Factors affecting communities in adopting sustainable peat cultivation techniques and strategies for implementation (a case study in Pulang Pisau, Central Kalimantan)

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Abstract. Peatlands have the primary source of livelihood for the surrounding communities, even though peatlands’ cultivation has several limiting factors. Drainage in peat cultivation has the potential to cause fires. Social and economic interests often conflict with ecological interests. The research was conducted in Pulang Pisau District using a semi-participatory approach through field observations, in-depth interviews with key informants, and focus group discussions. The study uses the descriptive qualitative method in the data analysis. The results showed that factors that influence the adoption of sustainable peat management techniques are: i) the introduced technique is following the community’s social and cultural characteristics, but most of the people belong to the early majority and late majority category; ii) the intrinsic nature of the innovation; iii) the absence of collective decision making to implement land clearing without burning and iv) lack of assistance. The study recommended five policy strategy: i) preparing peat-adaptive commodity market; ii) encouraging incentives for implementing non-burning land clearing; iii) coordination and synergy between institutions; iv) selection of superior rubber seed and Cajuput plantation as a substitute for galam, and v) development of participatory agrosilvofishery demonstration plots.

Introduction

Peatlands provide many essential ecosystem services, including climate regulation through carbon sequestration and storage, water regulation, provision of palaeo-environmental archives, and recreation opportunities [1]. Peatlands tend to be degraded from year to year. Peat degradation is characterized by a change of physical, biological, and chemical properties leading to functional deterioration and...
ecological decline that harms the environment and socio-economy development. The underlying causes of peat degradation are commonly land-use conversion from peat swamp forests into agriculture and other uses [2]. Several types of commercial agricultural crops require drainage which causes the peat hydrological system to be disturbed [3]; [4]; [5].

Paludiculture has been identified as an alternative management strategy consisting of biomass cultivation on wet and rewetted peatlands [6]; [7]; [8]. Paludiculture or wet agriculture is a sustainable land use alternative on peatlands. Paludiculture in the tropics is heavily influenced by socioeconomic considerations [9]; [10]. It might be a solution to reduce GHGs from peatland with continued land use while providing a profitable business and building on the bio-based economy [11]. Paludiculture will provide more direct and indirect ecosystem services.

Ziegler [12] in his study on paludiculture as a critical sustainability innovation mission, stated that the application of paludiculture is very complex because it is related to the diversity of locations, institutions, stakeholders, social networks, and tension among sectors. Therefore, according to Kuhlmann et al. [13], the government’s proactive role is needed. Besides, it is suggested to organize periodic discussions to explore and adjust the potential of the mission within the appropriate context and form of governance.

Adoption of innovation is a mental process or behaviour change in cognitive, affective, and psychomotor skills in a person since he knows the innovation until he decides to adopt it [14]. Colby [15] divides community readiness in applying new technologies into explorers, pioneers, skeptics, paranoids, and laggards. In line with Colby’s classification, Rogers (1995) in [16] classified five groups of people in implementing innovation: innovators, early adopters, early majority, late majority, and laggards. Each class or group has different levels of acceptance of innovations. In addition, many factors influence the adoption of new innovations. It’s been a long time, sustainable peat management techniques have been introduced, but community adoption is still low. It is deemed necessary to conduct research to find the cause of the low-level adoption of sustainable peat management techniques. This paper aims to: i) analyze factors that influence the application of sustainable peat management techniques, and ii) formulate strategies to encourage the application of these techniques.

**Methodology**

2.1. Study location

We conducted the study in Pulang Pisau District, Central Kalimantan Province, Indonesia. We chose three villages purposively, where each was representing three different typologies of peat depth. Gohong Village in Kahayan Hilir District represented shallow peat depth, Garung Village in Pulang Pisau District represented medium peat depth, and Tumbang Nusa in Pulang Pisau District represented deep peat depth (see Figure 1).

1.2. Data collection

Data was collected through literature studies, field observations, interviews, and focus group discussions (FGD). Interviews were conducted with key informants consist of farmers, village officials, extension workers, the Forestry and Plantation Office of Pulang Pisau Districts, the Forestry Office of Central Kalimantan Province, peat observers (universities and NGOs), and local humanist.

2.3. Data analysis

Data collected were analyzed using descriptive qualitative. Descriptive analysis aims to provide a description of the situation during the research was conducted, explain the subject matter, and provide alternative solutions to the problem studied (Miles & Huberman 1994 ; [17]. The qualitative and quantitative descriptive analysis results are presented in tabular, numerical, graphic, and narrative forms. To develop a strategy for sustainable peat cultivation, FGDs with local communities and village officials were conducted in the three villages. The communities were invited to identify their strengths, weaknesses, threats, and opportunities.
The framework of the study uses an adoption theory approach. According to Rogers [14] and Cees [18], several variables influence the adoption of new technologies, namely: the nature of innovation (relative advantage, compatibility, complexity, trialability, and observability), the type of innovation decision (optional decision, collective decision, and authority decision), communication channels, and socio-economic characteristics of the community. According to Scholz [19], three factors can influence the adoption of an innovation: benefit maximization, external environmental incentives, and technology perception associated with risks.

Figure 1. Study area

Figure 2. The framework of the study using the theory of innovation decision (adapted from Rogers [14])
Result and discussion

3.1. Factors affecting adoption

Within the adoption process, there are several stages that individuals go through before deciding whether to accept or reject an innovation. These stages start from introduction, where individuals begin to know about innovation, persuasion, decision, implementation, and confirmation [14]. One factor that influences adoption is the social characteristics of the community. Categories of people in the social system can be grouped based on their level of innovation or are called the adopter category which consists of the adopter, early adopter, early majority, late majority, and laggard.

Most people belong to the early majority (35%) and the late majority (35%). Both of these groups have a very careful character in deciding whether or not they adopt new techniques. These people wait for others to apply the latest techniques, then they follow. This explains why the introduced peat cultivation techniques are slow to be adopted.

![Community Category against New Innovation (%)](image)

**Figure 3.** Community category against new innovation (in percent)

From the social aspect, the application of sustainable peat cultivation techniques is in accordance with local customs and culture. Dayak Tribe has local wisdom that has been maintained to this day, including planting peat-adaptive species such as belangeran, yellow meranti, jelutong, galam; and utilizing those species by processing them into various products such as woven mats and household products.

3.1.1. Intrinsic characteristics of the proposed sustainable peat cultivation techniques. The government encourages the community to apply sustainable peat cultivation techniques in the form of land preparation without burning, canal blocking development, and paludiculture. Land preparation without burning is a severe challenge for the community because, for generations, the local community has a tradition of burning peatlands to prepare for rice planting [20]. Land preparation by burning is one of the easiest and cheapest techniques that people had been doing for years [21] [22]. However, this technique has the disadvantage of encouraging peatland fires. Peatland fires are tough to control so that the government prohibits this activity [23].

In recent years, the development of canal blocking has been intensified by the Peat and Mangrove Restoration Agency (Badan Restorasi Gambut dan Mangrove/BRGM). In some cases, the technique provides many advantages during the dry season, reducing the incidence of fires. However, in rainy seasons, the construction of canal blocking causes flooding. Before the existence of BRGM, the
community had made a simple canal blocking using galam wood, one of the wood species widely grown in the area.

Peat cultivation using the paludiculture technique ensure that peat can be managed sustainably as the peat planted by adaptive plants always is in wet condition. The community does not know the term paludiculture due to the lack of popularity of the term. Besides, alternative silvicultural techniques could generally be described using the traditional term, and applying a new term also might create confusion [24]. Still, they have applied the technique to deep peat by allowing the land to be overgrown with local plants such as jelutong, gemor, galam, purun, and balangeran. The paludiculture system is “easy to implement”; however, it is “less profitable” economically. According to the local community, the paludiculture technique is not suitable for certain types of plants, such as sengon, oil palm, and fruit trees, because the method causes those plants to be submerged so that trees growth slowing down and finally die. This condition makes people build mounds and ditches to dry the peatland. This technique is “less compatible” with sustainable peat cultivation techniques.

Adaptive peat plants are peat swamp native plants and non-peat swamp native plants that can grow on wet peatlands or re-wetted peatlands without drainage [25]. There are two types of peat adaptive plants preferred by the community, namely rubber and galam. Rubber is more suitable for shallow peat, while galam is suitable for medium and deep peat. Rubber and galam are preferred by the local people and are compatible with the peat ecosystem; however, they do significantly contribute to farmers’ income. The community in the study area has traditionally cultivated local rubber with very low productivity (one ounce/tree/tapping). Rubber plants provide continuity of income; as many as 87% of the community count on their income from a rubber plantation. The community has not grown galam even though the plant is quite adaptive and accepted by markets. People only cut down galam trees that grow naturally on neglected peat areas.

In fact, cultivating native peat swamp plants combined with commercial crops using dead-end small drainage ditches called “worm trenches”. However, the practice of mixed farming does not include paludiculture because there is still drainage [26]. Currently, around 379 types of non-timber forest products have been found and there are 81 species of peat swamp plants that can be used for economic purposes, but the lack of information causes people to have not adopted these plant species for paludiculture [27].

3.1.2. Innovation decision making. The decision to select the type of plants and their cultivation system becomes an optional decision for each farmer. Farmers tend to choose plants with good market prospects. Marketing is the key in selecting plant species [28]: [29]. Several types of plants that are currently preferred by the farmers (because of their selling prices) require land drying in their cultivation, such as oil palm, guava, rubber, Paraserianthes, and several vegetables. Farmers made ditches around the oil palm and guava plants so that the plants could grow well. In cultivating rubber and Paraserianthes, farmers make small trenches, while mounds are made in the land for vegetables or they are grown in polybags.

The government makes an authority decision in the form of a regulation prohibiting burning in land preparation activity. The local community agreed and obeyed the regulation, even though they could no longer grow rice. As the consequence, they have to buy rice to meet their staple food. Changing the land clearing practice from using fire into non-fire technique requires a collective agreement in the form of a collective decision to encourage the community to cooperate with a mutual cooperation system. Peat soil has overgrown with “kelakai”, whose roots are difficult to clean out. Preparation of peatland for rice planting requires a lot of labor and time, so farmers need to work together with others in a cooperative system.

3.1.3. Communication channel. Local communities in the research location have been received only a little bit of knowledge on sustainable peatlands culture. Most of the local community (64%) stated that they never received counseling (from forestry extension workers), as many as 27% stated that occasionally and 9% of the community stated that they often received counseling. Some of
information sources or knowledge obtained by the community was (45%) inherited from their ancestors and based on experiences in the field, extension workers, and several trainings held by the government (36%), and the rest (19%) from the mass media.

![Fig 4](image)

**Figure 4.** Frequency of extension activities and sources of information obtained by the community

### 3.2. Strategy for the implementation of sustainable peatlands culture techniques

In developing a sustainable peatlands culture strategy, it is necessary to map the existing strengths, weaknesses, opportunities, and threats, as shown in Table 1. Peatlands culture has many limitations, such as low nutrient content that causes low land productivity. In addition, there are several weaknesses on peatlands culture, i.e., i) the extension of less productive land due to the burning prohibiting regulation; ii) farmers have not attached by an easy to apply technology for peatlands clearing without burning; iii) the local community has not used the superior rubber seeds; iv) the less effective of village institutions; iv) the limitation of capital and v) the lack of community’s knowledge regarding innovations in sustainable peatlands culture techniques.

The strengths of the local community towards cultivating on peatlands are: i) the large of farmers owned peatlands area (around 2 – 5 Ha/family); ii) the community has long experience in peatlands culture (having local wisdom); iii) The growth of several types of adaptive plants on peatlands area (galam, belangeran, patung; iv) the cultivation of adaptive rubber plants on peatlands, providing daily livelihoods income, and in terms of social life, it is suitable with the culture of the Dayak tribe, and vi) some local communities have beje (fish pond).

The threat of peatlands culture is very large, therefore it is necessary to be cautious in controlling peatlands. Threats to cultivation on peatlands include: i) Peatlands are highly vulnerable to peat fire; ii) Peat is vulnerable to irreversible drying; iii) High acidity of peat soil; iv) Limited number of microorganisms in peat soil; v) Cultivation of cash crops requires drainage which causes subsidence; vi) Low density and bearing capacity of the peatlands against pressure; vii) There is no incentive for lands management without burning; viii) Lack of assistance and counseling to the community and ix) The unavailability of markets for some agricultural products.

Within the existing limitations, the local community has several opportunities to be optimized, e.g.: i) Peatlands is most of the community’s source of their livelihood income; ii) Peatlands is a unique ecosystem that has received international attention; iii) Peatlands conservation has the potency to receive payment for environmental service from donors; iv) Limited mineral land, therefore 30% of peatlands have the opportunity to be managed in terms of supporting food and energy security efforts; v) The peatlands ecosystem is maintained with the prohibition of slash and burn; vi) a lot of innovations related
to peatlands water management allow peatlands to be managed productively but sustainably; viii) BRG assists a lot in the construction of canal blocks and boreholes and ix) Availability of markets for rubber and galam commodities.

| Table 1. SWOT analysis for sustainable peatlands culture |
|--------------------------------------------------------|
| **Strength**                                             |
| • Farmers have long experience in farming on peatlands (local wisdom) |
| • The large of farmers’ land tenure (around 2 – 5 Ha/family) |
| • The growth of several types of adaptive plants on peatlands (galam, belangeran, patung), |
| • Adaptive rubber plants culture on peatlands, providing daily family income and it is accordance socially with the culture of Dayak tribe. |
| • Some of the villagers have a fish pond (beje) |
| **Weakness**                                             |
| • Peatlands have poor nutrient content and low land production. |
| • Creating a lot of unused land due to the declaration of prohibiting burning regulation. |
| • Farmers have not had a simple technique and cheap for peatlands management without burning |
| • Farmers have not used superior seeds in rubber cultivation |
| • A Farming institution at the village level has not been effective |
| • The limitation of working capital for farmers |
| • The lack of local community knowledge regarding innovations in sustainable peatlands culture |
| **Opportunities**                                        |
| • Peatlands have become the source of income for the livelihood of the surrounding community |
| • Peatlands is a unique ecosystem that has become an international concern |
| • Peatlands conservation has the potency to receive Payment environmental services from donors |
| • The limitation of mineral land, 30% of peatland has the opportunity to support food and energy security |
| • The ban on slash and burn encourages peatlands to be managed sustainably |
| • There are many new innovations related to peatlands water management that allow peatlands to be managed productively and sustainably |
| • BRGM has provided a lot of supports in the construction of canals and boreholes |
| • The establishment of a rubber processing factory around the village and the availability of a galam wood market |
| **Threats**                                              |
| • Peatlands are vulnerable to peat fire |
| • Peatlands is fragile |
| • The development of drainage in terms of land clearing caused a peatlands subsidence |
| • The low land density and bearing capacity against pressure |
| • Peatlands is vulnerable to irreversible drying |
| • The high acidity of peatlands soil |
| • The limitation of microorganisms in peatlands soil |
| • Commercial agricultural development is often confronted towards environmental issues |
| • There is no incentive for the implementation of land clearing without burning (PLTB) |
| • Lack of assistance and extension effort for the community |
| • There is no market for some agricultural products |

Sources: focus group discussion result between villagers and village staffs

Previous findings stated that most of the people belong to the early majority and late majority category, so they are a bit slow in accepting innovations in sustainable peat cultivation techniques submitted by the government. The intrinsic nature inherent in the offered peat cultivation technique is technically easy to do, the materials for which are available in the field, but economically less profitable. The sustainable peat cultivation techniques offered (such as the paludiculture technique) are not
compatible with other commercial crops. The research findings are also a consideration in determining strategies to accelerate the process of adopting sustainable peat cultivation techniques.

Based on the aforementioned analyses, there are some strategies for sustainable peatlands culture, i.e.:

1. The government needs to provide incentives to encourage the implementation of land clearing without burning (PLTB) in the form of assistance for agricultural mechanization equipment that is friendly for peatlands, dolomite, and herbicides. Peatlands clearing without burning needs to be activated into a community-based working group because it takes a long time and requires a lot of manpower.

2. The role of the extension staff as a companion and facilitator needs to be considered. The limitations of extension staff must be addressed by stimulating local extension people or local champions. Companions and local champions have the potency to become drivers for farmers to apply sustainable peatlands culture techniques.

3. The marketing factor is the key to select the type of plant. In terms of encouraging farmers to select types of plants that are adaptive on peatlands (rubber, purun, galam, belangeran, petai, durian, pineapple, chili, eggplant). The government must provide a market to accommodate agricultural products from sustainably managed peatland (paludiculture).

4. The existing institutions (Gapoktan, Fire Care Community, Tabat Care Community, Bumdes) are significant to strengthen and synergize with each other to improve community welfare and contribute to village income while maintaining environmental sustainability. Institutional collaboration at the village level is significant as well to be strengthened with the Perdes (village regulation) and it is possible to facilitate by the funding from the Village Fund.

Conclusion and recommendation
The communities Sustainable peatlands culture techniques are gradually being adopted by the local community because most people (70%) are in the early majority and late majority groups, these two groups have a very cautious character in deciding to apply new techniques after exploring some examples from other farmers. They would like to imitate the techniques. Communities are really keen to observe the sustainable peatlands culture models. Therefore it is necessary to make participatory agrosilvofishery demonstration plots with the introduction of simple and inexpensive PLTB techniques, as well as innovations in sustainable peatlands water irrigation techniques.

The other factor that inhibits the adoption of sustainable peatlands culture techniques is the intrinsic nature of innovation (easy to do but less profitable). The peatlands culture technique offered is technically exploitable to carry out because the raw materials are available in the field, but it is not economical and not profitable. According to the local community point of view, the paludiculture technique is not suitable for certain types of plants (sengon, oil palm, fruits) because it will cause the plants to be submerged, their growth will decelerate and they will die. This condition stimulates the community to build mounds and ditches to dry the land. This technique is "less compatible" with sustainable peatlands culture techniques. The community has less informed of the paludiculture terminology, but they have actually applied the technique to deep peatlands by allowing the land to be overgrown with local plants (jelutung, gemor, galam, purun, belangeran, etc.). The paludiculture system is "easy to implement" but from an economy point of view, it is "less profitable" because there is no satisfactory market for the commodities.

Technology innovation that is accepted in the economy, social and sustainable ecology perspective: 1) the introduction of superior rubber seed and 2) Cajuput (Melaleuca cajuputi ssp cajuputi) plant planting that would be extracted to produce cajuput oil afterwards. Cajuput is under the same species as galam (Melaleuca cajuputi ssp cumingiana).

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Acknowledgments
Authors would like to thank to the secreratiat of Forestry Research and Development Agency, the Research Team of the Center for Research and Development of Social Economic Policy and Climate Change (P3SEKPI) and Faculty of Forestry, Tanjungpura University. This study is the result of a collaboration between P3SEKPI and Tanjungpura University.