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by Muhammad Yazid

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Livelihood Alternatives in Restored Peatland Areas in South Sumatra Province, Indonesia

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Abstract: Livelihood loss and lower income because of peatland mismanagement are crucial issues that must be resolved in peatland areas. Although many studies have assessed farmers' livelihoods and income enhancement, progress in addressing these problems remains inadequate. To address this issue, this study aimed to analyze various existing alternative livelihoods in the peatland community in Ogan Komering Ilir District, South Sumatra Province, Indonesia, and analyze scenarios for creating livelihoods and increasing people's incomes through changes in peat ecosystem management and peatland restoration programs. This study used a survey method conducted in South Sumatra Province's OKI District, one of the four priority peat-restoration districts in the province. We used three sampling stages, while descriptive, tabulated, and mathematical methods were used for analysis. We analyzed the feasibility of livelihoods that used benefit-cost analysis. The results showed that Sonor cultivation of paddies and catching fish in Rawang (swamp) were the livelihoods of farmers in peatlands. The community has also been processing peatland commodities into other products, such as Purun woven, and Gula Puan (buffalo milk processing). Several alternative livelihood scenarios that are financially profitable and can be developed include salted and smoked fish, Purun woven handicrafts, paludiculture, and agrosilvofishery, which can provide farmers with short-, medium-, and long-term income opportunities. This study can contribute to policymaking by fully considering the role of peat resources in rural livelihoods.

Keywords: agroforestry; swamp buffalo; paludiculture; Purun woven; salted fish; smoked fish; Sonor rice cultivation

Citation: Adriani, D.; Yazid, M.; Riswani; Damayanthy, D.; Choi, E.; Yang, H. Livelihood Alternatives in Restored Peatland Areas in South Sumatra Province, Indonesia. *Land* **2024**, *13*, 643. https://doi.org/10.3390/land13050643

Academic Editor: Dingde Xu

Received: 20 March 2024
Revised: 20 April 2024
Accepted: 22 April 2024
Published: 9 May 2024

1. Introduction

Indonesia has a total peatland area of approximately 13.4 million hectares (equivalent to 80% of the total peatland in Southeast Asia). Tropical peatlands play a role in reducing greenhouse gas emissions and help control increasing global temperatures. Peatland restoration and protection in Indonesia has a significant impact on mitigating climate change [1]. Indonesia has the largest peatland area among tropical countries, spread mainly in Kalimantan, Sumatra, and Papua. The most extensive peatland in Indonesia is in Sumatra. On the Sumatran islands, peatlands are generally found along the east coast in the areas of Riau, South Sumatra, Jambi, North Sumatra, and Lampung [2]. South Sumatra has the second-largest peatland ecosystem area, after Riau Province. Particularly, the Ogan Komering Ilir (OKI) Regency in South Sumatra has the largest peatland, covering 769 thousand hectares. Unfortunately, the South Sumatran peatland ecosystem currently requires comprehensive restoration efforts. Based on these conditions, the South Sumatran Province was included as a priority province for peatland restoration [3].

Peatlands in Sumatra are under intense pressure from both legal and illegal parties. Land fires, illegal logging and conversion to plantation crops are one of them. On the other hand, peatlands are ecologically valuable and very sensitive to disturbance and therefore peatland use policies must be changed to ensure optimization of peatlands [1,4] Tens of millions of rural households in Indonesia, especially in South Sumatra, derive their income from managing and harvesting peatland [1,2]. Thus, peatlands contribute significantly to human welfare. However, the magnitude of the contribution of peatlands to people's welfare is often not well understood or appreciated, which can consequently lead to overexploitation. Efforts employed to exploit peatlands to meet human needs often neglect sustainability. Several studies have identified issues related to peatland mismanagement, including land use, law enforcement, community capacity, economic rent-seeking, exploitation of forest products (wood and non-wood), and climate change [1,4–6].

Peatland exploitation has led to many conflicts in Indonesia that have resulted in various negative technical, ecological, economic, social, and cultural impacts, such as (1) peatland fires due to misuse, carelessness, and neglect, and even intentional fires; (2) dry peatlands due to canal digging and planting nonpeatland-friendly plants; (3) damage to peatlands; (4) decreased productivity leading to negative economic impacts; (5) loss of livelihoods; and (6) decreased income [2,4,5,7]. Loss of livelihood and decreased income because of mismanagement of peatlands are crucial issues [6,8,9]. Various strategies have been proposed to address these issues [1,8,10,11].

However, while studies have been conducted on the livelihoods and income generation of farmers in peatlands, the problems of loss of livelihood options and decreased incomes have not yet been addressed. This is because of several reasons, such as ambiguity of policies, limited understanding of the impacts on ecosystems and the economy, unclear causes of the loss of livelihoods and decreased income, and uncertainty surrounding the economic and institutional responses of communities on peatlands. Additionally, various policy proposals are occasionally not based on a cost-benefit analysis of the specific actions to be taken to solve problems and their causes [6,12,13].

Moreover, the various proposed strategies will not be successful without the participation of all the involved stakeholders, such as the government, companies, nongovernmental organizations, universities, conservation groups, local communities, and research institutions. These stakeholders collaborate to develop plans that consider the needs and varied values of the community, and also particularly for preserving crucial wildlife habitats and species [14,15]. The Indonesia Peatland and Mangrove Restoration Agency (BRGM), with its 3R program (rewetting, revegetation, and revitalization of livelihood), provides great hope for the success of peat restoration in Indonesia. Managing the conservation and sustainable utilization of peat ecosystems in an equitable way, alongside the rehabilitation and mitigation of harmed peatlands, the BRGM launched the 2020–2049 National Peat Ecosystem Protection and Management Plan. The BRGM provides new directions for area restoration and the restoration of peatland hydrological functions affected by forest and land fires, in a specific, systematic, directed, integrated, and comprehensive manner, including improving the livelihoods of people in and/or around peatlands. During the United Nations Framework Convention on Climate Change (UNFCCC) Conference of Parties (COP) 22 held in Marrakech, Morocco, from 8 to 16 November 2016, BRGM affirmed that the revitalization of livelihoods in peatland areas and their surroundings could be achieved through the development of paludiculture farming systems, agroforestry, fisheries, and ecotourism. These sectors indeed represent key avenues for the sustainable development of livelihoods in areas where peatlands have been restored. Additionally, the harvesting of nontimber forest products (NTFPs) from regenerated or restored peat swamp forests could be further integrated into these efforts. On World Peatlands Day, that is 2 June 2022, Indonesia also signed the Venice Agreement, a commitment to act locally to conserve peatlands across the world [14–18].

Examining peatlands is also crucial to tackle social and economic concerns, including how local communities access and utilize natural resources for their livelihoods. Previous research assessed peatland management effects for both the greenhouse gas balance and the livelihoods of local communities. The majority of research found that the peatland management strategies can offer various environmental, technological, social, and economic benefits [7,16,17,19–21].

Some barriers that were also faced in implementing peatland management include a lack of expertise, technical skills, awareness among stakeholders, financial assets, institutional barriers, lack of training, and benefit cost information [6,11,16,17,19,20].

Peatlands have historically provided livelihoods for local communities through agricultural cultivation and fisheries and are carried out based on local culture. The transition of existing ways of life is still challenging because communities tend to resist change and favor maintaining the current status, which may include engaging in activities such as illegal logging, and relying on fire for cultivation, hunting, and fishing. The indigenous communities are engaged in extractive means of livelihood focused on economic gains, driven by the necessity to sustain themselves financially, exacerbated by the absence of viable, sustainable alternatives. Convincing these communities to shift towards new livelihoods remains challenging due to the scarcity of options that can rival their current economic activities. Securing additional funding is imperative to bolster the restoration program and introduce more promising sustainable livelihood alternatives within peatland areas [21–23].

Improving the lives of people in peatland areas by improving their livelihoods must be preceded by an understanding of the various alternative livelihoods that already exist in the community. Information on these alternatives is important not only for developing new business opportunities but also for understanding both the needs of people who conduct business in and/or around a peatland area and the impact of changes in the ecosystem. Some studies [11,16,24] have indicated that to restore peatlands, the livelihoods of communities should be improved; nonetheless, gaps exist in understanding the relationship between restoring peatlands and ensuring sufficient income for a community's needs. The constrained availability of potential commodities and markets stemming from livelihood alternatives poses obstacles to enhancing livelihoods through the restoration program [15,22,23]. While the concept and application of livelihood alternatives have been introduced through various initiatives, expanding their scale and commercial viability requires further dedication and resources. Additional research is crucial to support the restoration program and to provide sustainable livelihood options in peatland areas. Thus, to address these issues, further research is needed to provide an overview and validate the various alternative contributions that peatlands make to community livelihoods and the various dimensions of human well-being in restored peatlands.

1.1. Research Objectives

Accordingly, this study aimed to provide a better understanding of the dimensions of community life in peatlands to allow for effective and efficient community revitalization policies. The specific objectives of the study were to (1) analyze various alternative livelihoods that already exist in a peatland community and (2) analyze scenarios for creating livelihoods and increasing people's income through changes in peatland ecosystem management and peatland restoration programs.

1.2. Research Hypotheses

Hypothesis 1 (H1). *Various alternative livelihoods that already exist in a peatland community, such as buffalo farming, Gulo Puan, salted fish, smoked fish, and Purun woven crafts, are feasible financially.*

Hypothesis 2 (H2). *Scenarios for creating livelihoods and increasing people's income through changes in peatland ecosystem management and peatland restoration programs are developing, such as Sonor rice without burning, agrosilvofishery, and paludiculture are feasible financially.*

1.3. Significance of the Study

This study is of great importance to local communities, policymakers, regional planners, and stakeholders involved in peatland restoration efforts. It emphasizes the necessity of integrating diversification into peatland restoration initiatives, echoing the sentiments of livelihood diversification in the field. Additionally, it adds value to the existing literature by offering a nuanced understanding of peatland livelihoods, including their endeavors, achievements, and limitations, which can inform effective policymaking. By shedding light on the economic rationale behind alternative livelihoods in peatlands and presenting compelling evidence regarding their economic benefits and cost-effectiveness, the research provides valuable insights for policymakers and planners. Importantly, this research contributes forward-looking perspectives by identifying best practices, identifying gaps, and highlighting barriers in current livelihood alternatives, offering invaluable guidance for strategies aimed at revitalizing livelihoods.

2. Materials and Methods

2.1. Research Framework

One of the mandates of the Indonesia Peatland and Mangrove Restoration Organization (BRGM), built up by the Indonesian Government in 2016, was to renew the livelihoods of individuals living in communities that are subordinate to peatlands. This remains generally unmet owing to the complexity of the issue, the lack of knowledge about the rewetting preparation, and contradictions among partners with differing needs and objectives [25,26]. The primary focus of peatland restoration activities is the peatland community. At the field level, the indigenous people play a crucial role in ensuring the continuity and success of restoration efforts even after the peatland program is completed. To strike a balance between peatland restoration and existing livelihoods, new livelihood opportunities are necessary to enhance community income. In summary, peatland restoration aims to involve local communities, especially indigenous people, and create sustainable livelihoods while restoring degraded peatland ecosystems. The success of restoration efforts hinges on empowering these communities and addressing their economic needs [1,15,27,28].

To address the restoration impacts, it is acknowledged that livelihoods must shift towards more sustainable alternatives. Various options, such as paludiculture, agroforestry, and aquaculture, have been suggested, yet they still lack appeal compared to the prevailing dryland choices. Despite restoration efforts, there has not been a notable shift away from these lucrative but environmentally harmful options [8,25].

Peatlands play a crucial role in supporting the daily needs of people in many villages, including those in Indonesia, where they provide natural resources for fisheries, agriculture, plantations, and forestry. However, utilizing peatlands comes with several challenges, such as fire risk, soil acidity, inundation, low fertility, and limited suitable species choices. To address these challenges and promote sustainable livelihoods, researchers have been exploring innovative approaches. Sustainable livelihoods in peatland require a delicate balance between environmental conservation and community well-being. By developing innovative technologies and promoting responsible practices, we can simultaneously restore peatlands and improve the quality of life for those who depend on them [1,16,29].

Figure 1 presents the framework for guiding the progress of this study and achieving the target output. To achieve sustainable livelihoods, the creation of new livelihoods—as a form of business diversification—is considered a positive strategy that can increase resilience, support asset development, and reduce poverty, while maintaining local natural resources [30–32]. New livelihoods can increase the income and profits of peatland households with minimal capital. With only limited income possible from small plots, farmers and their families need to fulfill their household needs from other income sources; hence, there is an opportunity to create alternative livelihoods [1,33].

Livelihood activities can be divided into two major parts: (1) those that are already being conducted and (2) opportunities for creating new livelihood activities. Economic activities conducted by a household can lead to the achievement of peatland-restoration-friendly livelihoods in every region (according to spatial) and in a short, medium, and long time (according to time), as summarized in Figure 1.

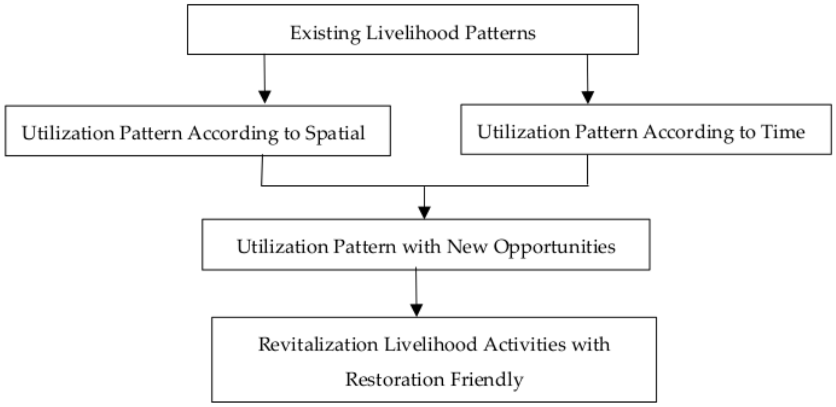

Figure 1. Research framework followed in this study.

2.2. Study Sites

This study used a survey method conducted in South Sumatra Province's OKI District, one of the four priority peat-restoration districts in the province. OKI covers five peatland hydrological areas (KHG), covering an area of 1,108,483.41 ha. The locations and areas of the five KHGs are shown in Figure 2, and their names and study areas are listed in Table 1. We selected three KHGs for sampling: (1) Sungai Sugihan–Sungai Lumpur, (2) Sungai Sibumbung–Sungai Batok, and (3) Sungai Saleh–Sungai Sugihan, based on variations in natural resources (including peatlands) and diversity of community livelihoods.

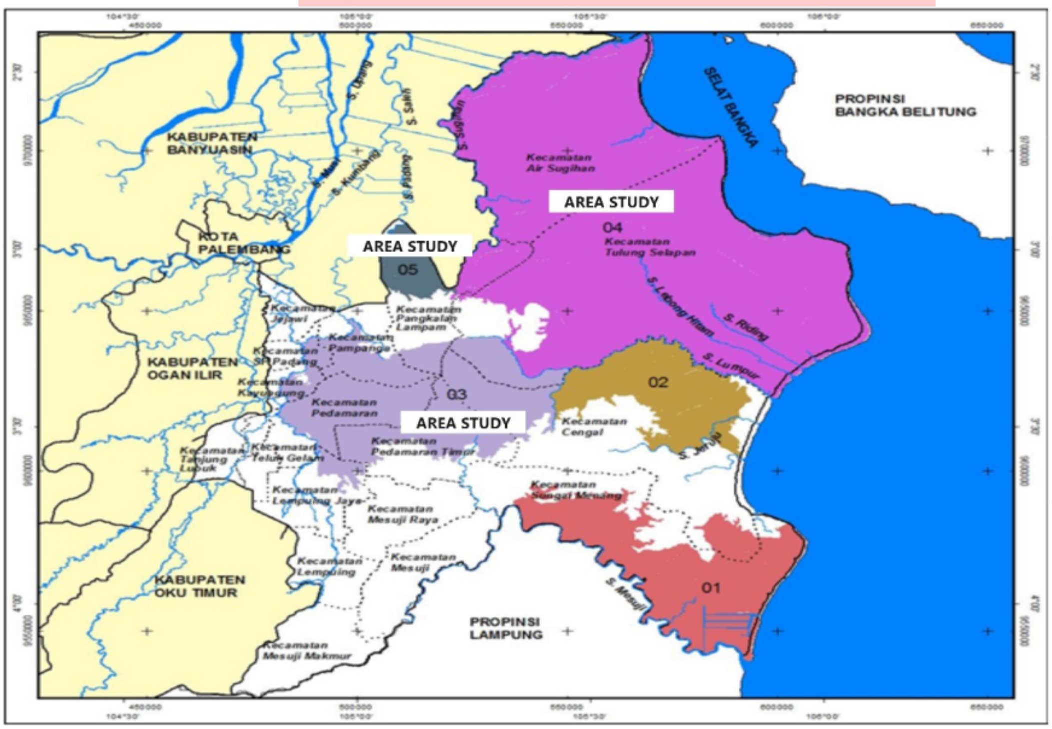

Figure 2. Sampling areas of the study.

Table 1. Study sites in OKI District.

Number of KHGs in Figure 2	Peatland Hydrological Areas	Area (ha)
03	Sungai Sibumbung–Sungai Batok	205,078.11
04	Sungai Sugihan–Sungai Lumpur	636,432.22
05	Sungai Sugihan–Sungai Saleh	24,097.17
Total		865,607.50

2.3. Sampling Method

Sampling was conducted using cluster sampling with three sampling stages, as follows:

1. In each KHG, subdistrict and village clusters were determined based on the main livelihoods of the population, such as food crop farming (rice and horticulture), plantation crops (rubber and oil palm), forest production, livestock farming (swamp buffalo, cows/goats, and chickens/ducks), fishery (cultivation and capture), home industry/small processing industry, and services.
2. From each subdistrict and village cluster, two sample villages representing the characteristics of the cluster were selected. We selected six villages from three KHGs.
    a. KHG Sungai Sibumbung–Sungai Batok in Pampangan Subdistrict: Ulak Kemang and Pulau Layang villages.
    b. KHG Sungai Saleh–Sungai Sugihan in Pangkalan Lampam Subdistrict: Perigi and Bukit Batu villages.
    c. KHG Sungai Sugihan–Sungai Lumpur in Air Sugihan Subdistrict: Kerta Mukti and Bandar Jaya villages.
3. Stratified random sampling was conducted in each village based on the land scale (paddy farming, agrosilvofishery, and paludiculture), number of livestock, number of business units (fisheries), amount of production (timber and nontimber forest products), and asset tenure (processing industry). The number of sampled households was adjusted for each population. For households whose main livelihood was outside the village area (for example, wood and nontimber forest products), sampling was conducted in their domicile area, not at their work location. In this study, the spatial mobility of the population was considered in relation to the impact of livelihoods on the peat ecosystem. From each village, we selected 50 sample households, and the total number of respondents was 300.

2.4. Data Collection

Data were collected in the following three ways:

1. We selected six villages from the three KHGs using field observations to collect data directly, wherein the researcher directly observed the sample characteristics being studied from a research object using instruments that have been designed for the particular task. We observed the respondents' activities related to their livelihoods.
    (a) KHG Sungai Sibumbung–Sungai Batok in Pampangan Subdistrict: Ulak Kemang Village was the smoked and salted fish sample location, and Pulau Layang villages were the buffalo sample locations.
    (b) KHG Sungai Saleh–Sungai Sugihan in Pangkalan Lampam Subdistrict: Perigi as the paludiculture and agrosilvofishery sample locations, and Bukit Batu villages as the Purun Woven sample locations.
    (c) KHG Sungai Sugihan–Sungai Lumpur in Air Sugihan Subdistrict: Kerta Mukti and Bandar Jaya villages as Sonor rice with and without burning sample locations.
2. Interviews (structured, in-depth) were conducted to obtain an in-depth understanding of the variations in livelihoods in each sample location. To simplify the interviews, we provided a list of structured and comprehensive questions in the form of a questionnaire on livelihoods.

3. A focus group discussion was conducted with 8–12 participants, led by a moderator in every village. The initial discussion began with questions from the moderator about economically valuable activities conducted on peatlands, which were then responded to and discussed by the participants. In this case, the moderator played an important role in producing useful discussions within a certain amount of time. Discussions were also held in a relaxed manner, so that participants could express their opinions and ideas without pressure.

2.5. Data Analysis

Benefit-cost analysis was used to assess household income data for various livelihood activities. The types of costs to be considered were as follows [31,34,35]:

1. Investment costs (IC): These are generally large and long-lasting (e.g., machinery, buildings, land, cages, ponds, preparing land, blocking canals, and canal channels).
2. Operational costs (OC): These costs are of raw materials, seeds, fertilizers, fuels, pesticides, and labor. The operational costs are divided into fixed and variable costs.
3. Total cost (TC): This is the sum of IC and OC.

A benefit is the amount received from the sale of goods and services and is calculated by multiplying the quantity of goods sold by the unit price. The net benefit is the difference between revenue and total costs. The net benefit is a cash flow element that can be used as a model to analyze aspects of financial feasibility.

$$\text{Total cost (TC)} = \text{IC} + \text{OC}$$

$$\text{Benefit (B)} = \text{P} \times \text{Q}$$

$$\text{Net benefit (NB)} = \text{B} - \text{TC}$$

where

IC: Investment cost
OC: Operational cost
P: Price
Q: Quantity

Various investment criteria were developed to find a comprehensive measure as a basis for livelihood benefit and net-benefit:

1. Net present value (*NPV*) method

NPV is the difference between the total present value of benefits and the total present value of costs, or the total present value of additional net benefits during the business period. A business can be declared feasible if its benefits are far greater than its costs. The criteria for measuring investment feasibility according to the NPV are divided into three categories: (1) when the NPV is greater than zero, the business is declared financially feasible and can therefore be implemented, (2) when the NPV value is equal to zero, the business is still neutral where the investment project is only sufficient to cover the costs without providing additional profits. In this situation, further evaluation needs to be carried out with investors to assess whether continuing the investment plan is still feasible or not, and (3) when the NPV is less than zero, the business is not worth running because the profits are lower than the costs. NPV can be calculated using the following formula:

$$\text{NPV} = \sum_{t=0}^{n} \frac{(B)t}{(1+i)^t} - \sum_{t=0}^{n} \frac{(C)t}{(1+i)^t}$$

where

NPV: Net present value
$(B)t$: Benefit/Cash inflows in year t
$(C)t$: Cost/Cash outflows in year t
t: Project economics year

i: Rate of return

2. Internal rate of return (IRR)

The feasibility of a business can also be assessed based on how much the business returns on the investment by measuring the IRR, which is the discount rate that produces an NPV of zero. A business is considered feasible if its IRR value is greater than the opportunity cost of capital.

IRR can be calculated based on the interpolation between a lower discount rate (resulting in a positive NPV) and a higher discount rate (resulting in a negative NPV) according to the following formula:

$$\text{IRR} = i_1 + (\frac{\text{NPV}_1}{\text{NPV}_1 - \text{NPV}_2})(i_2 - i_1)$$

where
IRR: Internal rate of return
NPV_1: Net present value is positive
NPV_2: Net present value is negative
i_1: Discount rate that results in NPV+
i_2: Discount rate that results in NPV−

3. Gross benefit-cost ratio

The gross benefit-cost ratio (gross B/C) is the ratio between profits from a business and the costs incurred. A business can be considered profitable if it has a gross B/C value of more than 1, implying that every unit of cost produces a profit of more than one unit. If the gross B/C result is equal to 1, then the business has no profit or loss; however, if the gross B/C result is less than 1, the business is not profitable or not worth running.

$$\text{Gross } B/C = \frac{(PV)B}{(PV)C} \quad (1)$$

where
Gross B/C: Gross benefit cost ratio
$(PV)B$: Current benefit value
$(PV)C$: Present value of costs

Cost-benefit analysis requires determining the discount rate and the economic life scale of the business being developed. (1) The discount rate is used to assess the feasibility of an investment. Using an appropriate discount rate, an investor or company can calculate the present value of the expected cash flows from an investment in the future. This helps in deciding whether an investment is suitable. The discount rate used in this research was 6%, which follows the credit interest rate for small and medium-sized businesses in Indonesia. (2) The economic life scale of a business is determined based on (1) the plant age that cultivated it or (2) the age of the investment item.

Considering that there are many types of livelihood activities with different economic scales, to compare each livelihood activity, we used the B-C criteria. The B-C criteria are not sensitive to project scale, but the IRR and NPV are sensitive to project scale [31,35]. The gross B-C criterion is an efficiency index that is calculated as the NPV. The difference is that NPV is the deviation between B and C, and gross B-C is the ratio of B and C. Thus, if a project has costs and benefits that are twice as large as those of another project, then the NPV will be twice as large, but the gross B-C will not change. In other words, the gross B-C value is not sensitive to project scale, while the NPV is sensitive to project scale. Based on this explanation, we used gross B-C to compare each activity [34,35].

3. Results

3.1. Various Alternative Livelihoods Existing in the Peatland Communities

Based on the results of previous studies [8,10,16,36,37], a gap was found between restoring peatlands and ensuring sufficient income for peatland communities. Thus, we conducted research analysis to bridge this gap to identify the existing sources of livelihood and identify new sources of livelihood that could be developed in peatlands.

Extensive peatland resources in the OKI District have been utilized by community members for various productive activities. These have been described below.

1. Catching and culturing swamp fish: Various species of native fish that are abundantly produced can be consumed fresh and/or processed into salted and smoked products [38,39].
2. Swamp buffalo and downstream industry: The swamp buffalo (*Bubalus bubalis*) has become one of the main livelihoods for communities in the OKI peatland. Some studies also agree [40,41]. Swamp buffaloes are bred for their milk, which is traditionally processed by the people of OKI, especially in the Pampangan subdistrict and its surroundings, into Gulo Puan and Sagon Puan (differently processed caramelized sugar sweet milk). Some previous research also found some opportunities for improving the swamp buffalo productivity of other products [42].

The large population of swamp buffaloes and the large potential for swamp fish together can be considered as potential sources of livelihood in the OKI peatland.

3. Purun (*Eleocharis acutangula*) is a spikerush-typical swamp area. In OKI and its surroundings, which have many swamps, Purun are found abundantly. Since long ago, this plant has been used to produce various woven household items, such as woven bags.
4. Rice: The use of peatlands for Sonor cultivation of rice is a practice that has been passed down from generation to generation, thus, becoming a major part of local knowledge. Sonor cultivation features clearing the land (typically from the buildup of Purun) by burning, which, as well as taking less effort than clearance by hand, is claimed by farmers to also produce nutrients for rice. They are also a major cause of forest fires. However, yields are typically low. The desire to provide income above subsistence requirements and the increasing need for food, in line with population growth, require increased productivity.

3.1.1. Swamp Buffalo

Swamp buffaloes, as the name implies, are typical of swamp areas, such as peatlands. Swamp buffaloes are part of the lives of peatland communities and are a livelihood source (Figure 3). Swamp buffaloes are highly valued agricultural animals for the community; however, production of this species has declined due to the increasing mechanization of agriculture.

(**a**) (**b**)

Figure 3. Swamp buffalo in Ogan Komering Ilir (photo by Muhammad Yazid). (**a**) Swamp buffalo in cage. (**b**) Swamp buffalo in peatlands.

Swamp buffaloes are bred in several villages in OKI. Initially, most of the swamp buffalo population was located in the Pampangan subdistrict, after which some developed in Jejawi, Pangkalan Lampam, Air Sugihan, Tulung Selapan, and Pedamaran subdistricts, and even expanded to the Banyuasin and Ogan Ilir districts. Swamp buffaloes in South Sumatra have several advantages as a large local livestock, namely, as a unique gene source with high adaptability to the local environment, feed, diseases, and parasites. Swamp buffaloes have strong geographic genetic differentiation (good adaptation across regions) and lack gene flow but exhibit strong phenotypic uniformity [32,41]. The South Sumatra Provincial Government designated OKI as a local swamp buffalo development area.

Wild grass, which is available year-round in swamp areas, is the main food source for swamp buffaloes. Types of plants commonly consumed by swamp buffalo are copper kumpai (*Ischaenum aristatum nina*), oil kumpai (*Himendchue ampleacaulinesness*), rice kumpai (*Himenacjua interupta* Buse), banto (*Leersia hexandra* Sw.), and parum (*Heliochis fistulosa*). The use of swamp buffaloes in South Sumatra has changed over time and is mostly being used currently as producers of meat, milk, and as a symbol of wealth, rather than for the cultivation of agricultural land [42,43].

Farmers rarely sell buffaloes in the market but slaughter them for meat for religious holidays, wedding ceremonies, and other social activities. Buffalo farms are managed by individual farmers. The corresponding benefit-cost analysis of buffalo farming is presented in Table 2, with the following assumptions: (1) three economic years of the business, (2) a discount factor of 6%, and (3) the economic scale of buffalo farming consists of one male and four female buffalo breeders that can produce four male and female calves for sale.

Table 2. Benefit-cost analysis of buffalo farming.

No.	Component	Amount
1.	Total benefit (USD/3 years/farmer)	25,933.20
2.	Total costs (USD/3 years/farmer)	5292.00
3.	Net present value/(NPV (USD/3 years/farmer)	15,531.96
4.	Internal rate of return/IRR (%)	30.28%
5.	Gross benefit-cost ratio	4.90

The swamp buffalo produce milk, but buffalo milk production is still limited, at 1–3 L/buffalo per day. The most common buffalo dairy product created from milk in South Sumatra is Gulo Puan (Figure 4). It has commercial value and provides a substantial economic contribution to farmers. Swamp buffalo milk has a high-fat content (7–12%) comparable to that of Sumbawa, Italian, and Indian breeds and has the potential to be developed into modern commercial dairy products.

(**a**) (**b**)

Figure 4. Buffalo milk Gulo Puan products (photo by Muhammad Yazid). (**a**) Gulo Puan after processing. (**b**) Gulo Puan in glass packaging.

The Gulo Puan businesses in OKI are at the home or cottage industry level (Figure 4). Labor availability is one of the factors that determines the success of this process. Our survey results showed that most of the workforce comprises families (children), with an average workforce of one person.

Processing buffalo milk in Gulo Puan is an existing source of livelihood for the peatland communities. However, Gulo Puan is not widely known to the public outside South Sumatra, and the volume of consumption is still relatively low.

Table 3 presents the results of the benefit-cost analysis. Processing buffalo milk into Gulo Puan is feasible financially for farmers, with the following assumptions: (1) three economic years of the business, (2) a discount factor of 6%, (3) an economic scale of Gulo Puan processing consisting of 38 L of buffalo milk per year to produce 36 kg of Gulo Puan.

Table 3. Benefit-cost analysis of processing buffalo milk into Gulo Puan.

No.	Component	Amount
1.	Total benefit (USD/3 years/farmer)	5215.49
2.	Total costs (USD/3 years/farmer)	4472.15
3.	NPV (USD/3 years/farmer)	554.621
4.	IRR (%)	47.75%
5.	Gross benefit-cost ratio	1.17

The marketing chain pattern for Gulo Puan in OKI involves a direct connection from producers to traders in Palembang, then to retailers in the area, and finally to consumers. Generally, sales transactions between producers and traders occur in Palembang's Jakabaring market.

A previous study found another potential dairy product of swamp buffalo in the Philippines, which was produced through fermentation and shimmering methods into several end products, such as Kesong Puti (fresh cheese type) and Pastillas (a type of desert) [42,44].

3.1.2. Swamp Fish

Rawa lebak lebung is a feature of the inland waters in South Sumatra. In addition to being part of the local knowledge of OKI communities, the use of swamp land for fisheries (Figure 5) was regulated by the OKI District Government under Regional Regulation Number 14 of 2015. The utilization of peatlands in the Lebak Lebung system is conducted through an auction mechanism.

Figure 5. Lebak lebung is partitioned from public waters so that its fish can be controlled by the auction winner (photo by Muhammad Yazid).

In this case, swamps where fishing can occur are auctioned, and the winners offer the highest value [45]. The winner of the auction (pengemin) will control the "various fish types of the swamp" that have economic value for a certain period, according to the time when the swamp water recedes, recover the auction price, and make a profit. Some fishery products are marketed as fresh fish, while others are processed into processed fish (Figure 6).

(**a**) (**b**)

Figure 6. Smoked and salted fish (photo by Muhammad Yazid). (**a**) Smoked fish. (**b**) Salted fish.

Fish processing conducted by the community currently includes both salted and smoked fish, which are among the traditional fish processing methods that use simple techniques without specialized packing. Smoking was performed using a wood fire. Previous studies have reported that smoking fish can increase basic nutrition and reduce fat intake [46,47]. The processing is still performed traditionally on a household scale. Salted fish are dried in an open space under the sun. [48] stated that fish processing can apply a small number of automation. Their number should be increased despite automated food processing problems and hygiene requirements.

Table 4 presents the results of the benefits of processing swamp fish into smoked and salted fish. The results of the benefit-cost analysis showed that processing salted and smoked fish is financially feasible for the farmer, with the following assumptions: (1) three economic years of the business, (2) a discount factor of 6%, and (3) an economic scale of fish processing consisting of 3000 kg of fish per farmer, producing 1000 kg each of salted and smoked fish.

Table 4. Benefit-cost analysis of processing swamp fish into salted and smoked fish.

No.	Component	Amount	
		Salted Fish	**Smoked Fish**
1.	Total benefit (USD/3 years/farmer)	153,333.33	230,000.00
2.	Total costs (USD/3 years/farmer)	149,886.67	218,233.33
3.	NPV (USD/3 years/farmer)	2443.36	9348.47
4.	IRR (%)	28%	82%
5.	Gross benefit-cost ratio	1.02	1.05

The pattern of the marketing chain for salted and smoked fish in OKI is generally the same, namely, through two marketing channels. The first channel (95%) is from producers or entrepreneurs of salted/smoked fish directly to wholesalers in the Bandung/Medan/Padang area, which is then passed on to retailers in the region to reach consumers. The second marketing chain is directly connected from producers to retailers or consumers who visit the business location (5%).

Although the data showed that Indonesia has good fishery supply potential, however, in reality, it is not included in the top 10 largest fish-exporting countries in the world [47,49,50]. The performance of fish exports in the global market declined for 20 years, from 1999 to 2019. Otherwise, processed fish products have a fairly high demand in the global market [32,33]. This condition, which is inversely related to that observed in countries, such as Bangladesh and Spain, shows that exporting frozen, dried, and salted fish has significant revenue potential [51,52]. Several factors, such as better supply strategies and new salting methods, could influence restrictions on the salted fish market in Spain [52]. To increase the competitiveness of processed products, such as smoked and dried salted fish, a fish processing industry is required based on automation and the implementation of solar energy for drying that can control the quality and processing of fish products [46].

3.1.3. Purun (*Eleocharis dulcis*)

Purun (*E. dulcis*) is a common type of peatland vegetation that forms a part of swamp ecosystems [53,54]. Purun is common in OKI-South Sumatra, particularly in peatland areas. It is not planted by the community, but its existence depends on the existence of peatlands. As long as the peatland does not change its function and is not converted, Purun will exist and can be utilized by the community. Several Purun artisan families are present as Purun community members are scattered in several areas of OKI [54,55] Communities living in peatlands have long benefited from Purun. The community uses Purun as a raw material to manufacture woven products. They consume the Purun found inlands around the village area, especially in peatlands that are not used for other activities [55,56]. The Purun is harvested according to the needs of each household. In identifying the value of processed products from Purun, Purun is utilized in several ways. There are members of the community who specialize in harvesting Purun, while others process it (drying, coloring, mashing/flattening, and weaving) into woven or semifinished materials.

Processed products derived from Purun are not only used by the local community in simple forms, such as woven products (Figure 7), but various types of Purun products, such as bags, hats, sandals, and keychains, are also known to the wider community as typical products of the swamp area. The various motifs used in making the products, as well as the artisanship of the craftsmen, are assessed by consumers, indicating that the products are sought not only for their functionality but also for their artistic and cultural value. Therefore, the OKI government introduced products from Purun at various sporting events, business meetings, seminars, and similar gatherings for potential consumers. To improve product marketing of Purun, green labeling of the products is recommended. A previous study found that consumers were willing to pay 30% more for these products owing to environmental concerns [38]. An analysis of the benefits and costs of processing Purun into woven products and other products is presented in Table 5. The results of the benefit-cost analysis showed that such processing is financially feasible for farmers, with the following assumptions: (1) three economic years of the business, (2) a discount factor of 6%, and (3) an economic processing scale consisting of 16 bunches of Purun plants (one bunch can produce three woven products), for a total of 48 Purun woven.

(**a**) (**b**) (**c**)

Figure 7. Purun plant and its process to woven Purun (photo by Dessy Adriani). (**a**) Purun weed. (**b**) Purun drying and coloring. (**c**) Woven Purun products.

Furthermore, Purun corm in Asia can also be consumed as food, such as fresh juice or ready-to-eat, healthy food, mainly owing to its antioxidant, antitumor, and antibacterial properties [57,58]. However, these products are not commonly consumed by people in OKI. Therefore, further research and product development are required.

Table 5. Analysis of the benefits and costs of processing Purun (*Eleocharis dulcis*) into woven products.

No.	Component	Amount
1.	Total benefit (USD/3 years/farmer)	3456.00
2.	Total costs (USD/3 years/farmer)	2306.83
3.	NPV (USD/3 years/farmer)	906.00
4.	IRR (%)	73%
5.	Gross benefit-cost ratio	1.50

3.2. Scenarios for Creating Livelihood Alternatives and Increasing People's Incomes through Changes in Peatland Management and Restoration Programs

3.2.1. Rice

Peatlands, owing to their hydrotopographic characteristics, are suitable ecosystems for planting food crops, especially rice [59,60]. Cultivating rice using the Sonor method has become part of the local knowledge of the people living around the peatland, in addition to catching and/or raising fish, swamp buffaloes, and using Purun. Rice planting in Lebak swamps is still practiced based on the natural changes in water levels (Figure 8). Sonor rice in bunds was cultivated earlier in the middle and lowlands of the "Lebak lands". Therefore, optimizing land use and increasing plantation intensity in peatlands can be achieved in the bund area if the water needed for rice plants can be supplied by the irrigation system that is being built [46]. There are at least seven types of rice varieties, such as Inpari-42, Inpari-43, Inpari IR Nutri Zinc, Inpari-8, Inpari-9, Inpari-10, and IR 42, which exhibit good performance for cultivation in peatlands [61,62]. Further research and product development are needed because the rice yield and quality in peatlands are not yet fully sustainable.

Figure 8. Sonor rice in peatland (photo by Dessy Adriani).

Most rice farming is conducted in Sonor during the dry season by burning the peatland. Cultivating rice using the Sonor method has become part of the local knowledge of the people who live around the peatland. Rice planting in the swampy land still follows the natural changes in the river water level. However, in line with the government's policy regarding managing peatlands without burning, the assistance provided regarding rice farming on peatlands without burning has been successfully implemented by several farmers in Perigi Village.

The average production of Sonor rice (approximately 2 tons of harvested dry grain per hectare) was considerably lower than that of irrigated and tidal lands (an average of 5 tons per hectare), and this finding is similar to [63,64]. Rice production in peatland areas lags behind other types because plantations can only be conducted once a year and without technology and maintenance. For lowland areas, the growing season is March–September, and for medium-elevated land areas, it is June–September. If land optimization is successful with technology and maintenance, production could be increased, and surplus production after supplying to farmers and local needs could be marketed on a wider scale.

However, with the introduction of agricultural technology, planting activities in peatlands can increase productivity, as shown in Table 6. Rice is sold in local markets to meet local needs. The rice produced by the peatland farmers in OKI is sold to middlemen or collectors who directly contact the farmers.

Table 6. Benefit-cost analysis of Sonor rice on peatland with and without technology.

No.	Component	Amount	
		Without Technology	**With Technology**
1.	Harvested dry grain Production (kg/ha/season)	1800.00	3303.75
2.	Harvested dry grain price (USD/kg)	0.30	0.30
3.	Total benefit (USD/years/farmer)	532.32	977.03
4.	Total costs (USD/years/farmer)	281.79	573.16
5.	Net benefit (USD/years/farmer)	250.53	403.87
6.	Benefit-cost ratio	0.89	0.70

Although the benefit-cost ratio of Sonor rice farming without technology was higher than that with technology, the application of technology provides additional benefits to the environment. Managing Sonor rice cultivation in peatlands using technology implied no burning, thus, indicating no air pollution from smoke, no spread of fires to neighboring environments, and no damage to biodiversity.

3.2.2. Agrosilvofishery

Agroforestry combines 'agro' or 'agri' (agricultural science) and forestry (forestry science). It is a land use system that combines woody plants (such as trees, shrubs, bamboo, and rattan) with nonwoody plants or grass (pasture). Agroforestry can be also combined with livestock or other animals, such as honeybees and fish [65,66]. Woody and nonwoody plants can be combined to form an optimal ecological and economic interaction [66]. Application of agroforestry principles and practices is a holistic approach for achieving global food security, sustainable economic conditions for farmers, and environmental benefits for society [67–74]. Agroforestry has been practiced by people in Indonesia for a long time and is currently being widely implemented worldwide [69–74].

There are several agroforestry classifications based on the composition of the main constituent components, for example: (1) agrosilviculture wherein forestry trees and various agricultural crops are grown on the same plot, (2) silvopasture wherein forestry trees are accompanied by grass and livestock, (3) agrosilvopasture wherein a combination of agricultural crops, timber species, and fodder plants are managed along with livestock, (4) agrosilvofishery wherein a combination of agricultural crops, various types of timber and fish farming occur on the same plot, and (5) bee-agroforestry wherein suitable flowering tree species are grown to provide shade, habitat, and food sources for beekeeping, along with other environmental and economic benefits from the trees [70,71].

In Perigi Village, Pangkalan Lampan subdistrict, a group of farmers have been developing agrosilvofishery for approximately 5 years, as agrosilvofishery is an alternative that can be developed on peatlands. The agrosilvofishery model built is a combination of Meranti (*Shorea* spp.), pineapples, and catfish. Figure 9 presents the site plan of the agrosilvofishery model being built. An analysis of the benefits and costs of agrosilvofishery is presented in Table 7. Agrosilvofishery was financially feasible for farmers, with the following assumptions: (1) 10 economic years of the business, (2) a discount factor of 6%, and (3) an economic scale of agrosilvofishery consisting of 1 ha of Meranti (*Shorea* spp.), pineapples, and catfish. The number of meranti plants is 311, with total wood production in the tenth year of 159 M^3 with a selling price of 1,270,000/m^3 IDR or 85/m^3 USD. Total pineapple production is 5727 per year, with three harvests for one planting cycle. The selling price for the first harvest is 3500 IDR or 0.023 USD, the second harvest is 3000 IDR, or 0.020 USD and the third harvest is 2500 IDR or 0.017 USD.

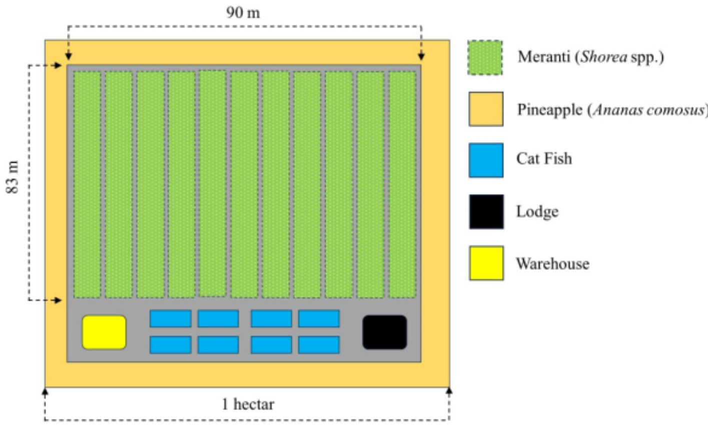

Figure 9. Example of an agrosilvofishery pattern on a 1 ha plot.

Table 7. Benefit-cost analysis for agrosilvofishery.

No.	Component	Amount
1.	Total benefit (USD/10 years/farmer)	779,221.03
2.	Total costs (USD/10 years/farmer)	735,277.58
3.	NPV (USD/10 years/farmer)	36,255.45
4.	IRR (%)	62.00%
5.	Gross benefit-cost ratio	1.06

3.2.3. Paludiculture

Other improved livelihood sources for peatland restoration also exist, such as paludiculture, which is the productive use of peatlands to protect the peatland soil and minimize CO_2 emissions [37,72,74]. The natural conditions of the water-saturated peatlands were maintained without creating drainage. Paludiculture is an alternative method of peatland management that can tolerate water-saturated peatland [24,37]. A paludicultural system can maintain peat conditions and produce biomass in wet and rewetted peatlands, preserving ecosystem services and facilitating carbon accumulation. Paludiculture products can provide food, feed, fiber, fuel, and raw materials for the wood industry. In conditions where the peatland has been drained, efforts are made to close the drainage channels so that the peat will be rewetted [65,68].

In practice, puludiculture can take the form of managing agriculture, animal husbandry, or fish cultivation on peatlands. The paludiculture analysis developed in this analysis is a combination of Jelutung Woods (*Dyera costulata*) and chili, two types of native commodities in peatlands that are widely cultivated by local people as a livelihood. The location design of the paludiculture model is presented in Figure 10.

Table 8 presents the analysis of the costs and benefits of paludiculture. The results showed that paludiculture was financially feasible for farmers, with the following assumptions: (1) 10 economic years of the business, (2) a discount factor of 6%, and (3) an economic scale of paludiculture consisting of 1 ha of Jelutung Woods (*Dyera costulata*) trees and chili plants. Based on Table 8, the estimated production of Jelutung on a 1 ha scale was 48 m^3 for thinned wood with a selling price of IDR 400,000/m^3 or 27 USD, and 159 m^3 of felled wood with a selling price of IDR 400,000/m^3 or 27 USD. Chili mixed with Jelutung can produce 2000 kg/ha/year at a selling price of IDR 20,000 per kg or 1.30 USD per kg. The NPV value of the financial feasibility of the Jelutung Woods (*Dyera costulata*)-chili paludiculture model was positive, indicating that benefits were possible. The IRR value was 64.67% greater than the discount factor used in the research (6%), indicating that the development of Jelutung Woods (*Dyera costulata*)-chili paludiculture will provide benefits. The gross B/C value was

2.85, thus, indicating that the business is profitable (if the gross B/C value is >1, then the business is profitable).

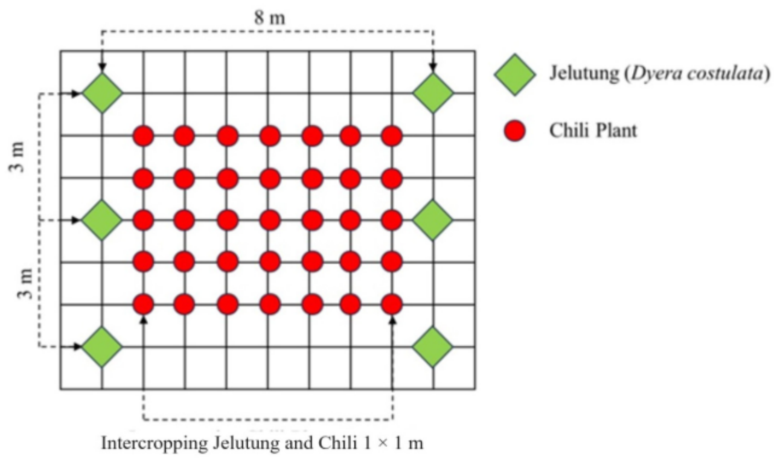

Figure 10. Example of a paludiculture model.

Table 8. Benefit-cost analysis for paludiculture.

No.	Component	Amount
1.	Total benefit (USD/10 years/farmer)	22,798.30
2.	Total costs (USD/10 years/farmer)	7996.51
3.	NPV (USD/10 years/farmer)	14,801.79
4.	IRR (%)	64.67%
5.	Gross benefit cost ratio	2.85

3.3. Comparation of the Dominance of Livelihoods

To provide an overview and validate the various alternative contributions that peatlands make to community livelihoods and various dimensions of human well-being in restored peatlands, the dominance of peatland livelihoods was compared, as shown in Table 9.

Table 9. Comparison of the dominance of livelihoods.

	Type of Livelihood	B/C Achievement
	Existing livelihood	
	Sonor rice with burning and without tillage and maintenance	0.89
1.	Alternatives to increase people's income	
	1–1. Buffalo farming	4.90
	1–2. Gulo Puan	1.17
	1–3. Salted fish	1.02
	1–4. Smoked fish	1.05
	1–5. Woven Purun products	1.05
2.	Alternative income for sustainable use of peatlands	
	2–1. Sonor rice without burning	0.70
	2–2. Agrosilvofishery	1.06
	2–3. Paludiculture	2.85

Based on the explanation in Sections 3.1–3.3, we state:

Hypothesis 1 (H1). *Various alternative livelihoods that already exist in a peatland community, are buffalo farming, Gulo Puan, salted fish, smoked fish, and Purun woven crafts, are feasible financially.*

Hypothesis 2 (H2). *Scenarios for creating livelihoods and increasing people's income through changes in peatland ecosystem management and peatland restoration programs—developing Sonor rice without burning, agrosilvofishery, and paludiculture—feasible financially.*

4. Discussion

Loss of livelihoods and decreased income because of degraded peatlands are crucial issues that must be resolved to ensure sustainable use and reduce the risk of further degradation [6,8]. Although many studies have been conducted on the livelihoods and income generation of farmers in peatlands, little progress has been made in addressing the problems of loss of livelihoods and decreased incomes [6,8–10,13]. Based on the results of an analysis of a sequence of community livelihoods in peatlands, existing sources of livelihood (forestry, agriculture, fisheries, livestock, and others) should be continuously examined, and new sources of livelihood that can be developed in peatlands should also be determined.

Several studies in the peatland areas of South Sumatra have shown a large dependence of rural households on work in the agriculture, forestry, fisheries, and livestock sectors. The income contribution of the agriculture, forestry, fisheries, and livestock sectors is approximately 40–65% of the total income of rural households in the peatlands of South Sumatra [5,7,40,43,59]. In OKI, the contribution to income from the agriculture, forestry, fisheries, and livestock sectors ranges from 40.18% to 56.92% which is similar to [75]. We cannot advocate for peatland restoration when it is still people's main source of income. It will be important to think about how to provide a stable income for people who depend on peatlands for their livelihoods while preventing further degradation in peatlands. Based on [60] research, there is potential for swamp land development to support the food estates program. Thus, peatlands provide opportunities to improve the livelihoods of people around them.

It is important to note also that threats to the livelihoods of local people accelerate the degradation of peatlands that use traditional Sonor cultivation [62,63]. The most effective way to halt this traditional way is to provide income alternatives to shifting cultivation. Therefore, firstly, we could consider the various income sources as Sonor cultivation alternatives. Secondly, even if the expected short-term income is not very high, the environmental benefits in the long term make it worthwhile to consider income alternatives such as agroforestry that can be implemented gradually.

4.1. Alternatives to Increase People's Income

Buffalo farming, fisheries (salted and smoked fish), and Purun products have shown great potential as income alternatives for farmers. They have B-C ratio not only greater than 1, but also higher than Sonor rice, making them suitable for alternative income. Purun can also be considered as an alternative source of income.

The large population of swamp buffaloes could be considered to be superior commodities from peatlands in OKI. Swamp buffalo is a profitable business, but it has often experienced problems. Maintenance and management methods by communities are still traditional and suboptimal. This can be reflected in the low growth and milk production (body weight gain of less than 0.3 kg/day with milk production of less than 3 L/day), as well as the long calving intervals [42,44].

Catching and raising fish are also important aspects of livelihood in OKI, South Sumatra. Abundant swamp fish that are not consumed in the form of fresh fish are processed into salted and smoked fish. Smoking and salting are the oldest fish processing methods that use simple techniques without specialized packaging [48]. Processed fish products are in high demand in the global market [47,49–51]. However, to increase the competitiveness of locally processed smoked and dried salted fish, a fish processing industry based on automation is necessary that can control quality and processing [48,76].

Purun is produced by several artisanal families scattered across various areas of OKI [60,61]. To increase the added value of Purun, a "green" product label is considerable. Consumers are willing to pay 30% more to address environmental issues [54,56], so the development of environmentally friendly products can translate into income for residents.

While we have found these alternative sources of income to be economically feasible and reflect the characteristics of the OKI region, the production process is traditional and requires the development of technologies to increase productivity and create added value, as well as the establishment of efficient management systems and markets.

4.2. Alternative Income for Sustainable Use of Peatlands

This study aims to provide models for the sustainable use of peatlands. Firstly, the results of the B/C analysis of rice cultivation with burning and without burning were compared. Second, agrosilvofishery and paludiculture models were analyzed, which can be used for peatland conservation and sustainable use.

In the case of rice farming using Sonor burning, labor can be saved, and peatlands can be cleared cost-effectively, but the cost of applying agricultural technology without burning is approximately twice as high. Although produced with technology 1.8 times more, the higher cost resulted in a lower B/C. More cost-effective technologies need to be developed.

There is also a need for seed improvement to increase productivity. Farmers need to maximize land productivity using superior rice seeds that are suitable for cultivation in Lebak swamplands. It is necessary to utilize the findings that the rice seed types Inpari-42, Inpari-43, Inpari IR Nutri Zinc, Inpari-8, Inpari-9, Inpari-10, and IR 42 are good for cultivation in Lebak land [60,61] and to develop varieties that are resilient to changes in peatland water levels and resilient to climate change.

This study focused also on B/C analysis of agrosilvofishery and paludiculture as alternative economic models with a focus on sustainability. This research proves that the paludiculture model is financially proven to obtain the highest B/C value compared to other livelihood opportunities. These economic models guarantee the availability of community income from peatlands throughout the year [62]. Being able to design a model to generate a steady income all year round is a huge advantage for low-income peatland-dependent farmers. Although the value of B/C analysis is not as high as that of swamp buffalo farming, these models are significant in terms of peatland conservation and restoration. Apart from being financially profitable, agrosilvofishery and paludiculture have a positive environmental impact, namely, by reducing emissions from degraded peatland and the risk of peatland fires related to previous research [65,73–76].

4.3. Implications and Limitations

The outcome of this study suggests alternatives to increase people's income through buffalo farming, Gulo Puan, processed fish, woven Purun products, Sonor rice farming without burning, and other potential income for sustainable use of peatland such as agrosilvofishery and paludiculture. By continuing to explore ways to use peatlands sustainably, peatland management can optimize productivity, minimize negative environmental impacts, and contribute to sustainable agriculture in Indonesia [7,21]. People who use peatlands for their livelihoods should be made aware of the various sources of income and supported to recognize and experience that sustainable practices can lead to more sustainable incomes [16,28].

This research proves that the development of mixed farming (such as paludiculture and agrosilvofishery) can potentially enrich the peatland restoration efforts and help the peatland communities transition to fully restored peatland, compared to other livelihood opportunities The production of diversified commodities from mixed farming systems is a characteristic of traditional farming that has been practiced for generations and has been proven through this research to provide the potential for significant economic returns to the population. In the context of food and livelihood security, smallholder farmers can implement mixed farming systems in peatland to minimize risk, provide various sources of income and ensure food security throughout the year. Adaptive agroforestry and adaptive paludiculture may help to reconcile improving livelihoods with peatland restoration.

Some of the livelihood projects linked with peatland restoration have challenges to achieve their intended goal of facilitating the shift towards more sustainable land-based livelihoods. One of the reasons for this lack of adoption is that many respondents are not accustomed to livelihoods based on peatlands, as they have traditionally relied on fishing and limited shifting agriculture on nonpeatland soils. Moreover, the new technologies introduced through these initiatives usually originate from external sources, resulting in the community being more passive recipients rather than active drivers of change. Additionally, the requirement for community members to work in groups contradicts their preferred individualistic approach, although local farmer institutions and groups can assist individuals in overcoming this obstacle through training, provision of information, offering incentives, and providing credit services.

Local residents cite several factors that restrict them from cultivating crops, fishery livestock, etc., including limited market access, price instability, transportation challenges, and the requirement for substantial investment. Hence, enhancing transportation networks, communication systems, and financial services for alternative agricultural products could facilitate a shift [8,25]. Conversely, it has been verified that converting degraded peatland areas into 'more sustainable' agricultural zones can enhance food self-sufficiency, thereby bolstering food security for local populations [36].

Additionally, there are methods to enhance the commercial value of horticultural produce; for instance, processing techniques such as fish drying, standardization of products, and effective packaging can augment product worth and broaden marketing prospects. Alternative land uses that are 'peatland-friendly' include agroforestry and sustainable forestry. Furthermore, peatland restoration efforts can generate employment, promote the recovery of fisheries and nontimber forest products, and offer opportunities for ecotourism. However, the appropriateness of each alternative livelihood approach is likely to vary depending on the physical and socioeconomic conditions unique to each community. Therefore, a participatory approach involving the engagement of local communities and other stakeholders is imperative. This approach should consider the needs and aspirations of local inhabitants, the characteristics of the ecosystem, as well as the availability of resources and markets [16,36].

Promoting collaborative efforts and creating additional opportunities for community involvement in sustainable peatland management are essential strategies to ensure the success of livelihood programs. Among stakeholders, the local community residing near degraded peatlands plays a key role in the extensive process of peatland restoration. Providing incentives for the development of promising livelihoods and products within peatlands can motivate communities to actively engage in restoration efforts. Furthermore, establishing multistakeholder partnerships in peatland restoration initiatives holds promise for enhancing public awareness and encouraging collective action towards exploring sustainable livelihood options in peatlands.

This study has a limitation in that environmental benefits were not included in the B/C analysis of alternative income sources. Therefore, future studies should extend the range of environmental benefits, calculating them quantitatively.

5. Conclusions

The dominant livelihood of communities in the OKI peatlands is farming. Several alternative livelihoods that are financially profitable include salted and smoked fish processing, Purun processing, rice farming, buffalo farming, paludiculture, and agrosilvofishery. All of these livelihoods are still pursued in a conventional pattern, indicating that there are opportunities for development through technological improvements, product diversification, packaging, and marketing efficiency, which can add value to the results of previous studies.

The B/C achievement of agrosilvofishery and paludiculture was greater than that of the other alternatives. Agrosilvofishery and paludiculture provide alternative economic models that can be developed for peatlands, providing short-, medium-, and long-term incomes for communities. Although the B-C value produced is not as high as that of buffalo farming, this economic model guarantees the availability of community income on peatlands throughout the year. Apart from being profitable from an economic perspective, agrosilvofishery and paludiculture have a positive environmental impact, by reducing emissions from peatland decomposition and the risk of peatland fires.

The optimization of livelihoods must be conducted through guidance and technical assistance, both formal and informal, to increase the productivity of livelihoods that have been conducted for generations. Formal institutions are further required to support alternative livelihoods through partnerships with governments, companies, and research institutions. Further, market development must be conducted to ensure market certainty for the products produced by such partnerships to increase household income and welfare.

The results of this study can contribute to policymaking that fully considers the role of peat resources in rural livelihoods, and the various dynamics that drive changes in livelihoods and income generation.

Author Contributions: Conceptualization, D.A., M.Y. and E.C.; Methodology, D.A., M.Y. and E.C.; Methodology; Software, D.D.; Validation, D.A., M.Y., R. and H.Y.; Formal analysis, D.A. and M.Y.; Investigation, M.Y. and R.; Resources, R. and D.D.; Writing—original draft, D.A. and E.C.; Writing—review and editing, D.A., H.Y. and E.C.; Visualization, D.D.; Supervision, H.Y.; Project administration, R. and D.D.; Funding acquisition, E.C. All authors have read and agreed to the published version of the manuscript.

Funding: The funding for this research and publication of its results come from the Korean National Institute of Forest Science (NIFoS) channelled through Center for International Forestry Research (CIFOR)-World Agroforestry (ICRAF).

Data Availability Statement: The original contributions presented in the study are included in the article, further inquiries can be directed to the corresponding author.

Acknowledgments: This study was supported also by the National Institute of Forest Science, Republic of Korea. The authors are grateful to Himlal Baral for comments on the manuscript.

Conflicts of Interest: The authors declare no conflicts of interest.

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