Choices of crops on establishing of agroforestry plot in peatland in Rasau Jaya Dua Village, West Kalimantan, Indonesia

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Abstract. Information about the choices of crops is essential to understand what is the community's preferences and consideration to understand the existence of crops on their community land. The research aimed to find out farmers' preferences and choices of crops on establishing an agroforestry plot in the peatland area. The research was conducted in Rasau Jaya Dua Village, Kubu Raya District, from August to November 2017. The primary data on this research were the community's socioeconomic condition and their preference for crops. Data on socioeconomic conditions were collected through in-depth interviews with 46 respondents. Data in choices of crops were collected through the Participatory Rural Appraisal (PRA) method using the ranking matrix of 20 farmers group members who involved in the development of the agroforestry plot on peatlands. The result showed that farmer has a preference of crops for their agroforestry plots on peatland. Corn is the most favorite crop to be planted on agroforestry plots. Corn is easy to grow, has a stable selling price, and has a short harvesting period (4 months). Meanwhile, for perennial tree crops, pulai (Alstonia pneumatophora), jelutung rawa (Dyera polyphylla), and gerunggang (Cratoxylum glaucum Korth) were the most favorite choices. Those trees have initially been grown on peatland, but the planting stocks were challenging to be found, and they need a more extended period to be harvested.

1. Introduction

In many parts of the world, tropical peatlands have an essential role in the ecosystem, primarily as the primary source of carbon stock [1] and economically valuable function for local communities livelihoods as the source of timber and non-timber forest products [2]. It also has potential function as the future food sources [3]. Peat degradation is characterized by a change of physical, biological and chemical properties, leading to the functional deterioration and ecological decline that harms the development of the environment and socio-economy sector. Therefore, peat degradation is a complex process associated with land-use changes and social perspectives. Unwise land-use practices drive significant changes of physical, biological, and chemical properties towards peat degradation, and increase carbon emission from land-use change [4]. The major drivers of peatland deforestation and degradation in the South-East Asia region are categorized as direct and indirect drivers. Direct drivers include logging, conversion to large-scale agriculture activities including industrial plantations, construction of artificial drainage canals, repeated fires, poverty, and fire-based traditional farming
practices. Meanwhile, indirect drivers stem from climate change and inconsistent land use policy and weak governance [5].

West Kalimantan Province (± 146,000 km$^2$) has lowlands, flat topography, swamps, and rivers predominantly. This region is rich in biodiversity living in both terrestrial and aquatic ecosystems. We found that drainage and the conversion of peat forests into agriculture, oil palm, and industrial timber plantation have caused major changes in selected peat properties [4].

The agroforestry system can be adopted in the peat swamp area to enhance the success of land rehabilitation and to improve national food security [6]. However, peatland rehabilitation by the agroforestry pattern becomes a rare effort in the program and its term of success.

Information about choices of crops is essential to understand what is its preferences and consideration [7] and to understand the existence of crops that exists on community land [8]. [7] stated that this knowledge could help scientists to share their information with farmers to improve agriculture productivity, product optimization, and product price. The research aimed to find out farmers' preference for choices of crops on establishing of agroforestry plot in peatland.

2. Methodology

2.1. Time and research location

The research was conducted in Rasau Jaya Dua Village, Kubu Raya District of West Kalimantan, from August to November 2017. Kubu Raya District is selected as a pilot district with several considerations: 1) this district has the most extensive area of peatland in West Kalimantan, 2) less publication in the peatland rehabilitation program, and 3) it has good access from the capital of West Kalimantan Province. The research location is presented in Figure 1.

![Figure 1](image1.png)

Figure 1. The research location in Rasau Jaya Dua Village Kubu Raya District.

2.2. Methodology for data collection and analysis

This research is a case study that seeks to explain, analyze, and understand a case using various data sources [9]. Primary data are the community's socioeconomic condition and crop preference. The socioeconomic condition was collected through an in-depth interview with 46 respondents. An in-depth interview is a process of obtaining information for research purposes using a question and answer through face to face interviews between the interviewer and the person being interviewed, with or without interview guidelines where they are involved in a relatively long social life [10]. Preference data in choices of crops were collected through the Participatory Rural Appraisal (PRA) method using
a ranking matrix of 20 farmers of farmer group members who involved in the agroforestry plot development on peatlands. PRA is an approach and method for studying rural conditions. This enables rural communities to share, multiply and analyze their knowledge of their conditions and lives to plan and take action [11] and also to plan development programs at the village level [12].

The ranking matrix is a PRA instrument to help identify community criteria related to a particular topic [13], assess and study farmers' preferences regarding certain things, including crops [14]. All data obtained was processed, analyzed, and presented according to the stages of the case study research, that is, the data managed, read, grouped, interpreted, and presented using narration, tables, and images [9].

3. Results and Discussions

3.1. Peatland condition in Kubu Raya District

A total estimate of 17.500 km$^2$ of peats is present in West Kalimantan Province [4]. Peat in West Kalimantan belongs to the suborders of fibric (least decomposed peat), hemic (half decomposed), and sapric (fully decomposed). In the lower category, the most commonly found great groups are Haplofibrists, Haplohemists, Sulfihemists, and Haplosaprists [15]. Kubu Raya District of West Kalimantan relies on future agricultural development on this environmentally fragile peatland. Kubu Raya has 408,369 ha (58%) of the total land area of the respective 698,520 ha [16]. The map of peatland distribution in Kubu Raya District can be seen in Figure 2.

The trend in the development of agricultural areas does not necessarily comply with regulatory and agronomic suitability standards, in such a way that development may not be sustainable. With relatively vast peat shrub and peat forest available for future agricultural development, it is strategically important to consider the suitability and environmental implications of peatland development, especially those related to greenhouse gas emissions and sustainability [15].

The underlying causes of peat degradation are commonly land-use conversion from peat swamp forests into agriculture and other uses. As peat growth depends on inputs of fresh vegetation biomass, the removals of peat-forming vegetation directly reduce the deposit of vegetation biomass into peat profile [4]. Field observations showed that many crops grow well in peat soils in Kubu Raya District. Thriving agriculture, especially vegetables farming on peats, can be found in Kubu Raya, especially in Rasau Jaya, Pinang Luar, Jangkang, and Siantan Subdistricts.

![Figure 2. Map of peatland distribution in Kubu Raya District.](image-url)
3.2. Community socioeconomic condition and agroforestry plots in Rasau Jaya Dua Village

Females (70%) are the most respondents in Rasau Jaya Dua Village. It was because men, as the head of the family, have to work out of town (Ketapang, Sambas, etc.) or even work abroad (Malaysia). Most respondents (92%), males, or females were in their productive ages (15 – 64 years old). The younger the farmers' age is usually considered to have greater enthusiasm for new things, so there is an impression that they are faster and responsive in renewal. Their perception of innovation is more precise, complete, and objective compared to older farmers. All respondents were the Javanese that have been living there since 1974 by the transmigration program. They came from Central Java, such as Blora, Grobogan, Kudus, Banyumas, Wonogiri, Kebumen, and Gunung Kidul (Yogyakarta). At the beginning of the arrival, the transmigrant's area was still dominated by forest and peat with 4.25 m thickness. The condition of the provided houses were very simple, namely half-boarded and half-walled house walls.

Most respondents (74%) have a low educational background (elementary school). This condition can be resolved by increasing farmers' non-formal education, such as training, because more knowledgeable farmers are expected to have higher ability in receiving, filtering and applying innovations that are developed for them. Most respondents have < 4 persons of family dependents (80%) and 80% work as farmers of secondary crops, rice farmers in peat, or non-peatland area. They have 0.5-1 hectares of peatland and 0.5 hectares of non-peatland (mineral soil) on average.

There are two locations of land for peatland agroforestry plots in Banjarsari Sub-Village, Rasau Jaya Dua Village that were categorized as private land (not forest area). The first location is at 109°24' N - 0° 15'34" E. The area is two ha, shallow peat (0 - 2 m), and covered by bushes such as fern and acacia. The second location is at 109°24'48" N - 0° 14'57" E. The area is two ha with the peat depth of 3 - 4 m and covered by bushes such as fern, acacia, and several trees such as nyatoh (Palaquium sp.), ramin (Gonystlus sp.), and jelutung (Dyera sp.) remaining from forest fire in 2009. The agrophysical characteristics of peatlands in Banjarsari sub-village are as follows: peat thickness of 0.5 cm - >3.5 cm, soil pH of 4.4, and groundwater level of -16 cm to -70 cm which is primarily used for the development of food crops [17].

Land fires occur almost every dry season, and this is caused by tillage through burning the land. One of the efforts to overcome forest and land fires is through controlled combustion by burning downwind. The worst fire in Rasau Jaya Dua Village peatland happened in 2012. It burned almost half of the farming peatland (= 600 ha).

3.3. Peatland for farming

Peatland has several problems in its utilization, utilization due to its low pH and soil fertility. Peatland for farming purposes requires high external input, in which ameliorant and fertilizer are required. Ameliorant and fertilizer only give temporary effect because peatland absorption power on cation and anion is very minimum [18]. The farmer has a general principle on peatland farming that peatland will survive and can be planted if using fertilizer [17]. Well-managed peatland (enough watering and ameliorant, such as calcium, compost, weed burning result, and hay) can support high productivity [19].

Another consideration in utilizing shallow peatlands is the plant root system. Annual crops are not recommended for cultivation on this type of land because it requires a broader and deeper root area. The thickness of shallow peatland is limited, so it is dangerous if the roots of annual crops touch the ground layer, which contains toxic compounds. Therefore, the use of shallow peatland is only for the cultivation of food crops and horticulture [20]. Shallow peatland can be utilized for the cultivation of food crops (rice, corn, and soybeans), horticultural crops (pineapple, banana, melon), and vegetable horticultural crops (tomatoes, pare, cucumber, chili, kale, and spinach) [20]. The Indonesian Center for Soil and Agroclimate Research and Development [21, 22] suggested that peatland with the peat thickness of 0.5 - 1.0 m can be used for annual crops cultivation, while that with 1.0 - 3.0 m thickness may be used for perennial tree crops. Suitable crops for peatland rehabilitation are presented in Table 1 and Table 2.
Table 1. Suitable crops for shallow peatland (< 1m depth).

| No. | Commodity                        | Annual crops                                                                 |
|-----|----------------------------------|-------------------------------------------------------------------------------|
| 1   | Rice or paddy for peatland       | local use: talang, ceko, mesir, jalawara, siam pandak                        |
|     |                                  | high quality: kapuas, cisanggarung, Sei Lilin, IR-42, lemang, cisadane, indragiri, punggur |
| 2   | Soybean for peatland             | wilis, rinjani, lokon, dempo, galunggung, lamet, lawit and kerinci.          |
| 3   | Corn for peatland                | arjunakalingga, wiyasa, bisma bayu, antasena, C-3, C-5, semar, sukmaraga, H-6 ans Bisi-2 |
| 4   | Green bean species for peatland   | betet, waliq, gelatik                                                        |
| 5   | Peanut                           | gajah, pelanduk, kelinci, singa, jerapah, komodo, and mahesa                 |
| 6   | Vegetables                       | chili, tomato, aubergine, long bean, bean, cucumber, red onion, mustard, lettuce, spinach, water spinach |
| 7   | Fruits                           | watermelon, pineapple                                                        |

Source: [23]

Table 2. Suitable crops for deep peatland (> 3m depth).

| No. | Commodity                        | Perennial tree crops                      |
|-----|----------------------------------|----------------------------------------|
| 1   | Food (fruits, carbohydrate, protein, seasoning, oil, fat) | sagu (*Metroxylon* spp.), asam kandis (*Garcinia xanthochymus*), kerantungan (*Durio oxleyanus*), pepaken (*Durio kutejensis*), mangga kasturi (*Mangifera casturi*), mangga kueni (*Mangifera odorata*), rambutan (*Nephelium spp.*), nipah (*Nypa fruticans*), kelakai (*Stenochlaena palustris*), tengkawang (*Shorea stenoptera, S. macrophylla*), geronggang (*Cratoxylum arborescens*), terentang (*Campnosperma auriculatum*), gelam (*Malaleuca cajuputi*) |
| 2   | Pulp and paper                   | gelam (*Malaleuca cajuputi*), sagu (*Metroxylon sago*), nipah (*Nypa fruticans*) |
| 3   | Bio-energy sources               | jelutung (*Dyera polyphylla*), nyatoh (*Palaquium leiocarpum*), sundi (*Payena spp., Madhuca spp.*) |
| 4   | Latex                            | akar kuning (*Coscinium fenestratum*), pulai (*Alstonia pneumatophora*) |
| 5   | Medicine                         | gaharu (*Aqualiria sp*), genor (*Alseodaphne sp*), purun tikus (*Elaeocarhis dulcis*), rotan irit (*Calamus trachycoleus*) |
| 6   | Other forest product             | ramin (*Gonystylus bancanus*), meranti merah (Shorea macrantha, S. balangeran) |

Source: [24]

3.4. Choices of crops in establishing agroforestry plots

Peatland is challenging to be developed as the planting media. One strategy needed is by choosing a suitable crop to be developed. On the shallow peatlands, only specific species could grow well [3, 23, 25]. The choice of crops is related to the typology of overflow, season, the economic value of crops, and the availability of technology. Horticultural crops (vegetables and fruits) have a higher economic value than food crops, but they require more intensive cultivation techniques [3].
PRA with the rank matrix was applied to determine the crops that will be planted on the agroforestry plot. Ranking based on preferences is the fastest way to identify the main problem, and the determination of the scores can be done without restriction from the maximum level, for example, score 5 for the most important to score 1 for the least important [13]. Crops rank matrix was made by giving a ranking for a favorite crop in the community version, but it was done before inventorying and checking for the existing crops around the plots. According to the field observation and interview with the local people, there were some existing annual crops around the plot sites, i.e., a) horticultural crops such as chili, ginger, tubers, cabbage, tomato, corn, beans, pineapple, and watermelon, b) perennial tree crops such as dog fruit, areca nut, rambutan, etc. Crops that are planted on peatland in Rasau Jaya Dua Village could be seen in Figure 3.

![Figure 3. Annual crops are planted on peatland in Rasau Jaya Dua Village.](image)

This information becomes a starting point for farmer's groups in determining their favorite crops through making a rank matrix of crops, according to 9 parameters, i.e., land suitability, the number of farmers, daily consumption, easiness in seedling procurement, easiness in crop treatment, resistance to pest and disease, harvesting period, easiness in marketing, and selling price. They were determined through discussion and agreement between researchers and farmer groups. It used a scoring system from 1 to 5. [17] stated that in general, determination of crops by farmers on peatland is determined by 1) suitability of crops, 2) availability of fertilizers (chemical, artificial, organic, ash and lime), 3) estimated water availability (weather), 4) availability of competitor commodity production supply 5) farming patterns, and 6) polyculture planting patterns.

The rank matrix results in determining crops for agroforestry plots in Banjarsari Sub-Village, Rasau Jaya Dua Village of Kubu Raya District is shown in Table 3. Based on Table 3, the most favorite crops, in sequence were corn, banana, areca nut, peanut, pepper, watermelon, and chili. Meanwhile, the most favorite of perennial tree crops were pulai (*Alstonia pneumatophora*), jelutung rawa (*Dyera polyphylla*), and geranggang (*Cratoxylum glaucum* Korth).

Corn was the most favorite crop as it is easy to grow, has a stable selling price, and has a short harvesting period (4 months) in which it is different from the chili. Although chili has a high selling price, it also requires high investment and intensive treatment. Therefore, only farmers with >1 ha of land and great assets would have planted chili and they would have a commercial orientation. It could be seen from their choices of crops, such as chili, peanut, and onion, that required intensive treatment and high investment for fertilizer and worker's procurement. On the contrary, farmers with land...
ownership less than 1 ha usually planted plant species that required easy treatment, such as corn and ginger.

*Jelutung rawa* (*Dyera polyphylla*) is a local plant that was introduced for peat forest rehabilitation in Sumatra and Kalimantan [26]. Implementation of agroforestry systems with *jelutung* is suitable to be applied in peatland. [27] stated that the application of *jelutung* with an agroforestry system on peatland, potentially increases the benefits of ecosystem services for local communities. *Jelutung* that was developed with rubber, had an NPV of IDR 59,247,417, a BCR of 5.35 and an IRR of 24.1%, at an interest rate of 12%. However, when it was developed in a monoculture system, it would result in an NPV of IDR 10,248,888, a BCR of 4.28 and an IRR of 14.7% [28].

Choices of perennial tree crops were supported by farmer's perception that the crops were grown initially on peatland, the planting stocks are difficult to be found, and they need a more extended period to be harvested. [29] stated that restoration of disturbed peatlands will be effective through the planting of native peatland plant species. Nowadays, for fulfilling the housing needs (building/ house construction), the farmers should buy the materials because there were no perennial tree crops to fulfill the needs.

**Figure 4.** PRA for choices of crops in women group (a) and men group (b).
### Table 3. The rank matrix in choices of annual crops for agroforestry plots in Rasau Jaya Dua Village.

| No | Crops     | Criteria for plant species assessment | Quantity | Rank |
|----|-----------|--------------------------------------|----------|------|
|    |           | Land suitability | The number of farmers | Daily consumption | Easiness in seedling procurement | Easiness in plant treatment | Resistance to pest and disease | Harvesting period | Easiness in marketing | Selling price |
| 1  | Corn      | 3 | 5 | 4 | 5 | 5 | 5 | 4 | 5 | 4 | 40 | 1 |
| 2  | Peanut    | 4 | 3 | 4 | 5 | 5 | 5 | 4 | 3 | 4 | 37 | 4 |
| 3  | Chili     | 1 | 1 | 2 | 1 | 3 | 2 | 5 | 5 | 2 | 22 | 7 |
| 4  | Watermelon| 1 | 3 | 4 | 3 | 3 | 2 | 5 | 5 | 2 | 28 | 6 |
| 5  | Areca nut | 4 | 3 | 3 | 5 | 5 | 4 | 4 | 5 | 5 | 38 | 3 |
| 6  | Pepper    | 3 | 2 | 5 | 1 | 3 | 4 | 3 | 5 | 5 | 31 | 5 |
| 7  | Banana    | 3 | 5 | 5 | 5 | 5 | 5 | 3 | 4 | 4 | 39 | 2 |
4. Conclusion

Farmers have a preference for choices of crops on their peatland agroforestry plots. They considered land suitability, the number of farmers, daily consumption, easiness in seedling procurement, easiness in crop treatment, resistance to pest and disease, harvesting period, easiness in marketing, and selling price. Corn was the most favorite crop to be planted on agroforestry plots. Corn is easy to grow, has a stable selling price, and has a short harvesting period (4 months). Meanwhile, for perennial tree crops, pulai (Alstonia pneumatophora), jelutung rawa (Dyera polyphylla), and gerunggang (Cratoxylum glaucum Korth) were the most favorite species. Choices of perennial tree crops were supported by farmer's perception that the crops were grown initially on peatland, the planting stocks are difficult to be found, and they need a more extended period of time to be harvested.

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