Bridging the Gap Between Economics and Ecology in Peatland Restoration (Case Study: Paludiculture of Sago in Pulau Padang Peatland Hydrological Unit, Riau)

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Abstract. The green economy development in forestry and other land use sectors has a close relationship with low carbon land use management. Peatlands are vulnerable ecosystems with a high capacity to store carbon. Drying peatlands will result in their ecosystem degradation through subsidence and decomposition processes, which cause carbon emissions. Local communities must be engaged in selective economic activities to revitalize their livelihoods while also protecting peatlands. Therefore, the purpose of the study was to evaluate and promote sago paludiculture in peatlands as a part of peatland restoration strategies in the Pulau Padang Peatland Hydrologycal Unit. The study was conducted from August to September 2022. Data were collected through inventoried sago cultivation and stakeholder interviews. Sago plants were inventoried to investigate their percentage growth and Business Canvas Model has used to develop a sago business model in the local community level. The results of the study showed that local communities in Mekarsari and Sungai Anak Kamal have utilized traditionally the products of sago. There are two species of sago cultivate in the program of revitalization of livelihood, namely *Metroxylon sagu* and *Metroxylon rumpii* with the percentage growth varied 68% and 87,2% respectively. Cultivating sago palm in peatlands has the potential to be economically profitable and could protect peatlands from degradation. To optimize economic benefits, increasing the added value of sago products is required together with implementing a sustainable harvesting system. Briefly, sago paludiculture is relevant to microscale green economic development.

Keywords: Sago · peatlands · revitalization · paludiculture · restoration

1 Introduction

Indonesia's development is shifting toward a new green, low-carbon development path. Reducing carbon emissions are a challenge in achieving the target of increasing economic growth. In Indonesia, peatland degradation is a major sources of greenhouse gas. The Ministry of Forestry recorded that the 2015 peatland fires emitted an estimated 0.40 Gt CO_2e in Sumatera, Kalimantan and Papua Islands [1]. Peatlands are an organic material accumulation formed naturally from plant remains that have not completely

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decomposed and accumulated in swamps. Indonesia has 13.9 million hectares peatlands [2]. Indonesia's peatlands hold the third largest carbon stock in the world (after Canada and Russia) which is around 54,016 Mton [3]. Peatlands in the tropical area can store 10 times more carbon in soil and plants than mineral soils [4]. On the one hand, the large number carbon stocks stored in peatlands, on the other hand, peatland ecosystem is extremely fragile. The process of drying and wetting in high intensity is an important process that can affect the stability of peat material. Excessive drying results in irreversible drying [5]. Furthermore, it also triggers gas emission, loss of biodiversity, and in some cases catastrophic peat fires [6]. The humidity of the peat material greatly determines the stability of the peat material [7]. Consequently, the physical characteristics of peatlands must receive the most attention, especially in the consideration of soil and water management. Ideally, the peatlands should be so wet that steady, in the long-term, peat accumulation is maintained or re-installed [8]. Reducing carbon emissions from degraded peatlands is relevance to a green economy concept. A green economy is defined as low carbon, resource efficient, and socially inclusive [9]. For the reasons, sustainable peatland management must be a central concern to mitigate climate change and support green economic development.

In Indonesia, peatland restoration is carried out by several institutions, including the Ministry of Environment and Forestry (MoEF) and the Peatlands and Mangrove Restoration Agency (PMRA). PMRA, through the Presidential Regulation of the Republic of Indonesia Number 120 of 2020, has the task of facilitating the acceleration of the implementation of peat restoration and efforts to improve community welfare in the peat restoration work areas in 7 Provinces covering an area of approximately 1,200,000 hectares and carrying out the acceleration of mangrove rehabilitation in work areas in 9 Provinces covering an area of 600,000 hectares for a period of 4 years.

In carrying out the restoration, PMRA has three approaches called 3R activities, namely *rewetting*; *revegetation*; and *revitalization of local livelihoods*. Rewetting of peatlands with canals that are prone to drought is one method considered effective for restoring damaged peatlands and is an effort to prevent peatland fires. Rewetting degraded peatlands has a sub-stantial positive effect on net greenhouse gas emissions [10]. Revegetation is the replanting of burned peatlands by planting local species that previously existed in the area. Planting peatlands can use three methods, which are determined by the condition of the burned peatlands, namely natural succession, enrichment, and maximum planting. Revitalization of local livelihoods by providing economic assistance to the community is a form of compensation for the communities close to the development of peatland wetting infrastructure.There are various forms of revitalization of local livelihoods programs that are categorized as land-based, water-based, and ecosystem service-based activities.

In several decades, agricultural practices in peatlands by drying peatlands using canals have impacted the environment, such as peatland fires and carbon emission releases. In many cases, palm oil expansions in peatlands tend to get economic benefits by neglecting its environment impacts. Because of its prone ecosystem, peatlands should be managed sustainably. Generally, paludiculture is considered as land-based agricultural practices on peatlands. Paludiculture is considered a sustainable peatland

management practice involving plant cultivation in wet conditions. A core paludiculture principle is the use of plants on wet or rewetted peatlands without drainage [8, 11, 12]. In natural condition, sago is found on river banks and wet soil. Planting sago is considered relevance with issues of green economic development. The benefits of sago paludiculture in peatland restoration programs need to be investigated. Therefore, the purpose of the study was to evaluate and promote sago paludiculture in peatlands as a part of peatland restoration strategies in the Pulau Padang Peatland Hydrological Unit (PHU). The approaches of this study by collecting data regarding sago ethnobotany, revitalization programs, and proposing a Business Model Canvas of sago products.

2 Methods

The research was conducted from August to September 2022. The sago palm inventory was conducted in Mekar Sari and Sungai Anak Kamal. Furthermore, administratively, they are located in Merbau District, Kepulauan Meranti Regency, Riau Province. The study sites are two of several PMRA site projects that are situated in the Pulau Padang Peatland Hydrological Unit (PHU). In those villages, 6 group communities have been supported by PMRA in sago palm planting since 2020. They are Sagu Mekar Baru, Sagu Kengkem Baru, Sagu Tunas Mekar, Harapan Jaya, Kidul Joyo and Rojo Gambut. The primary data of sago population was inventoried using sampling plots with 10% sampling intensity. However, interviews were conducted with community groups, technical workers, staff of the Riau worker group, and others. Furthermore, improving revitalization the livelihoods of local communities by cultivating sago palm was analyzed using Business Model Canvas. It is presented in a visual form to make it easier to understand the overall picture of the scope of a business, illustrated on a piece of canvas containing nine elements keys, such as value propositions, customer segments, channels, customer relationships, revenue streams, key resources, key activities, key partnerships, and cost structures (Fig. 1).

3 Results and Discussion

3.1 Ethnobotany of Sago

The sago palm stores a large amount of starch in its trunk. In South East Asia, Sago starch flour has been reported as early as 1200 AD [13]. In Vietnam, sago is also called “sagu”, tha-gu-bin in Myanmar, while “sakhu” and “sa:khu’u” are local names in Thailand and Laos [14]. Sago is a non-timber forest product which is a source of carbohydrates. Sago starch rules as a staple food in many regions in Indonesia. Kepulauan Meranti Regency is well known as the sago producer in Indonesia. Whereas, local communities in Mekar Sari and Sungai Anak Kamal Village have utilized and preserved sago around their villages for generations. There are two species of sago on this island, namely thornless sago (*Metroxylon sagu* Rottb) called *Bemban* and spiny sago (*Metroxylon rumpii* Mart). Both types of sago are easily recognized by the presence of thorns on the leaf midrib. The people of Mekarsari Village and Sungai Anak Kamal Village utilize the starch from cut sago for several purposes, such as sago noodles, crackers, or cakes. Moreover, *Sapuring*, dry grated sago, utilized by local communities as catle feed (Fig. 2).

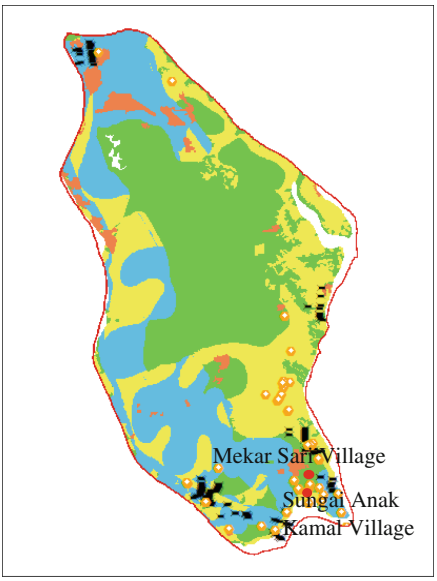

Fig. 1. Site of study in Pulau Padang PHU, Riau

Fig. 2. The traditional sago processing (Doc. Rita Illia Mandau)

3.2 Paludiculture of Sagu in Peatlands

Paludiculture is a cultivation system considered beneficial to be implemented in the tropical peatland ecosystem. However, not all plants can grow on peatlands, because peatlands have marginal fertility rates and low pH. Sago is considered to have high adaptability in peatlands. Sago occurs naturally on swamp areas, can tolerate with flooding, and can adapt to varying soil conditions, including peat soils [15].

In Pulau Padang PHU, PMRA's economic empowerment activities by sago palm planting, which has been ongoing since 2020. The selection of sago palm in the revitalization activity at Pulau Padang PHU is based on the results of studies and discussions with the local communities. Therefore, based on these considerations, the program is

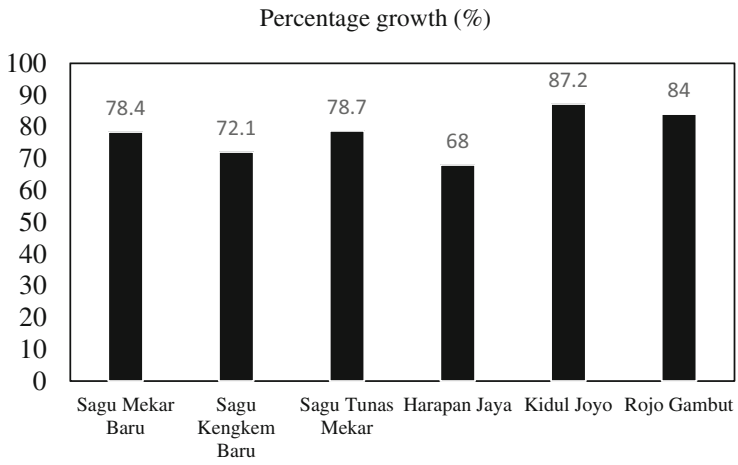

Fig. 3. The graph of percentage grwoth of sago palm in Mekarsari and Sungai Anak Kamal Village

expected to be successful. The sites of the study in Mekarsari and Sungai Anak Kamal Village that are planted sago palm in 95.26 ha peatland area. The area is owned community lands of six group communities. The peatland is categorized as a deep peatland (200–300 cm depth) and the conditions vary from wet to swamp. To determine the success of planting, an evaluation was carried out with the following results:

Sago palm was planted in 2020 and enriched in 2021 on the same site. The growth monitoring revealed variations in the survival percentage in different community groups' sago plantations. The life percentage varied from 68% to 87.2% (Fig. 3). In general, planting is usually declared successful if the percentage growth greater than 75%. It was quite good for planting in nutrient-poor peatlands. Sago palm cultivation is a form of paludiculture that is suitable for peatlands [16]. Sago grows well on marginal soils, which for other plants are difficult to grow [17]. Sago palms can withstand extremely low pH conditions, such as pH 3.6 [18]. From field measurements, they were identified that the lowest sago palm is 124 cm and the highest is 305 cm. Meanwhile, based on the composition of the species shown in Fig. 4.

Figure 3 shows that the species of sago is dominated by sago that has thorns (*Metroxylon rumpii*) in all areas. This fact is related to the availability of seedlings. Its thorns also give the advantage from wild boar attacks. Both sago species have capability of growing in wet peatlands. In wet conditiond, it is an ideal condition where peatlands decomposition can be minimized and less prone to fire. Forest fire is a serious issue because the Meranti Islands are close to neighboring countries.

3.3 Optimizing the Economic Value of Sago in the Restoration Area

Kepulaun Meranti Regency, including Mekar Sari and Suangai Anak Kamal Village, is well known for sago production. In 2020, there are 39,95 ha of sago plants around regency with production 243,710 ton [19]. The main product is sago starch flour, which

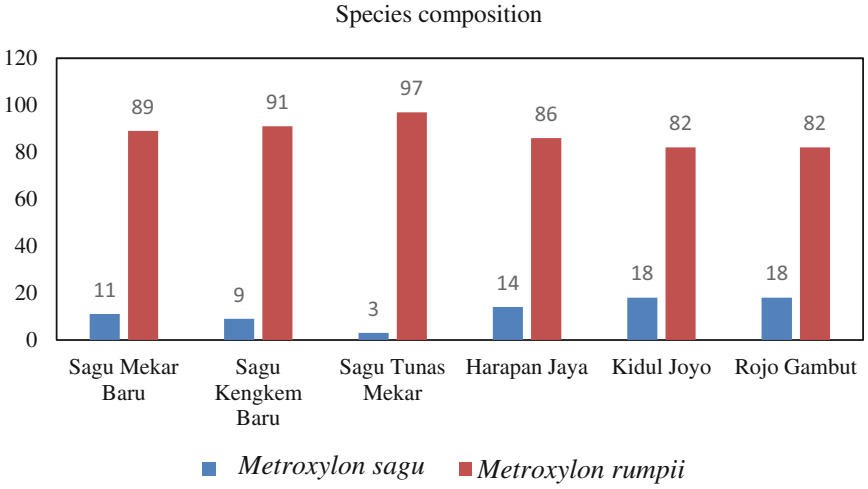

Fig. 4. Species composition of plated sago

(a) (b)

Fig. 5. (a) Sago cultivated in revitatalization of livelihood program; (b) a log of sago

is sold outside the region and exported. Selling the raw material means low value-added for the farmers (Fig. 5).

Although planting sago is ecologically safe for peatlands, the increase in added value of sago for the community is important. The revitalization of livelihood is proposed in order to increase added value while also protecting peatlands. Based on the Business Model Canvas analysis, sago plantation can be shown as follows (Fig. 6).

Improving the added value of sago is an important key to optimizing the local community's income. Sago plants will generally begin to be harvested at the age of 6–7 years**.** Generally, the local communities sell the logs of sago directly to collectors. The price of a log of sago, *tual*, roughly 1 m is varied from IDR 70,000. However, for further processing, such as wet sago starch flour, the price is IDR 10,000,- to IRD 15,000,- per kg and for dry starch flour, the price is IDR 20,000,- per kg. Local communities tend to sell in logs because it is easy to get cash income, although in the lower value. However, the local communities have been assisted by PMRA not only for growing sago palm, but

<table>
<tr>
<td rowspan="2">Key partners
• PMRA
• Agricultural Extension of the District
• Disperindag
• Gift shop
• Village-owned enterrises (BUMDes)
• Mills owner
• Traders</td>
<td>Key activities
• Nursery
• Tillage
• Providing plat stakes
• Planting
• Harvesting
• Raw material Processing
• Processing of derivative products
• Selling</td>
<td rowspan="2">Value propositions
• Peatlands endemic plants
• Livestock feed (sapuring)
• Spiny sago is more resistant in flooded swamp.
• Growing clusters so they are easy to breed
• Agroforestry system
• Wider market products</td>
<td>Customer relationships
• Selling stems/raw (unprocessed)
• Derivated product selling</td>
<td rowspan="2">Customer segments
• Middlemen
• Direct consumers
• Sellers</td>
</tr>
<tr>
<td>Key resources
• Institutional strengthening
• Community assistance
• Community-owned land
• Innovative derivated products</td>
<td>Channels
• Information network between farmers and middlemen
• Derindagkop for marketing
• Gift shop</td>
</tr>
<tr>
<td colspan="2">Cost structure
• Purchase of seedlings
• Land clearing
• Tillage
• Planting
• Maintenances
• Harvesting
• Prduct processing</td>
<td colspan="3">Revenue streams
• Sales of sago starch
• Processing of sago derivated products (sago noodles, sago flour, sago cakes, sago crackers etc.)</td>
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Fig. 6. Business Model Canvas of Sago

also how to increase added value of sago products. In Meranti Islands, sago processing does not have many derivative products. In those villages, the price of derivate products higher that sago starch flour, for instance, sago noodle is IDR 9,0000,-/kg, sago cracker is 25,000,-/kg, and Bangkit cake is IDR 50,000,-. Moreover, sago, as a paludiculture commodity, is a food source and can also be used in the bioethanol industry [20].

Planting sago in peatlands is the implementation of paludiculture that brings several benefits. Firstly, it gives economic benefits for the farmers and the market chain actors. Planting sago does not require large costs and investments. Under smallholder management, little or no maintenance is carried out after planting [21]. Secondly, for growing sago, it necessary keeps wet the land that the same time will conserve the peatlands from drying and decomposition. Thirdly, sago does not require fertilizer and has clumps that are easy to regenerate. Fourthly, sago can be processed with many derivative products to optimize added value. Finally, the market for sago products is wide, both in the local and international markets. Another study showed that sago plantation is compatible paludiculture practice in peatlands. The cultivation of sago can have a positive contribution in providing economic benefits to all actors and give important environmental benefits [22].

The quintessence of paludiculture is to cultivate plant species that thrive under wet conditions, produce biomass of sufficient quantity and quality, and contribute to peat formation [6]. Although sago palm has a habitat and can grow naturally on peatlands,

it needs sustainable harvesting arrangements. Only mature sago palms may be allowed to be cut and avoid clear cutting. Sago palm is ready to be harvested after 8–10 years. Nevertheless, sago palm can be combined with other crops that can be harvested during this transition period [23]. Enrichment planting is required for locations with low populations. It grows in cluster with growing its sapling surround it. Therefore, the population will increase after several years. However, strengthening community institutions is important by intensive assistance from PMRA's extension workers or from other stakeholders.

4 Conclusion

PMRA and local communities in Meranti Islands, Riau Province, have cultivated sago palm as a part of the revitalization of livelihoods program. There are 6 community groups involved in sago cultivation on the peatlands. Overall, 95.26 ha of peatlands in Mekarsari and Sungai Anak Kamal village have been successfully planted with sago. The results of our inventory show that the average growth percentage ranged from 68–87%. This excellent growth is also supported by the condition of the peatlands, which are always wet. This peatland condition is an ideal condition where peat decomposition can be minimized and less prone to fire. Therefore, it reduces carbon emissions. The paludiculture of sago palm brings benefits for both the economic and peatland ecosystem. For optimizing economic aspects, sago starch should be processed to increase the added value by processing the derivate products. The sago palm has relevance with the green economic concept at the micro level due to its carbon storage capability and efficient resource use.

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