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Enabling Factors of NTFP Business Development for Ecosystem Restoration: The Case of Tamanu Oil in Indonesian Degraded Peatland

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Abstract: Indonesia's tropical peatlands are one of the world's largest carbon sinks, and they are facing the threat of extensive degradation and conversion. The Indonesian government is committed to peat restoration. However, restoration is still a costly, top-down approach lacking community participation, and is focused on the 3R scheme (rewetting, revegetation, and revitalization). Peatland restoration businesses are part of the innovative effort to finance this endeavor. Unfortunately, there is not much information available about the pre-conditions required to create a restoration business. This study seeks to understand the enabling conditions for the development of peatland restoration, with a focus on the tamanu oil business, and to assess whether the same situation might apply in the context of the restoration of degraded peatland. PEST analysis is used to describe the macro-environmental factors of the tamanu oil business and its development opportunities in degraded peatlands. Tamanu oil-based peat ecosystem restoration businesses offer good prospects because of the growing it has grown the bioenergy and biomedical markets, and they can cover a larger area of degraded peatland landscape. For tamanu oil businesses to succeed in peat ecosystem restoration, we recommend that policy documents at various levels include tamanu as a priority commodity for peatland restoration and alternative community businesses, followed by planting programs by all stakeholders. The government and social organizations must take positions as initiators and catalysts, establish a significant number and extent of pilot tamanu plantations, and create a mutually supportive business climate between entrepreneurs and peatland managers.

Keywords: *Calophyllum*; ecological restoration; essential oil; forestry enterprise; PEST; peatland hydrological unit

1. Introduction

Tropical peatlands represent only 12% of the world's peatlands (38 Mha); however, they store more than 20% of the world's peatland carbon stocks [1–3], and 47% (21 Mha) of global tropical peatlands are located in Indonesia, containing about 65% (57 GtC) of the world's peat carbon [4]. Despite being a global carbon sink, Indonesia's peatlands face extensive degradation and transformation to large-scale plantations and industries, which make them prone to fire and produce a large amount of greenhouse gases (GHGs) [2,5,6].

Apart from the carbon stock, peat ecosystems have various ecological functions that are significant for human life, such as storing water and maintaining water quality [7,8]. Peatlands also provide benefits in the form of timber commodities and non-timber forest products (NTFPs), as well as habitats for endemic flora and fauna. The various important benefits of these ecosystems encourage efforts to restore degraded peatlands. The goal of restoration, which involves reintroducing trees [9], can only be achieved with the support of sustainable financing [10], including peat restoration [11,12]. In Indonesia, the availability of funds for peatland restoration through rewetting, revegetation, and revitalization from both the national budget and donor countries remains inadequate [11]. Restoration businesses are part of an innovative effort to finance peatland restoration. Revegetation is a peatland restoration scheme that provides business opportunities [13–16].

Restoration business practices can be said to be too focused on peatland environmental services, especially the carbon business [12,17]. The businesses do not have much in terms of high-value commodities in the market, whereas business success can only be achieved if there is a balance between ecological aspects, economic viability, and social interests [16]. NTFPs have great potential to be developed within the framework of peat restoration businesses. They have market value, harvesting them does not cause environmental degradation because it only takes part of the plant (such as fruit), and they are important for the livelihoods of local communities [16,18].

Studies conducted by Mohr and Metcalf [19] have shown that restoration businesses interact with various stakeholders to achieve ecological and business goals. They noted several critical directions for restoration businesses: (1) They must adjust to goals that can potentially be met and maintain ecological integrity while achieving profitability. (2) They must manage risks arising from variability in the natural environment and individual risk tolerance. (3) They must make decisions about innovations and new techniques. Understanding restoration businesses adds a significant perspective to the complex dynamics of socioecological systems. Unfortunately, there is inadequate information available about the pre-conditions required for creating a restoration business. On the other hand, there is information about the tamanu oil business [20–22], in which raw material comes from the genus *Calophyllum*. The genus *Calophyllum* includes native species that grow in peatlands [23]. These species easily adapt to changes that degrade peatlands [24–26].

Different species of the genus *Calophyllum* are native to Indonesia. These species can be developed as a restoration business commodity, as they are suitable in peatland and can be developed in a mixed/agroforestry system with seasonal commodities [27]. *Calophyllum inophyllum* L. (commonly called tamanu, with local names nyamplung and bintangor) is currently being developed as an alternative renewable fuel source through biological processes (bioenergy) as diesel fuel. *Calophyllum inophyllum* can produce 11.7 kg crude oil per tree, and the oil content per fruit is 65–75% higher than that of other vegetable oil-producing plants such as palm, *Jatropha*, etc. [28–30]. However, the use of nyamplung oil as a biofuel has not yet become a business, even though a study conducted by Sharmini and Tan in Malaysia [31] showed it was economically feasible.

In Indonesia, tamanu oil has been developed as a business commodity to meet the needs of the cosmetic and pharmaceutical industries in Indonesia and other countries [28]. Tamanu oil is extracted from the seeds of *C. inophyllum* plants [29]. Peatlands are the original habitat of some species of *Calophyllum* (bintangor). The question arises as to whether the development of the tamanu oil business can create opportunities for restoring degraded peatlands toward becoming a restoration business. This study sought to understand the conditions that could enable the development of the tamanu oil business, assess whether the same situation could apply in the context of the restoration of degraded peatlands, and formulate suggestions for achieving it. For this assessment, our analysis covers policy, economic, social, and technological aspects. The results of the research are expected to increase our understanding of how to develop an NTFP-based restoration business, and how to initiate and create preconditions so that financial support will be available for the restoration of degraded peatlands.

2. Materials and Methods

2.1. Theoretical Framework

The work of Marshall et al. [32] showed that product marketing and sales were the main factors inhibiting the commercialization of NTFPs. According to Debrot et al. [33], it is critical to understand NTFP production at economies of scale, including quality standards, marketing management, and value chains, so that these products can go beyond their subsistence role. In terms of NTFP business development by community enterprises, Dlamini [34] proposed a protocol to assess aspects, including business opportunity and suitable locations, sustainable supply of forest products, forest resource users and regulatory environment, technology, management and finance, and marketing and sales. To answer the research question, we limited the area of data collection and analysis to three locations: (1) the tamanu oil factory and marketing center in Bali, (2) sources of raw materials in Central Java and the Special Region of Yogyakarta, and (3) priority areas for peat restoration in Central Kalimantan, South Sumatra, Jambi, and Riau, with a special case in Musi Banyuasin Regency, South Sumatra.

For business analysis, we used political, economic, social, and technological (PEST) analysis to describe the macro-environmental factors of the tamanu oil business and its development opportunities in degraded peatlands. PEST analysis is the most commonly used approach to understand the external environment of a business [35,36]. The premise behind PEST analysis is that a company must respond to changes in its external environment. PEST analysis has been widely used to analyze the external environments of companies and industries, and contributes to the formulation of strategies to achieve satisfactory results [37].

The application of PEST analysis can be found in various studies. Kolios and Read [38] used PEST to analyze the possibility of changing the fuel in the textile industry in Portugal from fossil fuels to biomass. Iglinski et al. [39] used PEST to analyze the development opportunities of small hydropower plants for energy transformation in Poland. Pavloudakis et al. [40] used PEST as a framework to analyze prospects for sustainable rehabilitation of former mining land in West Macedonia. Piechota and Iglinski [41] used PEST to analyze the potential development of biomethane as an alternative fuel in Poland. These studies show similarities in using PEST analysis to assess the opportunities, potential, or prospects for the development of a business, product, or activity by considering external factors. This is in line with our research, which aims to understand the conditions that could enable the development of the tamanu oil business in the context of degraded peatlands by using PEST analysis based on political, economic, social, and technological factors.

2.2. Data Collection and Analysis

Data collection was carried out through literature review, observations, in-depth interviews, and focus group discussion (FGD). In-depth interviews were conducted with several parties: nyamplung farmer groups and nyamplung oil processing groups in Bantul, Purworejo, and Cilacap; communities around degraded peatlands in South Sumatra, Riau, and Central Kalimantan; managers of Berbak Sembilang National Park; research and development institution, and a tamanu oil factory in Bali. In addition, observations were made of the distribution of *Calophyllum* and the processing of tamanu oil into commercial products. FGDs were also conducted in a special social forestry area in Musi Banyuasin

Regency, South Sumatra, to identify opportunities for private sector involvement in the development of *Calophyllum* in degraded peatlands (Table 1 and Appendix A).

Table 1. Data collection.

Method	Collected Data	Data Sources/Location	Key Informants
Literature review	• Peat hydrological unit (PHU) (concepts, current conditions, and their relation to peatland restoration) • Paludiculture (concept related to peatland restoration and Calophyllum as a native peatland species) • Calophyllum (distribution, content, and benefits)	Journals, proceedings, technical reports, and government regulations	-
Observation	General biophysical condition of Calophyllum distributed in peatlands	Musi Banyuasin Regency	-
In-depth interview	Distribution of and results of research on Calophyllum plants and location of nyamplung oil processing	Research and development institute	1
	• General biophysical condition of Calophyllum distributed in peatlands • Fruiting season • Traditional use	Community around peatland forest (South Sumatra, Riau, and Central Kalimantan) and Berbak Sembilang National Park	10
	• Distribution of Calophyllum in surrounding area • History and management of Calophyllum in surrounding area • Flow of nyamplung fruit to oil processing group	Farmers (nyamplung fruit collectors)	4
	• History of nyamplung oil processing unit • Nyamplung oil processing • Marketing of nyamplung oil	Nyamplung oil processing group	4
	• History of tamanu oil factory • Reasons for producing tamanu oil • Supply of raw material • Production and marketing strategy of tamanu oil	Tamanu oil entrepreneur (factory)	1
FGD	• Peatland management related to restoration policy • Perspective on restoration business • Opportunities and challenges related to tamanu oil-based peatland restoration	Stakeholders related to peatland management	16

In-depth interviews were conducted with key informants determined using snowball sampling. The initial key informants were researchers at the Research and Development Institute who were determined purposively. Key informants at the Research and Development Institute then recommended other key informants to be interviewed, who subsequently made their own recommendations, continuing to roll like forming a snowball [42]. Interviews with key informants with snowball sampling are not absolute at a certain amount, but will be stopped if there is no addition of new information [43]. Data collection took place from August–December 2018.

The data were analyzed using a qualitative descriptive approach within the PEST analysis framework. The four factors in the PEST analysis were used to understand the existing conditions of the tamanu oil processing business in Indonesia and to formulate suggestions for developing the business with raw material sources originating from degraded peatlands.

In particular, the political factors analyzed in this study involved government and institutional policies related to the restoration of degraded peatlands. The focus of economic factor analysis was the availability of peatland areas as land for bintangor development, but these areas are in a damaged or degraded condition. Another analyzed economic factor was the cost of peatland restoration. The discussion of social factors in this study focused on the existence of multiple stakeholders in peat restoration and the tamanu oil business in Indonesia, as well as commodity-based livelihoods. This study focused on technological factors in the supply of raw materials for *Calophyllum* in peatlands, the distribution of *Calophyllum* in Indonesia, and information about the cultivation of *Calophyllum*.

3. Results

3.1. Paludiculture and Restoration of Degraded Peatlands

3.1.1. Peatland Hydrological Unit (PHU)

Deforestation, conversion to plantations, various cultivation interests, drainage, and repeated fires are the main direct causes of peatland degradation in Southeast Asia (including Indonesia) [2,44,45]. Uncontrolled conversion of peatlands to plantations and dryland, agricultural cultivation, and plantations with drainage/canalization systems cause continuous degradation of peatlands. Draining peatlands that are naturally wet and inundated with water causes various kinds of disasters, such as drought, fires, soil subsidence, flooding, and coastal abrasion. To restore the function of peatland ecosystems as carbon stores, protect biodiversity and habitats, store water, and reduce greenhouse gas emissions, it is necessary to restore peatlands [46].

The Indonesian government uses the peatland hydrological unit (PHU) as a basis for identifying the level of ecosystem damage and the success of efforts to restore peatland ecosystems. A PHU is a peatland ecosystem located between two rivers, between a river and the sea, or in a swamp or puddle (Government Regulation No. 57 of 2016). PHU mapping based on the Decree of the Minister of Environment and Forestry No. 129 of 2017 divided the peatland ecosystem into 207 PHUs on Sumatra Island, 190 on Kalimantan Island, 3 on Sulawesi Island, and 465 on Papua Island [47]. PHU-based management is not new; the idea of placing a peat dome and very deep peat (>3 m) for protection emerged in 1993. The concept of the PHU was formed based on long experience of converting peat to agricultural land in Sumatra when a massive drainage system was not able to save peat from extinction and even resulted in increased fires, including a major fire incident in 2015 [48].

Based on experience, there have been some challenges in understanding how peatland management and cultivation activities can provide ecological and economic benefits. The management of peatlands on a large scale, such as on industrial forest or oil palm plantations, must comply with existing regulations to prevent and minimize environmental damage in the future, as well as to ensure business sustainability in the long term. The management of peatlands by communities on a smaller scale needs to adopt cultivation patterns of natural peat resources that are more environmentally friendly, such as by adapting to existing peat conditions or replacing extractive use patterns [48,49] according to the function in either a protected zone or a production zone in one PHU.

3.1.2. Paludiculture

The principle of paludiculture is the sustainable cultivation of biomass on wetlands and rewetted peatlands [50]. Paludiculture historically began in several countries in Western Europe, including Germany, the Netherlands, and Poland. When paludiculture emerged in the 1990s, the focus was originally on peatlands in the Northern Hemisphere [51,52]; then, it shifted to tropical areas such as Indonesia [53]. In Indonesia, paludiculture has been developed for a long time, and is practiced by farmers around peat swamp forests area with various types of food crops. The appropriate paludiculture technique for degraded peatlands is the mixed cropping system, which is ecologically and economically more beneficial.

Paludiculture is the use of silvicultural systems [51,53], wetland species [53], or species adapted to high water levels [51] in wetlands or rewetted peatlands in order to mitigate GHG emissions. It is considered an alternative way to produce renewable raw materials and offers an economically feasible alternative for farmers [54]. In addition, paludiculture allows natural peatland conditions to be maintained (wet and rewetted) so that they can absorb and store more carbon, store water and nutrients, cool the local climate, and provide habitats for wildlife [55].

Paludiculture is an element of the green economy [53] or low-carbon economy [56] motivated by climate change, where drained peatlands contribute significantly to greenhouse gas emissions due to human activities (anthropogenic) [56]. Managing degraded peatlands by practicing paludiculture techniques, including rewetting, selecting adaptive plant species, and using mixed cropping patterns (agroforestry, agro-silvo-fishery, or agro-silvo-pastoral), has positive ecological and economic benefits [52,57,58]. Rewetting peatlands can prevent peat subsidence from getting worse. It can also prevent high carbon emissions from the forest and can curtail land fires that frequently occur in the dry season. Moreover, rewetting can also prevent the release of peat biomass [53,59–61].

The selection of endemic and adaptive species also supports the success of peatland ecosystem restoration in terms of conservation of species diversity. The combination of species selection and mixed cropping patterns enriches not only the flora but also the fauna in the area. Selection of plant species for paludiculture must consider the suitability of the peatland, as different sites and depths of peat affect the growth of different plant species. Therefore, species selection can be made based on the land conditions and the intended product or purpose, such as food, fiber, bioenergy, latex, medicine, conservation, etc. [53,62–64].

Practicing paludiculture requires selecting plant species that can adapt to acidic land conditions and are resistant to inundation. There are about 1376 species of plants growing in peat swamp forests in Southeast Asia, of which 38.8% (534 species) have medicinal, food, timber, and other uses [65]. The results of a study by Yuwati et al. in Central Kalimantan found several plant species with the potential to be developed as paludiculture species, namely *Shorea balangeran*, *Dyera polyphylla*, *Cratoxylon glaucum* Korth, and *purun* (*Eleocharis dulcis*) [66]. In addition, bintangor (*Calophyllum soulatri* Brum. f.) is another native plant species within peatland forests [23,67]. According to Triadi [60], examples of paludiculture species include: (1) food producers for carbohydrates (sago, *Nypa fruticans*), fruits (pineapple, *Ananas comosus* L. Merr.) and vegetables; (2) fiber producers (geronggang (*Cratoxylon arborescens* [Vahl.] Blume), terentang (*Campnosperma* sp.), and gelam (*Melaleuca* sp.); (3) bio-energy sources (sago, *Nypa fruticans*); (4) medicinal sources (aloe vera (*Nothaphoebe coriacea*), *Aquilaria malaccensis*); (5) sap producers (jelutong (*Dyera polyphylla* (Miq) Steenis)); (6) other forest products (rattan, leather tanning material, raw material for mosquito repellent); and (7) species with conservation value (*Gonystilus bancanus*, *Shore* sp.), either planted in monoculture or mixed (agroforestry).

The typical condition of peatland needs appropriate land treatment if the resulting economic benefit is also considered. The development of mixed-plantation paludiculture patterns applied to degraded peatland in Sumatera and Kalimantan showed excellent economic impact on land productivity. This means that with the mixed-plantation pattern, this participatory conservation will increase local communities' income, and at the same time will attract more community members to be involved in the program. Studies have noted that paludiculture can be applied not only in peatland but also non-peatland areas within one PHU [57,58,62,66,68]. If paludiculture is applied in one PHU, the ecological and economic benefits will be much greater [57,58,62,66,68]. Paludiculture applied in one intact PHU will create direct and indirect environmental interactions between the peatland ecosystem and the surrounding non-peatland area. If well-managed, this interaction will have a positive ecological and economic impact on the local community and other stakeholders involved in the paludiculture activity [57,69].

3.1.3. Calophyllum

The genus *Calophyllum* is distributed across almost all islands of Indonesia, including Sumatra, Java, Bali, Nusa Tenggara, Kalimantan, Sulawesi, Maluku, and Papua [70,71]. The range of natural growth of *Calophyllum* is from the coastal areas to the highlands (at an altitude of 50 to 1000 m above sea level). On Java Island, *C. inophyllum* (nyamplung) trees are planted and grow in sandy beach areas and mineral soils. The trees are found adjacent to the southern and western coasts of the island, with physical characteristics of the land classified as sea and coastal terrain systems, terrain systems, and alluvial terrain systems to limestone hill systems. The subsystems are undulating coastal subsystems, river plain subsystems, and alluvial fan subsystems, and sand sedimentary rock types and limestone types have been formed from estuary deposits and volcanic deposits [70]. Bintangor is a species of *Calophyllum* that is spread in peat, riparian, and other swamps. The main distribution area of bintangor in Indonesia is Sumatra and Kalimantan [72].

Bintangor is an endemic species of the peatland ecosystem that grows well in open spaces; thus, is categorized as an intolerant species (needs full light at juvenile level). Research results of Darwo and Bogidarmanti [67] showed that bintangor (*Calophyllum soulatri* Burm. f.) can grow in open space conditions with 75% survival at 4 years and reach 3.82 ± 0.90 cm diameter at breast height (dbh) and 3.39 ± 0.72 m total height, with increments of 0.95 cm/year in diameter and 0.85 m/year in height. At 3 years, bintangor already starts to fruit. Bintangor tends to have many branches and does not easily prune naturally [67]. Bintangor can grow on marginal sandy and saline soil or on clay at an elevation of 0–300 m above sea level; it requires 1000–3000 mm/year rainfall, good drainage, and pH 4–7.4; it is very tolerant to medium soils (sands, sandy loams, loams, and sandy clay loams). Bintangor grows well at 18–33 °C annual temperature [73].

The wood of *Calophyllum* spp. is generally of good quality, with class II-IV wood durability, and is usually used for carpentry and boatmaking, with durability of 10 years [71]. Different to oil palm fruit processing in fresh conditions, *Calophyllum* fruit processing is conducted in dry conditions (sun-drying or machine-drying) with 8–12% water content. *Calophyllum* fruits yield about 70% seed flesh and 30% shell [70,71]. Fresh bintangor seed contains 55% oil, while in the dried condition the oil content is 70.5% [23].

Tamanu oil consists of fatty acids (70–80%) [74] and resin parts that contain primary bioactive compounds (15–20%) such as sterols, coumarin, triterpenoids, and flavonoids [75]. The bioactive compound of tamanu oil is capable of absorbing UV A and UV B [76], and has anti-inflammatory, antioxidant, antimicrobial, analgesic, wound remedy [77], antitumor [78], antiviral, anticancer, antiplatelet, and anti-ulcer properties [79]. The fatty acid composition has an important role in the physicochemical attributes of biodiesel, as well as cosmetics and medicine. *C. inophyllum* has varying fatty acid content, which is affected by its biophysical and genetic condition. *C. inophyllum* from Indonesia has been reported to have excellent fatty acid content, as shown in Table 2.

Table 2. Fatty acid content of *C. inophyllum*.

Fatty Acids	Kalayasiri et al., 1996 [80]	Marutani et al., 2018 [81]	Raharivelomanana et al., 2018 [29]	Polsjak et al., 2019 [82]
Myristic acid	-	-	-	-
Palmitic acid	12.6	14.6	16.5 ± 1.59	13–15
Palmitoleic acid	0.2	-	0.2 ± 0.11	-
Oleic acid	19.8	40	23.6 ± 4.77	40

Table 2. *Cont.*

Fatty Acids	Kalayasiri et al., 1996 [80]	Marutani et al., 2018 [81]	Raharivelomanana et al., 2018 [29]	Polsjak et al., 2019 [82]
Linoleic acid	45.2	32.8	25.5 ± 3.87	28–31
α-Linolenic acid	20.3	16–24	0.26 ± 0.05	-
r-Linolenic acid	0.11	-	-	-
Arachidic acid	0.3	-	-	-

Calophyllum spp. are rich in bioactive compounds, which are found in almost all parts of the plant and have various biological functions, such as wound treatment, so they have potential use in medicines and cosmetics [29,83] *C. lanigerum* contains calanoide A, which has potential as an HIV medicine [84–86]. *C. ferrugenineum* and *C. incrassatum* have high antioxidant effects [83]. The skin of branches of *C. tetrapterum* has an active compound of calotetrapterins A–C, which has a very strong effect against leukemia [87]. The leaves of some species of *Calophyllum* contain bioactive compounds such as xanthones, coumarines, benzodipyranones, terpenes, terpenoids, steroids (campesterol), flavonoids, tannins, and esters. These bioactive compounds have antitumor, antibacterial, antioxidant, antimicrobial, antiviral, anti-inflammatory, anti-malaria, analgesic, and anti-hypertriglyceridemia activity [88,89]. *C. soulatri* leaves contain flavonoids, phenol hydrocarbons, steroids, triterpenoids, tannins, saponins, and acid hydrocarbons, which means they can potentially be used in antioxidant, antibacterial, anticancer, analgesic, hemorrhoid, skincare, and wound remedy treatments [23].

Traditionally, bintangor has been used to heal and relieve many diseases. Bintangor leaves (*C. soulatri*) have been used to treat vertigo and migraine by burning the dry leaves and then inhaling the smoke. On Fiji Island, infusion of bintangor leaves is used to soothe inflamed eyes. The seed of bintangor is used to overcome hair loss because it is anti-parasitic. The oil of bintangor seeds is used for rheumatic relief because it has a pain-relieving effect [23]. Seed oils of *C. apetalum* and *C. soulatri* have been used as leprosy medicine [84]. Seed oils of *C. apetalum* and *C. soulatri* have been used to treat skin infections. Infusion of *C. apetalum* mixed with honey has been used as scabies medicine. *C. apetalum*, *C. tacamahaca*, and *C. inophyllum* are used for rheumatic relief. Boiled stem skin of *C. brasiliense* together with root skin of *Coutarea hexandra* has been used as medicine for diabetes [90]. Boiled roots of *C. inophyllum* are used to treat abscesses, and boiled leaves are used for eye infections. Infusion of *C. soulatri* roots is used for rheumatic relief by rubbing it on the skin. Extracted oil from *C. tomentosum* seeds are used to treat skin disease.

3.2. The Developing Business of Tamanu Oil in Indonesia

Indonesia has many essential oils that attract the global market, such as citronella, cajuput, cinnamon, nutmeg, sandalwood, and eaglewood. Indonesia is among the countries that produce at least 40 kinds of essential oil for the global market [91,92]. The essential oil export value is USD 400 million, and the sector involves 3000 small distillation companies and supports over 200,000 farmers [93]. Essential oils are exported by 25 provinces in Indonesia to 102 countries around the world [94]. However, the quality of essential oils has, unfortunately, not met international standards [95]. This problem has made the export value lower than the value of imported oils and their derivative products [96]. An example of one of the micro- and medium-size businesses of essential oil products that have rapidly grown in Indonesia is in Bali. The results of a study on the essential oil processing factory with various enabling factors are shown in Figure 1. Entrepreneurs in Bali have a factory that produces herbal products from several kinds of essential oil materials. In the beginning, they produced only ointment oils for massage, cold relief, and flatulence. These products are formulated from essential oils such as coconut, neem tree leaves, asibata, purwoceng (*Pimpinella pruatjan*), curcuma, and eaglewood.

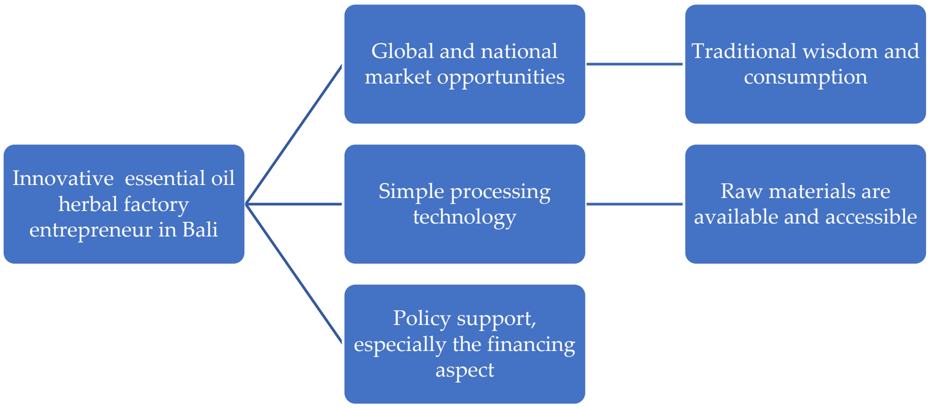

Figure 1. Enabling factors of tamanu oil business development: case study in Bali.

Essential oil entrepreneurs in Bali informed us that tamanu is one of the essential oil products with increasing demand around the world. The global market for tamanu oil was encouraged by growth in the skincare market, which reached approximately USD 148.82 billion in 2020. The skincare market is predicted to grow by 4.8% from 2022–2027 and reach USD 188.13 billion by 2026 [97]. They also observed that the demand for cosmetic/beauty products made with essential oils from Indonesia increases every year, along with the Indonesian population, and product diversification increases as a response to the increased national or global demand.

The tradition of using essential oils in treatments is also an enabling factor for tamanu oil product development. Traditional treatments using medicinal plants and herbs have been used around the world for a long time, mostly by tribes [98]. Various tribes in Indonesia use herbal treatments as internal and external medications. Medicinal components of plants and herbs come from parts such as fruits, flowers, stems, and sap. Plants are used as medicine because they are easy to get, have minimal side effects, and are cheaper than synthetic medicines [99].

Lifestyle changes, consumer awareness of the environment, and product safety create high demand for natural-based products [100–102]. Consumer values and lifestyles, in terms of knowledge and personal experience, culture, and community environment, encourage the demand for plant-based medicinal products [103]. Advances in knowledge and the modern technology of scientific instruments allow us to know the ingredients of biologically active compounds in medicinal plants, so the use of medicinal plants as raw materials is increasing [104]. Medicating and healing with medicinal plants have become more practical and effective. Many companies use medicinal plants as active agents to produce medicines to treat some diseases [105,106]; however, direct use of traditional plant-based medicines without machine processing remains a popular choice because they are inexpensive [107].

Tamanu oil has been chosen as a base for diversification of essential oils for use in cosmetics. The selection of tamanu oil as a major product material along with other essential oils was made considering the availability of equipment in the factory and the simple processing technology. By maintaining a company identity based on herbal essential oils, the company hopes for broader market share, not just from existing consumers. Essential oil manufacturers in Bali started with rubbing oil, then made new products from tamanu oil. A study by Castaldi and Giarratana in 2018 [108] stated that diversification and branding were aimed at increasing company performance, including income, business sustainability, and efficiency [109].

The availability of raw materials has also become a consideration in the choice of tamanu oil for product diversification. The nyamplung tree, as a source of raw tamanu oil, is spread widely in Indonesia. Manufacturers have searched the Internet and communicated to make sure there will be a continuous supply of nyamplung oil processed from *C. inophyllum* seeds. Though the nyamplung tree does exist in Bali, the manufacturer had a supply warranty of nyamplung oils from oil processing groups in Central Java and the Special Region of Yogyakarta. The abundant nyamplung trees on the southern coast of Central Java are utilized by groups of oil processors in Cilacap, Purworejo, Solo, and the Special Region of Yogyakarta as a continuous source of nyamplung oil. The abundance of raw tamanu oil materials is the result of an unsuccessful biodiesel program.

Tamanu oil processing factories are categorized as micro, small, and medium enterprises (MSMEs). The general constraint for MSME entrepreneurs is venture capital for operational and business expansion [110]. MSMEs expect access to loans with low interest and an easy process. Nowadays, many MSME entrepreneurs have limited access to loan information and information on how to present their business cash flow, process, and prospects accurately to qualify for loans [111]. However, financial resources are not the issue for the tamanu oil manufacturer in Bali, as their product is specific and certainly marketable. Therefore, their credit proposal will easily be approved by the bank whenever they present it.

3.3. Material Source of Tamanu Oil

The tamanu oil manufacturer noted that the demand for tamanu oil sharply increased by about 1500% from 2017 to 2018. This increase was expected because of intensive product promotion on social media by their marketing network, consisting of distributors and resellers. The increased demand for tamanu oil cannot be fulfilled by the factories in Bali because of the low production capacity and limited availability of raw materials [112,113]. The strategy is to establish a new factory in Gianyar Regency, Bali, and accept oil supplies from all kinds of *Calophyllum* species without limiting the amount or source.

The demand for nyamplung oil as a major raw material for the production of tamanu oil has been actively responded to by the groups of oil processors in Central Java and the Special Region of Yogyakarta. The oil processors can access nyamplung tree stands as seed producers. Nyamplung stands along the southern coast of Central Java are natural or were established through replanting projects in community lands and forest areas. Producers collect ripe nyamplung fruit from their gardens or forest areas, which are run by Perum Perhutani, and sell them to oil processors.

During our research, we found that there are four groups that process nyamplung seeds into oil. The first group is the Jarak Lestari Cooperative in Cilacap, which processes seeds collected from a local community near their gardens. The produced oils are then sent to the tamanu oil factory in Bali. The second group, in Purworejo Regency, processes nyamplung seeds from Purworejo and sends the oil to Solo. The third group is Village-Owned Enterprises (BUMDES in Indonesian) in Bantul, Special Region of Yogyakarta, which processes nyamplung seeds from Purworejo farmers. Oil produced by BUMDES is then sent to an oil processor in Solo. The oil processor in Solo processes nyamplung oils from Purworejo and Bantul to increase the quality before they are finally sent to the tamanu oil factory in Bali (Figure 2).

Other than being able to access raw materials (nyamplung seeds) for the tamanu oil factory, the processor groups in Central Java and the Special Region of Yogyakarta can also supply nyamplung oil to the tamanu oil factory in Bali because they have the processing machines. There is also an oil processing unit in Cilacap. Construction of the processing machine was initiated by the Ministry of Energy and Mineral Resources, Republic of Indonesia, with the initial goal of building a biodiesel processor for Jatropha seeds. The unavailability of Jatropha seeds led the group to find alternative raw materials. The research results of Leksono et al. [114] about the potency of nyamplung oil as biodiesel material and the abundance of materials around the area encouraged the processing of nyamplung seeds into oil.

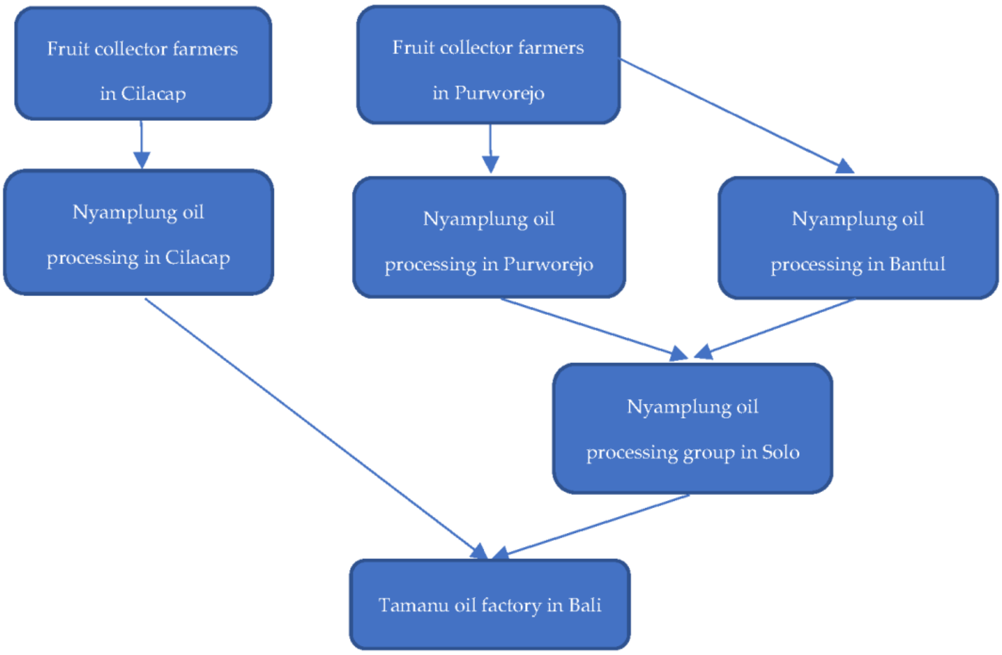

Figure 2. Supply chain flow of nyamplung oil from Central Java and Special Region of Yogyakarta to tamanu oil factory in Bali.

The nyamplung oil processing unit in Purworejo was initiated by the Ministry of Environment and Forestry through the Biodiesel Project. The abundance of raw materials and potency of nyamplung as a biodiesel material [114] encouraged farmers' groups in Purworejo to process nyamplung seeds into tamanu oil. However, BUMDES in Bantul has no source of nyamplung trees. They decided to produce nyamplung oil because of the market demand (market-driven) and the ability to access nyamplung fruit collectors, as well as due to the simple processing machine they have. The processor in Solo increases the quality of nyamplung oil from Purworejo and Bantul processors. The ability to access oil processor groups and master the technology to improve the quality of oil became the key factor for the processor in Solo to engage in chain marketing.

The simple processing machine owned by BUMDES was an innovation by BUMDES management and NGOs. The oil processor in Solo serves to improve the quality of nyamplung oils from Purworejo and Bantul, and was supported by a group of researchers from the State University of Surakarta (UNS). The Research and Innovation Agency of the Ministry of Environment and Forestry also cooperated with farmers in terms of sharing relevant information with them, creating innovative processing methods, and finding an effective technique for cultivating nyamplung trees to produce oils [27,70,114]. Support and assistance were provided related to biodiesel development in the form of equipment for a pilot project by the Ministry of Environment and Forestry.

Enabling factors that facilitate the sustainable supply of tamanu oils started from the demand for a tamanu oil factory in Bali (Figure 3). Information about demand communicated to suppliers became a logical basis for the decision to supply the needed materials/products [115,116]. Factory demand for tamanu oil communicated to suppliers become the decision basis for processors in Central Java (Cilacap, Purworejo, and Solo) and the Special Region of Yogyakarta (Bantul) to supply nyamplung oil. Processor groups in Cilacap and Purworejo can access raw materials for nyamplung oils, as there are endowments of renewable natural resources [117,118] in their regions. BUMDES in Bantul is indirectly accessed by farmers in Purworejo. The processor group in Solo accesses nyamplung oil product from groups in Purworejo and Bantul.

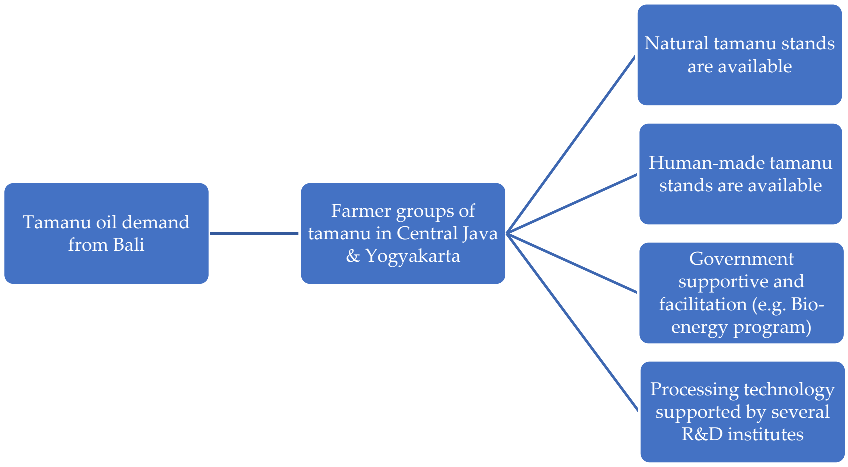

Figure 3. Enabling factors of tamanu oil material supply: case study in Central Java and Special Region of Yogyakarta.

The abundance of nyamplung trees as a raw material exported to other regions in the form of oils indicates the value-added process. Value-added benefits processor entrepreneurs and is expected to become a sustainable incentive supply, and it will not make natural endowment a resources curse [117,119]. Through the implementation of policy and support for the Biodiesel Project, the government can provide equipment or establish other processor groups, such as in Cilacap and Purworejo, while other stakeholders, such as research and development institutions, universities, and colleges, support the processing technology. Moreover, NGOs could assist in constructing processing machines. The meeting of supply demand and the collaboration among various stakeholders are expected to ensure a continued supply of raw materials for the tamanu oil factory (Figure 3).

3.4. Peatland Landscape and Bintangor

Degraded and abandoned peatlands are prone to fire during the long dry season [120,121]. Rewetting degraded peatland and revegetation with adaptive species are expected to reduce the risk of fire and provide an opportunity to increase community income [53,122]. Several peatland species can prospectively be developed as commodities, such as bintangor [27,123]. The development of bintangor as a commodity as a peatland restoration business faces various challenges. The opportunities and challenges were analyzed in four aspects based on the PEST framework: economy, technology, social, and policy. The analysis results of opportunities and challenges for bitangor are presented in Table 3.

3.4.1. Economy

The Peatland Restoration Agency (BRG) was responsible for coordinating and facilitating restoration in seven priority provinces with a total targeted area of 2.0 Mha during the period from 2016–2020 (Presidential decree No.1/2016). The BRG has used the 3R method, including rewetting, revegetation, and livelihood revitalization, to restore the peatlands. The BRG itself has targeted 1.09 million hectares of peatland outside the concession area [48,122]. The extent of the targeted restoration area outside the concession area (which has no permit yet) offers an opportunity for business actors to contribute to peatland restoration activities.

Successful forest landscape-based restoration not only restores the function of forest ecosystems, it also increases vegetation cover, plant growth, and species diversity, as well as livelihoods, prosperity, and local community resilience [124]. At the same time, it also reduces carbon emissions [125]. Several species of *Calophyllum* with natural habitats on peatlands can be used as vegetation to rehabilitate and restore degraded peatlands. Preliminary studies on *C. inophyllum* showed that it is not a natural peatland species but can grow on various degraded peatlands [24]. Further research [49,53] revealed that

C. inophyllum planted on degraded peatlands using agroforestry systems had better growth than plants in a monoculture system [27]. *C. inophyllum* planted in agroforestry systems with various commodities such as maize, cashews, honey, and rice could provide better financial benefits for the community [25].

Table 3. Opportunities and challenges for degraded peatlands as a source of raw material for tamanu oil.

Analyzed Aspect	Opportunities	Challenges
Economy	• Peat restoration target covers 1.09 Mha of non-private licensed area. • Peat is a natural habitat for some bintangor species. • Huge and unmet market for essential oils.	• Remaining natural peatland forests are sparse, scattered, and threatened with extinction by fire and illegal logging. • Cost of restoration estimated at 3225 USD/ha.
Technology	• Bintangor (*Calophyllum* spp.) is a recommended species for paludiculture. • Some residents in Riau, Jambi, and Central Kalimantan have experience collecting bintangor fruit. • Research is being done on peatland suitability of *C. inophyllum*, especially for bio-energy issues. • *C. inophyllum* planted on dry land around peatland in Musi Banyuasi (Muba) Regency, South Sumatra, grows well and bears fruit most of the year.	There is limited information on flowering season, best harvesting method, characteristics, and oil content of bintangor for tamanu oil production.
Social	• Many farmer groups, social forestry business groups, and local communities that care about fires have been fostered by the government and stakeholders and are ready to cooperate. • Commodity-based livelihood as socioeconomic pillar of local communities.	Dealing with degraded peatland involves many parties and interests.
Policy	• National policy on peatlands supports restoration activities through 3R approach (rewetting, revegetation, and revitalization) and protection of peat ecosystems. • Restoration targets in private licenses can take advantage of multi-business forestry schemes.	Government officials are often trapped in the sunk cost fallacy.

A study by Darwo and Bogidarmanti [67] reported that *C. soulatri* grows well on degraded peatlands and could produce fruit by 3 years of age. Based on many studies, some species of *Calophyllum* can potentially be planted for the restoration and rehabilitation of degraded peatlands. This is because the plants adapt well to various types of peatlands and mineral lands. Agroforestry systems could be used for land restoration and rehabilitation involving communities. The combination of various commodities and trees could also provide cash flow and profit. As an illustration, research conducted by Leksono et al. [123] showed that *C. inophyllum* developed on 25 hectares of marginal and mineral soil using an agroforestry system with 5 × 5 m spacing produced approximately 500 Kl *Calophyllum* oil per day. The yields of other intercropped products included about 2.4 tons/ha/year for corn, about 2.4 ton/ha/year for cassava, about 0.8 tons/ha/year for fodder grass, about 0.04 tons/ha/year for peanuts, and about 0.02 tons/ha/year for soybeans. All of these intercropped products contributed to additional income of 8.69 million IDR/ha/year.

Research conducted by Shanley et. al. showed that *C. inophyllum* has the potential to be developed in agroforestry systems, and one of the most common examples is using soybeans as an intercropping plant [126]. The rooting system of *C. inophyllum* is deeper than that of soybeans, and this reduces the competition for nutrient resources. Soybeans planted under 3-year-old *C. inophyllum* on mineral soil have the potential to produce higher yields, about 2.37 tons/ha.

The development of bintangor in peatlands as a target area for restoration and suitability for growth faces various challenges, especially the scarcity of plant material sources for large-scale development. Currently, remaining natural peatland forests are very rare. The locations are scattered and threatened with extinction due to legal and illegal logging and forest and land fires that occur frequently [2,44]. The destruction of these peatland forests has important implications for the scarcity of bintangor trees in their natural habitats in South Sumatra and Riau. The high cost of peatland restoration becomes one critical challenge. Rahman et al. noted that the estimated cost of land restoration in Indonesia is USD 398 to 12,153 per hectare [25]. The area of degraded land extends more than 1.2 million hectares; thus, it entails high cost. Multi-stakeholder support is needed to make peatland restoration successful since the government cannot manage it alone. Basing peatland restoration on commodity businesses is a good strategy considering it could attract public participation and private investors to get involved. This strategy certainly increases value and encourages economic actors to invest in peatlands.

3.4.2. Technology

Some species of *Calophyllum* have natural habitats in peatlands, such as *C. soulatri* and *C. inophyllum*, so they can adapt and grow there. Research conducted by Maimunah et al. [26,127] in Kalimantan showed that *C. inophyllum* planted on peatlands with a pH level between 2.88 and 3.19 and thinner peat (less than 100 cm) had a survival rate of 88%, higher than that of other commodities, including candlenut, calliandra, and gamal (*Gliricidia sepium*). However, *Calophyllum* has not been included as a recommended plant species for peatland restoration in Indonesia, although Maimunah et al. [26] have started research on the potential of this species for bioenergy resources and peatland restoration.

Based on field observation, nyamplung trees (*C. inophyllum*) planted on mineral soils around peatlands in Musi Banyuasin Regency have good growth and flowers and produce fruit almost every year. Based on these facts, *Calophyllum* could possibly be developed on a larger scale, not only in the PHU area, but specifically in peatland hydrological landscapes.

Information from communities in Riau, Jambi, and Central Kalimantan shows that recently it has been difficult to find bintangor fruit due to changes in fruit seasons. Climate change is expected to impact flowering and fruiting seasons. The biophysical and agroclimatic conditions of *Calophyllum* spp. habitat also affect flowering and fruiting seasons [128]. Limited information regarding flowering and fruiting seasons results in limited mastery of harvesting technology and analysis of bintangor oil content. This has become one of the challenges in the production and development of the bintangor-based tamanu oil business.

The development of *Calophyllum* spp. as a peatlands restoration business commodity could be similar to the development of palm oil and rubber plants, which are not original to Indonesia and wetlands but have good productivity on various types of land, including wetlands. Improved knowledge of tree development and land management practices (fertilization, spacing, pruning, and harvesting) could encourage the use of local types of peat as economically and ecologically productive commodities. Tissue culture and biotechnological approaches could provide genetic material for cultivation, as well as increase commodity productivity and resistance to various weather and soil conditions and diseases [129,130]. Additionally, to increase the productivity of nyamplung fruit as a raw material for tamanu oil, higher-yield fruit should be developed.

3.4.3. Social

The peatland restoration policy was launched after the 2015 forest fires. Forest and land fires in Indonesia caused economic losses estimated at USD 16.1 billion in GDP [131]. Economic sectors affected by fires included agriculture (plantations, food crops, and forestry), mining and energy, manufacturing, trade, transportation, tourism, health, education, and environment, plus the high cost of extinguishing forest and land fires [131–133].

In 2015, forest fires occurred in eight provinces in Indonesia [122,131,134]. About 33% of the total peatland area was burned [122,131]. Drainage and conversion of peatlands for palm oil production [2,131], development of industrial forest plantations [135], preparation of land for agriculture [2,131,136], and access to cheaper land [131,137] were thought to be the causative factors. The distribution of fire was both inside the concession/corporate area (34%) and outside the concession area (66%). The fire inside the concession area occurred in areas covered by the natural forest timber product concession business license (IUPHHK-HA) and timber forest product concession business license for plantation (IUPHHK-HT), a palm oil plantation, and the overlapping area between the three [134].

The involvement of various stakeholders as managers of forest and land fire areas is an opportunity for post-fire peat restoration efforts. Ministry of Environment and Forestry Regulation No. 32/2016 requires the active involvement of stakeholders in forest and land control, including prevention, response, and post-fire recovery. Peat restoration involves efforts to treat forest and land fires from prevention to extinguishing to post-fire recovery. The findings of Budiningsih et al. [138] show that preventing hotspots is more effective than controlling forest and peatland fires. Therefore, stakeholders related to sectors potentially affected by fires should be involved in efforts to prevent the emergence of hotspots and to restore peat. At the site level, there are community groups that partner with large-scale concession holders who care about forest and land fires [136,138,139]. They consist of farmer groups, social forestry business groups, fire care communities established by the government, and companies that hold forestry and plantation concessions. Stakeholders who are concerned about peatland fires represent an opportunity for collective action on peat restoration.

The traditional communities in Sumatra and Kalimantan have a commodity-based livelihood as a pillar of their economy. The commodities are obtained by extractive methods from the land (fruit, seeds, honey, wallet nests, bark, wood, and animals) [140,141] and water (fish) [140,142], or by shifting cultivation of commercial annual crops that require low input [140]. After large-scale natural forest wood extraction, the lowlands (including peatlands) in Sumatra and Kalimantan were converted for the cultivation of palm oil, rubber, and other agricultural commodities [2,44,45,137] and mining [140]. Research conducted by the Center for International Forestry Research (CIFOR) and the International Center for Agroforestry (ICRAF) in the lowlands of Sumatra, Kalimantan, and Papua identified potential commodities based on extensive agricultural systems within the agroecological zone and the diverse resources. The facts presented above show that local communities in seven priority restoration provinces in Sumatra, Kalimantan, and Papua have a commodity-based livelihood as a socioeconomic pillar. This is a provision for developing commodity-based peatland restoration.

Conflicts over natural resources are becoming more common because of increasing population, different value systems, and greater economic and environmental demands on limited resources. The dynamic of conflict becomes more complex due to the interaction of factors related to the parties involved, the characteristics of the resources, and the stage of development [137]. The involvement of stakeholders related to forest fires presents opportunities as well as challenges in peat restoration efforts. Companies with business permits for concession of timber forest products from plantation forests (IUPHHK-HT) and palm oil plantations have an interest in managing peatlands to achieve expected production. The efforts that are made are sometimes less adaptive to the nature of peatlands, which are naturally wet. Meanwhile, the social and economic aspects of peatland communities are still highly dependent on land-based livelihoods, most of which are managed by the business community. The Peatland Restoration Agency, an institution given a mandate for peat restoration, has an interest in achieving restoration targets, some of which are located in cultivated areas managed by HTI companies and palm oil plantations.

3.4.4. Policy

The BRG [122] states that 87% of the priority areas for peat restoration are in cultivated areas, and the remaining 13% are in protected areas. Most of the use and management of peatlands in cultivation areas is carried out by concession holders for forestry and palm oil plantations. There are 531 forestry and palm oil plantation companies operating on peatlands, including 174 as IUPHHK-HTI holders, 30 as IUPHHK-HA holders, and 327 oil palm companies. The concession area, which is located in a peat dome, is about 590 thousand hectares. In the restoration area, there are also community lands/areas that are controlled with or without customary claims.

The BRG offers a 3R scheme (rewetting, revegetation, socioeconomic revitalization of the community) and peat ecosystem protection to restore the peatlands in Indonesia [48]. Hydrological restoration involves rewetting dry peat material due to a lower level of peat water by increasing the water content and level of the peat soil [6,135,143]. Rewetting is a core part of peat ecosystem restoration [48]. Revegetation or rehabilitation of vegetation is an effort to restore landcover in peat ecosystems by planting endemic or adaptive plant species. The aim of revegetation is to restore landcover so that the function of the peat ecosystem can be restored [48]. Socioeconomic revitalization activities are carried out to support community participation in managing degraded peatlands in an effort to improve the community's economic level through peatland-based activities [48].

The 3R scheme and protection of the peat ecosystem indicate that the appropriate model is a nondestructive use model for the peat ecosystem as natural capital. Nondestructive use, which means not reducing or changing the forest cover, which is generally used to measure the success of conservation programs [144,145], can be applied to peat restoration in cultivated areas. The utilization of NTFPs is adaptive for peat ecosystems, so this is an alternative that can be applied to peat restoration and conservation of peat ecosystems. Using NTFPs can be an option because it can harmonize forest utilization and conservation [145–150]. NTFPs also have the potential to be developed as a global-scale business. A study conducted in Finland [151] reports that globalization and trends such as the popularity of superfoods has accelerated the export of non-timber forest products to the global market. It is estimated that there are between 3.5 billion and 5.76 billion users of NTFPs globally [152].

Based on government policy support, the abundance of users around the world, and a potential strategic role in restoration and peat conservation, NTFPs should take a more central role in sectoral and development policies. The integration of NTFPs as part of the forestry and plantation business on peatlands is a relatively new occurrence, although it has been discussed with regard to multi-business forestry as a simple implementation of the principles of sustainable forest management, economics, and socio-culture in forestry [153,154]. Permits for forestry businesses on peatlands are related to wood production and ecosystem restoration (carbon), while business permits are for palm oil plantations. The long history of timber forest products and palm oil may potentially be a sector- and policy-level challenge in developing the NTFP business on peatlands. The sunk cost fallacy [155,156] potentially applies to the government at the site level. The government, which is responsible for forestry and plantations, has invested a lot of money (state budget), energy, and decision-making to manage peatlands, and may not want to abandon strategies or actions that are "business as usual" (BAU), even after it has been proven that BAU has failed. People tend to believe that the country is more influenced by previous investments, so it is vulnerable to see that current decisions are still related to previous investments [157]. On the other side, the Peatland Restoration Agency, through the 3R scheme in peat restoration, will tend to continue the investments that have been made, which are different from the BAU of conventional forestry and plantation businesses.

4. Discussion

This research shows another aspect of business development for the restoration of Indonesia's degraded peatland ecosystem. Most of the research on peatland commodities is about selecting suitable species for paludiculture and starting from the situation on restoration land [66,68,158]. Several species are recommended for restoration, such as coffee (*Coffea liberica*) and pineapple (*Ananas comosus* L. Merr.), which were developed by local communities by converting peat swamps and that still require drainage [159]. The focus of this research is on commodities that are developing outside of peatlands but have the potential to be produced by restoring the peat ecosystem. The results of the research are about business behavior, in this case the production of tamanu oil, regarding both factories and suppliers of raw materials outside of peatlands, and are also related to the situation in degraded peatlands, to synthesize the enabling factors in the development of a restoration business on degraded peatlands.

The business of tamanu oil, as an essential oil, is based on the creativity and innovation of the leaders of small and medium enterprises (SME) in Bali, Indonesia. This innovation has good prospects because it has large market potential supported by the suitability of local Asian traditions, the availability of raw materials, and processing technology that can be undertaken by the entrepreneurs themselves. The findings of this study are in line with the results of research by Zivojinovic et al. [160], who reported that innovation in the development of NTFP businesses is strongly supported by networking and longstanding cooperation with individual entrepreneurs who have expertise. Innovation in NTFP businesses is only developed by the owners' ideas [160]. The results of this study show the feasibility and sustainability of NTFP businesses carried out by SMEs due to external factors and the abundance of raw material sources, most of which are the result of forest and land rehabilitation programs.

The innovation of tamanu oil production is the result of SME business development with essential oils as the core of the business. Their first product was coconut-based massage oil. Tamanu oil is a diversified product. These findings confirm the general knowledge of NTFP business innovation and add information about the market characteristics. Each business has its core and a variety of products. Food, medicine, and energy are common groupings in the business and trade of NTFPs [126,161]. The market and business characteristics of NTFPs should be a consideration for managers and policymakers related to degraded peatlands when providing management and preparing business plans. The behavior of a business portfolio at the factory level can be imitated by the raw material supplier at the site level to produce a variety of products, for example, various types of oil.

The business of nyamplung oil carried out by farmer groups in Central Java exists due to the demand for tamanu oil by herbal oil entrepreneurs in Bali. The entrepreneurs turn to the farmers because they have sufficient raw materials that they can process into oil. The farmer groups have this ability because of government and research institute support. This is also an enabling factor in developing nyamplung oil as a raw material for essential oils. For farmer groups, the initial purpose of nyamplung cultivation was to produce raw materials for bioenergy, but the demand from essential oil entrepreneurs made the business go further. The findings of this study add to the knowledge of supporting factors in the success of small and medium forest enterprises (SMFEs), especially in the initial phase of business development.

Mishra et al. [159] stated that the success of SMFEs was due to external and internal factors. External factors include the macroeconomic situation, regulatory framework, regulation of tenure and ownership rights, regulation of land-use management and planning, markets, enforcement of forestry laws, and natural capital. Internal factors consist of finances or capital, forest management capacity, business management capacity, organizational capacity, and clustering.

Another interesting finding regarding the enabling factors for the nyamplung oil business is the abundance of raw materials, some of which come from land rehabilitation and biofuel programs. The use of nyamplung oil in Central Java as an alternative source of bioenergy is widely reported, and information is easily found on the Internet. Ultimately, this environmentally based program found its market and business. These findings agree with the research results by De Groot et al. on ecosystem restoration projects.

According to their research, money spent on restoration is not just an expenditure, but a valuable investment that will generate a variety of benefits and can help achieve policy objectives [162].

The business of tamanu oil is hindered from being well-developed on degraded peatlands mainly due to raw material availability. Tamanu oil entrepreneurs in Bali are interested in trying tamanu oil from peatlands. Unfortunately, information on the abundance and diversity of potential species for producing tamanu oil, such as bintangor, is only anecdotal and available in publications but not in the field. This problem of sufficient quantities of raw materials meeting quality and sustainability standards is a common problem of NTFP businesses. In fact, in developed countries such as Finland, the main concern of NTFP businesses is still perceived to be the production and acquisition of raw materials, not sustainability or business logic [163].

The findings of the enabling factors of the tamanu oil business in Bali together with those of the nyamplung oil business in Central Java, associated with the opportunities and challenges of developing the tamanu oil business on peatlands, can be considered as new knowledge about how to start a restoration business on degraded peatlands. Nyamplung oil in Central Java is the result of properly growing and maintaining plants—the final phase of ecosystem restoration. Meanwhile, degraded peatlands are in the early stages of ecosystem restoration. Thus, in this early stage, the role of the government and non-profit institutions must come first.

This research adds knowledge about restoration business protocol, especially in the initial process of business development and the selection of NTFP commodities that have multiple benefits or can be produced by different plants. The initial study of this method was carried out by observing products for which demand is expanding in current markets and that can be produced in current and future restored landscapes. This contrasts with the general form of business development, which sees the potential or current availability of commodities on peatlands (see [15,31–33]).

The knowledge of enabling factors in the degraded peatlands restoration business has several policy and technical implications. From the perspective of policy analysis, ecological restoration projects take place in complex situations that involve interactions among technical decision-making, ideological, and political interests. Therefore, ecological restoration should be viewed not only as a technical issue, but also as a social and political issue [164,165]. The peat ecosystem restoration business based on tamanu oil, with diverse types of oil producers in one PHU, can be realized if technical, social, and political problems are resolved, in order to allow part of the landscape to produce a source of financing for other restoration areas.

Lessons from various cases of forest landscape restoration globally show that the success of the governance approach is closely related to being people-centered, being able to adapt to local contexts and needs, involving stakeholders with diverse backgrounds, and being flexible about involving local ideas and practices [166]. Lamsal et al. [167] conducted a study of forest-based small- and medium-sized enterprises (FMSEs) in Nepal. According to their study, without an entrepreneurial culture, the development of FMSEs is better when combined with businesses chosen by the community. Therefore, in the case of peat restoration in Musi Banyuasin Regency, for example, the cultivation of plants that produce tamanu oil is better when integrated into community businesses such as oil palm and rubber. The diversity aspect, in terms of both the products of production units and the options for types of products, is an important finding of this study.

This study shows that, as also happened in countries in southeastern Europe, there is no special policy designed for NTFPs [160]. In Indonesia, the district government can accommodate these issues, especially by making specific policies related to the development of NTFPs. For example, the government of Musi Banyuasin Regency supports the national policy of developing biofuels from palm oil, and plans to build a biofuel plant. Therefore, in the context of developing the tamanu oil-based restoration business, program support is better provided on a district scale derived from provincial and national government policies on peat ecosystem restoration. In a broader vision, district governments can commit to becoming vegetable oil producing regions through product diversity, such as palm oil and tamanu oil.

5. Conclusions

The tamanu oil-based peatland ecosystem restoration business has potential. There is a growing bioenergy and biomedicine market for this pro-environment business. Developing the tamanu oil business for peatland restoration could cover a large area of degraded peatland (based on the peatland hydrological unit), by revegetating with bintangor (*Calophyllum* spp.) and planting areas outside peatlands with nyamplung (*Calophyllum inophyllum*). This business can also be classified as an ecosystem service for the carbon market, with the advantage of social inclusion of smallholder farmers.

The basis of business development for both tamanu oil and nyamplung oil is product diversification. This can be an enabling factor for the development of tamanu oil business on degraded peatlands. PHUs should be sites for business unity, with nyamplung plants in mineral fields and bintangor plants in peatlands. Both plants can be grown in agroforestry patterns with agricultural commodities found in PHUs, even with oil palm. Concessionaires for industrial plantation forests can also be encouraged to participate in planting nyamplung and bintangor in unplanted areas in a multi-business forestry scheme.

To make the tamanu oil business work in peatland ecosystem restoration, we suggest that local–regional policy documents and their derivatives include tamanu as a priority commodity for peatland restoration and community business alternatives, along with a planting program by all stakeholders. Government and civil society organizations should take positions as initiators and catalysts, pilot a significant number and extent of tamanu plantations, and create a mutually supportive business climate between entrepreneurs and peatland managers.

Campaigns for the tamanu oil business in degraded peatland can start with product campaigns for the nyamplung plant, which grows well in peatland areas, to convince consumers and potential producers of the market vision of this business. Extrinsic product attributes such as packaging quality, labeling, and conformity with food or health standards are vital factors.

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Appendix A. List of Questions for Key Informants for In-Depth Interview and FGD

Appendix A.1. In-Depth Interview

1. Research and Development Institutions

- Where are the nyamplung plants/trees distributed?
- What are the results of research related to the nyamplung tree?
- Where is the location of the nyamplung oil processing?

2. Community around peatland forest

- What is the biophysical condition of the distribution of *Calophyllum* in peatland forest?
- When is the flowering and fruiting season of *Calohyllum* in peatland forest?
- What is traditional use of nyamplung/bintangor

3. Farmers groups

- What is the distribution of nyamplung plants/trees?
- What is the history of the existence of the nyamplung tree in the surrounding area?
- Who is the manager of the nyamplung tree/stand?
- What is the flow of nyamplung fruit collection activities to the oil processing group?

4. Nyamplung oil processing group

- What is the history of the oil processing unit used to process nyamplung oil?
- What is the form of management of the oil processing unit?
- How is nyamplung oil processed?
- What is the marketing process for nyamplung oil products?

5. Tamanu oil entrepreneur

- What is the history of the tamanu oil processing plant?
- Why produce tamanu oil?
- How do you access raw materials for tamanu oil products?
- What is the marketing strategy for tamanu oil products?

Appendix A.2. Focus Group Discussion (FGD) for Stakeholders Related to Peatland Management

- How is current peatland management related to the peat restoration policy?
- What is the perspective regarding peatland restoration businesses on managed land?
- What are the opportunities and challenges of tamanu oil-based restoration businesses?

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