20
Organic agriculture	16	
Purun (*Lepironia articulata*) grass weaving	10	
Fishing equipment	10	16
Goats	2	8
Cows		20
Gelam (*Melaleuca cajaputi*) seed	7	5

match those of parallel studies, for a range of reasons. For example, Njenga *et al.* (2021) found that low adoption rates of integrated soil fertility and water management strategies in sub-Saharan Africa was due to the wide communication gap between extension workers and farmers. In Ethiopia, Nguru *et al.* (2021) found that the adoption of crop residue management was severely constrained by lack of education and access to extension services, as well as access to credit services. Adoption is usually the result of a combination of both extrinsic and intrinsic factors .Extrinsic factors include economic, social and environmental factors, while intrinsic factors include human behavioural aspects such as perceptions and attitudes (Pierpaoli *et al.* 2013, Po *et al.* 2022). The dominant factor leading to low adoption at Tumbang Nusa was that the social change required was too great for the community to comfortably adapt.

Tumbang Nusa experienced significant environmental changes in a relatively short time, with fires and/or flooding becoming almost annual events (Sakuntaladewi *et al*. 2021). However, the community did not necessarily connect this with a need to adopt alternative livelihoods. Various development programmes have been implemented in the village to deal with fire and flooding and improve the community's economy, but often these have appeared conflicting and led to confusion. For example, several canal blocks and hundreds of deep wells have been constructed in the village to re-wet the peatlands while, at the same time, programmes to

improve the community's economy through the development of new oil palm plantations and canal technology to drain the peatlands have been offered. Both initiatives have good intent but do not complement one another, illustrating a disconnect between national and international priorities for peatland restoration and local priorities for improving lives and livelihoods (Jalilov *et al.* 2024).

One of the reasons for the focus on fishing-based livelihoods in Tumbang Nusa is that the population is dominated by Dayak people, who traditionally lived and made their civilisation around rivers (Wainarisi & Tumbol 2022). The Dayak community also utilises the mineral land around the river for cultivation of traditional agroforestry (Silvianingsih *et al*. 2021) and upland rice, rubber, rattan and vegetables, and has no history of cultivating peatland (Jasiah & Liadi 2021). At Tumbang Nusa the peatland was once a wilderness, and its development has been led by outsiders.

Extensive land clearing was associated with timber concessions that commenced in 1965, followed by the MRP between 1995 and 1998 (Sakuntaladewi *et al.* 2021). Canals were installed to open the land and transport wood to market. At that time the communities were not interested in moving to peatland because it was far from their original settlements and transportation was difficult, but after construction of the Tumbang Nusa Bridge in 2013 some households moved from the river to live alongside the Trans Kalimantan Road and started managing peatlands for agriculture as well as trading along the road. However, local knowledge of peatland management was a challenge for these people and limited technology and capital have resulted in many households choosing not to intensively crop their land.

The traditional culture of the Dayak community is based around hunting, gathering and rice growing through shifting cultivation (Crevello 2004) and forest gardens (known as simpukng; Mulyoutami *et al*. 2009). In the space they occupy on mineral soils, they are surrounded by sufficient natural resources to fulfil the needs of the family: water, wood, vegetables, fruits, herbal medicines, animals and fish. They take only what is necessary and this is their way of conserving (rather than exploiting) natural resources. Shifting rice cultivation is carried out on a land area that is manageable for each family (average 1–2 ha per household). Their non-agrarian approach of allowing nature to take care of their crops and leaving livestock to roam is very different from many of the new initiatives offered through the livelihood programmes, which are more suited to the new transmigrant communities.

Social capital is an invisible asset but exists in communities. It has three important elements, namely trust, networks, and norms or social rules (which can be used to facilitate good performance of social groups) that have been accepted by its members (Tulin *et al.* 2018, Akagawa 2019). The people of Tumbang Nusa Village have strong social capital around organisations and institutions that have formed organically in line with their interests in agriculture, animal husbandry and fisheries (Akbar *et al.* 2021). However, formation of groups through external influences and for the purpose of distributing resources has proven to be less successful; in Tumbang Nusa all 12 groups that had been formed for livelihood assistance programmes were no longer functioning well. This is probably a result of the "Free Rider" problem, whereby individuals can extract benefit from the group in return for minimal effort on their own behalf (Law *et al.* 2015). For example, the cattle livelihood group required members to take it in turns to collect fodder for the cattle, but enthusiasm waned amongst some group members who then relied on others to collect it. This resulted in the emergence of distrust, and disbandment of the group. Community empowerment is reduced when there is a lack of social capital elements such as local institutions, participation, networking, mutual work and social norms (Agussabti *et al.* 2022). An alternative option to overcome these issues would be to focus on empowering individuals (Barnes *et al.* 2011), since members of this community prefer to have a degree of autonomy in their actions. However, care needs to be taken around the choice of candidate beneficiaries, the form of incentives (tools or cash), the mechanism for delivering incentives, ensuring the success of incentive programmes through mentoring support, and independent financial audits of the beneficiaries.

Of the livelihood initiatives promoted in Tumbang Nusa, raising stingless bees (known locally as *kelulut* and belonging to the Meliponini family) for their honey was well received. Four individuals carried out this practice, three of whom lived on the peatlands. The beehives are placed in the shade under trees in the home yard. Bee cultivation is in demand because of the low capital cost, relatively easy maintenance, and honey that can harvested every two weeks. The annual returns (in Indonesian rupiah, IDR) are approximately IDR 1–2 million per hive, bees can utilise the surrounding flowers and one hive can produce around 500 mL of honey in a fortnight. It is critical to ensure that ants and other insects do not enter the hive. The increasing interest in raising bees has prompted local government to provide training in beekeeping and recently a fund of IDR 2M

was provided to the community to develop kelulut honey businesses. Kelulut honey cultivation is highly compatible with peatland restoration as it can function in very wet conditions, but it also requires healthy peatland trees and floral resources. Consequently, kelulut bee farmers are very concerned about the currently degraded environment and the need to protect bees from fire, which can affect honey production.

This study has shown that sustainable livelihood programmes need to be better targeted towards options that continue beyond their inception. A more integrated approach is needed, such that all stakeholders share a vision of the need for transition and how it is going to occur. Restoration needs to take place despite the potential barriers of unclear property rights, ineffective governance and lack of economic development (Larson 2011). Livelihood initiatives are usually intended to become self-perpetuating once the community recognises their value, rather than relying on continual external support (Puspitaloka *et al.* 2020). However, there are often differences between what the villagers want and what the projects deliver. For example, an environmental education programme in Kapuas in Central Kalimantan aimed to reduce logging and find ways for villagers to make a living that were less harmful to the environment (Sanders *et al.* 2019). However, the villagers wanted help with education in the form of money to build a school. The villagers did not refuse the programme; they recognised the environmental benefits, but they also did not think it would help them and their children get access to, or give rights to, alternative land or resources beyond the village.

Recovery of a degraded peatland ecosystem requires a transition that meets both ecologically desirable and socially feasible conditions (Puspitaloka *et al.* 2020). The involvement of local communities is very important to the creation of an awareness of peatland restoration. A social learning process is required in which people learn from one another through observation, imitation and modelling, and where the desire to participate comes from inside the community itself (Agussabti *et al.* 2022). At the village level, a champion is needed when conducting a programme. When people see that their neighbours are using rewetted peat successfully, even with their own money, they will copy and do the same. A shared vision can be realised when all stakeholders receive shared mutual benefits.

Although owned by a range of stakeholders from within and outside the village, most of the peatland in Tumbang Nusa is currently not used. If the villagers can be motivated to drive the restoration effort, this would provide a substantial opportunity to focus on revegetating peatland with local timber species such as *Shorea balangeran* which can be used to earn an income in the future, non-timber forest species such as bintangor (*Calophylum soultarri*) and nyamplung (*Calophylum inophylum*) which have potential to produce biofuel (Maimunah *et al.* 2018), *Dyera polyphylla* (jelutung) for latex production (Harun & Yuwati 2015) and *Melaleuca* spp. for essential oils (Giesen 2015, Widiana *et al.* 2015). Shortening the value chains by focusing on the market and marketability of peatland products would be of critical importance for adoption, and the palm oil industry offers a useful analogue.

The relationship between peatlands and communities is complex. There are many potential pathways to more sustainable use of peatlands, but at the moment these have been largely unsuccessful. Solutions need to be found that reduce the step change required of communities to become more sustainable, and restoration needs to take place at a landscape scale, so that communities are seen as part of the solution to restoration (Terzano *et al.* 2022). Further research into a functioning carbon market that allowed peatland communities to benefit from raising water tables to reduce CO_2 emissions and fire risk may facilitate the community to drive the restoration effort, but there is much work that needs to be done to ensure that communities benefit sufficiently from the change that they become the drivers of the restoration effort. For example, communities could benefit from a functioning REDD (Reducing Emissions from Deforestation and Degradation) scheme that paid for peatland carbon to be retained *in situ* (Larson 2011, Robinson *et al.* 2013, Bonn *et al.* 2014, Yamamoto & Takeuchi 2015, Kobayashi *et al.* 2016). The goal of REDD is to slow the release of carbon into the atmosphere by making payments that depend on the quality of forests over time (Robinson *et al.* 2013). Indonesia has considerable potential as a REDD+ target region (Yamamoto & Takeuchi 2015), but implementation of REDD+ has not matched its promise and needs to be reconsidered in terms of how it can work effectively (Fletcher *et al.* 2016). The Forest Carbon Index (FCI) examines a country's potential to earn carbon credits at a reasonable cost based on the state of its economy and forests, its capacity for governance, and its likelihood of implementation. Indonesia's FCI ranks sixth in the world, behind Brazil, Russia, Peru, Bolivia and Colombia (Yamamoto & Takeuchi 2015). One of the most important applications of REDD+ could be in restoration of deep peat, and Tumbang Nusa would be an obvious target. Implementing REDD+ requires

the carbon value to be integrated with other forest conservation benefits such as biodiversity. Payments for environmental services (PES) or carbon sequestered below ground would boost the remuneration for maintaining trees. An effective policy design should consider both economic incentives and non-economic factors such as mutual aid in local communities (Kobayashi *et al*. 2016), as well as the needs and wants of the local community. Changing the mindset of the community to more sustainable options will take a lot of education and time, but only once the community directly benefits from restoration will it willingly participate and ensure that it is successful.

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AUTHOR CONTRIBUTIONS

DSM, NS and R initiated the study, made baseline analysis of the data and wrote the first draft. All authors contributed to interpretation of the results, writing, and editing of the final manuscript.

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