Research Article

Sustaining Peatlands: Community-driven Fire Reduction and Land Management

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Abstract.
This study aimed to analyze sustainable peatland management to reduce the risk of peatland fires. Data were collected through observations and interviews with 20 informants, including farmers, civil servants, heads of government offices, and the Masyarakat Peduli Api (MPA) or Fire Care Community. Findings confirmed that knowledge of peatland characteristics, economic morals, local wisdom, and adaptation carried out by the community has an impact on sustainable peatland management. Local knowledge about the peatland, economic morals, and adaptations have been passed on from generation to generation by reducing land preparation by burning and using appropriate agricultural equipment and farming systems. Managing peatlands while maintaining local wisdom through the tapulikampar system is a better option to reduce the risk of land fires. If the community continues to maintain the local values in managing peatlands, the risk of fires on peatlands can be reduced.

Keywords: Ce4ommunity, land management, sustainable, fire reduction, peatland

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1. INTRODUCTION

Peatlands have ecological, economic, and socio-cultural functions [1, 2]. Peatlands can support the community's economic life because they can be used as agricultural areas and control floods and global climate [3]. Peatlands are also a source of livelihood, economic development, and terrestrial carbon storage [4].

Tropical peatlands are the most vulnerable ecosystems because they are rapidly degraded. The pressure of advanced agricultural and economic activities, human population growth, infrastructure development, climate change, and pollution cause degradation. Indonesia's tropical peatlands have also mainly been converted to other uses for economic purposes at the expense of significant environmental, health, and economic risks [5]. Draining peatlands has long been carried out for roads, houses, industrial areas, and plantations [6].

Exploiting peatlands for various needs with improper management and conversion of peatlands in Indonesia has led to land degradation, fires, and increasingly widespread haze [7–9]. Many peatlands in Indonesia are managed improperly by burning for cultivation. Land burning can pose a threat to sustainable peat ecosystems [10]. People think that burning land can increase soil fertility, even though land fertility only has a temporary impact, while land fires cause peatland degradation [11–13].

Sustainable land management is crucial to prevent the degradation of peatlands and reduce the risk of fire. Sustainable peatland management is beneficial for economic purposes, protecting species, and ensuring the sustainable use of natural resources [14]. Sustainable peatland management to support the community's economy considers technological innovation, understanding of land characteristics, participation from local communities, and aspects of traditional knowledge [15].

Several factors mark sustainable peatland management, including the knowledge and experience of farmers on peatlands, water and soil management technology, and institutional revitalization [16]. The practice can also be viewed from three dimensions: (1) the criteria for peatlands, (2) the use of peatlands, and (3) peatland development and supervision. The first dimension for peatlands is related to the characteristics of peatlands. The second dimension concerns using peatlands without burning, drainage channels, plant maintenance, and conservation. Peatland development and supervision are related to monitoring the risk of peatland damage and community empowerment [17]. Peatland sustainable development is also determined by land use function and future land use demand [18] and land characterization, landscape design and land use, and community development [19].

Historically, peatlands in Indonesia have been used for many purposes ranging from agricultural land to large-scale plantations [20]. The sustainable use of peatlands must consider the characteristics of the peatlands. Shallow peat can be used for rice plants and vegetables. Rice plants and vegetables have higher sustainability than oil palm and rubber plantations [21]. Deep peat (>3 meters) is allocated as a conservation area or forest protection. Other uses of peatlands, such as cattle breeding and fisheries, are better for peatlands because there is no burning and drying that will cause damage to peatlands [22, 23]. Using peatlands according to their characteristics will result in sustainable land management [4, 24]. Sustainable land management practices such as the surjan system and traditional agroforestry are essential for restoring degraded and burnt peat. An agricultural system is a form of community adaptation to managing peatlands. The system is applied to prevent land degradation and fires [25–27].

Kalimantan has Indonesia's second-largest peatland area, around 4.8 million hectares. Peatlands in South Kalimantan are among the least in the Kalimantan region compared to other provinces, namely 106.271 hectares [28]. Although the peat area in South Kalimantan is small, it is included in the peat restoration area along with seven other provinces in Indonesia due to severe fires in 2015 [29]. Based on data from http://sipongi.menlhk.go.id, in 2015, 196,516.77 hectares of land were caught by fires, with the worst fires occurring on peatlands [30, 31]. Severe peat fires in the South Kalimantan region occurred in Banjarbaru, occupying over 1,500 hectares of land [32]. Fires in the Banjarbaru area have become a problem because there is a vital object, the International Syamsudin Noor Airport, and the area is the government center. Fires have caused many flights to be delayed due to smog [11, 33, 34].

Peatlands in South Kalimantan have experienced significant land-use changes—they have been converted into plantations. The plantations were developed from a scrubland cover. From 1988 to 2014, land cover changes in the South Kalimantan region happened to secondary forest shrubs or old scrub plantations [35]. The spatial pattern and density of land fires in the South Kalimantan region occurred on peatlands that had changed into agricultural land and shrubs [36].

Community knowledge, community adaptation in managing peatlands, economic morals, and local wisdom prevailing in the community determine the sustainability of peatlands and the risk of peatland fires. The community adapts to the environment by developing wisdom through knowledge or ideas tools, combined with customary norms, cultural values, and activities to manage the environment to meet their needs without destroying their natural environment [37]. The community's active role can ensure sustainable peatland management [14]. People who have lived on peatlands for a long time already understand the peatland characteristics and have adapted to the peatland environment; as such, they know how to reduce land degradation, which causes land fires. Based on the background, this study aimed to analyze sustainable peatland management carried out by the community to reduce the risk of peatland fires.

2. METHODOLOGY/ MATERIALS

2.1. Research Location

This study was conducted in Banjarbaru, South Kalimantan, Indonesia. Banjarbaru is located at $3^0$25'40" S-$3^0$28' 37" S and $114^0$41'22" E-$114^0$54'25" E [38]. The area has

peatlands that burn annually, especially during the dry season [30, 33]. The map of the study site is shown in Figure 1.

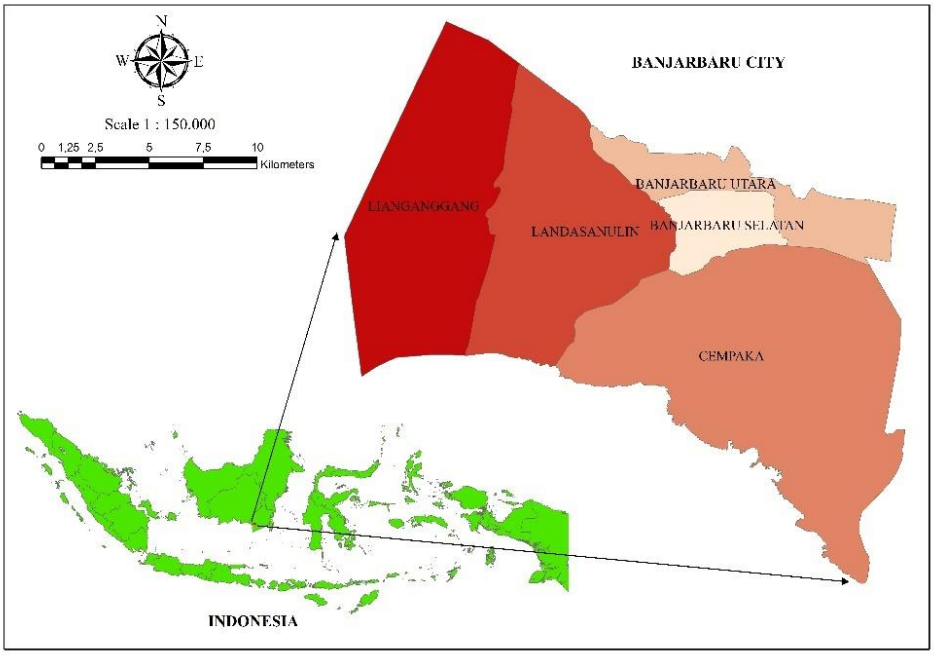

Figure 1: Research Location.

2.2. Data Collection

This study used observations and interviews with people living on peatlands—observation about the community activity for fire reduction in Banjarbaru. We interviewed 20 informants, including farmers, civil servants, heads of government offices, and *Masyarakat Peduli Api (MPA)* or Fire Care Community. Observations and interviews were carried out from April 2023 to May 2023. We ask about management to prevent land fires, community knowledge about the characteristics of peatlands, knowledge in utilizing peatlands, adaptation to peatlands, economic morals on peatlands, and local wisdom prevailing in communities related to peatlands.

2.3. Data Analysis

The results of interviews and observations were validated using triangulation techniques. Data analysis included reducing, displaying, and verifying data [39, 40]. Data

analysis with a qualitative approach occurs simultaneously with data collection, reduction, presentation, and conclusions (verification) [41]. The results of this qualitative analysis were used to strengthen quantitative data analysis.

3. RESULTS AND DISCUSSIONS

3.1. The community's knowledge of peatland characteristics and the use of peatlands

The communities in peatland areas already knew the presence of water sources on peatlands during the rainy season. The community also knew that peatlands were water reserves because of their proximity to rivers and organic matter accumulation in basins that stored water. Peatlands are always in low areas and are areas of waterlogging—the main constituent of peat is water [42].

The communities in the peatland environment at the research location knew the characteristics of peatlands that were easily burnt during the dry season. They understood the situation because of several fires on peatlands—fire and thick smoke. The community observed and understood that the fire would spread quickly and cover large peatlands. It has always been difficult to extinguish fires on burning peatlands because the fires penetrate the deeper layer, not only on the surface. In addition, peatland plants, primarily shrubs, cause a higher vulnerability to land fires. Peatlands are easily burnt because they keep a collection of organisms, wood stems, and twigs that have settled and mixed chemically into organic substances—the reduced water concentration and dryness in the dry season also trigger fires. Clearing peatlands by burning them can also cause widespread fires [11].

The people already understood that peatlands could be used for their livelihoods based on the peatland characteristics. Shallow peat is cultivated for agriculture and other businesses that support the community's economy, such as chicken farms and fisheries. They also used peatlands for growing short-lived food crops and horticultural crops during the rainy season, such as chilies, tomatoes, mustard greens, sweet potatoes, cassava, bananas, and oranges. Peatlands are potential natural resources for agriculture; various horticultural crops can be cultivated on peatlands because the crops are short-lived [43].

Peatlands in Banjarbaru have been converted into built-up areas such as settlements and offices. The rapid development of settlements and offices in Banjarbaru is closely related to the relocation of the central government of South Kalimantan Province from

Banjarmasin to Banjarbaru in 2016. However, settlements are found on shallow peat, while protected areas are still used as protected areas. Stilt houses are built on inundated peatlands as a form of adaptation to avoid damage to peatlands.

The community explained that the often-burnt peatlands were uncultivated land or vacant land. The community makes special preparations before burning peatlands for agricultural land. The community made special preparations before preparing agricultural land by burning, such as calculating wind direction and speed, making trenches, preparing boreholes as a water source, preparing canal blocking and water reservoirs, preparing fire extinguishers, and preparing tools to provide fire information. Knowledge of land management in preparing land for agriculture keeps fires from spreading. Wind direction and speed must be calculated before burning so the fire neither spreads nor reaches the settlements. Before burning land for agriculture, farmers usually dig trenches to prevent the spread of fire. At the bottom of the peat, the pile of organic remains extends over a large area, making trenches wet the peat soil and preventing the spread of fire [11].

Informants stated that farmers already had the bore wells. They use drilled wells to wet agricultural land during the dry season and extinguish fires when fires occur. The local government built the reservoir and canal blocking in the Banjarbaru area as a water source when fires occur. However, the reservoir is far from agricultural land, making the community use it less when a fire occurs. They mostly use drilled wells and canal blocking to cultivate their agricultural land—the drilled wells and canal also serve as a source of water when land fires occur. However, the community realizes that land burning is prohibited, no matter the reason. The community still does that now but with strict control and careful preparations.

The community agreed that land fires were more common on land not managed as agricultural land or for other economic purposes, such as raising livestock or fisheries. Empty land is generally overgrown with weeds, making it easy to burn uncontrollably. Communities do not care much when fires occur on vacant land. They focus on preventing fires from vacant land from spreading to their land. Therefore, land fires still happen today in this area. The active participation of the community in protecting peatlands and processing peatlands without burning or burning with control is necessary to keep peatlands from burning.

The community agreed that intercropping, the *surjan* system, and traditional agroforestry systems were better done on peatlands. Uncontrolled drainage channels will cause drought in the land, and drought in peatlands will cause the land to be quickly burned [27]. This system is more profitable economically because land can be planted

with various crops, both annual crops and vegetable crops. The *surjan* system arranges rice plants in wetlands, while banana and *petai* plants (*Parkia speciosa)* are planted on dry land. The system can also be done by planting rice on wetlands and citrus on dry land. In addition, the system can also be combined with chicken and duck farming and fisheries. Proper land management can improve the community's economy because harvesting can be done throughout the year.

3.2. The community adaptation to peatlands

Knowledge of cultivation can be obtained from indigenous people and has been passed down from generation to generation. The community agreed that migrant communities needed to understand the characteristics and management of peatlands. Based on the interview results with migrants from other districts, it was found that the place they lived at present had similar characteristics to their previous place of residence and that they had no difficulty adapting to their current environment. Some informants had lived in this area since the transmigration program in the 1980s. Their parents brought them to move from Java to Banjar Regency (another regency in South Kalimantan), then to Banjarbaru. Because they have lived in areas with peatland environments, they already understood the characteristics of peatlands.

Agriculture without burning is a form of adaptation passed down from generation to generation by Banjar farmers. They adapt to vulnerable peatlands through local wisdom that applies in the community. This local wisdom has been passed down from generation to generation as a form of respect for nature while utilizing the land and maintaining environmental sustainability.

They used traditional tools such as hoes and tajak (long machetes) to manage water on peatlands and *tetujah* to make holes in the soil when inserting rice seeds. These tools are a form of adaptation to the peatland environment, which is acidic and difficult to cultivate. The function of the tool is to help water circulation and accelerate the washing of soil acidity. They burn weeds before the rainy season, so the land remains submerged in water, and fire does not damage the land—as such, their land keeps fertile. Farmers refuse to use tractors because it will cause pyrite to rise to the ground. They prepare the land with the help of relatives. It is a form of adjustment or adaptation to the physical and social environment to minimize problems or risks of land damage and fires and ensure that the resources remain sustainable [44]. The knowledge transmitted and interpreted is then applied to adapt to their environment and the land they cultivate as an economic resource in harmony with their physical and social environment.

The community agreed with innovations in plant species, in peatland fertilization, against uncertain climatic conditions, and in peatland management such as the surjan system, planting of adaptive varieties, and soil fertilization—these are some of the principal treatments needed on peatlands. The rice varieties that are tolerant to drought, inundation, and relatively acidic water conditions are a form of adaptation by the community [44]. Plants adaptive to other peatlands can also be used on peatlands. At the research site, many vegetables are planted with rice plants. On other peatlands, rice plants are combined with citrus plants or rice plants are combined with banana plants and petai plants (Parkia speciosa) (Figure 2). To adapt to the uncertain season, the community makes water reservoirs around the land in the form of holes that can be used during the dry season. Shallow water systems also need to be considered on peatlands. The groundwater depth must be maintained at a 30 to 40 cm height so plants can be planted and used for land fire prevention [45]. Proper land management can restore land conditions and reduce potential land damage [46, 47].

Figure 2: Agriculture land in peatland area.

The community also agreed on the need for innovation in monitoring land fires by forming a fire care community (*Masyarakat Peduli Api – MPA*). MPA was initially created and trained by the Regional Disaster Management Agency. With community control as a form of community adaptation in dealing with land fires, fires on peatlands will be easier to monitor and control.

3.3. Economic morals of the community on peatlands

The community agreed that farmers and the community, in general, could set aside their income to carry out ancestral traditions to express gratitude to God for preventing land fires. The customary practice is rarely carried out. Usually, people read prayers to God together according to their beliefs as followers of Islam. The prayer is intended to ask

for salvation and show gratitude to God. The customary ritual costs some money, and usually, the host of the ritual pays for that.

The community also agreed that they needed to set aside income for peatland maintenance, monitoring land fires, firefighting equipment, health, drilling wells, and food kitchens in the event of a land fire. Based on the results of the interviews, they explained that they drilled wells and bought fire extinguishers with their money while the local government built the reservoirs that needed more funds. The government also made 50 drilled wells in Banjarbaru. Unfortunately, the drilled well is not optimally functioning because of poor maintenance. The drilled wells built with the community's funds turned out to be better managed because their function was to extinguish fires and wet the agricultural land.

The community also forms a fire care community (*Masyarakat Peduli Api – MPA*). MPA collects money independently to monitor and control land fires so that fires do not spread. Usually, MPAs are formed in every village where land fires often occur. Funds for this community also come from the government. Because the funds are limited, the community uses self-help funds, and they voluntarily work to monitor fires and treat peatlands. Firefighting is done using simple tools. Likewise, funds for food kitchens and medical costs when fires occur are still limited. The local government will build a disaster center when a fire occurs. MPA will volunteer according to their ability. This community's limited funds and human resources make it sometimes difficult for them to deal with land fires on peatlands. However, morally and economically, they can set aside their income to sustain peatlands.

3.4. Local wisdom that applies to the community

The community agreed that it was necessary to understand the ancestral traditions in managing peatlands and dealing with land fires. The introduction and knowledge of peatlands and the community's tools prove that farmers still applied local wisdom at the study site. According to interviews with informants, they cut tall grass, weeds, and remnants of the previous harvest to be used as fertilizer. Informants stated they obtained local knowledge, so the land should be fertilized every two years. This tradition is called *tapulikampar* by the Banjar tribe in South Kalimantan.

The system of *tapulikampar (tabas* or cutting the grass, *puntal* or rolling the grass, *balik* or flipping the grass, and *ampar* or spreading the grass) is a land preparation system without burning but using grass and crop residues that are cut, spun, turned over, and spread out as fertilizer. This system has been carried out for generations and

contains land conservation principles helpful in maintaining soil fertility and improving water quality. Using traditional tools in cultivating peatlands with a pyrite layer causes the pyrite layer not to reach the soil surface. The community agreed that this system was better than burning land because it protected peatlands from being degraded and from wider fires.

The ability to adapt to the environment makes humans try to take advantage of existing resources to support their needs. It helps to build a bond between humans and their natural habitat. Communities that adapt to the environment will acquire and develop local wisdom through knowledge, customary norms, cultural values, activities, and life support equipment. Thus, local wisdom is rooted in local or traditional knowledge and management systems. Local wisdom on the environment raises the community's collective behavior in interacting with the environment to balance the ecosystem. The close relationship of local communities to the environment and natural resources makes them understand the ecological system in which they live through various trials [48].

Adaptation is one part of the process of cultural evolution. This process includes a series of human efforts to adapt or respond to changes in the physical and social environment that occur temporally. Bennett views adaptation as human-responsive behavior to environmental changes [49]. This responsive behavior allows them to organize specific systems for their actions or behavior to adapt to existing situations and conditions.

Based on the concept of adaptation, the relationship between humans and the natural environment is circular. It means that human behavior (culture) can change an environment, and conversely, a changing environment requires continuous adaptation so humans can survive and live [50]. [51] support the opinion that structural ecology is an interaction between the mind (thought patterns), life attitude, and behavior.

The response made by the Banjar community explains the form of adaptation to environmental changes. It follows the concept of adaptation strategy as a specific action chosen by individuals or communities in the decision-making process, with a predictable degree of success [49]. The importance of considering the social, economic, and cultural factors of the people on peatlands encourages the achievement of successful peatland restoration [52].

Local resource-based peatland management can be an option for the success of agricultural businesses [53]. Sustainable development requires harmony between environmental, economic, and social dimensions. For this reason, it is necessary to develop peatland management technology that follows the nature and characteristics of the local ecosystem. Developing and applying modern technology with local wisdom can

be an alternative to peatland management [54]. One form of this technology is Land Management Without Burning (LMWB). LMWB is a land-clearing technique that does not damage the physical and chemical properties of the soil and does not disturb the environment. LMWB builds a new agricultural culture, not limited to technology without burning but also a perspective and attitude of zero-waste and harmony with nature.

In line with LMWB, the Banjar ethnic people living on the peatlands of South Kalimantan also have a traditional method of land preparation known as the system of *tapulikampar. Tapulikampar (tabas* or cutting the grass, *puntal* or rolling the grass, *balik* or flipping the grass, and *ampar* or spreading the grass) is a local culture practiced by the Banjar community [36, 55]. This traditional land preparation represents a relatively good organic matter management system. Therefore, traditional farmers rarely use artificial fertilizers. *Tapulikampar* can improve land productivity because weeds enrich soil organic matter to contribute several soil nutrients [55]. Land preparation using a traditional *tajak t*ool is considered better, especially on land with a shallow pyrite layer, because this tillage method is carried out without exposing the pyrite layer [56]. This system contains land conservation principles that help maintain soil fertility and improve water quality and has been applied by Banjar tribal farmers for generations. What the Banjar community (farmers) do follows the view of cultural ecology. This approach examines the relationship between the technology of a particular culture and the environment [57, 58]. It means that the life pattern of a community and technology must be adapted to the environment to survive. According to [59], all forms of behavior are essentially adaptations or human reactions to environmental conditions for survival.

The *Banjar* community has long applied an environmentally friendly and sustainable agricultural system to cultivate peat and tidal lands. This local wisdom has helped the Banjar community (especially farmers) maintain their land productivity until now. Internalizing local wisdom in environmental management by the community is a dialectical process between individuals in community groups with the same culture and environment. This dialectic is expected to minimize the risk of peatland fires.

4. CONCLUSION

Sustainable land management on peatlands in reducing peatland fires was determined by community knowledge of the characteristics of peatlands, community knowledge about the use of peatlands, community adaptation to peatlands economic moral applied, and local wisdom in the community. Adaptations, local wisdom, economic morals, and knowledge carried out by the community as an ancestral heritage are still valid today.

Not everyone carries out this tradition since some people cultivate the land by burning or controlled burning. We recommend that local governments and communities continue educating and counseling the community to reduce land management by burning and preventing fires on vacant land. The economic value of peatlands to support people's lives can also be increased by considering the characteristics of the peatlands.

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