Innovation for the development of environmentally friendly oil palm plantation in Indonesia

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Abstract. Oil palm is a very common commodity in rural communities of Sumatra and Kalimantan, Indonesia, and the farming activities in these areas create a high multiplier effect and increase welfare. However, the expansion of oil palm areas puts pressure on forests and resources. The research was carried out through a survey using the developmental research method. Efforts to implement sustainable development in the plantation sector need to be carried out to develop palm in the second cycle. One of the efforts is to implement agroforestry by planting forestry plants between oil palm trees, namely meranti trees (Shorea leprosula Miq). The model for the development of meranti is a monoculture palm plantation that is integrated with meranti trees. This has ecological, economic, and social benefits, following the basic concepts of environmental management. Planting copper meranti between palm trees has multiple benefits for the community, such as wood production. Planting copper meranti between oil palm trees has multiple benefits for the community, timber production as additional income for farmer families.

1. Introduction
Currently, Riau has the largest palm plantation in Indonesia, reaching 2,537,375 ha in 2019. Over the past 15 years, land area growth has increased by 2.55% per year, and processing factories’ development supports it. Therefore, palm oil has become a leading commodity in Riau’s economy because of its multiplier effect [1]. Palm oil has provided a high level of welfare in rural areas, both directly and indirectly. Research in Riau showed that this commodity positively impacts the economy, especially in rural areas. Since 2012, the welfare index has a positive value of 0.43, which means that these communities’ welfare has increased by 43%. Meanwhile, from 2016-2018, the index increased by 18%, one of palm farms [2]. The welfare felt by rural communities is one of the contributions of oil palm farming [3].

The conversion of industrial timber estates (HTI) and the expansion of palm areas put pressure on forest and resources. From 2000 to 2012, Indonesia lost 15.8 million hectares, with a forest loss rate of 8.4% per year. Furthermore, 98% of deforestation occurred in high-density areas in Sumatra and Kalimantan. Riau Province ranked the first position with the highest forest loss [4]. The high rate of deforestation is partly due to the conversion of land to palm plantations. In Riau 2009-2015, changes
in the designation of areas converted for agriculture reached 1,547,079.70 ha. Meanwhile, WWF’s [5] findings showed that the environment’s negative impact is becoming more serious because palm plantations’ development occurs in conversion forest areas and penetrates production areas. Furthermore, the impact affects conservation forest areas with unique ecosystems and high biodiversity values [5]. Therefore, it has become a political issue that harms the international community, prohibiting Indonesian palm products. This is because it is considered to affect the environment and unsustainable management of forest resources negatively. Research results Irianti et al. showed that land clearing for palm plantation in the upstream watershed (DAS) had increased the rate of erosion, leading to high silt sedimentation along rivers [6].

The question is: “how to develop palm plantations to be more environmentally friendly and meet wood needs in the long term without destroying the remaining natural forests? One effort that can be implemented is to apply agroforestry by planting forestry plants between the palms. Forestry plants that are recommended in the application of agroforestry are endemic types (not exotic species), which grow quickly without an umbrella canopy. The types include meranti clan (Shorea spp), gaharu (Aquilaria malaccensis), and others. These crops can be a source of additional income for farmers, and the wood produced is used to overcome the need for development. Besides, at the end of the cycle, the sales of meranti wood are added to farmers’ income. It assists farmers in providing costs for replanting palms obtained from the harvested timber production.

Meranti (Shorea leprosula Miq), also known as red or copper meranti, is mostly cut down and used from natural forests in Riau. This species is one of the meranti groups with very fast growth, endemic to the region, and has high economic value. The advantage of this plant is its potential as an intercrop between palms (agroforestry). Research result, meranti is one of the most important commercial timber in Southeast Asia. This wood is commonly used as construction wood, wood panels for walls, attics, room dividers, furniture, household furniture, toys, caskets, etc. The red-dark meranti wood is commonly used for medium to heavy construction, bridge decks, and building boats [7-9].

This study aims to find a form of oil palm development based on sustainable plantation development, especially preparing for the second cycle of oil palm development (rejuvenation) in Indonesia. Several research types on agroforestry have been conducted, but information about meranti planted between palms, both from the ecological, economic, and social aspects, is still lacking. Therefore, it is important to research to provide a holistic picture of the application as a model for developing environmentally friendly plantations.

2. Method

The research location was conducted in Rokan Hulu Regency, Riau Province. In the selected location, the community has carried out intercropping farming of oil palm and meranti. This research was conducted through a survey with the developmental method. It was intended to study the implementation process of meranti agroforestry intensively. Furthermore, it was intended to study the impact on ecological aspects in the form of carbon uptake and the economic aspect in community participation. The research was conducted in Riau with two districts, namely Rokan Hulu and Kampar. These areas are characterized by high productivity, have been farming for more than 25 years, and have entered the second cycle in oil palm rejuvenation.

The research samples were owners of meranti agroforestry gardens (intercropping meranti wood and oil palm) or owners of monoculture oil palm plantations in the vicinity of the meranti agroforestry model area. Sampling was carried out using a purposive method, assuming the planting year of oil palm. The number of farmers who intercropping meranti wood is 25 people, each with a one-hectare land area. Primary information is carried out using a list of questions that have been compiled based on research needs. This information collection is carried out using the rapid rural appraisal method or the RRA method [10,11]. The RRA method is a participatory approach to obtaining information and assessing the activities of a sample of farmers in the field. The advantage of the RRA method is that it can provide accurate information in a limited time. The information collected is adjusted to the purpose of the research, carried out by tracing the information sources to obtain complete information.
3. Results and discussion

3.1. Model of Meranti copper agroforestry development

The model for the development of copper meranti (Shorea leprosula Miq.) agroforestry is conceptually a monoculture integrated with meranti. It is a very beneficial form of environmental interaction because it minimizes the concept of land management. Ecologically, it functions in carbon sequestration to reduce greenhouse gas emissions [12, 13]. Other benefits are maintaining soil physical properties and fertility and being relatively environmentally friendly [14, 15]. Explicitly, it can be concluded that the model for integrated palm plantation is beneficial from ecological, economic, and social aspects. This is following the basic concepts and principles of environmental management.

Based on the Triple Bottom Line (TBL) concept model, the three considered sustainable management aspects are ecological, economic, and social. There are similarities in these aspects of objectives; therefore, the meranti-oil palm agroforestry development model is feasible to be developed [16]. The results showed that the carbon uptake resulting from copper meranti and monoculture oil palm has an average of 1.531 tonnes/ha. Meanwhile, the projected carbon uptake in one oil palm plantation cycle of 25 years is 15.81 tonnes/ha. This value will increase when the cycle has reached 30 years [17]. Also, the growth of copper meranti is very significant, with 59% in the 11-15 cm diameter class distribution. The increase in diameter determines the amount of carbon contained in vegetation. Also, with increasing tree diameter, storing free carbon in the air is higher [13]. Therefore, to reduce these emissions, the most appropriate method is to plant more trees.

The simultaneous integration of monoculture palm with copper meranti increases carbon sequestration in the area. Also, copper meranti, which is ready to be harvested at the end of the cycle, economically increases income. By measuring and projecting its growth for 20 years, one tree trunk’s net volume is $0.43 m^3$. Meanwhile, the average number of fellable trees is 82% of the total. Therefore, in an area of one hectare of agroforestry land, the meranti-oil palm will produce wood with a volume of $38.99 m^3$.

It was assumed that the price of wood in the garden is 40% of sawn timber in the market. Therefore, as long as the price increases by 5% annually, by 2025, the copper meranti wood price will reach $119.7/m^3. This means an additional income for farmers by selling logs, which is about $4,668.18 per hectare. This will help them manage and cultivate palm in a sustainable manner. The outcomes will be useful to support life and improve the welfare of the farming community. Therefore, it becomes an internal motivation that influences community participation in environmental management.

The structural design and vegetation composition in the meranti-oil palm support conservation functions as preserving biodiversity, habitat, and animal corridors. Research results Purnomo [18] stated that habitat corridor development needs to be based on several important criteria, including inter-block characteristics. In general, the width and length of the connected size and proximity to natural components provide added value and environmental diversity. Also, the economy is a consideration in determining the location of the corridor [18].

In the agroforestry development model, meranti-oil palm still maintains the composition; therefore, companies still harvest the products on the boundary between the plantations (during the first cycle). This is done by defending the meranti tree, which is still maintained. Therefore, it is hoped that the meranti’s existence becomes an assessment factor for the company to obtain a plantation business permit extension.

After the first cycle, palm plantations’ boundaries have changed to a vegetated area dominated by copper meranti. After replanting, the company needs to maintain its existence and not exploit it in the second cycle. The vegetated areas will gradually change through a natural process of interaction to form ecosystem communities. Therefore, the formed ecosystem will become a biodiversity source and a corridor for animals with conservation value. This developmental concept is expected to realize the sustainable development goals (SDGs).
In plasma plantations designated for surrounding communities, the agroforestry application among the palms is feasible to develop. Meranti-oil palm agroforestry development model in plasma is the same as in independent oil palm plantation. Therefore, the planting of copper meranti between oil palms provides multiple benefits to the community. These benefits come from palm oil production and the economic value of meranti wood at the end of the cycle. Meranti-palm oil agroforestry development models both in plasma and independent plantations are presented in Fig 1.

![Figure 1. Model of Meranti Copper Agroforestry Development among Palms (Meranti-Palm Oil) in Plasma and Independent Gardens.](image)

Meranti and oil palm agroforestry develop models that can also be implemented in large-scale oil palm plantations—setting spacing for oil palms 9m x 9m. The structure design and composition of the vegetation in the agroforestry development model can support the conservation function. The conservation function referred to is the preservation of biodiversity, habitat, and animal corridors. In Fig1, planting meranti trees between oil palms will provide multiple benefits to the community. These benefits come from the oil palm tree production as a staple crop and the economic benefits from the value of meranti tree wood at the end of the cycle.

The vegetation design form of oil palm composition as a staple crop with copper meranti is called interpolated pattern [19]. This pattern emphasizes treating the types of plants in an interpolated manner during the cultivation period. Meanwhile, the long-term integration (agroforestry) in a landscape positively impacts maintaining land fertility and options for sustainable land use [20]. Besides, it is very good as carbon storage and plays a role in mitigating carbon dioxide [13, 12].

Government and stakeholder policies for oil palm plantation management are needed, especially to avoid monoculture farming in business permit areas. This policy will provide high environmental, economic, and social benefits. Moreover, it can reduce environmental degradation, deforestation, and land fires. However, the policies will affect the continuity of investment in palm plantations. Through the meranti-palm plantation business development model, cooperation or partnership between all parties and farmer communities is required, both at the expense of independent and plasma. Therefore, a partnership’s existence has implications for all parties’ consistency and commitment to implement the development of meranti-palm plantations.

### 3.2. Model development problems and solutions

Agroforestry is a solution for the management of environmentally friendly oil palm plantations. Ecologically, it can absorb more carbon than the monoculture type. Economically, this model provides additional finance for the community through the BoR mechanism from the produced meranti wood.
Besides, the community is motivated to participate in the agroforestry model development actively from the social aspect.

Recognizing the increasing expansion rate of palm plantations, especially in Riau, raises problems involving related parties, which resulted in a prolonged conflict. A conflict is a dissociative interaction that expresses differences in opinions, views, interests, or even disputes between individuals and groups for several reasons. In this view, disputes indicate differences between two or more individuals. Of the total area of 2,537,375 ha palm plantations, approximately 1,050,015 farmers (54% of smallholder plantations) in all districts or cities in Riau. Meanwhile, the total area of large private and state plantations is around 46%. This high percentage of farmers indicates that Riau’s problem is an important and serious matter. Not to mention the conflicts that occur between the community and the company and related sectors.

Based on the actors and resources, plantation conflicts arise between companies, the government, and surrounding communities [21]. The source of the conflict depends on the parties with interest in the existing resources. Therefore, it is necessary to look proportionally and contextually to manage conflict potentials and resolution from community empowerment. Meranti-palm agroforestry as a model for the development of environmentally friendly plantation is a solution to overcoming problems. It was chosen in community empowerment, including capacity building of farmers, organizations, development of cross-sectoral coordination, and coordination within government agencies. The description of the problems and alternative solutions for developing the meranti-oil palm agroforestry model is shown in Table 1.

**Table 1. Problems and alternative solutions for the development of the Meranti-Palm Oil Agroforestry Model.**

| No | Problem                                      | Alternative Solutions                                                                 | Engagement of Stakeholders |
|----|---------------------------------------------|---------------------------------------------------------------------------------------|---------------------------|
| 1  | Lack of knowledge and information           | 1. Advocacy                                                                            | - Government              |
|    |                                             | 2. Socialization and capacity building                                                | - Company                 |
|    |                                             |                                                                                        | - Academics, NGOs         |
| 2  | Lack of capital or costs                    | 1. Development of economic enterprise institutions (cooperatives)                      | - Government              |
|    |                                             | 2. Skills training                                                                    | - Company                 |
|    |                                             | 3. Community development                                                             | - Academics, NGOs         |
| 3  | Availability of quality copper and oil palm meranti seeds | 1. Provision of quality seeds                                                        | - Government              |
|    |                                             | 2. Skills training                                                                    | - Company                 |
|    |                                             | 3. Community empowerment                                                              | - Academics, NGOs         |
| 4  | Marketing of palm oil and meranti wood products | 1. Institutional strengthening                                                        | - Government              |
|    |                                             | 2. There is trust between the government, society, and the company                    | - Company                 |
|    |                                             |                                                                                        | - Academics, NGOs         |
|    |                                             | 3. Skills training                                                                    |                          |
| 5  | Implementation of regulations               | 1. Law enforcement                                                                    | - Government              |
|    |                                             | 2. Stakeholder Communication Forum                                                   | - Company                 |
|    |                                             |                                                                                        | - Academics, NGOs         |
| 6  | Overlapping land                            | 1. Law enforcement                                                                    | - Government              |
|    |                                             | 2. Stakeholder Communication Forum                                                   | - Company                 |
|    |                                             |                                                                                        | - Academics, NGOs         |
|    |                                             | 3. Cross-sector coordination                                                          |                          |

Source: Survey results (processed)
4. Conclusion

Briefly, to maintain ecological balance in the oil palm community, an effective empowerment program needs to be implemented. The change from the traditional social system took place through awareness and participatory process. The social capital that develops in the community in the form of local wisdom needs to be maintained. Adopting local wisdom by empowering the community will minimize conflicts, among others, based on economic inequality. Meranti-oil palm agroforestry as a model for the development of environmentally friendly plantations is economically able to provide benefits from wood, which has high selling value. Furthermore, it is more environmentally friendly by absorbing more carbon than monoculture plantations. The other vegetation on oil palm plantations serves as a conservation habitat and increases animal species diversity.

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