Bukti Korespondensi

Judul Artikel:	Farm Household Vulnerability Due to Land and Forest Fire in Peatland Areas in South Sumatra
Jurnal:	Land 13(5) ISSN 2073-445X
doi:	https://doi.org/10.3390/land13050642

Bukti korespondensi:

1) Submission: 12 Maret 2024
2) Request for revision: 29 Maret 2024
3) Response to Reviewer 1
4) Response to Reviewer 2
5) Response to Reviewer 3
6) Revised article as the responses to all the reviewers
7) Notification of resubmission of revised article: 13 April 2024
8) Acceptance letter: 21 April 2024
9) Request for final proofreading before publication: 22 April 2024
10) Article after proofread
11) Confirmation of proofreading: 6 Mei 2024
12) Notification of published on open access: 9 Mei 2024

1. Submission: 12 Maret 2024

[Land] Manuscript ID: land-2923239 - Article Processing Charge Confirmation

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Tanggal: Selasa, 12 Maret 2024 pukul 08.00 WIB

Dear Dr. Yazid,

Thank you very much for submitting your manuscript to Land:

Journal name: Land
Manuscript ID: land-2923239
Type of manuscript: Article
Title: Farm Household Vulnerability due to Land and Forest Fire in Peatland Areas in South Sumatra
Authors: Muhammad Yazid *, Dessy Adriani, Riswani Riswani, Dini Damayanthy
Received: 4 Mar 2024
E-mails: yazid_ppmal@yahoo.com, dessyadriani@fp.unsri.ac.id, riswani@fp.unsri.ac.id, damayanthy@fp.unsri.ac.id
Restoration of Tropical Peatlands: Science Policy and Practice
https://www.mdpi.com/journal/land/special_issues/7MDUHZ4GXG

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2. Request for Revision:
29 Maret 2024

[Land] Manuscript ID: land-2923239 - Major Revisions(Deadline: 8 April 2024)

Dari: Land Editorial Office (land@mdpi.com)

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Tanggal: Jumat, 29 Maret 2024 pukul 08.06 WIB

Dear Dr. Yazid,

Thank you again for your manuscript submission:
==========
Notes for Authors:
Major revisions are needed. Authors need to respond to all reviewer's comments.
==========

Manuscript ID: land-2923239
Type of manuscript: Article
Title: Farm Household Vulnerability due to Land and Forest Fire in Peatland Areas in South Sumatra
Authors: Muhammad Yazid *, Dessy Adriani, Riswani Riswani, Dini Damayanthy
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Restoration of Tropical Peatlands: Science Policy and Practice
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Please revise the manuscript according to the referees' comments and upload the revised file within 10 days.

Please use the version of your manuscript found at the above link for your revisions.

(I) Please check that all references are relevant to the contents of the manuscript.
(II) Any revisions to the manuscript should be highlighted, such that any changes can be easily reviewed by editors and reviewers.
(III) Please provide a cover letter to explain, point by point, the details of the revisions to the manuscript and your responses to the referees' comments.
(IV) If the reviewer(s) recommended references, please critically analyze them to ensure that their inclusion would enhance your manuscript. If you believe these references are unnecessary, you should not include them.
(V) If you found it impossible to address certain comments in the review reports, please include an explanation in your appeal.
(VI) The revised version will be sent to the editors and reviewers.

If one of the referees has suggested that your manuscript should undergo extensive English revisions, please address this issue during revision. We propose that you use one of the editing services listed at

https://www.mdpi.com/authors/english or have your manuscript checked by a colleague fluent in English writing.
Please do not hesitate to contact us if you have any questions regarding the revision of your manuscript or if you need more time. We look forward to hearing from you soon.

Kind regards,
Best Regards,
Ms. Vickie He
Assistant Editor
E-Mail: vickie.he@mdpi.com

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3. Response to Reviewer 1

Farm Household Vulnerability due to Land and Forest Fire in Peatland Areas in South Sumatra

Response to Reviewer 1 Comments

1. Summary

Thank you very much for taking the time to review this manuscript. Please find the detailed responses below and the corresponding revisions/corrections in the re-submitted files as indicated in the blue color.

2. Questions for General Evaluation	**Reviewer's Evaluation**	**Response and Revisions**
Does the introduction provide sufficient background and include all relevant references?	Must be improved	Thank you for your correction. Please kindly see our response in the point-by-point response below.
Are all the cited references relevant to the research?	Not applicable	-
Is the research design appropriate?	Can be improved	This research is designed as a household sample survey in the most severely impacted land and forest fire in OKI District. The coverage of the fire impacted areas were so large and the affected people were so many such that cluster sampling was applied to select the areas base on the peatland hidrological units (PHUs) and random sampling to select the sample

		household to represent the impacted households at the village level (line 97-100).
Are the methods adequately described?	Can be improved	Thank you for your suggestions, the description of methods has been improved. Please see in the point-by-point responses below.
Are the results clearly presented?	Must be improved	Thank you, the response on the presentation of results is discussed in the point-by-point response below.
Are the conclusions supported by the results?	Can be improved	Thank you for your suggestion. The results of the study have been used to improved the conclusion number 1 (line 471-472) as indicated in green color to accommodate the similar comment from another reviewer. Whereas conclusion 2 and 3 have been clearly supported by the results.

3. Point-by-point response to Comments and Suggestions for Authors

Comments 1:

Congratulations to your manuscript. I found the topic very interesting and important.

Abstract/Introduction

These chapters provide an important introduction to the situation of fires in Indonesia. Nevertheless, they should also provide clear conceptualisation, and I feel there is some overlap in how fires "contribute" to vulnerabilities - sometimes you include "livelihoods" and sometimes not. I assume that

the livelihood approach consists of 5 "capitals" covering your focus areas. Moreover, this approach would fit perfectly with your descriptive study (as a framework).

Response 1: Thank you for pointing this out. We agree with this comment. Livelihood vulnerability is one of several vulnerabilities caused by land and forest fire, but probably is the most important one. In addition, we also observed the impacts of land and forest fire on other vulnerabilities, such social, economic, ecological and climate change vulnerabilities. Then, we addressed the 5 vulnerabilities as the framework to understand the multifaceted impacts of land and forest fire in the peatlands.

Comments 2:

Methodology

The sampling method seems to be clear but lacks references to existing studies and a clear definition of the extent to which it is random/non-random/purposive, etc. Also, I suggest to merge sub-chapters 2.2. with 2.3. for better flow of the text, and similarly 2.4. with 2.5.

Social vulnerability - I miss some memberships or external linkages that provide social back-up in times of crisis.

Economic vulnerability - The shadow economy (subsistence) might influence the final results a lot. An explanation in the chapter Limitation is needed. How was income calculated? As financial income?

Livelihood - It seems to be a mixture of livelihood strategies and demographic/HH head characteristics.

Ecological - Natural resources.

Climate change - First time mentioned.

I think we need some conceptual framework here to keep the consistency of the paper and methodology.

Family - I suggest using "household" as the main economic (task-oriented, incl. vulnerability) unit.

Response 2: Agree. We have, accordingly, revised the methodology to include the above comments as follow:

- Sampling was done randomly at the village level to select households as respondents (line 118 and 129-133).
-Sub-chapters 2.2 and 2.3 have been merged (line 101).
-Sub-chapters 2.4 and 2.5 have been merged (line 135).
-You are true to include memberships or external linkages in the social vulnerability that provide social back-up in times of crisis. We missed this important concept and admit this in the implication of the study (line 501).
-In the economic vulnerability, income was calculated from both financial income (e.g. from selling the products) and the products that were self-consumed (subsistence) (line 166-168).
-You are true, culturally the head of household holds the responsibility to earn income for

the household and we consider this as main indicators for livelihood vulnerability (line 192-194).
-The words family when applied have been replace with household.
Comments 3:

Results

I have a feeling that too many tables make a reader lost. These could be moved to Supplementary files and in the results should be placed more analytical (even from qualitative research) findings.

Also, synthesis with existing sources could be useful. For example, consider merging Results with Discussion.
Response 3: We agree with your point. However, separating table with many data from its description/explanation will cause similar difficulty. Therefore, in addition to the tables, we summarize the data from each table in figures to ease the readers to understand the numbers.

We also agree with your suggestion to merge the results with discussion such that synthesis with existing sources could be done. However, the journal format requires that the results must be separated from the discussion. Conditionally we have to comply with this regulation.
Comments 4:

Discussion

The chapter lacks some coping strategies or alternative strategies. What households do or should do.
Response 4: Thank you for your point. This study has gathered the information from a quite large number of sample in term of a sample survey collecting data from sample households through face-to-face interview. Consequently, it has reduced some important points including the questions on how the affected households have coped with the difficulties experienced caused by land and forest fire. Therefore, we consider this important points in the study implications (line 507-508).
Comments 5:

Overall layout

The manuscript needs some final tuning to remove all typos, missing values and grammar.
Response 5: All typos, missing values and grammar have so far been checked and corrected. Thank you for your suggestions.
4. Response to Comments on the Quality of English Language
Point 1: (x) I am not qualified to assess the quality of English in this paper
Response 1: -
5. Additional clarifications: -

For review article

Response to Reviewer X Comments

1. Summary

Thank you very much for taking the time to review this manuscript. Please find the detailed responses below and the corresponding revisions/corrections highlighted/in track changes in the re-submitted files. *[This is only a recommended summary. Please feel free to adjust it. We do suggest maintaining a neutral tone and thanking the reviewers for their contribution although the comments may be negative or off-target. If you disagree with the reviewer's comments please include any concerns you may have in the letter to the Academic Editor.]*

2. Questions for General Evaluation	**Reviewer's Evaluation**	**Response and Revisions**
Is the work a significant contribution to the field?		*[Please give your response if necessary. Or you can also give your corresponding response in the point-by-point response letter. The same as below]*
Is the work well organized and comprehensively described?		
Is the work scientifically sound and not misleading?		
Are there appropriate and adequate references to related and previous work?		
Is the English used correct and readable?		

3. Point-by-point response to Comments and Suggestions for Authors

Comments 1: *[Paste the full reviewer comment here.]*

Response 1: *[Type your response here and mark your revisions in red]* Thank you for pointing this out. I/We agree with this comment. Therefore, I/we have….*[Explain what change you have made. Mention exactly where in the revised manuscript this change can be found – page number, paragraph, and line.]*

"[updated text in the manuscript if necessary]"

Comments 2: *[Paste the full reviewer comment here.]*

Response 2: Agree. I/We have, accordingly, done/revised/changed/modified…..to emphasize this point. *Discuss the changes made, providing the necessary explanation/clarification. Mention exactly where in the revised manuscript this change can be found – page number, paragraph, and line.]*

"[updated text in the manuscript if necessary]"

4. Response to Comments on the Quality of English Language

Point 1:

Response 1: (in red)

5. Additional clarifications

[Here, mention any other clarifications you would like to provide to the journal editor/reviewer.]

4. Response to Reviewer 2

Farm Household Vulnerability due to Land and Forest Fire in Peatland Areas in South Sumatra

Response to Reviewer 2 Comments

1. Summary

Thank you very much for taking the time to review this manuscript. Please find the detailed responses below and the corresponding revisions/corrections highlighted in the re-submitted files. The revised parts in the manuscript are indicated in green color.

2. Questions for General Evaluation	**Reviewer's Evaluation**	**Response and Revisions**
Does the introduction provide sufficient background and include all relevant references?	Can be improved	In the introduction we indicated the significance of forest lost including peatland forest due to land and forest fire based on reliable data from national agency (Ministry of Environment and Forestry) as well as global institutes such as WWF, the World Bank and the Global Forest Watch. We also addressed the impacts of land and forest fire on the environment as well as on the people that caused vulnerability in several aspects (social, economy, people's livelihood, and environment). We

		have also added some more relevant references.
Are all the cited references relevant to the research?	Yes	Thank you for your evaluation.
Is the research design appropriate?	Can be improved	The research design has been improved to merge Sampling and Data Collection into a single sub-chapter (2.2). Data Processing and Measurement of Vulnerability are also merged into a single sub-chapter as well (2.3) for better flow of text.
Are the methods adequately described?	Can be improved	The methods have been improved, especially with regard to the justification of the number of samples used.
Are the results clearly presented?	Can be improved	The presentation of results has been improved.
Are the conclusions supported by the results?	Can be improved	The results of the study have been used to improved the conclusion number 1, whereas conclusion 2 and 3 have been clearly supported by the results.

3. Point-by-point response to Comments and Suggestions for Authors

Comments 1: The title"Farm Household Vulnerability due to Land and Forest Fire in Peatland Areas in South Sumatra" is very interesting and scientific significant. But the content of this manuscript is lack of scientific basis and can not reflect the title , it should be well revised . And what are the indicators for vulnerability classification based on? Are three hundred household samples enough to conclude? The authors should think deeply to discuss these questions.

Response 1: Thank you for pointing these out. Our responses are described below

according to each comments:

(1) Thank you for pointing out the lack of scientific basis in our manuscript such that it can not reflect the title. In our opinion, scientific basis is the use of theories or concepts and empirical evidences in a research or a scientific paper. Therefore, in the manuscript we have pointed out the scientific basis we use in the introduction, methodology, results, and discussion as indicated in the green color.

(2) Regarding the indicators for vulnerability classification, we refer the indicators from various sources. For example, social vulnerability indicators were based on Fatemi et al. (2017), Defiesta et al. (2014) specifically for the indicator of the "number of household members", Naz et al. (2021) for the indicator of the "number of children under five and the elderly in the household", and Cohen et al. (2023) for the indicators of the "residential status", the "length of stay", and the "poverty status". Indicators for other vulnerability types (economic, livelihood, ecological, and climate change vulnerability) are also explained based on its respective aspect as indicated in the 2.5 (The Measurement of Vulnerability) and in the References.

(3) Regarding the number of samples which were 300 farm households, we consider this enough with regard to sampling technique that we applied, which was clustered sampling. First, we select 3 PHUs out of 5 PHUs in OKI District based on the variety of natural resources (peatlands) and the diversity of people livelihood. Secondly, within each PHUs, districts and villages are selected to represent the variety of resources and the types of livelihood such as crop farming, plantation, fishery, animal husbandry, forest and non-timber forest product collector, small processing industry, and various services. Finally, sample characteristics within each livelihood types were quite homogeneous such that they were randomly drawn from their respective population. Therefore, we are sure that the samples are representative and the results are conclusive.

4. Response to Comments on the Quality of English Language

Point 1: The manuscript should be checked by the authors carefully and further edited.

Response 1: The manuscript has carefully been checked and the attached revised manuscript has accommodated all typos, inconsistency in spellings, and difficulties in capturing the meanings of sentences.

5. Additional clarifications

-

For review article

Response to Reviewer X Comments

1. Summary

Thank you very much for taking the time to review this manuscript. Please find the detailed responses below and the corresponding revisions/corrections highlighted/in track changes in the re-submitted files. *[This is only a recommended summary. Please feel free to adjust it. We do suggest maintaining a neutral tone and thanking the reviewers for their contribution although the comments may be negative or off-target. If you disagree with the reviewer's comments please include any concerns you may have in the letter to the Academic Editor.]*

2. Questions for General Evaluation	**Reviewer's Evaluation**	**Response and Revisions**
Is the work a significant contribution to the field?		*[Please give your response if necessary. Or you can also give your corresponding response in the point-by-point response letter. The same as below]*
Is the work well organized and comprehensively described?		
Is the work scientifically sound and not misleading?		
Are there appropriate and adequate references to related and previous work?		
Is the English used correct and readable?		

3. Point-by-point response to Comments and Suggestions for Authors

Comments 1: *[Paste the full reviewer comment here.]*

Response 1: *[Type your response here and mark your revisions in red]* Thank you for pointing this out. I/We agree with this comment. Therefore, I/we have….*[Explain what change you have made. Mention exactly where in the revised manuscript this change can be found – page number, paragraph, and line.]*

"[updated text in the manuscript if necessary]"

Comments 2: *[Paste the full reviewer comment here.]*

Response 2: Agree. I/We have, accordingly, done/revised/changed/modified…..to emphasize

this point. *Discuss the changes made, providing the necessary explanation/clarification. Mention exactly where in the revised manuscript this change can be found – page number, paragraph, and line.] "[updated text in the manuscript if necessary]"*

4. Response to Comments on the Quality of English Language

Point 1:

Response 1: (in red)

5. Additional clarifications

[Here, mention any other clarifications you would like to provide to the journal editor/reviewer.]

5. Response to Reviewer 3

Farm Household Vulnerability due to Land and Forest Fire in Peatland Areas in South Sumatra

Response to Reviewer 3 Comments

1. Summary

Thank you very much for taking the time to review this manuscript. Please find the detailed responses below and the corresponding revisions/corrections highlighted in the re-submitted files. The revised parts in the paper are indicated in yellow color.

2. Questions for General Evaluation	**Reviewer's Evaluation**	**Response and Revisions**
Does the introduction provide sufficient background and include all relevant references?	Yes	Thank you for your evaluation.
Are all the cited references relevant to the research?	Yes	Thank you for your evaluation.
Is the research design appropriate?	Yes	Thank you for your evaluation.
Are the methods adequately described?	Yes	Thank you for your evaluation.
Are the results clearly presented?	Must be improved	We have improved the presentation of the results.
Are the conclusions supported by the results?	Can be improved	We have improved the conclusions accordingly.

3. Point-by-point response to Comments and Suggestions for Authors

Comments 1: Image 1 is virtually invisible.

Response 1: Thank you for pointing this out. We agree with this comment. The image is meant to point the study areas. Therefore, we have included arrow pointers to indicate the study areas as in the revised Figure 1.

Comments 2: Throughout the document, various tables are presented, yet they are not referenced in the text.

Response 2: Agree. We have indicated in the text to refer to the tables as in the revised article.

Comments 3: In section 2.5.5. on climate change vulnerability, Table 6 is mentioned. However, the location of this table is not provided.

Response 3: Thank you for your comment, Table 6 does not exist, therefor the phrase "Table 6" has been removed from the text.

Comments 4: Lastly, a series of policy proposals are made. How effective do you think they could be? Do you truly believe these measures can be implemented?

Response 4: Even though all five categories of vulnerability are identified in the research, we believe that proposing activities that overcome the economic vulnerability is an important start to overcome other vulnerabilities. This is because the economic activities that we proposed are based on local resources (purun, local fish and water buffalo) and the outputs are the cultural products of the indigenous people. To ensure that the economic activities will resolve the vulnerabilities, we also propose to establish local institutions as well as the markets of the local products. When the local products find the markets and the income flow to local people, they are willing to keep the local resources from degrading caused by land and forest fire.

Comments 5: From my point of view, it would be better if you present the different indicators in the form of a list, as it is repeated several times (1), (2), etc...

Response 5: Thank you for your suggestions.

Comments 6: This is just a suggestion, but for example, in section 2.5.2. Economic vulnerability, (1), (2) appears 2 or 3 times without referring to the same thing. As an idea, I propose that you create a table, diagram, or chart with all the indicators for each vulnerability measurement, even if you explain them in the text later. I believe it will be clearer and all the data and/or values used will be gathered.

Response 6: Thank you for your suggestion. You are true that both indicators reflect different things. For example, households with higher income, but with more household members will have lower per capita income. In comparison, households with the same income, but with fewer household member will have higher per capita income, and as results will be economically less vulnerable. Therefore, we include both indicators to measure the economic vulnerability. We will consider your suggestions.

4. Response to Comments on the Quality of English Language

Point 1: (x) I am not qualified to assess the quality of English in this paper

Response 1: -

5. Additional clarifications

-

For review article

Response to Reviewer X Comments

1. Summary

Thank you very much for taking the time to review this manuscript. Please find the detailed responses below and the corresponding revisions/corrections highlighted/in track changes in the re-submitted files. *[This is only a recommended summary. Please feel free to adjust it. We do suggest maintaining a neutral tone and thanking the reviewers for their contribution although the comments may be negative or off-target. If you disagree with the reviewer's comments please include any concerns you may have in the letter to the Academic Editor.]*

2. Questions for General Evaluation	**Reviewer's Evaluation**	**Response and Revisions**
Is the work a significant contribution to the field?		*[Please give your response if necessary. Or you can also give your corresponding response in the point-by-point response letter. The same as below]*
Is the work well organized and comprehensively described?		
Is the work scientifically sound and not misleading?		
Are there appropriate and adequate references to related and previous work?		
Is the English used correct and readable?		

3. Point-by-point response to Comments and Suggestions for Authors

Comments 1: *[Paste the full reviewer comment here.]*

Response 1: *[Type your response here and mark your revisions in red]* Thank you for pointing

this out. I/We agree with this comment. Therefore, I/we have….*[Explain what change you have made. Mention exactly where in the revised manuscript this change can be found – page number, paragraph, and line.]*
"[updated text in the manuscript if necessary]"
Comments 2: *[Paste the full reviewer comment here.]*
Response 2: Agree. I/We have, accordingly, done/revised/changed/modified…..to emphasize this point. *Discuss the changes made, providing the necessary explanation/clarification. Mention exactly where in the revised manuscript this change can be found – page number, paragraph, and line.]*
"[updated text in the manuscript if necessary]"

4. Response to Comments on the Quality of English Language

Point 1:

Response 1: (in red)

5. Additional clarifications

[Here, mention any other clarifications you would like to provide to the journal editor/reviewer.]

6. Revised Article as the Responses to All the Reviewers

land

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Article

Farm Household Vulnerability due to Land and Forest Fire in Peatland Areas in South Sumatra

Muhammad Yazid[1,*], Dessy Adriani[1], Riswani[1], Dini Damayanthy[1]

[1] Department of Agribusiness, Faculty of Agriculture, Universitas Sriwijaya
* Correspondence: yazid_ppmal@yahoo.com

Abstract: Land and forest fires in peatland areas in Indonesia have a widespread negative impact on surrounding communities. Possible vulnerabilities relate to economic, social, ecological, livelihoods and environmental vulnerability. This study aimed to assess household vulnerability due to land and forest fires on peatland areas in Ogan Komering Ilir District in South Sumatra and observe changes in peat ecosystems in those areas. The study was conducted in three peatland hydrological units (PHUs) — (1) PHU Sungai Sugihan–Sungai Lumpur; (2) PHU Sungai Sibumbung–Sungai Batok; and (3) PHU Sungai Saleh–Sungai Sugihan — covering 300 households as samples. Primary data were collected through structured interviews and analyzed descriptively. The analysis revealed that: (1) PHU Sungai Sibumbung–Sungai Batok had the highest score for livelihood vulnerability and climate change but the lowest score for social, economic and ecological vulnerability; (2) PHU Sungai Saleh–Sungai Sugihan had the highest score for economic and ecological vulnerability but the lowest score for livelihood vulnerability; (3) PHU Sungai Sugihan–Sungai Lumpur had the highest score for social vulnerability but lowest score for climate change vulnerability; and (4) the number of household members, toddlers, the elderly and all economic indicators except land ownership contributed relatively similarly to social vulnerability in all PHUs.

Keywords: ecosystem, social, economic, livelihood, ecological, climate change

Citation: To be added by editorial staff during production.

Academic Editor: Firstname Lastname

Received: date
Revised: date
Accepted: date
Published: date

1. Introduction

Peatland is a unique ecosystem in terms of structure and function with high vulnerability to disturbance [1–4] . Currently, most of the peatland and forests in Indonesia experience severe damage as a result of human activities that pay little attention to environmental issues. Land and forest fires in peatland areas have caused various conflicts with extensive negative impacts — technically, ecologically, economically, socially, and culturally [5] — such as: (1) peatland fires caused by misuse, carelessness, neglect, and intentionally; (2) dry peats formed by creating canals and planting non-peat-friendly plants; (3) damage to peatland; and (4) decreased productivity of peatlands. Such conditions lead to negative economic impacts, such as loss of livelihoods and decreased incomes.

Forest loss in Indonesia continued to increase since 2002, reaching the highest loss of more than 900,000 ha in 2016 due to the forest fires in 2015 [6]. Much of the forest loss in the period was within areas classified as secondary forest and other land cover (for example, mixed dry land agriculture, estate crop, plantation forest, shrub and others) [7,8] . Forest loss decreased from then until 2022. However, forest loss in 2022 still reached over 100,000 ha [9]

Vulnerability is determined by physical, social, economic and environmental factors or processes in a community and by the impact of hazards [10]. Vulnerability is a condition influenced by physical, social, economic and environmental processes that

can increase the risk of the impact of a hazard [11]. In general terms, vulnerability is a condition where the system cannot adjust to the impact of a change [12]. The nature of vulnerability differs temporally and spatially [13,14] . Vulnerability can be divided based on impact, such as those related to economic, social, ecological, livelihoods and environmental aspects. According to [11], vulnerability in a social context is a function of exposure, adaptive capability and sensitivity. Community vulnerability is a condition in which a community cannot adapt to ecosystem changes caused by a particular threat [15]. From an economic perspective, vulnerability includes population and institutional vulnerability depending on the existence of institutions in the area or the village. Vulnerability factors include [16] : (1) Physical vulnerability: basic infrastructure, construction, buildings; (2) Economic vulnerability: poverty, income, nutrition; (3) Social vulnerability: education, health, politics, legal, institutional; and (4) Environmental vulnerability: soil, water, plants, forests, oceans.

In addition, vulnerability can also affect the welfare of a community, whereby the greatest impact can be seen from shifting or reducing livelihoods [17,18] . Improving people's livelihoods on peatland through developing business opportunities is important and inherent as understanding the vulnerability of the people who do business in and/or around the peat ecosystem who are affected by changes to the ecosystem [19].

This study aims to describe, measure and analyze the level of vulnerability of farm households due to land and forest fires in peatland areas and observe the changes in ecosystems in those areas in three peatland hydrological units (PHUs) in Ogan Komering Ilir (OKI) District, South Sumatra Province, Indonesia. It is expected that outputs from this research will improve understanding of the levels of social, economic, livelihood, ecological and climate vulnerability. The study also assisted with mapping community conditions based on the distribution of levels of vulnerability and provided indicators for interventions to address vulnerability in the affected areas.

2. Materials and methods

2.1. Study sites

OKI District is one of four peat restoration priority districts in South Sumatra. The district includes five PHUs with an estimated area of 1,108,483.41 ha. The names of the five PHUs as the study areas are presented in Figure 1.

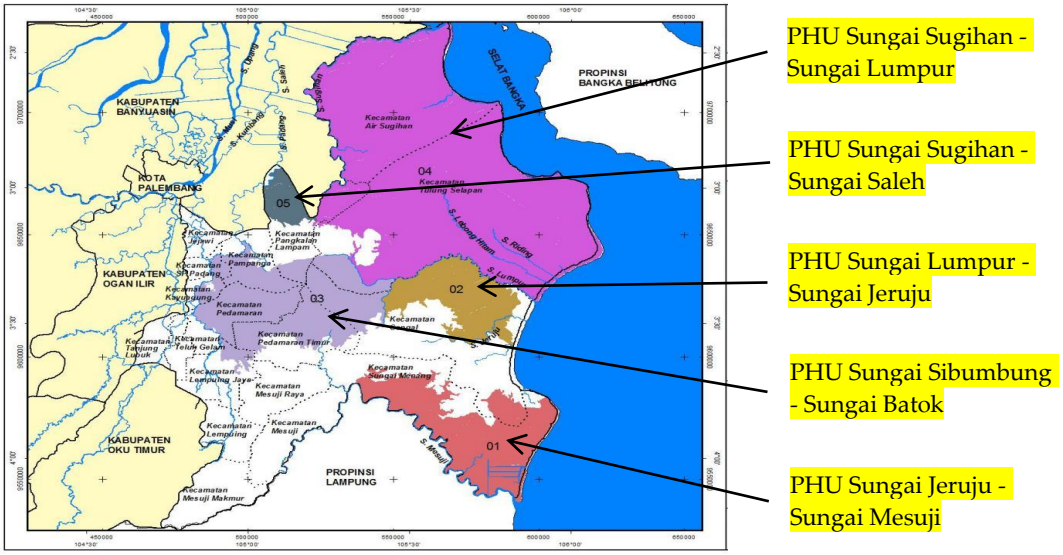

Figure 1. Locations and areas of PHUs in OKI District

Given the large size of the study area and the large number of affected households, this study was carried out using a household sample survey method and three approaches: (1) PHU approach; (2) administrative area approach; and (3) activity space approach.

2.2. *Sampling and Data Collection*

Sampling was carried out using a cluster sampling method with three sampling stages: (1) determining the PHU; (2) selecting sub-districts and sample villages; and (3) selecting household samples. The description of the sampling follows.

1. Of the five PHUs in OKI District, three were selected based on the variety of natural resources (including peatland) and the diversity of people's livelihoods: (1) PHU Sungai Sugihan–Sungai Lumpur; (2) PHU Sungai Sibumbung–Sungai Batok; (3) PHU Sungai Saleh–Sungai Sugihan.
2. In each PHU, sub-district and village clusters were determined based on the main livelihood of the population, for example, sub-district and village clusters with the main livelihood of the population being food crop farming (rice, other crops, horticulture), plantation crop clusters (rubber, oil palm, etc.), forest plant clusters and non-timber forest product (NTFP) collection, livestock clusters (swamp buffalo, cows/goats, chickens/ducks), fishery clusters (aquaculture, capture), home industry clusters/small processing industries, service clusters, and others.
3. From each sub-district and village cluster, two sample villages were selected representing the characteristics of the cluster.
4. Stratified random sampling was done in each village based on the area of cultivated land (for the livelihoods of crop and estate farming), number of livestock, number of business units (fisheries), production amount (timber collection and NTFPs), ownership of assets (manufacturing industry), etc. The sample characteristics within each livelihood type are quite homogeneous such that the number of sample households drawn were adjusted to their respective populations.

For households whose main livelihoods were outside the village area, for example, looking for wood and NTFPs, the sampling was carried out in their home area not at their work location. In this case, the spatial mobility of the population was considered in relation to the impact of livelihoods on the peat ecosystem.

Upon randomly selected household respondents were then interviewed and followed by indepth interview as necessary. In addition, field observations were also conducted to confirm the data collected during the interview. Also, focus group discussions (FGDs) were implemented to clarify and triangulate some important and specific findings.

2.3. *Data Processing and Measurement of Vulnerability*

Data obtained through this study were processed using descriptive analysis, namely, calculating the average sample value (mean, median or mode and standard deviation). The level of household vulnerability was measured with scores for indicators obtained from the survey. The vulnerability level was then presented in tables and graphs for easy interpretation and comparison.

2.3.1. Social vulnerability

Social vulnerability is a condition in which a household is in a state of vulnerability as shown by several household social indicators [20]. In this study, social vulnerability was measured using scores for five indicators: (1) number of household members [21]; (2) number of children under five (including infants) and the elderly in the household [22]; (3) residential status, that is, whether a local resident or a migrant; (4) length of stay; and (5) poverty status [23].

In our study, social vulnerability was divided into three groups. Household vulnerability was categorized as high if there were three or more members aged under 5 and elderly members of one or more; moderate if there were one to two members aged under 5 and elderly members of one or more; and low if there were no children under 5 nor any elderly members. Migrant households were categorized as high vulnerability while local residents were rated as low vulnerability since the latter were easily supported by families who lived nearby when facing a vulnerable situation.

In terms of length of residence, household vulnerability was categorized as high if resident for 20 years or less; moderate if resident for up to 40 years; and low if resident for more than 40 years. Likewise, household vulnerability was categorized as high if the household fell into the 'poor' group and low if not.

2.3.2. Economic vulnerability

Economic vulnerability is a condition in which a household is in a state of vulnerability as measured by several indicators [24,25]. In our study, we used scores for five indicators: (1) household income; (2) household per capita income; (3) household expenditure; (4) business land ownership; and (5) condition of the housing. Household income was estimated using both financial income (e.g. from selling the products) and the products that were self-consumed (subsistence). Based on household income, the level of household economic vulnerability was divided into three classes: (1) low vulnerability if household income was greater than IDR 3,500,000 per month; (2) moderate vulnerability if it was between IDR 1,750,000 up to IDR 3,500,000 per month, (3) high vulnerability if it was IDR 1,750,000 per month or less.

Based on the per capita income, the household economic vulnerability was divided into 3 classes, namely: (1) low vulnerability if per capita income was greater than IDR 750,000 (≈ USD 48) per month; (2) moderate vulnerability if it was between IDR 370,000 (≈ USD 24) to IDR 750,000 per month; and (3) high vulnerability if it was IDR 370,000 per month or less.

Household expenditure per month was also divided into three classes: (1) low vulnerability if expenditure was greater than IDR 1,500,000 (≈ USD 96) per month; (2) medium vulnerability if it was between IDR 1,000,000 (≈ USD 64) to IDR 1,500,000 per month; and (3) high vulnerability if it was IDR 1,000,000 per month or less.

Based on business land ownership, household economic vulnerability was also divided into three classes: (1) low vulnerability if business land ownership was larger than 1.0 ha; (2) moderate vulnerability if it was between 0.5 to 1.0 ha; and (3) high vulnerability if it was 0.5 ha or less [23, 24].

The condition of housing was also divided into three classes: (1) low vulnerability if permanent housing; (2) moderate vulnerability if semi-permanent housing; and (3) high vulnerability if emergency housing.

2.3.3. Livelihood vulnerability

A household's livelihood vulnerability [28] is measured using scores for four indicators of livelihoods applied to the household head and/or household members: (1) the main type of livelihood of the household head; (2) the length of time (in months) the household head worked in a year; (3) the education level of the household head; and (4) the number of household members who were working.

Respondents were divided into three groups: (1) farmers, fishers and laborers as a group with a high level of vulnerability due to the seasonal nature of their livelihoods; (2) planters, traders and entrepreneurs as a group with a moderate level of vulnerability; and (3) employers/employees as a group with a low level of vulnerability.

The working period of the head of the household in a year (in months) was also grouped in three classes: (1) working up to 4 months was categorized as high vulnerability; (2) working 5 to 8 months was categorized as moderate vulnerability; and (3) working 9 to 12 months as low vulnerability.

The education level of the head of the household was divided into three groups: (1) primary school education was categorized as having high vulnerability; (2) secondary school education was moderate vulnerability; and (3) undergraduate education was low vulnerability.

The number of working household members (other than the head of the household) was also grouped into three: (1) if no working household members, household vulnerability was categorized as high; (2) if one working household member, vulnerability was moderate; and (3) if two or more working household members, it was categorized as low vulnerability.

2.3.4. Ecological vulnerability

Ecological vulnerability is a condition in which a household is in a state of vulnerability as shown by several indicators registering negative changes (damage or deterioration) in ecosystem components, including land, water, plantations, and the availability of NTFPs [29,30]. The damage or deterioration of ecosystem components was measured based on the opinion of the respondents, using the following criteria: (1) if there was no change or slight damage to land, water or crops, then the ecological vulnerability was categorized as low; (2) if there was moderate damage, then it was categorized as moderate; and (3) if there was severe damage, then it was categorized as high.

In terms of changes in resource availability, the level of ecological vulnerability was measured using the following criteria: (1) if the availability of resources was constant, then ecological vulnerability was considered to be low; (2) if resource availability was reduced, it was moderate; and (3) if resource availability was very highly reduced, then it was considered to be highly vulnerable.

2.5.5. Climate change vulnerability

Climate change vulnerability is measured by the impact of climate change on people's livelihoods [31,32]. In our study, we measured two types of climate change impacts (drought and floods) and four types of community livelihoods (agriculture, plantation, animal husbandry, and forestry) resulting in eight climate change indicators. We measured based on community respondents' observations of changes that had occurred: (1) if there was no change or a slight change/impact, then it was categorized as low; (2) if there was a moderate level of change, then it was categorized as moderate; and (3) if there were severe changes, it was categorized as high vulnerability.

3. Results

3.1. Social vulnerability

Considering the "number of household members" and "number of children under 5 and the elderly" indicators, results showed that most of the sample households in the three PHUs were at a moderate level of social vulnerability.

Based on the "poor" indicator, the majority of sample households in PHU Sungai Sebumbung–Sungai Batok and PHU Sungai Sugihan–Sungai Lumpur were at a low level of social vulnerability while in PHU Sungai Saleh–Sungai Sugihan, the distribution of low and high levels of social vulnerability was relatively the same (Table 1).

Table 1. Results of social vulnerability measurement

No.	Indicator	Level of social vulnerability (%)			Average score
		Low	Medium	High	
PHU S. Sebumbung–S. Batok					
1	Number of household members	10.0	48.0	42.0	2.32
2	Number of toddlers and elderly	49.0	48.0	3.0	1.54

3	Resident status	87.0	0	13.0	1.26
4	Length of stay	47.0	47.0	6.0	1.59
5	Poverty status	80.0	0	20.0	1.40
	Total score (interval 5–15)				8.11
PHU S. Saleh–S. Sugihan					
1	Number of household members	5.0	64.0	31.0	2.26
2	Number of toddlers and elderly	25.0	63.0	12.0	1.87
3	Resident status	49.0	46.0	5.0	1.56
4	Length of stay	95.0	0.0	5.0	1.10
5	Poverty status	49.0	0.0	51.0	2.02
	Total score (interval 5–15)				8.81
PHU S. Sugihan–S. Lumpur					
1	Number of household members	9.0	81.0	10.0	2.01
2	Number of toddlers and elderly	47.0	47.0	6.0	1.59
3	Resident status	0.0	84.0	16.0	2.16
4	Length of stay	35.0	0.0	65.0	2.30
5	Poverty status	80.0	0.0	20.0	1.40
	Total score (interval 5–15)				9.46
	Average score for all PHUs				8.79

When compared among the three PHUs, the highest social vulnerability score was observed for PHU Sungai Sugihan–Sungai Lumpur while the lowest vulnerability was observed for PHU Sungai Sebumbung–Sungai Batok. Differences in social vulnerability among the three PHUs were observed mainly for the indicators "length of stay" and "residential status". In terms of the indicators "number of household members" and the "number of children under five and the elderly", there were no significant differences among the three PHUs (Figure 2).

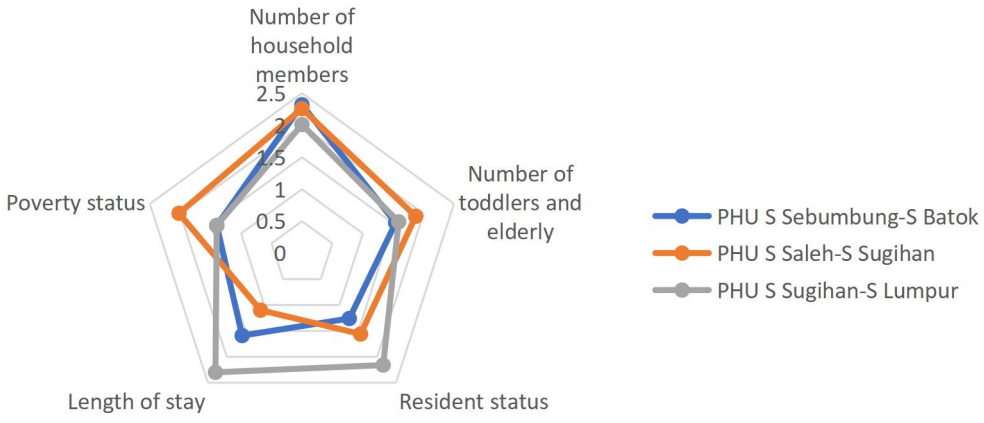

Figure 2. Social vulnerability score based on indicators

3.2. Economic vulnerability

Considering "household income", "per capita income" and "household expenditure" indicators, results show that economic vulnerability is relatively even in PHU Sungai Sebumbung–Sungai Batok. In PHU Sungai Saleh–Sungai Sugihan, the percentage of high vulnerability is greater than medium and low vulnerability. In PHU Sungai Sugihan–Sungai Lumpur, based on household income indicators most households are at a high level of vulnerability (Table 2).

Table 2. Results of economic vulnerability measurement

No.	Indicator	Level of economic vulnerability (%)			Average score
		Low	Medium	High	
PHU S. Sebumbung–S. Batok					
1	Household income	330	34.0	33.3	2.00
2	Income per capita	32.0	36.0	32.0	2.00
3	Household expenses	27.0	41.0	32.0	2.05
4	Land ownership	12.0	53.0	35.0	2.23
5	Home conditions	53.0	44.0	3.0	1.50
	Total score (interval 5–15)				9.78
PHU S. Saleh–S. Sugihan					
1	Household income	22.0	33.0	45.0	2.23
2	Income per capita	22.0	33.0	45.0	2.23
3	Household expenses	24.0	31.0	45.0	2.21
4	Land ownership	9.0	28.0	63.0	2.54
5	Home conditions	24.0	73.0	3.0	1.79
	Total score (interval 5–15)				11.00
PHU S. Sugihan–S. Lumpur					
1	Household income	29.0	0.0	71.0	2.42
2	Income per capita	32.0	36.0	32.0	2.00
3	Household expenses	22.0	45.0	33.0	2.11
4	Land ownership	32.0	35.0	33.0	2.01
5	Home conditions	62.0	27.0	11.0	1.49
	Total score (interval 5–15)				10.03
	Average score for all PHUs				10.27

When compared among the three PHUs, the highest economic vulnerability score was observed for PHU Sungai Saleh–Sungai Sugihan. The difference in economic vulnerability scored between PHU Sungai Sugihan–Sungai Lumpur and PHU Sungai Sebumbung–Sungai Batok was not significant. The difference in economic vulnerability scores between PHU Sungai Saleh–Sungai Sugihan and the other two PHUs was mainly found in the land ownership and home conditions indicators (Figure 3).

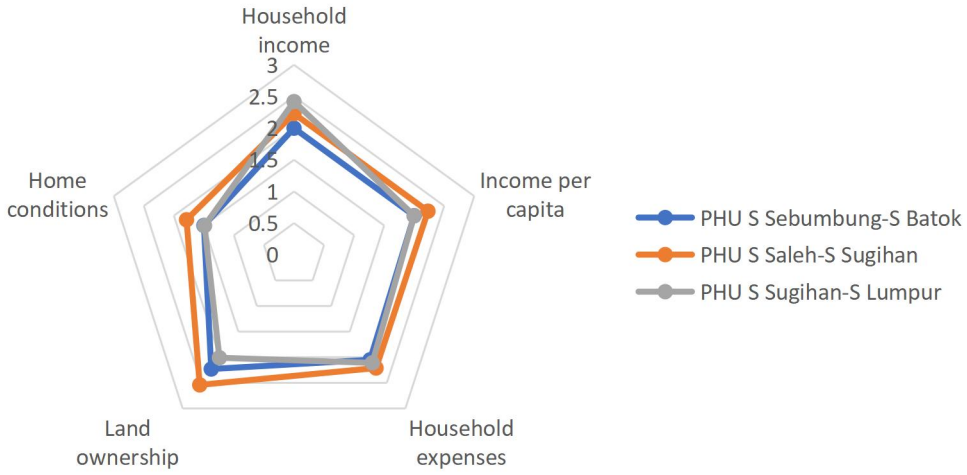

Figure 3. Economic vulnerability score based on indicators

3.3. Livelihood vulnerability

Considering the "household head's main occupation" indicator, results show that livelihood vulnerability level was high in the three PHUs, especially, in PHU Sungai Saleh–Sungai Sugihan.

The level of livelihood vulnerability in the three PHUs is also high based on the "household head's education" indicator, especially in PHU Sungai Saleh–Sungai Sugihan.

However, the level of livelihood vulnerability in PHU Sungai Saleh–Sungai Sugihan based on "the amount of working months" and "the number of working household members" indicators is the lowest among the three PHUs (Table 3).

Table 3. Results of livelihood vulnerability measurement

No.	Indicator	Level of livelihood vulnerability (%)			Average score
		Low	Medium	High	
PHU S. Sebumbung–S. Batok					
1	Household head's main occupation	2.0	44.0	54.0	2.52
2	Number of working months in a year	8.0	55.0	37.0	2.29
3	Household head's education	2.0	40.0	58.0	2.56
4	Number of working household members	28.0	39.0	33.0	2.05
	Total score (interval 4–12)				9.42
PHU S. Saleh–S. Sugihan					
1	Household head's main occupation	3.0	1.0	**96.0**	2.93
2	Number of working months in a year	100.0	0.0	0.0	1.00
3	Household head's education	4.0	23.0	73.0	2.69
4	Number of working household members	72.0	28.0	0.0	1.28
	Total score (interval 4–12)				7.90
PHU S. Sugihan–S. Lumpur					
1	Household head's main occupation	0.0	45.0	55.0	2.55
2	Number of working months	51.0	42.0	7.0	1.56

	in a year				
3	Household head's education	3.0	38.0	59.0	2.56
4	Number of working household members	38.0	62.0	0.0	1.62
	Total score (interval 4–12)				7.29
	Average score for all PHUs				8.20

When compared among the three PHUs, the highest livelihood vulnerability score was observed for PHU Sungai Sebumbung–Sungai Batok. Between PHU Sungai Saleh–Sungai Sugihan and PHU Sungai Sugihan–Sungai Lumpur, the level of livelihood vulnerability was only slightly different. PHU Sungai Saleh–Sungai Sugihan had the lowest livelihood vulnerability score among the three PHUs. Differences in livelihood vulnerability between the three PHUs are mainly found in "the number of working household members" and "the number of working months" indicators (Figure 4).

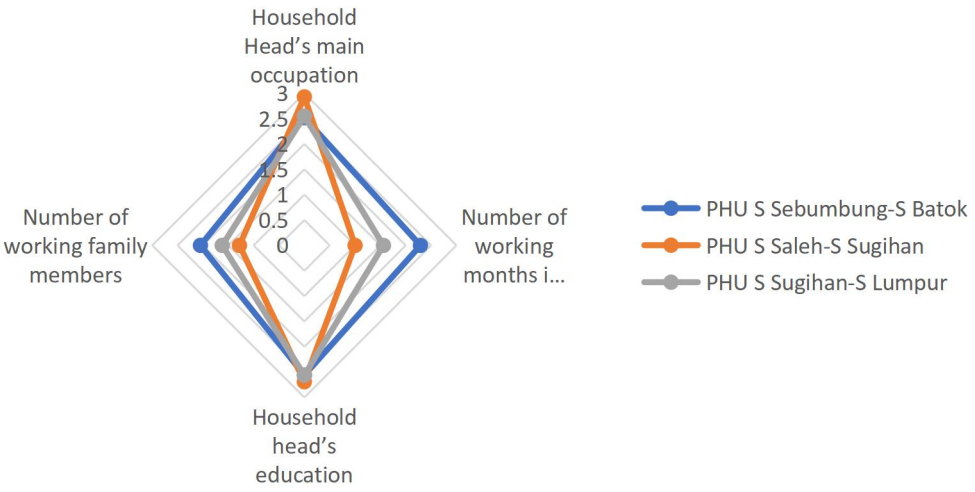

Figure 4. Livelihood vulnerability score based on indicators

3.4. Ecological vulnerability

Considering the "damage to soil", the "damage to water' and the "damage to cultivation" indicators, results show that the ecological vulnerability in the three PHUs is relatively low. The indicator of ecological vulnerability is considered moderate based on the availability of NTFPs, especially, in PHU Sungai Saleh–Sungai Sugihan and PHU Sungai Sugihan–Sungai Lumpur (Table 4).

Table 4. Results of ecological vulnerability measurement

No.	Indicator	Level of ecological vulnerability (%)			Average score
		Low	Medium	High	
PHU S. Sebumbung–S. Batok					
1	Damage to soil	85.0	6.0	9.0	1.24
2	Damage to water	90.0	6.0	4.0	1.14
3	Damage to cultivation	98.0	2.0	0.0	1.02
4	Availability of non-timber forest products	59.0	41.0	0.0	1.41
	Total score (interval 4–12)				4.81
PHU S. Saleh–S. Sugihan					

1	Damage to soil	65.0	24.0	11.0	1.46
2	Damage to water	69.0	19.0	12.0	1.43
3	Damage to cultivation	59.0	17.0	24.0	1.65
4	Availability of non-timber forest products	11.0	60.0	29.0	2.18
	Total score (interval 4–12)				6.72
PHU S. Sugihan–S. Lumpur					
1	Damage to soil	93.0	4.0	3.0	1.10
2	Damage to water	92.0	7.0	1.0	1.09
3	Damage to cultivation	87.0	12.0	1.0	1.14
4	Availability of non-timber forest products	28.0	67.0	5.0	1.77
	Total score (interval 4–12)				5.10
	Average score for all PHUs				5.54

When compared among the three PHUs, the highest ecological vulnerability score was observed for PHU Sungai Saleh–Sungai Sugihan and the lowest ecological vulnerability was observed for PHU Sungai Sebumbung–Sungai Batok. PHU Sungai Saleh–Sungai Sugihan had the highest ecological vulnerability, based on the all four indicators. The four indicators of ecological vulnerability are consistent in ranking the ecological vulnerability of the three PHUs (Figure 5).

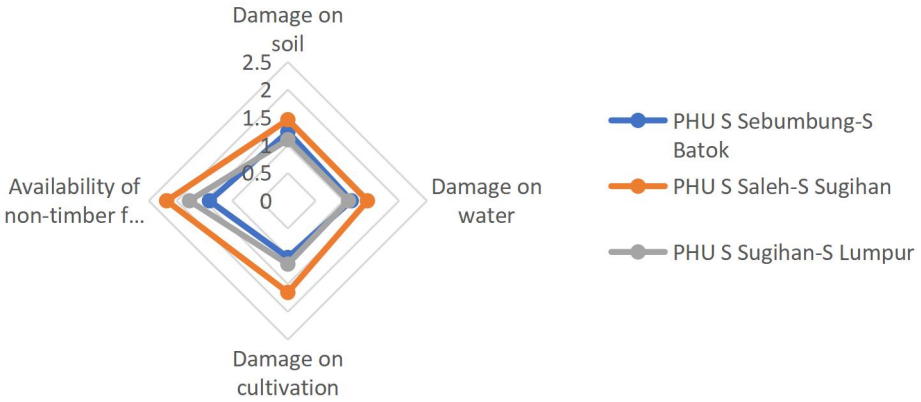

Figure 5. Ecological vulnerability score based on indicators

3.5. Climate change vulnerability

The results show that vulnerability due to climate change in the three PHUs is low, based on all the indicators, except the "flooding in the agricultural sector" and the "drought in the agricultural sector" indicators. Flooding has an impact on the vulnerability of the agricultural sector in PHU Sungai Sebumbung–Sungai Batok while drought has an impact on the vulnerability of the agricultural sector in PHU Sungai Saleh–Sungai Sugihan (Table 5).

Table 5. Results of climate change vulnerability indicators

No.	Indicator	Level of climate change vulnerability (%)			Average score
		Low	Medium	High	
PHU S. Sebumbung–S. Batok					
1	Drought in crop cultivation	57.0	25.0	18.0	1.61
2	Drought in estate	79.0	11.0	10.0	1.31

	plantation				
3	Drought in aquaculture	74.0	13.0	13.0	1.39
4	Drought in animal husbandry	77.0	9.0	14.0	1.37
5	Flood in crop cultivation	30.0	36.0	34.0	2.04
6	Flood in estate plantation	81.0	8.0	11.0	1.30
7	Flood in aquaculture	78.0	10.0	12.0	1.34
8	Flood in animal husbandry	80.0	9.0	11.0	1.31
	Total score (interval 8–24)				11.67
PHU S. Saleh–S. Sugihan					
1	Drought in crop cultivation	24.0	20.0	56.0	2.32
2	Drought in estate plantation	50.0	27.0	23.0	1.73
3	Drought in aquaculture	68.0	18.0	14.0	1.46
4	Drought in animal husbandry	83.0	11.0	6.0	1.23
5	Flood in crop cultivation	64.0	18.0	18.0	1.54
6	Flood in estate plantation	92.0	7.0	1.0	1.09
7	Flood in aquaculture	85.0	13.0	2.0	1.17
8	Flood in animal husbandry	95.0	5.0	0.0	1.05
	Total score (interval 8–24)				11.59
PHU S. Sugihan–S. Lumpur					
1	Drought in crop cultivation	89.0	9.0	2.0	1.13
2	Drought in estate plantation	86.0	12.0	2.0	1.16
3	Drought in aquaculture	89.0	10.0	1.0	1.12
4	Drought in animal husbandry	94.0	5.0	1.0	1.07
5	Flood in crop cultivation	87.0	12.0	1.0	1.14
6	Flood in estate plantation	91.0	9.0	0.0	1.09
7	Flood in aquaculture	93.0	7.0	0.0	1.07
8	Flood in animal husbandry	97.0	3.0	0.0	1.03
	Total score (interval 8–24)				8.81
	Average score all PHUs				10.69

When compared among the three PHUs, the highest climate change vulnerability was observed for PHU Sungai Sebumbung–Sungai Batok followed by PHU Sungai Saleh–Sungai Sugihan. PHU Sungai Sugihan–Sungai Lumpur has the lowest climate change vulnerability score among the three PHUs. Differences in climate change vulnerability between the three PHUs were mainly found in the "drought for agriculture" and "flood for agriculture" indicators. The influence of drought indicator on plantations only occurs in PHU Sungai Saleh–Sungai Sugihan (Figure 6).

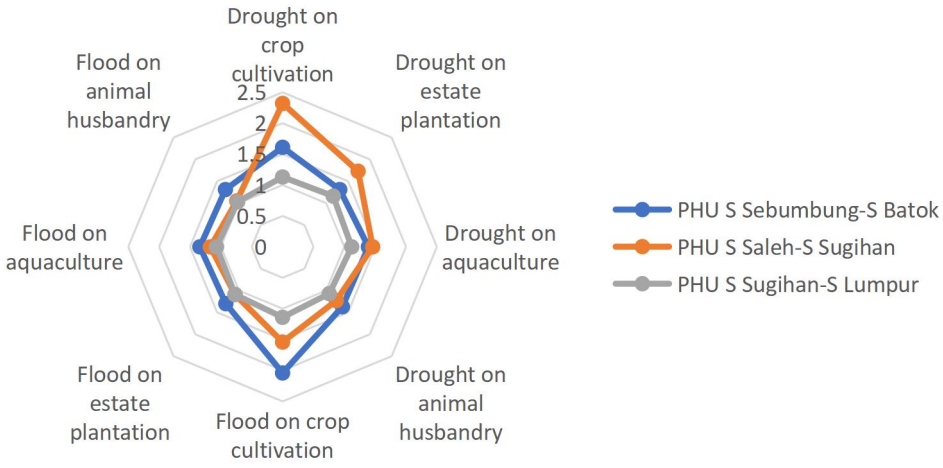

Figure 6. Climate change vulnerability score based on indicators

4. Discussion

In this study, we measured and analyzed vulnerability in five categories: social, economic, livelihood, ecological and climate change. First, for social vulnerability, this study showed that among the three PHUs, the highest vulnerability score was observed for PHU Sungai Sugihan–Sungai Lumpur while the lowest was observed for PHU Sungai Sebumbung–Sungai Batok. The data also show, based on the residency indicator, that the PHU Sungai Sugihan area had the highest social vulnerability level. The results showed that the population domiciled in this area is dominated by indigenous people, with some working as day laborers in large, company-controlled, land concession areas to fulfill their daily needs [33].

Previous research in Banjar Baru, Kalimantan found that social vulnerability was high of a community in an area prone to fire. Overcrowding caused by the large number of household members in an area also leads to greater social vulnerability. Increased public awareness, including an understanding of the causes, and handling of, disasters can help reduce social vulnerability [34] . Overall, in an effort to reduce social vulnerability in a fire-prone area, physical restoration activities, such as canal blocking and canal back-filling, will be useful [2,33].

Second, for economic vulnerability, we found that the highest economic vulnerability score occurred in PHU Sungai Saleh–Sungai Sugihan. Meanwhile, between PHU Sungai Sugihan–Sungai Lumpur and PHU Sungai Sebumbung–Sungai Batok, the difference in the level of economic vulnerability was not great. This finding aligns with the 'household income' indicator, in which the residents of PHU Sungai Sugihan–Sungai Lumpur area fall into the highest economic vulnerability category. One of the reasons for this could be due some residents undertaking day laboring in concession areas as their main job to meet their daily needs [33].

In areas outside large company concessions, peat restoration activities will be easier to implement because the Government can directly carry out restoration activities in those areas [35,36] unlike the company-controlled concession areas wherein the responsibility for any restoration falls to the company. Nevertheless, restoration indirectly has an impact on the income of farming households in a concession area because an increase in farming household income on peatland has been shown to be strongly influenced by restoration activities [37–39] . However, peatland restoration activities cannot take place without collaboration and coordination among several related parties [40].

In addition to farmers' household income, the area of land owned by farmers can also determine the degree of economic vulnerability [41], as experienced by farmers' groups in the PHU Sungai Saleh–Sungai Sugihan area where economic vulnerability measured based on the area of land owned was in the highest category. The larger the land area, the higher the net income that will be received by farmers [42,43].

Based on the indicator 'household head employment', PHU Sungai Saleh–Sungai Sugihan had high economic vulnerability wherein the head of a household worked as a farmer, fisher or laborer, occupations that are highly dependent on natural conditions.

In line with the results of this research, natural capital-based livelihood strategies that use existing natural resources combined with agricultural cultivation are the main strategies chosen by the community to sustain their livelihoods [44]. Nevertheless, the use of peatland for agricultural activities has its own challenges, including fires, soil acidity, low fertility and limited choice of suitable species [45]. Some of these challenges increase the risk of the income of the head of the household being uncertain. To reduce income uncertainties, it is important to have specially designed farming systems and patterns that can provide direct and multiple benefits to the local community.

Agrosilvofishery is an agricultural system that can be applied on peatland to reduce income uncertainties. The system combines different activities, including agriculture (such as agroforestry and small-scale farming), aquaculture (fish farming), and forestry (sustainable timber extraction), to create a multi-functional and sustainable system [46]. Agrosilvofishery is not just an agricultural system; it can also diversify and enhance the various livelihood practices on peatland and has the potential to reduce income uncertainty or risk and improve household welfare and food security through diversifying livelihoods [47,48].

Some countries with peatland area have implemented integrated approaches such as agrosilvofishery systems more extensively than others. For example, in Bangladesh, agrosilvofishery is promoted to enhance agricultural productivity and rural livelihoods [49–51]. In certain regions of China, agrosilvofishery practices are implemented to improve sustainable land use and enhance agricultural productivity. Examples include integrating aquaculture with wetland agriculture or incorporating fish production in rice fields [52–54]. Agrosilvofishery practices are also promoted in Costa Rica as part of sustainable agricultural systems in which combining agricultural activities with reforestation efforts and fish production is encouraged [55].

Ecological vulnerability can be divided into those caused by natural or human factors [56]. However, most of the research on ecological vulnerability in peatland areas has considered only natural factors [57]. Our study considers ecological vulnerability caused by both human and natural factors.

Ecological vulnerability assessment is an effective tool to alleviate contradictions [58]. The different assessment in our study compared with that of others shows the role of human society in changing inherent natural ecological vulnerability [58]. For example, land destruction can occur due to land disturbance in peatland [56]. This can occur naturally due to the El Niño–Indian Ocean Dipole phenomenon or by humans who deliberately set fires to clear land. One of the impacts of fire is that it can lead to higher acidity levels. This will certainly be very detrimental to farmers because they have to spend more to prepare the land for cultivation [59].

Evaluating ecological vulnerability is significant for protecting and promoting eco-system stability. However, attention to the dimensions of vulnerability and socio-ecological risk is lacking, indicating a large knowledge gap, especially, when considering that environmental degradation is considered one of the main causes of natural disaster risk worldwide [60]. As an effort to reduce ecological vulnerability, one of the adaptable frameworks that can be applied is to overcome the driving factors of unwanted ecological changes caused by humans. In addition, to implement effective, long-term and sustainable behavioral adaptation there needs to be a greater emphasis on strategies that are capable of improving human values, skills and behaviors. In other

words, a participatory approach to environmental management could be part of the solution to reduce the percentage of ecological vulnerability [61].

In previous studies, climate change vulnerabilities were measured using indicators such as drought, temperature increase, pests and land degradation. However, in this study, climate change vulnerability that occurs in four agribusiness sub-sectors — crop cultivation, aquaculture, estate plantation and animal husbandry — have a low climate change vulnerability category.

Some of the causes of climate change vulnerability, especially, in peatlands include (1) farmers lack of knowledge and information related to the phenomenon of climate change; (2) weakness of farmers' memory in monitoring climate change; [62] and (3) climate change does not occur instantly but continuously. If left unaddressed, droughts and floods will have a long-term negative impact, including environmental damage, decreased productivity of agricultural, plantation, fishery and livestock products, and crop failure. This will certainly increase the economic vulnerability of farming households because the damage will reduce farmers' household income, especially, of small-scale and subsistence farmers [63].

There is a need for integration and implementation of climate change adaptation policies in local government operations to reduce the vulnerability of smallholders and increase their ability to absorb, adapt and transform in the face of climate change [64]. In addition, other forms of adaptation strategies that can be applied by farmers would be using superior seed, adjusting planting patterns and times, carrying out water management and fish farming techniques that are suitable all-year round [65].

5. Conclusions and implications

The results of this study led to the following conclusions.

1. Conflicts that often occur in the management of livelihoods on peatland are more related to the use of natural resources and ecological limitations in meeting human needs since the livelihood of local people were still dependent on the availability of natural resources in and surrounding the peatland areas.
2. Vulnerability scores vary by the type of vulnerability and PHU. PHU Sungai Sebumbung–Sungai Batok had the highest score for livelihood and climate change vulnerability but the lowest for social, economic and ecological vulnerability. PHU Sungai Saleh–Sungai Sugihan had the highest score for economic and ecological vulnerability but the lowest for livelihood vulnerability. PHU Sungai Sugihan–Sungai Lumpur had the highest score for social vulnerability but the lowest for climate change vulnerability.
3. The indicators "number of household members" and "number of children under 5 and the elderly" make relatively equal contributions to the social vulnerability score in the three PHUs. All economic indicators except "business land ownership" make relatively equal contributions to the economic vulnerability score in the three PHUs. The indicator "length of time a household works in a year" is an important indicator in determining variations in livelihood vulnerability among the three PHUs. Sungai Saleh–Sungai Sugihan is the PHU with the highest ecological vulnerability score for all vulnerability indicators. The agricultural sector has the highest vulnerability due to the impact of climate change, such as droughts and floods.

The following implications are proposed for mitigating vulnerability before it becomes severe and difficult to tackle.

1. Development of various alternatives of resource-based local livelihoods, such as processing buffalo milk into various products, processing local fish into smoked and salted fish, processing *purun* (*Eleocharis dulcis*) (in partnership with companies) to improve living standards, and reduce the need for annual burning.

2. Community involvement in resource management and fire prevention is seen as an effective way to prevent forest and peatland fires. This can be implemented through provision of socio-economic incentives to communities for sustainable management of peatland, creating and strengthening local institutions and maintaining regulations for fire management.
3. Provision of social back-up in times of crisis due to land and forest fire.
4. Development of formal institutions to support the processing of local resources into various products, such as buffalo milk products, smoked and salted fish, and *purun*-based products.
5. Development of markets to ensure that economic activities can result in an increase of household income and welfare.
6. Inclusion of alternative strategies that households do or should do in coping with the difficulties caused by land and forest fire based in their past experience.

References

Page, S.; Mishra, S.; Agus, F.; Anshari, G.; Dargie, G.; Evers, S.; Jauhiainen, J.; Jaya, A.; Jovani-Sancho, A.J.; Laurén, A.; et al. Anthropogenic Impacts on Lowland Tropical Peatland Biogeochemistry. *Nat Rev Earth Environ* **2022**, *3*, 426–443, doi:10.1038/s43017-022-00289-6.

Ward, C.; Stringer, L.C.; Warren-Thomas, E.; Agus, F.; Hamer, K.; Pettorelli, N.; Hariyadi, B.; Hodgson, J.; Kartika, W.D.; Lucey, J. Wading through the Swamp: What Does Tropical Peatland Restoration Mean to National-level Stakeholders in Indonesia? *Restor Ecol* **2020**, *28*, 817–827.

Syahza, A.; Bakce, D.; Nasrul, B.; Irianti, M. Peatland Policy and Management Strategy to Support Sustainable Development in Indonesia. In Proceedings of the Journal of Physics: Conference Series; IOP Publishing, 2020; Vol. 1655, p. 012151.

Yang, G.; Peng, C.; Chen, H.; Dong, F.; Wu, N.; Yang, Y.; Zhang, Y.; Zhu, D.; He, Y.; Shi, S. Qinghai–Tibetan Plateau Peatland Sustainable Utilization under Anthropogenic Disturbances and Climate Change. *Ecosystem Health and Sustainability* **2017**, *3*, e01263.

Yeny, I.; Garsetiasih, R.; Suharti, S.; Gunawan, H.; Sawitri, R.; Karlina, E.; Narendra, B.H.; Surati; Ekawati, S.; Djaenudin, D.; et al. Examining the Socio-Economic and Natural Resource Risks of Food Estate Development on Peatlands: A Strategy for Economic Recovery and Natural Resource Sustainability. *Sustainability (Switzerland)* **2022**, *14*, doi:10.3390/su14073961.

Global Forest Watch Indonesia Primary Forest Loss, 2002-2022.

World Wide Fund for Nature (WWF) *Fire, Forest and The Future: A Crisis Raging Out of Control?*; 2020;

World Bank *The Cost of Fire*; 2016;

Departemen Kehutanan *Badan Planologi Kehutanan Rekalkulasi Penutupan Lahan Indonesia Tahun 2005*; Jakarta, 2005;

International Strategy for Disaster Reduction Living with Risk: A Global Review of Disaster Reduction Initiatives. **2004**.

Herawaty, H.; Santoso, H. Pengarus-tamaan Adaptasi Perubahan Iklim Ke Dalam Agenda Pembangunan: Tantangan Kebijakan Dan Pembangunan. Adaptasi Terhadap Bahaya Gerakan Tanah Di Masa Yang Akan Dating Akibat Pengaruh Perubahan Iklim 2006.

Füssel, H.-M.; Klein, R.J.T. Climate Change Vulnerability Assessments: An Evolution of Conceptual Thinking. *Clim Change* **2006**, *75*, 301–329.

IPCC Third Assessment Report of the Intergovernmental Panel on Climate Change IPCC (WG I & II) 2001.

Griggs, D.J.; Noguer, M. Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change. *Weather* **2002**, *57*, 267–269.

Dockendorff, C.; Fuss, S.; Agra, R.; Guye, V.; Herrera, D.; Kraxner, F. Committed to Restoring Tropical Forests: An Overview of Brazil's and Indonesia's Restoration Targets and Policies. *Environmental Research Letters* **2022**, *17*, doi:10.1088/1748-9326/ac8ab2.

Good Local Governance Pedoman Penyusunan Rencana Aksi Daerah (RAD) Pengurangan Risiko Bencana (PRB) Bagi Kabupaten. *Kota Semarang* **2008**.

Labadi, S.; Giliberto, F.; Rosetti, I.; Shetabi, L.; Yildirim, E. Heritage and the Sustainable Development Goals: Policy Guidance for Heritage and Development Actors. *International Journal of Heritage Studies* **2021**.

Roka, K. Community-Based Natural Resources Management. In *Life on Land*; Leal Filho, W., Azul, A.M., Brandli, L., Lange Salvia, A., Wall, T., Eds.; Springer International Publishing: Cham, 2021; pp. 161–174 ISBN 978-3-319-95981-8.

Ziegler, R.; Wichtmann, W.; Abel, S.; Kemp, R.; Simard, M.; Joosten, H. Wet Peatland Utilisation for Climate Protection – An International Survey of Paludiculture Innovation. *Clean Eng Technol* **2021**, *5*, 100305, doi:https://doi.org/10.1016/j.clet.2021.100305.

Fatemi, F.; Ardalan, A.; Aguirre, B.; Mansouri, N.; Mohammadfam, I. Social Vulnerability Indicators in Disasters: Findings from a Systematic Review. *International journal of disaster risk reduction* **2017**, *22*, 219–227.

Defiesta, G.; Rapera, C. Measuring Adaptive Capacity of Farmers to Climate Change and Variability: Application of a Composite Index to an Agricultural Community in the Philippines. *Journal of Environmental Science and Management* **2014**, *17*.

Naz, L.; Patel, K.K.; Dilanchiev, A. Are Socioeconomic Status and Type of Residence Critical Risk Factors of Under-Five Mortality in Pakistan? Evidence from Nationally Representative Survey. *Clin Epidemiol Glob Health* **2021**, *10*, 100670.

Cohen, D.A.; Talarowski, M.; Han, B.; Williamson, S.; Galfond, E.; Young, D.R.; Eng, S.; McKenzie, T.L. Playground Design: Contribution to Duration of Stay and Implications for Physical Activity. *Int J Environ Res Public Health* **2023**, *20*, 4661.

Adger, W.N. Indicators of Social and Economic Vulnerability to Climate Change in Vietnam. *CSERGE GEC WORKING PAPER* **1998**.

Adger, W.N. Indicators of Social and Economic Vulnerability to Climate Change in Vietnam. *CSERGE GEC WORKING PAPER* **1998**.

Purnawan, E.; Brunori, G.; Prosperi, P. Small household Farms; a Perspective from Indonesia, Challenges and Investment. *No. Dec* **2020**.

Jayne, T.S.; Yamano, T.; Weber, M.T.; Tschirley, D.; Benfica, R.; Chapoto, A.; Zulu, B. Smallholder Income and Land Distribution in Africa: Implications for Poverty Reduction Strategies. *Food Policy* **2003**, *28*, 253–275.

Huong, N.T.L.; Yao, S.; Fahad, S. Assessing Household Livelihood Vulnerability to Climate Change: The Case of Northwest Vietnam. *Human and Ecological Risk Assessment: An International Journal* **2019**, *25*, 1157–1175.

Roy, B.; Lourenço, T.C.; Lisboa, F.; Penha-Lopes, G.; Santos, F.D. Impacts of Climate and Land Use Change on Surface Water Content and Quality in Low-Lying Coastal Areas of Bangladesh. In *Handbook of Climate Change Management: Research, Leadership, Transformation*; Springer, 2021; pp. 1–28.

Rajesh, S.; Jain, S.; Sharma, P. Inherent Vulnerability Assessment of Rural Households Based on Socio-Economic Indicators Using Categorical Principal Component Analysis: A Case Study of Kimsar Region, Uttarakhand. *Ecol Indic* **2018**, *85*, 93–104.

Afjal Hossain, M.; Imran Reza, M.; Rahman, S.; Kayes, I. Climate Change and Its Impacts on the Livelihoods of the Vulnerable People in the Southwestern Coastal Zone in Bangladesh. *Climate change and the sustainable use of water resources* **2012**, 237–259.

Poudel, S.; Funakawa, S.; Shinjo, H.; Mishra, B. Understanding Households' Livelihood Vulnerability to Climate Change in the Lamjung District of Nepal. *Environ Dev Sustain* **2020**, *22*, 8159–8182.

Budiman, I.; Hapsari, R.D.; Wijaya, C.I.; Sari, E.N.N. The Governance of Risk Management on Peatland: A Case Study of Restoration in South Sumatra, Indonesia. *World Resources Institute* **2021**, doi:10.46830/wriwp.20.00008.

Arisanty, D.; Zaenal, M.; Anis, A.; Porda, H.; Putro, N.; Hastuti, K.P.; Angriani, P. *Social Vulnerability of Land Fires in Banjarbaru*; 2021;

Wicaksono, A.; Zainal Peatlands Restoration Policies in Indonesia: Success or Failure? *IOP Conf Ser Earth Environ Sci* **2022**, *995*, 012068, doi:10.1088/1755-1315/995/1/012068.

Saputra, E. Beyond Fires and Deforestation: Tackling Land Subsidence in Peatland Areas, A Case Study from Riau, Indonesia. *Land (Basel)* **2019**, *8*, doi:10.3390/land8050076.

Sheng, W.; Zhen, L.; Xiao, Y.; Hu, Y. Ecological and Socioeconomic Effects of Ecological Restoration in China's Three Rivers Source Region. *Science of The Total Environment* **2019**, *650*, 2307–2313, doi:https://doi.org/10.1016/j.scitotenv.2018.09.265.

Wang, J.; Liu, Y.; Li, Y. Ecological Restoration under Rural Restructuring: A Case Study of Yan'an in China's Loess Plateau. *Land use policy* **2019**, *87*, 104087.

Urzedo, D.I. de; Piña-Rodrigues, F.C.M.; Feltran-Barbieri, R.; Junqueira, R.G.P.; Fisher, R. Seed Networks for Upscaling Forest Landscape Restoration: Is It Possible to Expand Native Plant Sources in Brazil? *Forests* **2020**, *11*, 259.

Pratama, I.; Purnomo, E.P.; Mutiaran, D.; Adrian, M.M.; Sundari, C. Creating Peatland Restoration Policy for Supporting in Indonesian Economic in a Sustainable Way. *IOP Conf Ser Earth Environ Sci* **2022**, *1111*, 012004, doi:10.1088/1755-1315/1111/1/012004.

Fahad, S.; Wang, J. Climate Change, Vulnerability, and Its Impacts in Rural Pakistan: A Review. *Environmental Science and Pollution Research* **2020**, *27*, 1334–1338, doi:10.1007/s11356-019-06878-1.

Clough, Y.; Kirchweger, S.; Kantelhardt, J. Field Sizes and the Future of Farmland Biodiversity in European Landscapes. *Conserv Lett* **2020**, *13*, e12752.

Ren, C.; Liu, S.; van Grinsven, H.; Reis, S.; Jin, S.; Liu, H.; Gu, B. The Impact of Farm Size on Agricultural Sustainability. *J Clean Prod* **2019**, *220*, 357–367, doi:https://doi.org/10.1016/j.jclepro.2019.02.151.

Ulya, N.A.; Waluyo, E.A.; Nurlia, A.; Rahmat, M.; Martin, E. Alternative Natural Capital-Based Livelihoods in Facing Peatland Degradation in Rengas Merah Hamlet, Ogan Komering Ilir Regency, Indonesia: A Financial Analysis Approach. *IOP Conf Ser Earth Environ Sci* **2021**, *917*, 012017, doi:10.1088/1755-1315/917/1/012017.

Sakuntaladewi, N.; Rachmanadi, D.; Mendham, D.; Yuwati, T.W.; Winarno, B.; Premono, B.T.; Lestari, S.; Ardhana, A.; Ramawati; Budiningsih, K. Can We Simultaneously Restore Peatlands and Improve Livelihoods? Exploring Community Home Yard Innovations in Utilizing Degraded Peatland. *Land (Basel)* **2022**, *11*, 150.

Alam, S.; Nurhidayah, L.; Lim, M. Towards a Transnational Approach to Transboundary Haze Pollution: Governing Traditional Farming in Fire-Prone Regions of Indonesia. *Transnational Environmental Law* **2023**, *12*, 424–450, doi:DOI: 10.1017/S2047102522000450.

Girkin, N.T.; Cooper, H. V; Ledger, M.J.; O'Reilly, P.; Thornton, S.A.; Åkesson, C.M.; Cole, L.E.S.; Hapsari, K.A.; Hawthorne, D.; Roucoux, K.H. Tropical Peatlands in the Anthropocene: The Present and the Future. *Anthropocene* **2022**, *40*, 100354, doi:https://doi.org/10.1016/j.ancene.2022.100354.

Indrajaya, Y.; Yuwati, T.W.; Lestari, S.; Winarno, B.; Narendra, B.H.; Nugroho, H.Y.S.H.; Rachmanadi, D.; Pratiwi, P.; Turjaman, M.H.; Adi, R.N.; et al. Tropical Forest Landscape Restoration in Indonesia: A Review. *Land (Basel)* **2022**, *11*, doi:10.3390/land11030328.

Islam, S.; Ghosh, S.; Podder, M. Fifty Years of Agricultural Development in Bangladesh: A Comparison with India and Pakistan. *SN Business & Economics* **2022**, *2*, 71, doi:10.1007/s43546-022-00240-3.

Rahman Sunny, A.; Jimi Reza, M.; Anas Chowdhury, M.; Nazmul Hassan, M.; Abdul, M.; Ratul Hasan, M.; Mostafa Monwar, M.; Solaiman Hossain, M.; Mosarof Hossain, M. *Biodiversity Assemblages and Conservation Necessities of Ecologically Sensitive Natural Wetlands of North-Eastern Bangladesh*; 2020; Vol. 49;.

Barua, P.; Rahman, S.H.; Barua, M. Sustainable Management of Agriculture Products Value Chain in Responses to Climate Change for South-Eastern Coast of Bangladesh. *Modern Supply Chain Research and Applications* **2021**, *3*, 98–126.

Hu, F.; Zhong, H.; Wu, C.; Wang, S.; Guo, Z.; Tao, M.; Zhang, C.; Gong, D.; Gao, X.; Tang, C. Development of Fisheries in China. *Reproduction and Breeding* **2021**, *1*, 64–79.

Wen, X.; Liu, D.; Qiu, M.; Wang, Y.; Niu, J.; Liu, Y. Estimation of Maize Yield Incorporating the Synergistic Effect of Climatic and Land Use Change in Jilin, China. *Journal of Geographical Sciences* **2023**, *33*, 1725–1746, doi:10.1007/s11442-023-2150-6.

Ibrahim, L.A.; Shaghaleh, H.; Abu-Hashim, M.; Elsadek, E.A.; Hamoud, Y.A. Exploring the Integration of Rice and Aquatic Species: Insights from Global and National Experiences. *Water (Switzerland)* 2023, *15*.

Peguero, F.; Zapata, S.; Sandoval, L. Challenges and Opportunities. *Choices* **2019**, *34*, 1–10.

Li, H.; Zhu, D.; Cook, M. A Statistical Framework for Consolidating "Sibling" Probe Sets for Affymetrix GeneChip Data. *BMC Genomics* **2008**, *9*, 188, doi:10.1186/1471-2164-9-188.

Ghosh, S.; Das, A. Urban Expansion Induced Vulnerability Assessment of East Kolkata Wetland Using Fuzzy MCDM Method. *Remote Sens Appl* **2019**, *13*, 191–203, doi:https://doi.org/10.1016/j.rsase.2018.10.014.

Hu, X.; Ma, C.; Huang, P.; Guo, X. Ecological Vulnerability Assessment Based on AHP-PSR Method and Analysis of Its Single Parameter Sensitivity and Spatial Autocorrelation for Ecological Protection – A Case of Weifang City, China. *Ecol Indic* **2021**, *125*, 107464, doi:https://doi.org/10.1016/j.ecolind.2021.107464.

Coulibaly, B.; Li, S. Impact of Agricultural Land Loss on Rural Livelihoods in Peri-Urban Areas: Empirical Evidence from Sebougou, Mali. *Land (Basel)* **2020**, *9*, 470.

Depietri, Y. The Social–Ecological Dimension of Vulnerability and Risk to Natural Hazards. *Sustain Sci* **2020**, *15*, 587–604, doi:10.1007/s11625-019-00710-y.

Eriksen, S.; Schipper, E.L.F.; Scoville-Simonds, M.; Vincent, K.; Adam, H.N.; Brooks, N.; Harding, B.; Khatri, D.; Lenaerts, L.; Liverman, D.; et al. Adaptation Interventions and Their Effect on Vulnerability in Developing Countries: Help, Hindrance or Irrelevance? *World Dev* **2021**, *141*, 105383, doi:https://doi.org/10.1016/j.worlddev.2020.105383.

Ricart, S.; Castelletti, A.; Gandolfi, C. On Farmers' Perceptions of Climate Change and Its Nexus with Climate Data and Adaptive Capacity. A Comprehensive Review. *Environmental Research Letters* **2022**, *17*, 083002, doi:10.1088/1748-9326/ac810f.

Shrestha, R.; Rakhal, B.; Adhikari, T.R.; Ghimire, G.R.; Talchabhadel, R.; Tamang, D.; KC, R.; Sharma, S. Farmers' Perception of Climate Change and Its Impacts on Agriculture. *Hydrology* **2022**, *9*, doi:10.3390/hydrology9120212.

Twecan, D.; Wang, W.; Xu, J.; Mohmmed, A. Climate Change Vulnerability, Adaptation Measures, and Risk Perceptions at Households Level in Acholi Sub-Region, Northern Uganda. *Land use policy* **2022**, *115*, 106011, doi:https://doi.org/10.1016/j.landusepol.2022.106011.

Eka Suranny, L.; Gravitiani, E.; Rahardjo, M. Impact of Climate Change on the Agriculture Sector and Its Adaptation Strategies. *IOP Conf Ser Earth Environ Sci* **2022**, *1016*, 012038, doi:10.1088/1755-1315/1016/1/012038.

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[Land] Manuscript ID: land-2923239 - Manuscript Resubmitted

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Type of manuscript: Article
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Authors: Muhammad Yazid *, Dessy Adriani, Riswani Riswani, Dini Damayanthy
Received: 4 Mar 2024
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Type of manuscript: Article
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Authors: Muhammad Yazid *, Dessy Adriani, Riswani Riswani, Dini Damayanthy
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Authors: Muhammad Yazid *, Dessy Adriani, Riswani Riswani, Dini Damayanthy
Received: 4 Mar 2024
E-mails: yazid_ppmal@yahoo.com, dessyadriani@fp.unsri.ac.id, riswani@fp.unsri.ac.id, damayanthy@fp.unsri.ac.id
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Article

Farm Household Vulnerability Due to Land and Forest Fire in Peatland Areas in South Sumatra

Muhammad Yazid *, Dessy Adriani, Riswani and Dini Damayanthy

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Abstract: Land and forest fires in peatland areas in Indonesia have a widespread negative impact on surrounding communities. Possible vulnerabilities relate to economic, social, ecological, livelihoods, and environmental vulnerability. This study aimed to assess household vulnerability due to land and forest fires in peatland areas in Ogan Komering Ilir District in South Sumatra and observe changes in peat ecosystems in those areas. The study was conducted in three peatland hydrological units (PHUs)—(1) PHU Sungai Sugihan–Sungai Lumpur; (2) PHU Sungai Sibumbung–Sungai Batok; and (3) PHU Sungai Saleh–Sungai Sugihan—covering 300 households as samples. Primary data were collected through structured interviews and analyzed descriptively. The analysis revealed the following: (1) PHU Sungai Sibumbung–Sungai Batok had the highest score for livelihood vulnerability and climate change but the lowest score for social, economic, and ecological vulnerability; (2) PHU Sungai Saleh–Sungai Sugihan had the highest score for economic and ecological vulnerability but the lowest score for livelihood vulnerability; (3) PHU Sungai Sugihan–Sungai Lumpur had the highest score for social vulnerability but lowest score for climate change vulnerability; and (4) the number of household members, toddlers, and elderly, and all economic indicators except land ownership, contributed relatively similarly to social vulnerability in all PHUs.

Keywords: ecosystem; social; economic; livelihood; ecological; climate change

Citation: Yazid, M.; Adriani, D.; Riswani; Damayanthy, D. Farm Household Vulnerability Due to Land and Forest Fire in Peatland Areas in South Sumatra. *Land* **2024**, *13*, x. https://doi.org/10.3390/xxxxx

Academic Editor(s): Name

Received: 4 March 2024
Revised: 12 April 2024
Accepted: 21 April 2024
Published: date

1. Introduction

Peatland is a unique ecosystem in terms of structure and function, with high vulnerability to disturbance [1–4]. Currently, most of the peatland and forests in Indonesia experience severe damage as a result of human activities that pay little attention to environmental issues. Land and forest fires in peatland areas have caused various conflicts with extensive negative impacts—technically, ecologically, economically, socially, and culturally [5]—such as (1) peatland fires caused by misuse, carelessness, and neglect, and intentionally; (2) dry peats formed by creating canals and planting non-peat-friendly plants; (3) damage to peatland; and (4) decreased productivity of peatlands. Such conditions lead to negative economic impacts, such as loss of livelihoods and decreased incomes.

Forest loss in Indonesia has continued to increase since 2002, reaching the highest loss of more than 900,000 ha in 2016 due to the forest fires in 2015 [6]. Much of the forest loss in the period was within areas classified as secondary forest and other land cover (for example, mixed dry land agriculture, estate crop, plantation forest, shrub, and others) [7,8]. Forest loss decreased from then until 2022. However, forest loss in 2022 still reached over 100,000 ha [9]

Vulnerability is determined by physical, social, economic, and environmental factors or processes in a community and by the impact of hazards [10]. Vulnerability is a

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condition influenced by physical, social, economic, and environmental processes that can increase the risk of the impact of a hazard [11]. In general terms, vulnerability is a condition where the system cannot adjust to the impact of a change [12]. The nature of vulnerability differs temporally and spatially [13,14]. Vulnerabilities can be divided based on impact, such as those related to economic, social, ecological, livelihood, and environmental aspects. According to [11], vulnerability in a social context is a function of exposure, adaptive capability, and sensitivity. Community vulnerability is a condition in which a community cannot adapt to ecosystem changes caused by a particular threat [15]. From an economic perspective, vulnerability includes population and institutional vulnerability depending on the existence of institutions in the area or the village. Vulnerability factors include the following [16]: (1) physical vulnerability: basic infrastructure, construction, buildings; (2) economic vulnerability: poverty, income, nutrition; (3) social vulnerability: education, health, politics, legal, institutional; and (4) environmental vulnerability: soil, water, plants, forests, oceans.

In addition, vulnerability can also affect the welfare of a community, whereby the greatest impact can be seen from shifting or reducing livelihoods [17,18]. Improving people's livelihoods on peatland through developing business opportunities is important and inherent in the understanding of the vulnerability of the people who do business in and/or around the peat ecosystem who are affected by changes to the ecosystem [19].

This study aims to describe, measure, and analyze the level of vulnerability of farm households due to land and forest fires in peatland areas and observe the changes in ecosystems in those areas in three peatland hydrological units (PHUs) in Ogan Komering Ilir (OKI) District, South Sumatra Province, Indonesia. It is expected that outputs from this research will improve understanding of the levels of social, economic, livelihood, ecological, and climate vulnerability. The study also assists with mapping community conditions based on the distribution of levels of vulnerability and provides indicators for interventions to address vulnerability in the affected areas.

2. Materials and Methods

2.1. Study Sites

OKI District is one of four peat restoration priority districts in South Sumatra. The district includes five PHUs with an estimated area of 1,108,483.41 ha. The names of the five PHUs as the study areas are presented in Figure 1.

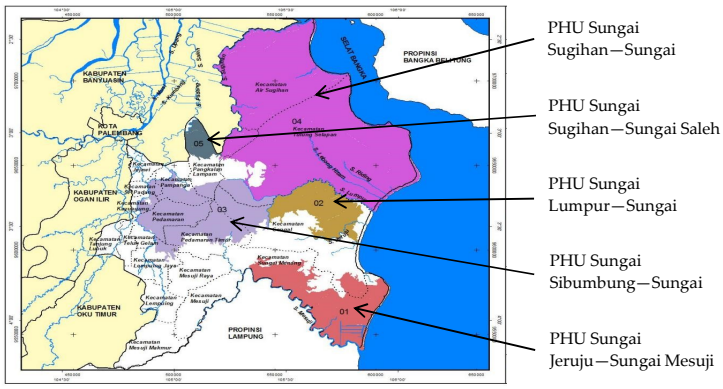

Figure 1. Locations and areas of PHUs in OKI District.

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Given the large size of the study area and the large number of affected households, this study was carried out using a household sample survey method and three approaches: (1) PHU approach; (2) administrative area approach; and (3) activity space approach.

2.2. Sampling and Data Collection

Sampling was carried out using a cluster sampling method with three sampling stages: (1) determining the PHU; (2) selecting sub-districts and sample villages; and (3) selecting household samples. The description of the sampling follows.

1. Of the five PHUs in OKI District, three were selected based on the variety of natural resources (including peatland) and the diversity of people's livelihoods: (1) PHU Sungai Sugihan–Sungai Lumpur; (2) PHU Sungai Sibumbung–Sungai Batok; (3) PHU Sungai Saleh–Sungai Sugihan.
2. In each PHU, sub-district and village clusters were determined based on the main livelihood of the population, for example, sub-district and village clusters with the main livelihood of the population being food crop farming (rice, other crops, horticulture), plantation crop clusters (rubber, oil palm, etc.), forest plant clusters and non-timber forest product (NTFP) collection, livestock clusters (swamp buffalo, cows/goats, chickens/ducks), fishery clusters (aquaculture, capture), home industry clusters/small processing industries, service clusters, and others.
3. From each sub-district and village cluster, two sample villages were selected representing the characteristics of the cluster.
4. Stratified random sampling was conducted in each village based on the area of cultivated land (for the livelihoods of crop and estate farming), number of livestock, number of business units (fisheries), production amount (timber collection and NTFPs), ownership of assets (manufacturing industry), etc. The sample characteristics within each livelihood type are quite homogeneous, such that the number of sample households drawn was adjusted to their respective populations.

For households whose main livelihoods were outside the village area, for example, looking for wood and NTFPs, the sampling was carried out in their home area not at their work location. In this case, the spatial mobility of the population was considered in relation to the impact of livelihoods on the peat ecosystem.

Upon random selection, household respondents were then interviewed, which was followed by an in-depth interview as necessary. In addition, field observations were also conducted to confirm the data collected during the interview. Furthermore, focus group discussions (FGDs) were implemented to clarify and triangulate some important and specific findings.

2.3. Data Processing and Measurement of Vulnerability

Data obtained through this study were processed using descriptive analysis, namely, calculating the average sample value (mean, median or mode, and standard deviation). The level of household vulnerability was measured with scores for indicators obtained from the survey. The vulnerability level is presented in tables and graphs for easy interpretation and comparison.

2.3.1. Social Vulnerability

Social vulnerability is a condition in which a household is in a state of vulnerability as shown by several household social indicators [20]. In this study, social vulnerability was measured using scores for five indicators: (1) number of household members [21]; (2) number of children under five (including infants) and elderly in the household [22]; (3) residential status, that is, whether a local resident or a migrant; (4) length of stay; and (5) poverty status [23].

In our study, social vulnerability was divided into three groups. Household vulnerability was categorized as high if there were three or more members aged under 5 and elderly members of one or more; moderate if there were one to two members aged under 5 and elderly members of one or more; and low if there were no children under 5 nor any elderly members. Migrant households were categorized as high vulnerability, while local residents were rated as low vulnerability since the latter were easily supported by families who lived nearby when facing a vulnerable situation.

In terms of length of residence, household vulnerability was categorized as high if resident for 20 years or less; moderate if resident for up to 40 years; and low if resident for more than 40 years. Likewise, household vulnerability was categorized as high if the household fell into the "poor" group and low if not.

2.3.2. Economic Vulnerability

Economic vulnerability is a condition in which a household is in a state of vulnerability as measured by several indicators [24,25]. In our study, we used scores for five indicators: (1) household income; (2) household per capita income; (3) household expenditure; (4) business land ownership; and (5) condition of the housing. Household income was estimated using both financial income (e.g., from selling the products) and the products that were self-consumed (subsistence). Based on household income, the level of household economic vulnerability was divided into three classes: (1) low vulnerability if household income was greater than IDR 3,500,000 per month; (2) moderate vulnerability if it was between IDR 1,750,000 and IDR 3,500,000 per month, (3) high vulnerability if it was IDR 1,750,000 per month or less.

Based on the per capita income, the household economic vulnerability was divided into 3 classes, namely: (1) low vulnerability if per capita income was greater than IDR 750,000 (≈ USD 48) per month; (2) moderate vulnerability if it was between IDR 370,000 (≈ USD 24) and IDR 750,000 per month; and (3) high vulnerability if it was IDR 370,000 per month or less.

Household expenditure per month was also divided into three classes: (1) low vulnerability if expenditure was greater than IDR 1,500,000 (≈ USD 96) per month; (2) medium vulnerability if it was between IDR 1,000,000 (≈ USD 64) and IDR 1,500,000 per month; and (3) high vulnerability if it was IDR 1,000,000 per month or less.

Based on business land ownership, household economic vulnerability was also divided into three classes: (1) low vulnerability if business land ownership was larger than 1.0 ha; (2) moderate vulnerability if it was between 0.5 and 1.0 ha; and (3) high vulnerability if it was 0.5 ha or less [23,24].

The condition of housing was also divided into three classes: (1) low vulnerability if permanent housing; (2) moderate vulnerability if semi-permanent housing; and (3) high vulnerability if emergency housing.

2.3.3. Livelihood Vulnerability

A household's livelihood vulnerability [28] was measured using scores for four indicators of livelihoods applied to the household head and/or household members: (1) the main type of livelihood of the household head; (2) the length of time (in months) the household head worked in a year; (3) the education level of the household head; and (4) the number of household members who were working.

Respondents were divided into three groups: (1) farmers, fishers, and laborers as a group with a high level of vulnerability due to the seasonal nature of their livelihoods; (2) planters, traders, and entrepreneurs as a group with a moderate level of vulnerability; and (3) employers/employees as a group with a low level of vulnerability.

The working period of the head of the household in a year (in months) was also grouped in three classes: (1) working up to 4 months was categorized as high

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vulnerability; (2) working 5 to 8 months was categorized as moderate vulnerability; and (3) working 9 to 12 months as low vulnerability.

The education level of the head of the household was divided into three groups: (1) primary school education was categorized as having high vulnerability; (2) secondary school education was moderate vulnerability; and (3) undergraduate education was low vulnerability.

The number of working household members (other than the head of the household) was also grouped into three: (1) if there were no working household members, household vulnerability was categorized as high; (2) if there was one working household member, vulnerability was moderate; and (3) if there were two or more working household members, it was categorized as low vulnerability.

2.3.4. Ecological Vulnerability

Ecological vulnerability is a condition in which a household is in a state of vulnerability, as shown by several indicators registering negative changes (damage or deterioration) in ecosystem components, including land, water, plantations, and the availability of NTFPs [29,30]. The damage or deterioration of ecosystem components was measured based on the opinion of the respondents, using the following criteria: (1) if there was no change or slight damage to land, water, or crops, then the ecological vulnerability was categorized as low; (2) if there was moderate damage, then it was categorized as moderate; and (3) if there was severe damage, then it was categorized as high.

In terms of changes in resource availability, the level of ecological vulnerability was measured using the following criteria: (1) if the availability of resources was constant, then ecological vulnerability was considered to be low; (2) if resource availability was reduced, it was moderate; and (3) if resource availability was very highly reduced, then it was considered to be highly vulnerable.

2.3.5. Climate Change Vulnerability

Climate change vulnerability is measured by the impact of climate change on people's livelihoods [31,32]. In our study, we measured two types of climate change impacts (drought and floods) and four types of community livelihoods (agriculture, plantation, animal husbandry, and forestry) resulting in eight climate change indicators. We measured based on community respondents' observations of changes that had occurred: (1) if there was no change or a slight change/impact, then it was categorized as low; (2) if there was a moderate level of change, then it was categorized as moderate; and (3) if there were severe changes, it was categorized as high vulnerability.

3. Results

3.1. Social Vulnerability

Considering the "number of household members" and "number of children under 5 and the elderly" indicators, results showed that most of the sample households in the three PHUs were at a moderate level of social vulnerability.

Based on the "poor" indicator, the majority of sample households in PHU Sungai Sebumbung–Sungai Batok and PHU Sungai Sugihan–Sungai Lumpur were at a low level of social vulnerability, while in PHU Sungai Saleh–Sungai Sugihan, the distribution of low and high levels of social vulnerability was the same (Table 1).

Table 1. Results of social vulnerability measurement.

No.	Indicator	Level of Social Vulnerability (%)			Average Score
		Low	Medium	High	
PHU S. Sebumbung–S. Batok					

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1	Number of household members	10.0	48.0	42.0	2.32
2	Number of toddlers and elderly	49.0	48.0	3.0	1.54
3	Resident status	87.0	0	13.0	1.26
4	Length of stay	47.0	47.0	6.0	1.59
5	Poverty status	80.0	0	20.0	1.40
	Total score (interval 5–15)				8.11
	PHU S. Saleh–S. Sugihan				
1	Number of household members	5.0	64.0	31.0	2.26
2	Number of toddlers and elderly	25.0	63.0	12.0	1.87
3	Resident status	49.0	46.0	5.0	1.56
4	Length of stay	95.0	0.0	5.0	1.10
5	Poverty status	49.0	0.0	51.0	2.02
	Total score (interval 5–15)				8.81
	PHU S. Sugihan–S. Lumpur				
1	Number of household members	9.0	81.0	10.0	2.01
2	Number of toddlers and elderly	47.0	47.0	6.0	1.59
3	Resident status	0.0	84.0	16.0	2.16
4	Length of stay	35.0	0.0	65.0	2.30
5	Poverty status	80.0	0.0	20.0	1.40
	Total score (interval 5–15)				9.46
	Average score for all PHUs				8.79

When compared among the three PHUs, the highest social vulnerability score was observed for PHU Sungai Sugihan–Sungai Lumpur, while the lowest vulnerability was observed for PHU Sungai Sebumbung–Sungai Batok. Differences in social vulnerability among the three PHUs were observed mainly for the indicators "length of stay" and "residential status". In terms of the indicators "number of household members" and the "number of children under five and the elderly", there were no significant differences among the three PHUs (Figure 2).

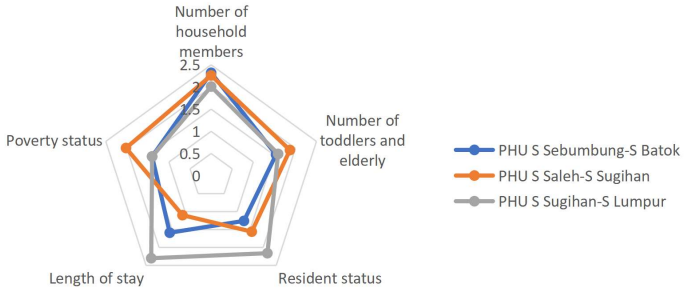

Figure 2. Social vulnerability score based on indicators.

3.2. Economic Vulnerability

Considering "household income", "per capita income", and "household expenditure" indicators, results show that economic vulnerability is relatively even in PHU Sungai Sebumbung–Sungai Batok. In PHU Sungai Saleh–Sungai Sugihan, the

percentage of high vulnerability is greater than that of medium and low vulnerability. In PHU Sungai Sugihan–Sungai Lumpur, based on household income indicators, most households are at a high level of vulnerability (Table 2).

Table 2. Results of economic vulnerability measurement.

No.	Indicator	Level of Economic Vulnerability (%)			Average Score
		Low	Medium	High	
PHU S. Sebumbung–S. Batok					
1	Household income	330	34.0	33.3	2.00
2	Income per capita	32.0	36.0	32.0	2.00
3	Household expenses	27.0	41.0	32.0	2.05
4	Land ownership	12.0	53.0	35.0	2.23
5	Home conditions	53.0	44.0	3.0	1.50
Total score (interval 5–15)					9.78
PHU S. Saleh–S. Sugihan					
1	Household income	22.0	33.0	45.0	2.23
2	Income per capita	22.0	33.0	45.0	2.23
3	Household expenses	24.0	31.0	45.0	2.21
4	Land ownership	9.0	28.0	63.0	2.54
5	Home conditions	24.0	73.0	3.0	1.79
Total score (interval 5–15)					11.00
PHU S. Sugihan–S. Lumpur					
1	Household income	29.0	0.0	71.0	2.42
2	Income per capita	32.0	36.0	32.0	2.00
3	Household expenses	22.0	45.0	33.0	2.11
4	Land ownership	32.0	35.0	33.0	2.01
5	Home conditions	62.0	27.0	11.0	1.49
Total score (interval 5–15)					10.03
Average score for all PHUs					10.27

When compared among the three PHUs, the highest economic vulnerability score was observed for PHU Sungai Saleh–Sungai Sugihan. The difference in economic vulnerability scores between PHU Sungai Sugihan–Sungai Lumpur and PHU Sungai Sebumbung–Sungai Batok was not significant. The difference in economic vulnerability scores between PHU Sungai Saleh–Sungai Sugihan and the other two PHUs was mainly found in the land ownership and home conditions indicators (Figure 3).

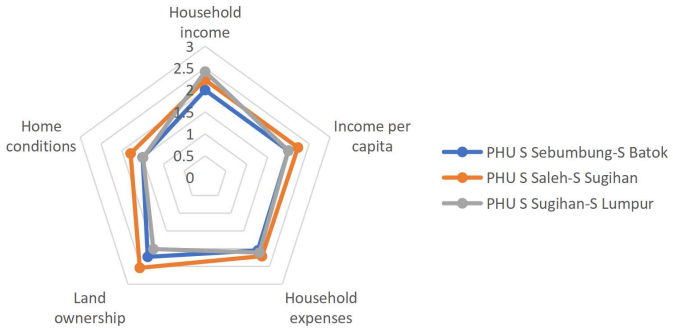

Figure 3. Economic vulnerability score based on indicators.

3.3. Livelihood Vulnerability

Considering the "household head's main occupation" indicator, results show that livelihood vulnerability level was high in the three PHUs, especially in PHU Sungai Saleh–Sungai Sugihan.

The level of livelihood vulnerability in the three PHUs is also high based on the "household head's education" indicator, especially in PHU Sungai Saleh–Sungai Sugihan.

However, the level of livelihood vulnerability in PHU Sungai Saleh–Sungai Sugihan based on "the amount of working months" and "the number of working household members" indicators is the lowest among the three PHUs (Table 3).

Table 3. Results of livelihood vulnerability measurement.

No.	Indicator	Level of Livelihood Vulnerability (%)			Average Score
		Low	Medium	High	
	PHU S. Sebumbung–S. Batok				
1	Household head's main occupation	2.0	44.0	54.0	2.52
2	Number of working months in a year	8.0	55.0	37.0	2.29
3	Household head's education	2.0	40.0	58.0	2.56
4	Number of working household members	28.0	39.0	33.0	2.05
	Total score (interval 4–12)				9.42
	PHU S. Saleh–S. Sugihan				
1	Household head's main occupation	3.0	1.0	96.0	2.93
2	Number of working months in a year	100.0	0.0	0.0	1.00
3	Household head's education	4.0	23.0	73.0	2.69
4	Number of working household members	72.0	28.0	0.0	1.28
	Total score (interval 4–12)				7.90
	PHU S. Sugihan–S. Lumpur				
1	Household head's main occupation	0.0	45.0	55.0	2.55
2	Number of working months in a	51.0	42.0	7.0	1.56

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	year				
3	Household head's education	3.0	38.0	59.0	2.56
4	Number of working household members	38.0	62.0	0.0	1.62
	Total score (interval 4–12)				7.29
	Average score for all PHUs				8.20

When compared among the three PHUs, the highest livelihood vulnerability score was observed for PHU Sungai Sebumbung–Sungai Batok. Between PHU Sungai Saleh–Sungai Sugihan and PHU Sungai Sugihan–Sungai Lumpur, the level of livelihood vulnerability was only slightly different. PHU Sungai Saleh–Sungai Sugihan had the lowest livelihood vulnerability score among the three PHUs. Differences in livelihood vulnerability between the three PHUs are mainly found in "the number of working household members" and "the number of working months" indicators (Figure 4).

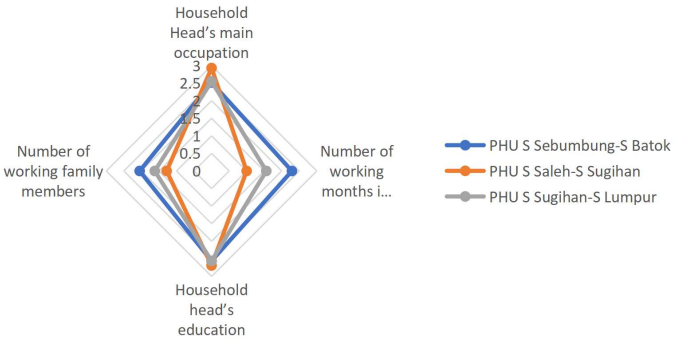

Figure 4. Livelihood vulnerability score based on indicators.

3.4. Ecological Vulnerability

Considering the "damage to soil", the "damage to water", and the "damage to cultivation" indicators, results show that the ecological vulnerability in the three PHUs is relatively low. The indicator of ecological vulnerability is considered moderate based on the availability of NTFPs, especially in PHU Sungai Saleh–Sungai Sugihan and PHU Sungai Sugihan–Sungai Lumpur (Table 4).

Table 4. Results of ecological vulnerability measurement.

No.	Indicator	Level of Ecological Vulnerability (%)			Average Score
		Low	Medium	High	
	PHU S. Sebumbung–S. Batok				
1	Damage to soil	85.0	6.0	9.0	1.24
2	Damage to water	90.0	6.0	4.0	1.14
3	Damage to cultivation	98.0	2.0	0.0	1.02
4	Availability of non-timber forest products	59.0	41.0	0.0	1.41
	Total score (interval 4–12)				4.81
	PHU S. Saleh–S. Sugihan				

1	Damage to soil	65.0	24.0	11.0	1.46
2	Damage to water	69.0	19.0	12.0	1.43
3	Damage to cultivation	59.0	17.0	24.0	1.65
4	Availability of non-timber forest products	11.0	60.0	29.0	2.18
	Total score (interval 4–12)				6.72
	PHU S. Sugihan–S. Lumpur				
1	Damage to soil	93.0	4.0	3.0	1.10
2	Damage to water	92.0	7.0	1.0	1.09
3	Damage to cultivation	87.0	12.0	1.0	1.14
4	Availability of non-timber forest products	28.0	67.0	5.0	1.77
	Total score (interval 4–12)				5.10
	Average score for all PHUs				5.54

When compared among the three PHUs, the highest ecological vulnerability score was observed for PHU Sungai Saleh–Sungai Sugihan and the lowest ecological vulnerability was observed for PHU Sungai Sebumbung–Sungai Batok. PHU Sungai Saleh–Sungai Sugihan had the highest ecological vulnerability, based on the all four indicators. The four indicators of ecological vulnerability are consistent in ranking the ecological vulnerability of the three PHUs (Figure 5).

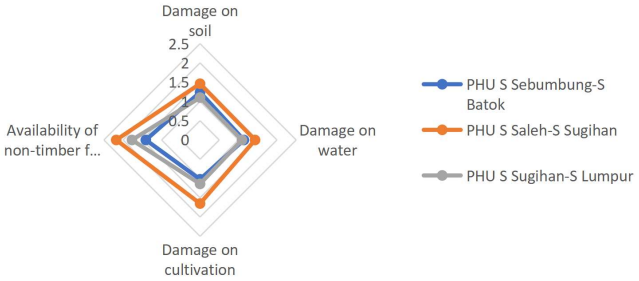

Figure 5. Ecological vulnerability score based on indicators.

3.5. Climate Change Vulnerability

The results show that vulnerability due to climate change in the three PHUs is low, based on all the indicators, except the "flooding in the agricultural sector" and the "drought in the agricultural sector" indicators. Flooding has an impact on the vulnerability of the agricultural sector in PHU Sungai Sebumbung–Sungai Batok, while drought has an impact on the vulnerability of the agricultural sector in PHU Sungai Saleh–Sungai Sugihan (Table 5).

Table 5. Results of climate change vulnerability indicators.

No.	Indicator	Level of Climate Change Vulnerability (%)			Average Score
		Low	Medium	High	
	PHU S. Sebumbung–S. Batok				
1	Drought in crop cultivation	57.0	25.0	18.0	1.61
2	Drought in estate plantation	79.0	11.0	10.0	1.31
3	Drought in aquaculture	74.0	13.0	13.0	1.39

4	Drought in animal husbandry	77.0	9.0	14.0	1.37
5	Flood in crop cultivation	30.0	36.0	34.0	2.04
6	Flood in estate plantation	81.0	8.0	11.0	1.30
7	Flood in aquaculture	78.0	10.0	12.0	1.34
8	Flood in animal husbandry	80.0	9.0	11.0	1.31
	Total score (interval 8–24)				11.67
	PHU S. Saleh–S. Sugihan				
1	Drought in crop cultivation	24.0	20.0	56.0	2.32
2	Drought in estate plantation	50.0	27.0	23.0	1.73
3	Drought in aquaculture	68.0	18.0	14.0	1.46
4	Drought in animal husbandry	83.0	11.0	6.0	1.23
5	Flood in crop cultivation	64.0	18.0	18.0	1.54
6	Flood in estate plantation	92.0	7.0	1.0	1.09
7	Flood in aquaculture	85.0	13.0	2.0	1.17
8	Flood in animal husbandry	95.0	5.0	0.0	1.05
	Total score (interval 8–24)				11.59
	PHU S. Sugihan–S. Lumpur				
1	Drought in crop cultivation	89.0	9.0	2.0	1.13
2	Drought in estate plantation	86.0	12.0	2.0	1.16
3	Drought in aquaculture	89.0	10.0	1.0	1.12
4	Drought in animal husbandry	94.0	5.0	1.0	1.07
5	Flood in crop cultivation	87.0	12.0	1.0	1.14
6	Flood in estate plantation	91.0	9.0	0.0	1.09
7	Flood in aquaculture	93.0	7.0	0.0	1.07
8	Flood in animal husbandry	97.0	3.0	0.0	1.03
	Total score (interval 8–24)				8.81
	Average score all PHUs				10.69

When compared among the three PHUs, the highest climate change vulnerability was observed for PHU Sungai Sebumbung–Sungai Batok, followed by PHU Sungai Saleh–Sungai Sugihan. PHU Sungai Sugihan–Sungai Lumpur has the lowest climate change vulnerability score among the three PHUs. Differences in climate change vulnerability between the three PHUs were mainly found in the "drought for agriculture" and "flood for agriculture" indicators. The influence of drought indicators on plantations only occurs in PHU Sungai Saleh–Sungai Sugihan (Figure 6).

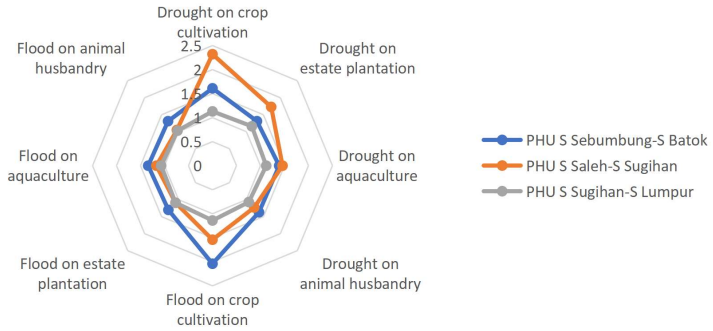

Figure 6. Climate change vulnerability score based on indicators.

4. Discussion

In this study, we measured and analyzed vulnerability in five categories: social, economic, livelihood, ecological, and climate change. First, for social vulnerability, this study showed that among the three PHUs, the highest vulnerability score was observed for PHU Sungai Sugihan–Sungai Lumpur, while the lowest was observed for PHU Sungai Sebumbung–Sungai Batok. The data also show, based on the residency indicator, that the PHU Sungai Sugihan area had the highest social vulnerability level. The results showed that the population domiciled in this area is dominated by indigenous people, with some working as day laborers in large, company-controlled, land concession areas to fulfill their daily needs [33].

Previous research in Banjar Baru, Kalimantan found that social vulnerability was high in a community in an area prone to fire. Overcrowding caused by the large number of household members in an area also leads to greater social vulnerability. Increased public awareness, including an understanding of the causes, and handling of, disasters can help reduce social vulnerability [34]. Overall, in an effort to reduce social vulnerability in a fire-prone area, physical restoration activities, such as canal blocking and canal back-filling, will be useful [2,33].

Second, for economic vulnerability, we found that the highest economic vulnerability score occurred in PHU Sungai Saleh–Sungai Sugihan. Meanwhile, between PHU Sungai Sugihan–Sungai Lumpur and PHU Sungai Sebumbung–Sungai Batok, the difference in the level of economic vulnerability was not great. This finding aligns with the "household income" indicator, in which the residents of PHU Sungai Sugihan–Sungai Lumpur area fall into the highest economic vulnerability category. One of the reasons for this could be because some residents undertake day laboring in concession areas as their main job to meet their daily needs [33].

In areas outside large company concessions, peat restoration activities will be easier to implement because the Government can directly carry out restoration activities in those areas [35,36], unlike the company-controlled concession areas wherein the responsibility for any restoration falls to the company. Nevertheless, restoration indirectly has an impact on the income of farming households in a concession area because an increase in farming household income on peatland has been shown to be strongly influenced by restoration activities [37–39]. However, peatland restoration

activities cannot take place without collaboration and coordination among several related parties [40].

In addition to farmers' household income, the area of land owned by farmers can also determine the degree of economic vulnerability [41], as experienced by farmers' groups in the PHU Sungai Saleh–Sungai Sugihan area where economic vulnerability measured based on the area of land owned was in the highest category. The larger the land area, the higher the net income that will be received by farmers [42,43].

Based on the indicator "household head employment", PHU Sungai Saleh–Sungai Sugihan had high economic vulnerability wherein the head of a household worked as a farmer, fisher, or laborer, occupations that are highly dependent on natural conditions.

In line with the results of this research, natural capital-based livelihood strategies that use existing natural resources combined with agricultural cultivation are the main strategies chosen by the community to sustain their livelihoods [44]. Nevertheless, the use of peatland for agricultural activities has its own challenges, including fires, soil acidity, low fertility, and limited choice of suitable species [45]. Some of these challenges increase the risk of the income of the head of the household being uncertain. To reduce income uncertainties, it is important to have specially designed farming systems and patterns that can provide direct and multiple benefits to the local community.

Agrosilvofishery is an agricultural system that can be applied on peatland to reduce income uncertainties. The system combines different activities, including agriculture (such as agroforestry and small-scale farming), aquaculture (fish farming), and forestry (sustainable timber extraction), to create a multi-functional and sustainable system [46]. Agrosilvofishery is not just an agricultural system; it can also diversify and enhance the various livelihood practices on peatland and has the potential to reduce income uncertainty or risk and improve household welfare and food security through diversifying livelihoods [47,48].

Some countries with peatland areas have implemented integrated approaches such as agrosilvofishery systems more extensively than others. For example, in Bangladesh, agrosilvofishery is promoted to enhance agricultural productivity and rural livelihoods [49–51]. In certain regions of China, agrosilvofishery practices are implemented to improve sustainable land use and enhance agricultural productivity. Examples include integrating aquaculture with wetland agriculture or incorporating fish production in rice fields [52–54]. Agrosilvofishery practices are also promoted in Costa Rica as part of sustainable agricultural systems in which combining agricultural activities with reforestation efforts and fish production is encouraged [55].

Ecological vulnerabilities can be divided into those caused by natural or human factors [56]. However, most of the research on ecological vulnerability in peatland areas has considered only natural factors [57]. Our study considers ecological vulnerability caused by both human and natural factors.

Ecological vulnerability assessment is an effective tool to alleviate contradictions [58]. The different assessment in our study compared with that of others shows the role of human society in changing inherent natural ecological vulnerability [58]. For example, land destruction can occur due to land disturbance in peatland [56]. This can occur naturally due to the El Niño–Indian Ocean Dipole phenomenon or because of humans who deliberately set fires to clear land. One of the impacts of fire is that it can lead to higher acidity levels. This will certainly be very detrimental to farmers because they have to spend more to prepare the land for cultivation [59].

Evaluating ecological vulnerability is significant for protecting and promoting eco-system stability. However, attention to the dimensions of vulnerability and socio-ecological risk is lacking, indicating a large knowledge gap, especially when considering that environmental degradation is considered one of the main causes of natural disaster risk worldwide [60]. As an effort to reduce ecological vulnerability, one of the adaptable frameworks that can be applied is to overcome the driving factors of unwanted ecological changes caused by humans. In addition, to implement effective,

long-term, and sustainable behavioral adaptation, there needs to be a greater emphasis on strategies that are capable of improving human values, skills, and behaviors. In other words, a participatory approach to environmental management could be part of the solution to reduce the percentage of ecological vulnerability [61].

In previous studies, climate change vulnerabilities were measured using indicators such as drought, temperature increase, pests, and land degradation. However, in this study, climate change vulnerability that occurs in four agribusiness sub-sectors—crop cultivation, aquaculture, estate plantation, and animal husbandry—have a low climate change vulnerability category.

Some of the causes of climate change vulnerability, especially in peatlands, include (1) farmers' lack of knowledge and information related to the phenomenon of climate change; (2) weakness of farmers' memory in monitoring climate change; [62] and (3) the fact that climate change does not occur instantly but continuously. If left unaddressed, droughts and floods will have a long-term negative impact, including environmental damage, decreased productivity of agricultural, plantation, fishery and livestock products, and crop failure. This will certainly increase the economic vulnerability of farming households because the damage will reduce farmers' household income, especially that of small-scale and subsistence farmers [63].

There is a need for integration and implementation of climate change adaptation policies in local government operations to reduce the vulnerability of smallholders and increase their ability to absorb, adapt, and transform in the face of climate change [64]. In addition, other forms of adaptation strategies that can be applied by farmers would be using superior seed, adjusting planting patterns and times, and carrying out water management and fish farming techniques that are suitable all-year round [65].

5. Conclusions and Implications

The results of this study led to the following conclusions:

1. Conflicts that often occur in the management of livelihoods on peatland are more related to the use of natural resources and ecological limitations in meeting human needs since the livelihoods of local people were still dependent on the availability of natural resources in the peatland areas and their surrounds.
2. Vulnerability scores vary by the type of vulnerability and PHU. PHU Sungai Sebumbung–Sungai Batok had the highest score for livelihood and climate change vulnerability, but the lowest for social, economic, and ecological vulnerability. PHU Sungai Saleh–Sungai Sugihan had the highest score for economic and ecological vulnerability, but the lowest for livelihood vulnerability. PHU Sungai Sugihan–Sungai Lumpur had the highest score for social vulnerability, but the lowest for climate change vulnerability.
3. The indicators "number of household members" and "number of children under 5 and the elderly" make relatively equal contributions to the social vulnerability score in the three PHUs. All economic indicators except "business land ownership" make relatively equal contributions to the economic vulnerability score in the three PHUs. The indicator "length of time a household works in a year" is an important indicator in determining variations in livelihood vulnerability among the three PHUs. Sungai Saleh–Sungai Sugihan is the PHU with the highest ecological vulnerability score for all vulnerability indicators. The agricultural sector has the highest vulnerability due to the impact of climate change, such as droughts and floods.

The following implications are proposed for mitigating vulnerability before it becomes severe and difficult to tackle:

1. Development of various alternatives of resource-based local livelihoods, such as processing buffalo milk into various products, processing local fish into smoked

and salted fish, processing *purun* (*Eleocharis dulcis*) (in partnership with companies) to improve living standards, and reducing the need for annual burning.
2. Community involvement in resource management and fire prevention is seen as an effective way to prevent forest and peatland fires. This can be implemented through provision of socio-economic incentives to communities for sustainable management of peatland, creating and strengthening local institutions and maintaining regulations for fire management.
3. Provision of social back-up in times of crisis due to land and forest fire.
4. Development of formal institutions to support the processing of local resources into various products, such as buffalo milk products, smoked and salted fish, and *purun*-based products.
5. Development of markets to ensure that economic activities can result in an increase in household income and welfare.
6. Inclusion of alternative strategies that households do or should do in coping with the difficulties caused by land and forest fire based on their past experience.

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

Funding: The APC was funded by the CIFOR-ICRAF.

Data Availability Statement: The data that support the findings in this article are not publicly available, but may be made available upon request to corresponding author.

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

References

1. Page, S.; Mishra, S.; Agus, F.; Anshari, G.; Dargie, G.; Evers, S.; Jauhiainen, J.; Jaya, A.; Jovani-Sancho, A.J.; Laurén, A.; et al. Anthropogenic Impacts on Lowland Tropical Peatland Biogeochemistry. *Nat. Rev. Earth Environ.* **2022**, *3*, 426–443. https://doi.org/10.1038/s43017-022-00289-6.
2. Ward, C.; Stringer, L.C.; Warren-Thomas, E.; Agus, F.; Hamer, K.; Pettorelli, N.; Hariyadi, B.; Hodgson, J.; Kartika, W.D.; Lucey, J. Wading through the Swamp: What Does Tropical Peatland Restoration Mean to National-level Stakeholders in Indonesia? *Restor. Ecol.* **2020**, *28*, 817–827.
3. Syahza, A.; Bakce, D.; Nasrul, B.; Irianti, M. Peatland Policy and Management Strategy to Support Sustainable Development in Indonesia. *J. Phys. Conf. Ser.* **2020**, *1655*, 012151.
4. Yang, G.; Peng, C.; Chen, H.; Dong, F.; Wu, N.; Yang, Y.; Zhang, Y.; Zhu, D.; He, Y.; Shi, S. Qinghai–Tibetan Plateau Peatland Sustainable Utilization under Anthropogenic Disturbances and Climate Change. *Ecosyst. Health Sustain.* **2017**, *3*, e01263.
5. Yeny, I.; Garsetiasih, R.; Suharti, S.; Gunawan, H.; Sawitri, R.; Karlina, E.; Narendra, B.H.; Surati; Ekawati, S.; Djaenudin, D.; et al. Examining the Socio-Economic and Natural Resource Risks of Food Estate Development on Peatlands: A Strategy for Economic Recovery and Natural Resource Sustainability. *Sustainability* **2022**, *14*, 3961. https://doi.org/10.3390/su14073961.
6. Global Forest Watch Indonesia Primary Forest Loss, 2002–2022. https://www.globalforestwatch.org/dashboards/country/IDN/
7. World Wide Fund for Nature (WWF) Fire, Forest and The Future: A Crisis Raging Out of Control? 2020. https://wwf.panda.org/wwf_news/?661151/fires2020report
8. World Bank. *The Cost of Fire*; World Bank: Washington, DC, USA, 2016.
9. Departemen Kehutanan Badan Planologi Kehutanan Rekalkulasi Penutupan Lahan Indonesia Tahun 2005; Jakarta, 2005. https://muspera.menlhk.go.id/Perpus_search/detail/17846
10. International Strategy for Disaster Reduction of The United Nation. Living with Risk: A Global Review of Disaster Reduction Initiatives. 2004 Version Volume 1. https://www.unisdr.org/files/657_lwr1.pdf
11. Herawaty, H.; Santoso, H. Pengarus-tamaan Adaptasi Perubahan Iklim Ke Dalam Agenda Pembangunan: Tantangan Kebijakan Dan Pembangunan. Adaptasi Terhadap Bahaya Gerakan Tanah Di Masa Yang Akan Datang Akibat Pengaruh Perubahan Iklim 2006. Dialog Gerakan Tanah dan Perubahan Iklim, 7-8 Desember 2006. Bogor: CIFOR. 11, 1.
12. Füssel, H.-M.; Klein, R.J.T. Climate Change Vulnerability Assessments: An Evolution of Conceptual Thinking. *Clim. Chang.* **2006**, *75*, 301–329.

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13. IPCC Third Assessment Report of the Intergovernmental Panel on Climate Change IPCC (WG I & II) 2001. https://www.ipcc.ch/assessment-report/ar3/
14. Griggs, D.J.; Noguer, M. Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change. *Weather* **2002**, *57*, 267–269.
15. Dockendorff, C.; Fuss, S.; Agra, R.; Guye, V.; Herrera, D.; Kraxner, F. Committed to Restoring Tropical Forests: An Overview of Brazil's and Indonesia's Restoration Targets and Policies. *Environ. Res. Lett.* **2022**, *17*, 093002. https://doi.org/10.1088/1748-9326/ac8ab2.
16. Bappeda Kota Semarang. Pedoman Penyusunan Rencana Aksi Daerah (RAD) Pengurangan Risiko Bencana (PRB) Bagi Kabupaten. 2008.
17. Labadi, S.; Giliberto, F.; Rosetti, I.; Shetabi, L.; Yildirim, E. Heritage and the Sustainable Development Goals: Policy Guidance for Heritage and Development Actors. ICOMOS 134p. ISBN 978-2-918086-87-1. 2021. https://openarchive.icomos.org/id/eprint/2453/
18. Roka, K. Community-Based Natural Resources Management. In *Life on Land*; Leal Filho, W., Azul, A.M., Brandli, L., Lange Salvia, A., Wall, T., Eds.; Springer International Publishing: Cham, Switzerland, 2021; pp. 161–174, ISBN 978-3-319-95981-8.
19. Ziegler, R.; Wichtmann, W.; Abel, S.; Kemp, R.; Simard, M.; Joosten, H. Wet Peatland Utilisation for Climate Protection—An International Survey of Paludiculture Innovation. *Clean. Eng. Technol.* **2021**, *5*, 100305. https://doi.org/10.1016/j.clet.2021.100305.
20. Fatemi, F.; Ardalan, A.; Aguirre, B.; Mansouri, N.; Mohammadfam, I. Social Vulnerability Indicators in Disasters: Findings from a Systematic Review. *Int. J. Disaster Risk Reduct.* **2017**, *22*, 219–227.
21. Defiesta, G.; Rapera, C. Measuring Adaptive Capacity of Farmers to Climate Change and Variability: Application of a Composite Index to an Agricultural Community in the Philippines. *J. Environ. Sci. Manag.* **2014**, *17* (2):48-62. https://doi.org/10.47125/jesam/2014_2/05.
22. Naz, L.; Patel, K.K.; Dilanchiev, A. Are Socioeconomic Status and Type of Residence Critical Risk Factors of Under-Five Mortality in Pakistan? Evidence from Nationally Representative Survey. *Clin. Epidemiol. Glob. Health* **2021**, *10*, 100670.
23. Cohen, D.A.; Talarowski, M.; Han, B.; Williamson, S.; Galfond, E.; Young, D.R.; Eng, S.; McKenzie, T.L. Playground Design: Contribution to Duration of Stay and Implications for Physical Activity. *Int. J. Environ. Res. Public Health* **2023**, *20*, 4661.
24. Adger, W.N. Indicators of Social and Economic Vulnerability to Climate Change in Vietnam. *Cserge Gec Working Paper* **1998**.
25. Adger, W.N. Indicators of Social and Economic Vulnerability to Climate Change in Vietnam. *Cserge Gec Working Paper* **1998** p.1-39. ISSN 0967-8875. https://www.researchgate.net/profile/W-Adger/publication/237292216_INDICATORS_OF_SOCIAL_AND_ECONOMIC_VULNERABILITY_TO_CLIMATE_CHANGE_IN_VIETNAM/links/0c9605300fc078a925000000/INDICATORS-OF-SOCIAL-AND-ECONOMIC-VULNERABILITY-TO-CLIMATE-CHANGE-IN-VIETNAM.pdf
26. Purnawan, E.; Brunori, G.; Prosperi, P. Small household Farms; a Perspective from Indonesia, Challenges and Investment. *No. Dec* 2020. DOI:10.13140/RG.2.2.29704.03849.
27. Jayne, T.S.; Yamano, T.; Weber, M.T.; Tschirley, D.; Benfica, R.; Chapoto, A.; Zulu, B. Smallholder Income and Land Distribution in Africa: Implications for Poverty Reduction Strategies. *Food Policy* **2003**, *28*, 253–275.
28. Huong, N.T.L.; Yao, S.; Fahad, S. Assessing Household Livelihood Vulnerability to Climate Change: The Case of Northwest Vietnam. *Hum. Ecol. Risk Assess. Int. J.* **2019**, *25*, 1157–1175.
29. Roy, B.; Lourenço, T.C.; Lisboa, F.; Penha-Lopes, G.; Santos, F.D. Impacts of Climate and Land Use Change on Surface Water Content and Quality in Low-Lying Coastal Areas of Bangladesh. In *Handbook of Climate Change Management: Research, Leadership, Transformation*; Springer: Berlin/Heidelberg, Germany, 2021; pp. 1–28.
30. Rajesh, S.; Jain, S.; Sharma, P. Inherent Vulnerability Assessment of Rural Households Based on Socio-Economic Indicators Using Categorical Principal Component Analysis: A Case Study of Kimsar Region, Uttarakhand. *Ecol. Indic.* **2018**, *85*, 93–104.
31. Afjal Hossain, M.; Imran Reza, M.; Rahman, S.; Kayes, I. Climate Change and Its Impacts on the Livelihoods of the Vulnerable People in the Southwestern Coastal Zone in Bangladesh. In *Climate Change and the Sustainable Use of Water Resources*; Springer: Berlin/Heidelberg, Germany, 2012; pp. 237–259.
32. Poudel, S.; Funakawa, S.; Shinjo, H.; Mishra, B. Understanding Households' Livelihood Vulnerability to Climate Change in the Lamjung District of Nepal. *Environ. Dev. Sustain.* **2020**, *22*, 8159–8182.
33. Budiman, I.; Hapsari, R.D.; Wijaya, C.I.; Sari, E.N.N. *The Governance of Risk Management on Peatland: A Case Study of Restoration in South Sumatra, Indonesia*; World Resources Institute: Washington, DC, USA, 2021. https://doi.org/10.46830/wriwp.20.00008.
34. Arisanty, D.; Zaenal, M.; Anis, A.; Porda, H.; Putro, N.; Hastuti, K.P.; Angriani, P. *Social Vulnerability of Land Fires in Banjarbaru*; 2021. https://doi.org/10.2991/assehr.k.210222.042
35. Wicaksono, A. Zainal Peatlands Restoration Policies in Indonesia: Success or Failure? *IOP Conf. Ser. Earth Environ. Sci.* **2022**, *995*, 012068. https://doi.org/10.1088/1755-1315/995/1/012068.
36. Saputra, E. Beyond Fires and Deforestation: Tackling Land Subsidence in Peatland Areas, A Case Study from Riau, Indonesia. *Land* **2019**, *8*, 76. https://doi.org/10.3390/land8050076.
37. Sheng, W.; Zhen, L.; Xiao, Y.; Hu, Y. Ecological and Socioeconomic Effects of Ecological Restoration in China's Three Rivers Source Region. *Sci. Total Environ.* **2019**, *650*, 2307–2313. https://doi.org/10.1016/j.scitotenv.2018.09.265.
38. Wang, J.; Liu, Y.; Li, Y. Ecological Restoration under Rural Restructuring: A Case Study of Yan'an in China's Loess Plateau. *Land Use Policy* **2019**, *87*, 104087.

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39. Urzedo, D.I.d.; Piña-Rodrigues, F.C.M.; Feltran-Barbieri, R.; Junqueira, R.G.P.; Fisher, R. Seed Networks for Upscaling Forest Landscape Restoration: Is It Possible to Expand Native Plant Sources in Brazil? *Forests* **2020**, *11*, 259.
40. Pratama, I.; Purnomo, E.P.; Mutiaran, D.; Adrian, M.M.; Sundari, C. Creating Peatland Restoration Policy for Supporting in Indonesian Economic in a Sustainable Way. *IOP Conf. Ser. Earth Environ. Sci.* **2022**, *1111*, 012004. https://doi.org/10.1088/1755-1315/1111/1/012004.
41. Fahad, S.; Wang, J. Climate Change, Vulnerability, and Its Impacts in Rural Pakistan: A Review. *Environ. Sci. Pollut. Res.* **2020**, *27*, 1334–1338. https://doi.org/10.1007/s11356-019-06878-1.
42. Clough, Y.; Kirchweger, S.; Kantelhardt, J. Field Sizes and the Future of Farmland Biodiversity in European Landscapes. *Conserv. Lett.* **2020**, *13*, e12752.
43. Ren, C.; Liu, S.; van Grinsven, H.; Reis, S.; Jin, S.; Liu, H.; Gu, B. The Impact of Farm Size on Agricultural Sustainability. *J. Clean. Prod.* **2019**, *220*, 357–367. https://doi.org/10.1016/j.jclepro.2019.02.151.
44. Ulya, N.A.; Waluyo, E.A.; Nurlia, A.; Rahmat, M.; Martin, E. Alternative Natural Capital-Based Livelihoods in Facing Peatland Degradation in Rengas Merah Hamlet, Ogan Komering Ilir Regency, Indonesia: A Financial Analysis Approach. *IOP Conf. Ser. Earth Environ. Sci.* **2021**, *917*, 012017. https://doi.org/10.1088/1755-1315/917/1/012017.
45. Sakuntaladewi, N.; Rachmanadi, D.; Mendham, D.; Yuwati, T.W.; Winarno, B.; Premono, B.T.; Lestari, S.; Ardhana, A.; Ramawati; Budiningsih, K. Can We Simultaneously Restore Peatlands and Improve Livelihoods? Exploring Community Home Yard Innovations in Utilizing Degraded Peatland. *Land* **2022**, *11*, 150.
46. Alam, S.; Nurhidayah, L.; Lim, M. Towards a Transnational Approach to Transboundary Haze Pollution: Governing Traditional Farming in Fire-Prone Regions of Indonesia. *Transnatl. Environ. Law* **2023**, *12*, 424–450. https://doi.org/10.1017/S2047102522000450.
47. Girkin, N.T.; Cooper, H.V.; Ledger, M.J.; O'Reilly, P.; Thornton, S.A.; Åkesson, C.M.; Cole, L.E.S.; Hapsari, K.A.; Hawthorne, D.; Roucoux, K.H. Tropical Peatlands in the Anthropocene: The Present and the Future. *Anthropocene* **2022**, *40*, 100354. https://doi.org/10.1016/j.ancene.2022.100354.
48. Indrajaya, Y.; Yuwati, T.W.; Lestari, S.; Winarno, B.; Narendra, B.H.; Nugroho, H.Y.S.H.; Rachmanadi, D.; Pratiwi, P.; Turjaman, M.H.; Adi, R.N.; et al. Tropical Forest Landscape Restoration in Indonesia: A Review. *Land* **2022**, *11*, 328. https://doi.org/10.3390/land11030328.
49. Islam, S.; Ghosh, S.; Podder, M. Fifty Years of Agricultural Development in Bangladesh: A Comparison with India and Pakistan. *SN Bus. Econ.* **2022**, *2*, 71. https://doi.org/10.1007/s43546-022-00240-3.
50. Rahman Sunny, A.; Jimi Reza, M.; Anas Chowdhury, M.; Nazmul Hassan, M.; Abdul, M.; Ratul Hasan, M.; Mostafa Monwar, M.; Solaiman Hossain, M.; Mosarof Hossain, M. *Biodiversity Assemblages and Conservation Necessities of Ecologically Sensitive Natural Wetlands of North-Eastern Bangladesh*; 2020; Indian Journal of Geo-Marine Sciences 49(1):135-148. https://www.researchgate.net/publication/333194233_Biodiversity_assemblages_and_conservation_necessities_of_ecologically_sensitive_natural_wetlands_of_north_eastern_Bangladesh
51. Barua, P.; Rahman, S.H.; Barua, M. Sustainable Management of Agriculture Products Value Chain in Responses to Climate Change for South-Eastern Coast of Bangladesh. *Mod. Supply Chain. Res. Appl.* **2021**, *3*, 98–126.
52. Hu, F.; Zhong, H.; Wu, C.; Wang, S.; Guo, Z.; Tao, M.; Zhang, C.; Gong, D.; Gao, X.; Tang, C. Development of Fisheries in China. *Reprod. Breed.* **2021**, *1*, 64–79.
53. Wen, X.; Liu, D.; Qiu, M.; Wang, Y.; Niu, J.; Liu, Y. Estimation of Maize Yield Incorporating the Synergistic Effect of Climatic and Land Use Change in Jilin, China. *J. Geogr. Sci.* **2023**, *33*, 1725–1746. https://doi.org/10.1007/s11442-023-2150-6.
54. Ibrahim, L.A.; Shaghaleh, H.; Abu-Hashim, M.; Elsadek, E.A.; Hamoud, Y.A. Exploring the Integration of Rice and Aquatic Species: Insights from Global and National Experiences. *Water* **2023**, *15*, 2750.
55. Peguero, F.; Zapata, S.; Sandoval, L. Challenges and Opportunities. *Choices* **2019**, *34*, 1–10.
56. Li, H.; Zhu, D.; Cook, M. A Statistical Framework for Consolidating "Sibling" Probe Sets for Affymetrix GeneChip Data. *BMC Genom.* **2008**, *9*, 188. https://doi.org/10.1186/1471-2164-9-188.
57. Ghosh, S.; Das, A. Urban Expansion Induced Vulnerability Assessment of East Kolkata Wetland Using Fuzzy MCDM Method. *Remote Sens. Appl.* **2019**, *13*, 191–203. https://doi.org/10.1016/j.rsase.2018.10.014.
58. Hu, X.; Ma, C.; Huang, P.; Guo, X. Ecological Vulnerability Assessment Based on AHP-PSR Method and Analysis of Its Single Parameter Sensitivity and Spatial Autocorrelation for Ecological Protection—A Case of Weifang City, China. *Ecol. Indic.* **2021**, *125*, 107464. https://doi.org/10.1016/j.ecolind.2021.107464.
59. Coulibaly, B.; Li, S. Impact of Agricultural Land Loss on Rural Livelihoods in Peri-Urban Areas: Empirical Evidence from Sebougou, Mali. *Land* **2020**, *9*, 470.
60. Depietri, Y. The Social–Ecological Dimension of Vulnerability and Risk to Natural Hazards. *Sustain. Sci.* **2020**, *15*, 587–604. https://doi.org/10.1007/s11625-019-00710-y.
61. Eriksen, S.; Schipper, E.L.F.; Scoville-Simonds, M.; Vincent, K.; Adam, H.N.; Brooks, N.; Harding, B.; Khatri, D.; Lenaerts, L.; Liverman, D.; et al. Adaptation Interventions and Their Effect on Vulnerability in Developing Countries: Help, Hindrance or Irrelevance? *World Dev.* **2021**, *141*, 105383. https://doi.org/10.1016/j.worlddev.2020.105383.
62. Ricart, S.; Castelletti, A.; Gandolfi, C. On Farmers' Perceptions of Climate Change and Its Nexus with Climate Data and Adaptive Capacity. A Comprehensive Review. *Environ. Res. Lett.* **2022**, *17*, 083002. https://doi.org/10.1088/1748-9326/ac810f.
63. Shrestha, R.; Rakhal, B.; Adhikari, T.R.; Ghimire, G.R.; Talchabhadel, R.; Tamang, D.; KC, R.; Sharma, S. Farmers' Perception of Climate Change and Its Impacts on Agriculture. *Hydrology* **2022**, *9*, 212. https://doi.org/10.3390/hydrology9120212.

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64. Twecan, D.; Wang, W.; Xu, J.; Mohmmed, A. Climate Change Vulnerability, Adaptation Measures, and Risk Perceptions at Households Level in Acholi Sub-Region, Northern Uganda. *Land Use Policy* **2022**, *115*, 106011. https://doi.org/10.1016/j.landusepol.2022.106011.
65. Eka Suranny, L.; Gravitiani, E.; Rahardjo, M. Impact of Climate Change on the Agriculture Sector and Its Adaptation Strategies. *IOP Conf. Ser. Earth Environ. Sci.* **2022**, *1016*, 012038. https://doi.org/10.1088/1755-1315/1016/1/012038.

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Article

Farm Household Vulnerability Due to Land and Forest Fire in Peatland Areas in South Sumatra

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Abstract: Land and forest fires in peatland areas in Indonesia have a widespread negative impact on surrounding communities. Possible vulnerabilities relate to economic, social, ecological, livelihoods, and environmental vulnerability. This study aimed to assess household vulnerability due to land and forest fires in peatland areas in Ogan Komering Ilir District in South Sumatra and observe changes in peat ecosystems in those areas. The study was conducted in three peatland hydrological units (PHUs)—(1) PHU Sungai Sugihan–Sungai Lumpur; (2) PHU Sungai Sibumbung–Sungai Batok; and (3) PHU Sungai Saleh–Sungai Sugihan—covering 300 households as samples. Primary data were collected through structured interviews and analyzed descriptively. The analysis revealed the following: (1) PHU Sungai Sibumbung–Sungai Batok had the highest score for livelihood vulnerability and climate change but the lowest score for social, economic, and ecological vulnerability; (2) PHU Sungai Saleh–Sungai Sugihan had the highest score for economic and ecological vulnerability but the lowest score for livelihood vulnerability; (3) PHU Sungai Sugihan–Sungai Lumpur had the highest score for social vulnerability but lowest score for climate change vulnerability; and (4) the number of household members, toddlers, and elderly, and all economic indicators except land ownership, contributed relatively similarly to social vulnerability in all PHUs.

Keywords: ecosystem; social; economic; livelihood; ecological; climate change

Citation: Yazid, M.; Adriani, D.; Riswani; Damayanthy, D. Farm Household Vulnerability Due to Land and Forest Fire in Peatland Areas in South Sumatra. *Land* **2024**, *13*, 642. https://doi.org/10.3390/land13050642

Academic Editor: Richard Smardon

Received: 4 March 2024
Revised: 12 April 2024
Accepted: 21 April 2024
Published: 9 May 2024

1. Introduction

Peatland is a unique ecosystem in terms of structure and function, with high vulnerability to disturbance [1–4]. Currently, most of the peatland and forests in Indonesia experience severe damage as a result of human activities that pay little attention to environmental issues. Land and forest fires in peatland areas have caused various conflicts with extensive negative impacts—technically, ecologically, economically, socially, and culturally [5]—such as (1) peatland fires caused by misuse, carelessness, and neglect, and intentionally; (2) dry peats formed by creating canals and planting non-peat-friendly plants; (3) damage to peatland; and (4) decreased productivity of peatlands. Such conditions lead to negative economic impacts, such as loss of livelihoods and decreased incomes.

Forest loss in Indonesia has continued to increase since 2002, reaching the highest loss of more than 900,000 ha in 2016 due to the forest fires in 2015 [6]. Much of the forest loss in the period was within areas classified as secondary forest and other land cover (for example, mixed dry land agriculture, estate crop, plantation forest, shrub, and others) [7,8]. Forest loss decreased from then until 2022. However, forest loss in 2022 still reached over 100,000 ha [9].

Vulnerability is determined by physical, social, economic, and environmental factors or processes in a community and by the impact of hazards [10]. Vulnerability is a condition influenced by physical, social, economic, and environmental processes that can increase the risk of the impact of a hazard [11]. In general terms, vulnerability is a condition where the system cannot adjust to the impact of a change [12]. The nature of vulnerability differs

temporally and spatially [13,14]. Vulnerabilities can be divided based on impact, such as those related to economic, social, ecological, livelihood, and environmental aspects. According to [11], vulnerability in a social context is a function of exposure, adaptive capability, and sensitivity. Community vulnerability is a condition in which a community cannot adapt to ecosystem changes caused by a particular threat [15]. From an economic perspective, vulnerability includes population and institutional vulnerability depending on the existence of institutions in the area or the village. Vulnerability factors include the following [16]: (1) physical vulnerability: basic infrastructure, construction, buildings; (2) economic vulnerability: poverty, income, nutrition; (3) social vulnerability: education, health, politics, legal, institutional; and (4) environmental vulnerability: soil, water, plants, forests, oceans.

In addition, vulnerability can also affect the welfare of a community, whereby the greatest impact can be seen from shifting or reducing livelihoods [17,18]. Improving people's livelihoods on peatland through developing business opportunities is important and inherent in the understanding of the vulnerability of the people who do business in and/or around the peat ecosystem who are affected by changes to the ecosystem [19].

This study aims to describe, measure, and analyze the level of vulnerability of farm households due to land and forest fires in peatland areas and observe the changes in ecosystems in those areas in three peatland hydrological units (PHUs) in Ogan Komering Ilir (OKI) District, South Sumatra Province, Indonesia. It is expected that outputs from this research will improve understanding of the levels of social, economic, livelihood, ecological, and climate vulnerability. The study also assists with mapping community conditions based on the distribution of levels of vulnerability and provides indicators for interventions to address vulnerability in the affected areas.

2. Materials and Methods

2.1. Study Sites

OKI District is one of four peat restoration priority districts in South Sumatra. The district includes five PHUs with an estimated area of 1,108,483.41 ha. The names of the five PHUs as the study areas are presented in Figure 1.

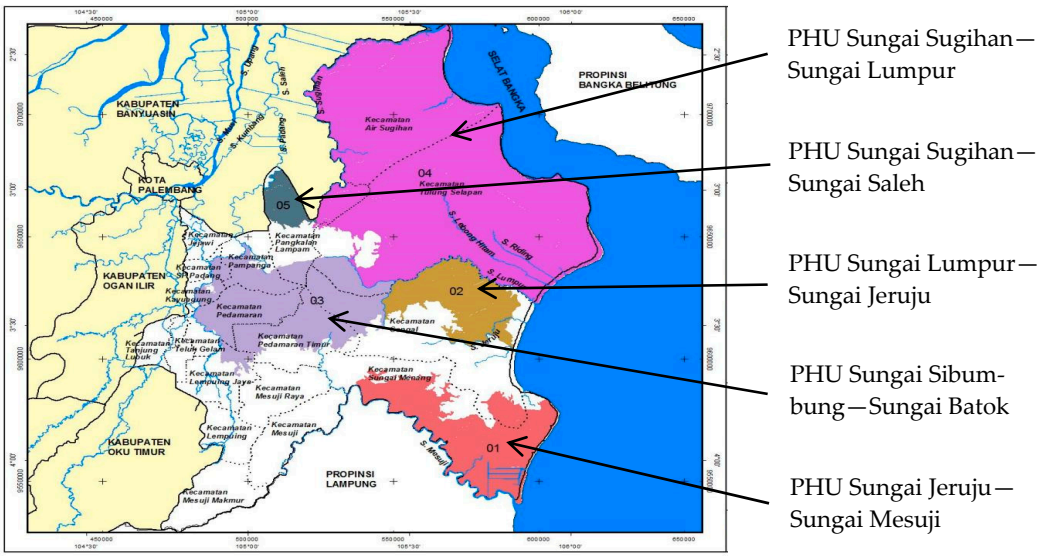

Figure 1. Locations and areas of PHUs in OKI District.

Given the large size of the study area and the large number of affected households, this study was carried out using a household sample survey method and three approaches: (1) PHU approach; (2) administrative area approach; and (3) activity space approach.

2.2. Sampling and Data Collection

Sampling was carried out using a cluster sampling method with three sampling stages: (1) determining the PHU; (2) selecting sub-districts and sample villages; and (3) selecting household samples. The description of the sampling follows.

1. Of the five PHUs in OKI District, three were selected based on the variety of natural resources (including peatland) and the diversity of people's livelihoods: (1) PHU Sungai Sugihan–Sungai Lumpur; (2) PHU Sungai Sibumbung–Sungai Batok; (3) PHU Sungai Saleh–Sungai Sugihan.
2. In each PHU, sub-district and village clusters were determined based on the main livelihood of the population, for example, sub-district and village clusters with the main livelihood of the population being food crop farming (rice, other crops, horticulture), plantation crop clusters (rubber, oil palm, etc.), forest plant clusters and non-timber forest product (NTFP) collection, livestock clusters (swamp buffalo, cows/goats, chickens/ducks), fishery clusters (aquaculture, capture), home industry clusters/small processing industries, service clusters, and others.
3. From each sub-district and village cluster, two sample villages were selected representing the characteristics of the cluster.
4. Stratified random sampling was conducted in each village based on the area of cultivated land (for the livelihoods of crop and estate farming), number of livestock, number of business units (fisheries), production amount (timber collection and NTFPs), ownership of assets (manufacturing industry), etc. The sample characteristics within each livelihood type are quite homogeneous, such that the number of sample households drawn was adjusted to their respective populations.

For households whose main livelihoods were outside the village area, for example, looking for wood and NTFPs, the sampling was carried out in their home area not at their work location. In this case, the spatial mobility of the population was considered in relation to the impact of livelihoods on the peat ecosystem.

Upon random selection, household respondents were then interviewed, which was followed by an in-depth interview as necessary. In addition, field observations were also conducted to confirm the data collected during the interview. Furthermore, focus group discussions (FGDs) were implemented to clarify and triangulate some important and specific findings.

2.3. Data Processing and Measurement of Vulnerability

Data obtained through this study were processed using descriptive analysis, namely, calculating the average sample value (mean, median or mode, and standard deviation). The level of household vulnerability was measured with scores for indicators obtained from the survey. The vulnerability level is presented in tables and graphs for easy interpretation and comparison.

2.3.1. Social Vulnerability

Social vulnerability is a condition in which a household is in a state of vulnerability as shown by several household social indicators [20]. In this study, social vulnerability was measured using scores for five indicators: (1) number of household members [21]; (2) number of children under five (including infants) and elderly in the household [22]; (3) residential status, that is, whether a local resident or a migrant; (4) length of stay; and (5) poverty status [23].

In our study, social vulnerability was divided into three groups. Household vulnerability was categorized as high if there were three or more members aged under 5 and elderly members of one or more; moderate if there were one to two members aged under 5 and elderly members of one or more; and low if there were no children under 5 nor any elderly members. Migrant households were categorized as high vulnerability, while local

residents were rated as low vulnerability since the latter were easily supported by families who lived nearby when facing a vulnerable situation.

In terms of length of residence, household vulnerability was categorized as high if resident for 20 years or less; moderate if resident for up to 40 years; and low if resident for more than 40 years. Likewise, household vulnerability was categorized as high if the household fell into the "poor" group and low if not.

2.3.2. Economic Vulnerability

Economic vulnerability is a condition in which a household is in a state of vulnerability as measured by several indicators [24]. In our study, we used scores for five indicators: (1) household income; (2) household per capita income; (3) household expenditure; (4) business land ownership; and (5) condition of the housing. Household income was estimated using both financial income (e.g., from selling the products) and the products that were self-consumed (subsistence). Based on household income, the level of household economic vulnerability was divided into three classes: (1) low vulnerability if household income was greater than IDR 3,500,000 per month; (2) moderate vulnerability if it was between IDR 1,750,000 and IDR 3,500,000 per month, (3) high vulnerability if it was IDR 1,750,000 per month or less.

Based on the per capita income, the household economic vulnerability was divided into 3 classes, namely: (1) low vulnerability if per capita income was greater than IDR 750,000 (≈USD 48) per month; (2) moderate vulnerability if it was between IDR 370,000 (≈USD 24) and IDR 750,000 per month; and (3) high vulnerability if it was IDR 370,000 per month or less.

Household expenditure per month was also divided into three classes: (1) low vulnerability if expenditure was greater than IDR 1,500,000 (≈USD 96) per month; (2) medium vulnerability if it was between IDR 1,000,000 (≈USD 64) and IDR 1,500,000 per month; and (3) high vulnerability if it was IDR 1,000,000 per month or less.

Based on business land ownership, household economic vulnerability was also divided into three classes: (1) low vulnerability if business land ownership was larger than 1.0 ha; (2) moderate vulnerability if it was between 0.5 and 1.0 ha; and (3) high vulnerability if it was 0.5 ha or less [23,24].

The condition of housing was also divided into three classes: (1) low vulnerability if permanent housing; (2) moderate vulnerability if semi-permanent housing; and (3) high vulnerability if emergency housing.

2.3.3. Livelihood Vulnerability

A household's livelihood vulnerability [25] was measured using scores for four indicators of livelihoods applied to the household head and/or household members: (1) the main type of livelihood of the household head; (2) the length of time (in months) the household head worked in a year; (3) the education level of the household head; and (4) the number of household members who were working.

Respondents were divided into three groups: (1) farmers, fishers, and laborers as a group with a high level of vulnerability due to the seasonal nature of their livelihoods; (2) planters, traders, and entrepreneurs as a group with a moderate level of vulnerability; and (3) employers/employees as a group with a low level of vulnerability.

The working period of the head of the household in a year (in months) was also grouped in three classes: (1) working up to 4 months was categorized as high vulnerability; (2) working 5 to 8 months was categorized as moderate vulnerability; and (3) working 9 to 12 months as low vulnerability.

The education level of the head of the household was divided into three groups: (1) primary school education was categorized as having high vulnerability; (2) secondary school education was moderate vulnerability; and (3) undergraduate education was low vulnerability.

The number of working household members (other than the head of the household) was also grouped into three: (1) if there were no working household members, household

vulnerability was categorized as high; (2) if there was one working household member, vulnerability was moderate; and (3) if there were two or more working household members, it was categorized as low vulnerability.

2.3.4. Ecological Vulnerability

Ecological vulnerability is a condition in which a household is in a state of vulnerability, as shown by several indicators registering negative changes (damage or deterioration) in ecosystem components, including land, water, plantations, and the availability of NTFPs [26,27]. The damage or deterioration of ecosystem components was measured based on the opinion of the respondents, using the following criteria: (1) if there was no change or slight damage to land, water, or crops, then the ecological vulnerability was categorized as low; (2) if there was moderate damage, then it was categorized as moderate; and (3) if there was severe damage, then it was categorized as high.

In terms of changes in resource availability, the level of ecological vulnerability was measured using the following criteria: (1) if the availability of resources was constant, then ecological vulnerability was considered to be low; (2) if resource availability was reduced, it was moderate; and (3) if resource availability was very highly reduced, then it was considered to be highly vulnerable.

2.3.5. Climate Change Vulnerability

Climate change vulnerability is measured by the impact of climate change on people's livelihoods [28,29]. In our study, we measured two types of climate change impacts (drought and floods) and four types of community livelihoods (agriculture, plantation, animal husbandry, and forestry) resulting in eight climate change indicators. We measured based on community respondents' observations of changes that had occurred: (1) if there was no change or a slight change/impact, then it was categorized as low; (2) if there was a moderate level of change, then it was categorized as moderate; and (3) if there were severe changes, it was categorized as high vulnerability.

3. Results

3.1. Social Vulnerability

Considering the "number of household members" and "number of children under 5 and the elderly" indicators, results showed that most of the sample households in the three PHUs were at a moderate level of social vulnerability.

Based on the "poor" indicator, the majority of sample households in PHU Sungai Sebumbung–Sungai Batok and PHU Sungai Sugihan–Sungai Lumpur were at a low level of social vulnerability, while in PHU Sungai Saleh–Sungai Sugihan, the distribution of low and high levels of social vulnerability was the same (Table 1).

Table 1. Results of social vulnerability measurement.

No.	Indicator	Level of Social Vulnerability (%)			Average Score
		Low	Medium	High	
PHU S. Sebumbung–S. Batok					
1	Number of household members	10.0	48.0	42.0	2.32
2	Number of toddlers and elderly	49.0	48.0	3.0	1.54
3	Resident status	87.0	0	13.0	1.26
4	Length of stay	47.0	47.0	6.0	1.59
5	Poverty status	80.0	0	20.0	1.40
Total score (interval 5–15)					8.11

Table 1. *Cont.*

No.	Indicator	Level of Social Vulnerability (%)			Average Score
		Low	Medium	High	
PHU S. Saleh–S. Sugihan					
1	Number of household members	5.0	64.0	31.0	2.26
2	Number of toddlers and elderly	25.0	63.0	12.0	1.87
3	Resident status	49.0	46.0	5.0	1.56
4	Length of stay	95.0	0.0	5.0	1.10
5	Poverty status	49.0	0.0	51.0	2.02
Total score (interval 5–15)					8.81
PHU S. Sugihan–S. Lumpur					
1	Number of household members	9.0	81.0	10.0	2.01
2	Number of toddlers and elderly	47.0	47.0	6.0	1.59
3	Resident status	0.0	84.0	16.0	2.16
4	Length of stay	35.0	0.0	65.0	2.30
5	Poverty status	80.0	0.0	20.0	1.40
Total score (interval 5–15)					9.46
Average score for all PHUs					8.79

When compared among the three PHUs, the highest social vulnerability score was observed for PHU Sungai Sugihan–Sungai Lumpur, while the lowest vulnerability was observed for PHU Sungai Sebumbung–Sungai Batok. Differences in social vulnerability among the three PHUs were observed mainly for the indicators "length of stay" and "residential status". In terms of the indicators "number of household members" and the "number of children under five and the elderly", there were no significant differences among the three PHUs (Figure 2).

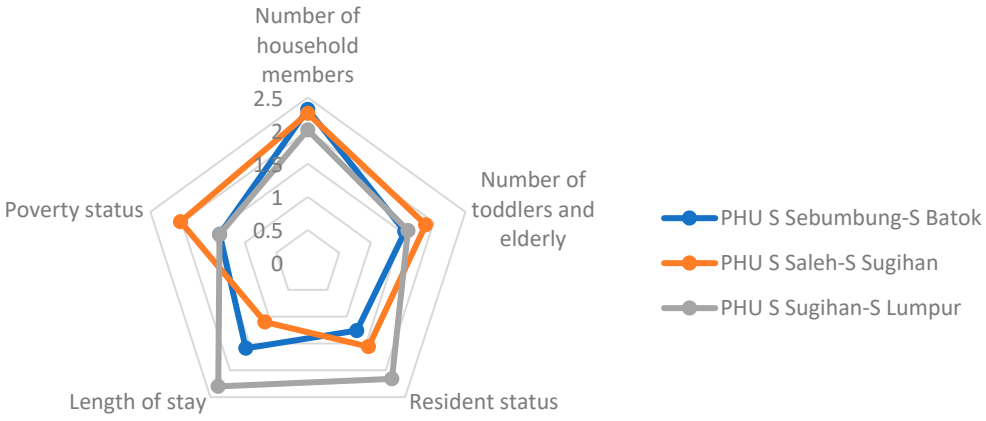

Figure 2. Social vulnerability score based on indicators.

3.2. Economic Vulnerability

Considering "household income", "per capita income", and "household expenditure" indicators, results show that economic vulnerability is relatively even in PHU Sungai Sebumbung–Sungai Batok. In PHU Sungai Saleh–Sungai Sugihan, the percentage of high vulnerability is greater than that of medium and low vulnerability. In PHU Sungai Sugihan–Sungai Lumpur, based on household income indicators, most households are at a high level of vulnerability (Table 2).

Table 2. Results of economic vulnerability measurement.

No.	Indicator	Level of Economic Vulnerability (%)			Average Score
		Low	Medium	High	
PHU S. Sebumbung–S. Batok					
1	Household income	330	34.0	33.3	2.00
2	Income per capita	32.0	36.0	32.0	2.00
3	Household expenses	27.0	41.0	32.0	2.05
4	Land ownership	12.0	53.0	35.0	2.23
5	Home conditions	53.0	44.0	3.0	1.50
Total score (interval 5–15)					9.78
PHU S. Saleh–S. Sugihan					
1	Household income	22.0	33.0	45.0	2.23
2	Income per capita	22.0	33.0	45.0	2.23
3	Household expenses	24.0	31.0	45.0	2.21
4	Land ownership	9.0	28.0	63.0	2.54
5	Home conditions	24.0	73.0	3.0	1.79
Total score (interval 5–15)					11.00
PHU S. Sugihan–S. Lumpur					
1	Household income	29.0	0.0	71.0	2.42
2	Income per capita	32.0	36.0	32.0	2.00
3	Household expenses	22.0	45.0	33.0	2.11
4	Land ownership	32.0	35.0	33.0	2.01
5	Home conditions	62.0	27.0	11.0	1.49
Total score (interval 5–15)					10.03
Average score for all PHUs					10.27

When compared among the three PHUs, the highest economic vulnerability score was observed for PHU Sungai Saleh–Sungai Sugihan. The difference in economic vulnerability scores between PHU Sungai Sugihan–Sungai Lumpur and PHU Sungai Sebumbung–Sungai Batok was not significant. The difference in economic vulnerability scores between PHU Sungai Saleh–Sungai Sugihan and the other two PHUs was mainly found in the land ownership and home conditions indicators (Figure 3).

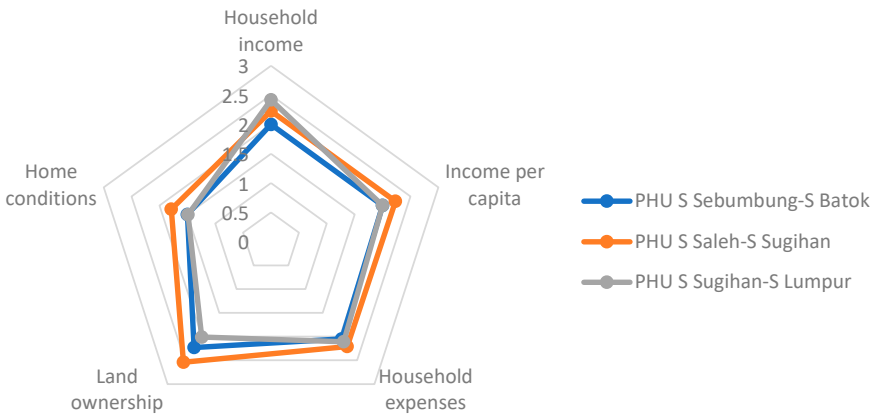

Figure 3. Economic vulnerability score based on indicators.

3.3. Livelihood Vulnerability

Considering the "household head's main occupation" indicator, results show that livelihood vulnerability level was high in the three PHUs, especially in PHU Sungai Saleh–Sungai Sugihan.

The level of livelihood vulnerability in the three PHUs is also high based on the "household head's education" indicator, especially in PHU Sungai Saleh–Sungai Sugihan.

However, the level of livelihood vulnerability in PHU Sungai Saleh–Sungai Sugihan based on "the amount of working months" and "the number of working household members" indicators is the lowest among the three PHUs (Table 3).

Table 3. Results of livelihood vulnerability measurement.

No.	Indicator	Level of Livelihood Vulnerability (%)			Average Score
		Low	Medium	High	
	PHU S. Sebumbung–S. Batok				
1	Household head's main occupation	2.0	44.0	54.0	2.52
2	Number of working months in a year	8.0	55.0	37.0	2.29
3	Household head's education	2.0	40.0	58.0	2.56
4	Number of working household members	28.0	39.0	33.0	2.05
	Total score (interval 4–12)				9.42
	PHU S. Saleh–S. Sugihan				
1	Household head's main occupation	3.0	1.0	96.0	2.93
2	Number of working months in a year	100.0	0.0	0.0	1.00
3	Household head's education	4.0	23.0	73.0	2.69
4	Number of working household members	72.0	28.0	0.0	1.28
	Total score (interval 4–12)				7.90
	PHU S. Sugihan–S. Lumpur				
1	Household head's main occupation	0.0	45.0	55.0	2.55
2	Number of working months in a year	51.0	42.0	7.0	1.56
3	Household head's education	3.0	38.0	59.0	2.56
4	Number of working household members	38.0	62.0	0.0	1.62
	Total score (interval 4–12)				7.29
	Average score for all PHUs				8.20

When compared among the three PHUs, the highest livelihood vulnerability score was observed for PHU Sungai Sebumbung–Sungai Batok. Between PHU Sungai Saleh–Sungai Sugihan and PHU Sungai Sugihan–Sungai Lumpur, the level of livelihood vulnerability was only slightly different. PHU Sungai Saleh–Sungai Sugihan had the lowest livelihood vulnerability score among the three PHUs. Differences in livelihood vulnerability between the three PHUs are mainly found in "the number of working household members" and "the number of working months" indicators (Figure 4).

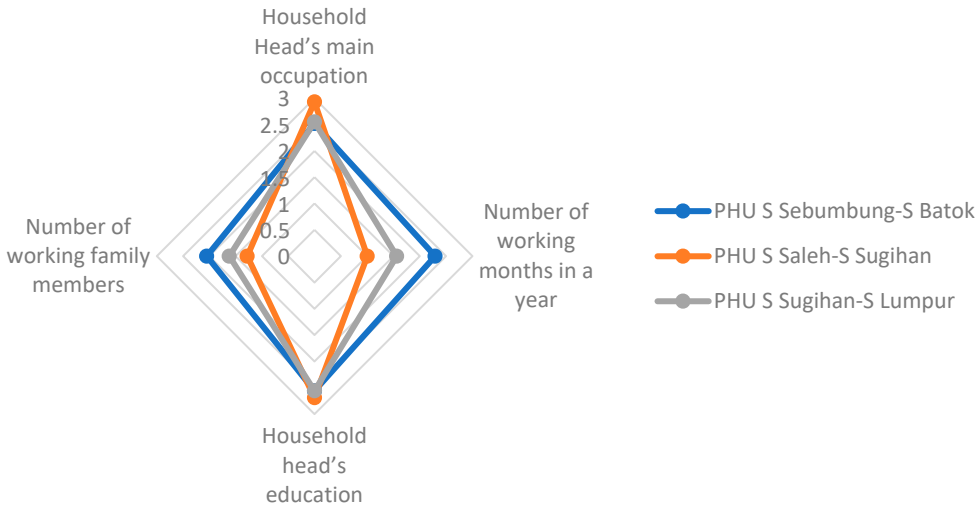

Figure 4. Livelihood vulnerability score based on indicators.

3.4. Ecological Vulnerability

Considering the "damage to soil", the "damage to water", and the "damage to cultivation" indicators, results show that the ecological vulnerability in the three PHUs is relatively low. The indicator of ecological vulnerability is considered moderate based on the availability of NTFPs, especially in PHU Sungai Saleh–Sungai Sugihan and PHU Sungai Sugihan–Sungai Lumpur (Table 4).

Table 4. Results of ecological vulnerability measurement.

No.	Indicator	Level of Ecological Vulnerability (%)			Average Score
		Low	Medium	High	
	PHU S. Sebumbung–S. Batok				
1	Damage to soil	85.0	6.0	9.0	1.24
2	Damage to water	90.0	6.0	4.0	1.14
3	Damage to cultivation	98.0	2.0	0.0	1.02
4	Availability of non-timber forest products	59.0	41.0	0.0	1.41
	Total score (interval 4–12)				4.81
	PHU S. Saleh–S. Sugihan				
1	Damage to soil	65.0	24.0	11.0	1.46
2	Damage to water	69.0	19.0	12.0	1.43
3	Damage to cultivation	59.0	17.0	24.0	1.65
4	Availability of non-timber forest products	11.0	60.0	29.0	2.18
	Total score (interval 4–12)				6.72
	PHU S. Sugihan–S. Lumpur				
1	Damage to soil	93.0	4.0	3.0	1.10
2	Damage to water	92.0	7.0	1.0	1.09
3	Damage to cultivation	87.0	12.0	1.0	1.14
4	Availability of non-timber forest products	28.0	67.0	5.0	1.77
	Total score (interval 4–12)				5.10
	Average score for all PHUs				5.54

When compared among the three PHUs, the highest ecological vulnerability score was observed for PHU Sungai Saleh–Sungai Sugihan and the lowest ecological vulnerability was observed for PHU Sungai Sebumbung–Sungai Batok. PHU Sungai Saleh–Sungai Sugihan had the highest ecological vulnerability, based on the all four indicators. The four indicators of ecological vulnerability are consistent in ranking the ecological vulnerability of the three PHUs (Figure 5).

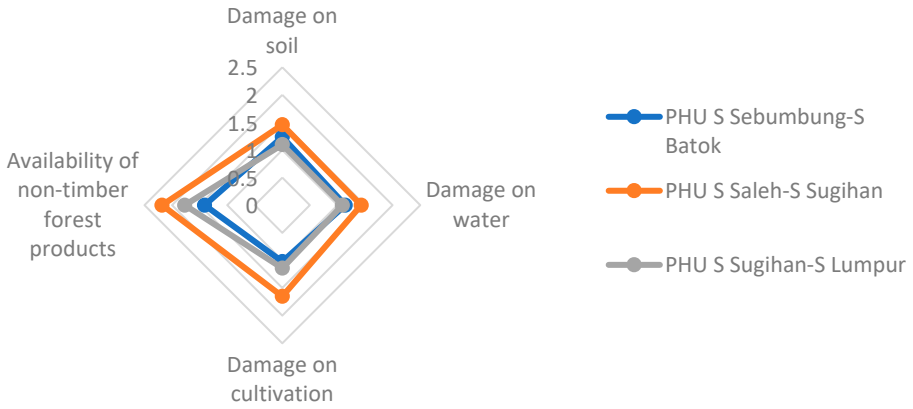

Figure 5. Ecological vulnerability score based on indicators.

3.5. Climate Change Vulnerability

The results show that vulnerability due to climate change in the three PHUs is low, based on all the indicators, except the "flooding in the agricultural sector" and the "drought in the agricultural sector" indicators. Flooding has an impact on the vulnerability of the agricultural sector in PHU Sungai Sebumbung–Sungai Batok, while drought has an impact on the vulnerability of the agricultural sector in PHU Sungai Saleh–Sungai Sugihan (Table 5).

When compared among the three PHUs, the highest climate change vulnerability was observed for PHU Sungai Sebumbung–Sungai Batok, followed by PHU Sungai Saleh–Sungai Sugihan. PHU Sungai Sugihan–Sungai Lumpur has the lowest climate change vulnerability score among the three PHUs. Differences in climate change vulnerability between the three PHUs were mainly found in the "drought for agriculture" and "flood for agriculture" indicators. The influence of drought indicators on plantations only occurs in PHU Sungai Saleh–Sungai Sugihan (Figure 6).

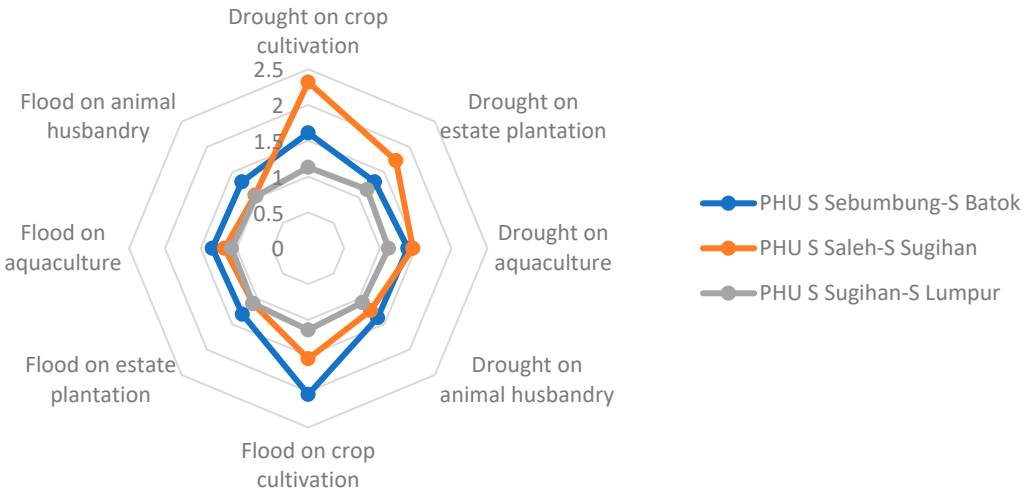

Figure 6. Climate change vulnerability score based on indicators.

Table 5. Results of climate change vulnerability indicators.

No.	Indicator	Level of Climate Change Vulnerability (%)			Average Score
		Low	Medium	High	
	PHU S. Sebumbung–S. Batok				
1	Drought in crop cultivation	57.0	25.0	18.0	1.61
2	Drought in estate plantation	79.0	11.0	10.0	1.31
3	Drought in aquaculture	74.0	13.0	13.0	1.39
4	Drought in animal husbandry	77.0	9.0	14.0	1.37
5	Flood in crop cultivation	30.0	36.0	34.0	2.04
6	Flood in estate plantation	81.0	8.0	11.0	1.30
7	Flood in aquaculture	78.0	10.0	12.0	1.34
8	Flood in animal husbandry	80.0	9.0	11.0	1.31
	Total score (interval 8–24)				11.67
	PHU S. Saleh–S. Sugihan				
1	Drought in crop cultivation	24.0	20.0	56.0	2.32
2	Drought in estate plantation	50.0	27.0	23.0	1.73
3	Drought in aquaculture	68.0	18.0	14.0	1.46
4	Drought in animal husbandry	83.0	11.0	6.0	1.23
5	Flood in crop cultivation	64.0	18.0	18.0	1.54
6	Flood in estate plantation	92.0	7.0	1.0	1.09
7	Flood in aquaculture	85.0	13.0	2.0	1.17
8	Flood in animal husbandry	95.0	5.0	0.0	1.05
	Total score (interval 8–24)				11.59
	PHU S. Sugihan–S. Lumpur				
1	Drought in crop cultivation	89.0	9.0	2.0	1.13
2	Drought in estate plantation	86.0	12.0	2.0	1.16
3	Drought in aquaculture	89.0	10.0	1.0	1.12
4	Drought in animal husbandry	94.0	5.0	1.0	1.07
5	Flood in crop cultivation	87.0	12.0	1.0	1.14
6	Flood in estate plantation	91.0	9.0	0.0	1.09
7	Flood in aquaculture	93.0	7.0	0.0	1.07
8	Flood in animal husbandry	97.0	3.0	0.0	1.03
	Total score (interval 8–24)				8.81
	Average score all PHUs				10.69

4. Discussion

In this study, we measured and analyzed vulnerability in five categories: social, economic, livelihood, ecological, and climate change. First, for social vulnerability, this study showed that among the three PHUs, the highest vulnerability score was observed for PHU Sungai Sugihan–Sungai Lumpur, while the lowest was observed for PHU Sungai Sebumbung–Sungai Batok. The data also show, based on the residency indicator, that the PHU Sungai Sugihan area had the highest social vulnerability level. The results showed that the population domiciled in this area is dominated by indigenous people, with some

working as day laborers in large, company-controlled, land concession areas to fulfill their daily needs [30].

Previous research in Banjar Baru, Kalimantan found that social vulnerability was high in a community in an area prone to fire. Overcrowding caused by the large number of household members in an area also leads to greater social vulnerability. Increased public awareness, including an understanding of the causes, and handling of, disasters can help reduce social vulnerability [31]. Overall, in an effort to reduce social vulnerability in a fire-prone area, physical restoration activities, such as canal blocking and canal back-filling, will be useful [2,30].

Second, for economic vulnerability, we found that the highest economic vulnerability score occurred in PHU Sungai Saleh–Sungai Sugihan. Meanwhile, between PHU Sungai Sugihan–Sungai Lumpur and PHU Sungai Sebumbung–Sungai Batok, the difference in the level of economic vulnerability was not great. This finding aligns with the "household income" indicator, in which the residents of PHU Sungai Sugihan–Sungai Lumpur area fall into the highest economic vulnerability category. One of the reasons for this could be because some residents undertake day laboring in concession areas as their main job to meet their daily needs [30].

In areas outside large company concessions, peat restoration activities will be easier to implement because the Government can directly carry out restoration activities in those areas [32,33], unlike the company-controlled concession areas wherein the responsibility for any restoration falls to the company. Nevertheless, restoration indirectly has an impact on the income of farming households in a concession area because an increase in farming household income on peatland has been shown to be strongly influenced by restoration activities [34–36]. However, peatland restoration activities cannot take place without collaboration and coordination among several related parties [37].

In addition to farmers' household income, the area of land owned by farmers can also determine the degree of economic vulnerability [38], as experienced by farmers' groups in the PHU Sungai Saleh–Sungai Sugihan area where economic vulnerability measured based on the area of land owned was in the highest category. The larger the land area, the higher the net income that will be received by farmers [39,40].

Based on the indicator "household head employment", PHU Sungai Saleh–Sungai Sugihan had high economic vulnerability wherein the head of a household worked as a farmer, fisher, or laborer, occupations that are highly dependent on natural conditions.

In line with the results of this research, natural capital-based livelihood strategies that use existing natural resources combined with agricultural cultivation are the main strategies chosen by the community to sustain their livelihoods [41]. Nevertheless, the use of peatland for agricultural activities has its own challenges, including fires, soil acidity, low fertility, and limited choice of suitable species [42]. Some of these challenges increase the risk of the income of the head of the household being uncertain. To reduce income uncertainties, it is important to have specially designed farming systems and patterns that can provide direct and multiple benefits to the local community.

Agrosilvofishery is an agricultural system that can be applied on peatland to reduce income uncertainties. The system combines different activities, including agriculture (such as agroforestry and small-scale farming), aquaculture (fish farming), and forestry (sustainable timber extraction), to create a multi-functional and sustainable system [43]. Agrosilvofishery is not just an agricultural system; it can also diversify and enhance the various livelihood practices on peatland and has the potential to reduce income uncertainty or risk and improve household welfare and food security through diversifying livelihoods [44,45].

Some countries with peatland areas have implemented integrated approaches such as agrosilvofishery systems more extensively than others. For example, in Bangladesh, agrosilvofishery is promoted to enhance agricultural productivity and rural livelihoods [46–48]. In certain regions of China, agrosilvofishery practices are implemented to improve sustainable land use and enhance agricultural productivity. Examples include integrating

aquaculture with wetland agriculture or incorporating fish production in rice fields [49–51]. Agrosilvofishery practices are also promoted in Costa Rica as part of sustainable agricultural systems in which combining agricultural activities with reforestation efforts and fish production is encouraged [52].

Ecological vulnerabilities can be divided into those caused by natural or human factors [53]. However, most of the research on ecological vulnerability in peatland areas has considered only natural factors [54]. Our study considers ecological vulnerability caused by both human and natural factors.

Ecological vulnerability assessment is an effective tool to alleviate contradictions [55]. The different assessment in our study compared with that of others shows the role of human society in changing inherent natural ecological vulnerability [55]. For example, land destruction can occur due to land disturbance in peatland [53]. This can occur naturally due to the El Niño–Indian Ocean Dipole phenomenon or because of humans who deliberately set fires to clear land. One of the impacts of fire is that it can lead to higher acidity levels. This will certainly be very detrimental to farmers because they have to spend more to prepare the land for cultivation [56].

Evaluating ecological vulnerability is significant for protecting and promoting ecosystem stability. However, attention to the dimensions of vulnerability and socio-ecological risk is lacking, indicating a large knowledge gap, especially when considering that environmental degradation is considered one of the main causes of natural disaster risk worldwide [57]. As an effort to reduce ecological vulnerability, one of the adaptable frameworks that can be applied is to overcome the driving factors of unwanted ecological changes caused by humans. In addition, to implement effective, long-term, and sustainable behavioral adaptation, there needs to be a greater emphasis on strategies that are capable of improving human values, skills, and behaviors. In other words, a participatory approach to environmental management could be part of the solution to reduce the percentage of ecological vulnerability [58].

In previous studies, climate change vulnerabilities were measured using indicators such as drought, temperature increase, pests, and land degradation. However, in this study, climate change vulnerability that occurs in four agribusiness sub-sectors—crop cultivation, aquaculture, estate plantation, and animal husbandry—have a low climate change vulnerability category.

Some of the causes of climate change vulnerability, especially in peatlands, include (1) farmers' lack of knowledge and information related to the phenomenon of climate change; (2) weakness of farmers' memory in monitoring climate change; [59] and (3) the fact that climate change does not occur instantly but continuously. If left unaddressed, droughts and floods will have a long-term negative impact, including environmental damage, decreased productivity of agricultural, plantation, fishery and livestock products, and crop failure. This will certainly increase the economic vulnerability of farming households because the damage will reduce farmers' household income, especially that of small-scale and subsistence farmers [60].

There is a need for integration and implementation of climate change adaptation policies in local government operations to reduce the vulnerability of smallholders and increase their ability to absorb, adapt, and transform in the face of climate change [61]. In addition, other forms of adaptation strategies that can be applied by farmers would be using superior seed, adjusting planting patterns and times, and carrying out water management and fish farming techniques that are suitable all-year round [62].

5. Conclusions and Implications

The results of this study led to the following conclusions:

1. Conflicts that often occur in the management of livelihoods on peatland are more related to the use of natural resources and ecological limitations in meeting human needs since the livelihoods of local people were still dependent on the availability of natural resources in the peatland areas and their surrounds.

2. Vulnerability scores vary by the type of vulnerability and PHU. PHU Sungai Sebumbung–Sungai Batok had the highest score for livelihood and climate change vulnerability, but the lowest for social, economic, and ecological vulnerability. PHU Sungai Saleh–Sungai Sugihan had the highest score for economic and ecological vulnerability, but the lowest for livelihood vulnerability. PHU Sungai Sugihan–Sungai Lumpur had the highest score for social vulnerability, but the lowest for climate change vulnerability.
3. The indicators "number of household members" and "number of children under 5 and the elderly" make relatively equal contributions to the social vulnerability score in the three PHUs. All economic indicators except "business land ownership" make relatively equal contributions to the economic vulnerability score in the three PHUs. The indicator "length of time a household works in a year" is an important indicator in determining variations in livelihood vulnerability among the three PHUs. Sungai Saleh–Sungai Sugihan is the PHU with the highest ecological vulnerability score for all vulnerability indicators. The agricultural sector has the highest vulnerability due to the impact of climate change, such as droughts and floods.

The following implications are proposed for mitigating vulnerability before it becomes severe and difficult to tackle:

1. Development of various alternatives of resource-based local livelihoods, such as processing buffalo milk into various products, processing local fish into smoked and salted fish, processing *purun* (*Eleocharis dulcis*) (in partnership with companies) to improve living standards, and reducing the need for annual burning.
2. Community involvement in resource management and fire prevention is seen as an effective way to prevent forest and peatland fires. This can be implemented through provision of socio-economic incentives to communities for sustainable management of peatland, creating and strengthening local institutions and maintaining regulations for fire management.
3. Provision of social back-up in times of crisis due to land and forest fire.
4. Development of formal institutions to support the processing of local resources into various products, such as buffalo milk products, smoked and salted fish, and *purun*-based products.
5. Development of markets to ensure that economic activities can result in an increase in household income and welfare.
6. Inclusion of alternative strategies that households do or should do in coping with the difficulties caused by land and forest fire based on their past experience.

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

Funding: The APC was funded by the CIFOR-ICRAF.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to privacy restrictions.

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

References

1. Page, S.; Mishra, S.; Agus, F.; Anshari, G.; Dargie, G.; Evers, S.; Jauhiainen, J.; Jaya, A.; Jovani-Sancho, A.J.; Laurén, A.; et al. Anthropogenic Impacts on Lowland Tropical Peatland Biogeochemistry. *Nat. Rev. Earth Environ.* **2022**, *3*, 426–443. [CrossRef]
2. Ward, C.; Stringer, L.C.; Warren-Thomas, E.; Agus, F.; Hamer, K.; Pettorelli, N.; Hariyadi, B.; Hodgson, J.; Kartika, W.D.; Lucey, J. Wading through the Swamp: What Does Tropical Peatland Restoration Mean to National-level Stakeholders in Indonesia? *Restor. Ecol.* **2020**, *28*, 817–827. [CrossRef]
3. Syahza, A.; Bakce, D.; Nasrul, B.; Irianti, M. Peatland Policy and Management Strategy to Support Sustainable Development in Indonesia. *J. Phys. Conf. Ser.* **2020**, *1655*, 012151. [CrossRef]

4. Yang, G.; Peng, C.; Chen, H.; Dong, F.; Wu, N.; Yang, Y.; Zhang, Y.; Zhu, D.; He, Y.; Shi, S. Qinghai–Tibetan Plateau Peatland Sustainable Utilization under Anthropogenic Disturbances and Climate Change. *Ecosyst. Health Sustain.* **2017**, *3*, e01263. [CrossRef]
5. Yeny, I.; Garsetiasih, R.; Suharti, S.; Gunawan, H.; Sawitri, R.; Karlina, E.; Narendra, B.H.; Surati; Ekawati, S.; Djaenudin, D.; et al. Examining the Socio-Economic and Natural Resource Risks of Food Estate Development on Peatlands: A Strategy for Economic Recovery and Natural Resource Sustainability. *Sustainability* **2022**, *14*, 3961. [CrossRef]
6. Global Forest Watch Indonesia Primary Forest Loss, 2002–2022. Available online: https://www.globalforestwatch.org/dashboards/country/IDN/ (accessed on 3 March 2024).
7. World Wide Fund for Nature (WWF) Fire, Forest and The Future: A Crisis Raging Out of Control? 2020. Available online: https://wwf.panda.org/wwf_news/?661151/fires2020report (accessed on 3 March 2024).
8. World Bank. *The Cost of Fire*; World Bank: Washington, DC, USA, 2016.
9. Departemen Kehutanan Badan Planologi Kehutanan Rekalkulasi Penutupan Lahan Indonesia Tahun 2005; Jakarta, 2005. Available online: https://muspera.menlhk.go.id/Perpus_search/detail/17846 (accessed on 3 March 2024).
10. International Strategy for Disaster Reduction of The United Nation. Living with Risk: A Global Review of Disaster Reduction Initiatives. 2004 Version Volume 1. Available online: https://www.unisdr.org/files/657_lwr1.pdf (accessed on 3 March 2024).
11. Herawaty, H.; Santoso, H. Pengarus-tamaan Adaptasi Perubahan Iklim Ke Dalam Agenda Pembangunan: Tantangan Kebijakan Dan Pembangunan. Adaptasi Terhadap Bahaya Gerakan Tanah Di Masa Yang Akan Datang Akibat Pengaruh Perubahan Iklim 2006. In *Dialog Gerakan Tanah dan Perubahan Iklim*; 7–8 Desember, 11, 1; CIFOR: Bogor, Indonesia, 2006.
12. Füssel, H.-M.; Klein, R.J.T. Climate Change Vulnerability Assessments: An Evolution of Conceptual Thinking. *Clim. Change* **2006**, *75*, 301–329. [CrossRef]
13. IPCC Third Assessment Report of the Intergovernmental Panel on Climate Change IPCC (WG I & II) 2001. Available online: https://www.ipcc.ch/assessment-report/ar3/ (accessed on 3 March 2024).
14. Griggs, D.J.; Noguer, M. Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change. *Weather* **2002**, *57*, 267–269. [CrossRef]
15. Dockendorff, C.; Fuss, S.; Agra, R.; Guye, V.; Herrera, D.; Kraxner, F. Committed to Restoring Tropical Forests: An Overview of Brazil's and Indonesia's Restoration Targets and Policies. *Environ. Res. Lett.* **2022**, *17*, 093002. [CrossRef]
16. Bappeda Kota Semarang. *Pedoman Penyusunan Rencana Aksi Daerah (RAD) Pengurangan Risiko Bencana (PRB) Bagi Kabupaten*; Bappeda Kota Semarang: Kota Semarang, Indonesia, 2008.
17. Labadi, S.; Giliberto, F.; Rosetti, I.; Shetabi, L.; Yildirim, E. Heritage and the Sustainable Development Goals: Policy Guidance for Heritage and Development Actors. ICOMOS 134p, ISBN 978-2-918086-87-1. 2021. Available online: https://openarchive.icomos.org/id/eprint/2453/ (accessed on 3 March 2024).
18. Roka, K. Community-Based Natural Resources Management. In *Life on Land*; Leal Filho, W., Azul, A.M., Brandli, L., Lange Salvia, A., Wall, T., Eds.; Springer International Publishing: Cham, Switzerland, 2021; pp. 161–174, ISBN 978-3-319-95981-8.
19. Ziegler, R.; Wichtmann, W.; Abel, S.; Kemp, R.; Simard, M.; Joosten, H. Wet Peatland Utilisation for Climate Protection—An International Survey of Paludiculture Innovation. *Clean. Eng. Technol.* **2021**, *5*, 100305. [CrossRef]
20. Fatemi, F.; Ardalan, A.; Aguirre, B.; Mansouri, N.; Mohammadfam, I. Social Vulnerability Indicators in Disasters: Findings from a Systematic Review. *Int. J. Disaster Risk Reduct.* **2017**, *22*, 219–227. [CrossRef]
21. Defiesta, G.; Rapera, C. Measuring Adaptive Capacity of Farmers to Climate Change and Variability: Application of a Composite Index to an Agricultural Community in the Philippines. *J. Environ. Sci. Manag.* **2014**, *17*, 48–62. [CrossRef]
22. Naz, L.; Patel, K.K.; Dilanchiev, A. Are Socioeconomic Status and Type of Residence Critical Risk Factors of Under-Five Mortality in Pakistan? Evidence from Nationally Representative Survey. *Clin. Epidemiol. Glob. Health* **2021**, *10*, 100670. [CrossRef]
23. Cohen, D.A.; Talarowski, M.; Han, B.; Williamson, S.; Galfond, E.; Young, D.R.; Eng, S.; McKenzie, T.L. Playground Design: Contribution to Duration of Stay and Implications for Physical Activity. *Int. J. Environ. Res. Public Health* **2023**, *20*, 4661. [CrossRef] [PubMed]
24. Adger, W.N. Indicators of Social and Economic Vulnerability to Climate Change in Vietnam. *Cserge Gec Working Paper*. 1998, pp. 1–39, ISSN 0967-8875. Available online: https://www.researchgate.net/profile/W-Adger/publication/237292216_INDICATORS_OF_SOCIAL_AND_ECONOMIC_VULNERABILITY_TO_CLIMATE_CHANGE_IN_VIETNAM/links/0c9605300fc078a925000000/INDICATORS-OF-SOCIAL-AND-ECONOMIC-VULNERABILITY-TO-CLIMATE-CHANGE-IN-VIETNAM.pdf (accessed on 3 March 2024).
25. Huong, N.T.L.; Yao, S.; Fahad, S. Assessing Household Livelihood Vulnerability to Climate Change: The Case of Northwest Vietnam. *Hum. Ecol. Risk Assess. Int. J.* **2019**, *25*, 1157–1175. [CrossRef]
26. Roy, B.; Lourenço, T.C.; Lisboa, F.; Penha-Lopes, G.; Santos, F.D. Impacts of Climate and Land Use Change on Surface Water Content and Quality in Low-Lying Coastal Areas of Bangladesh. In *Handbook of Climate Change Management: Research, Leadership, Transformation*; Springer: Berlin/Heidelberg, Germany, 2021; pp. 1–28.
27. Rajesh, S.; Jain, S.; Sharma, P. Inherent Vulnerability Assessment of Rural Households Based on Socio-Economic Indicators Using Categorical Principal Component Analysis: A Case Study of Kimsar Region, Uttarakhand. *Ecol. Indic.* **2018**, *85*, 93–104. [CrossRef]
28. Afjal Hossain, M.; Imran Reza, M.; Rahman, S.; Kayes, I. Climate Change and Its Impacts on the Livelihoods of the Vulnerable People in the Southwestern Coastal Zone in Bangladesh. In *Climate Change and the Sustainable Use of Water Resources*; Springer: Berlin/Heidelberg, Germany, 2012; pp. 237–259.

29. Poudel, S.; Funakawa, S.; Shinjo, H.; Mishra, B. Understanding Households' Livelihood Vulnerability to Climate Change in the Lamjung District of Nepal. *Environ. Dev. Sustain.* **2020**, *22*, 8159–8182. [CrossRef]
30. Budiman, I.; Hapsari, R.D.; Wijaya, C.I.; Sari, E.N.N. *The Governance of Risk Management on Peatland: A Case Study of Restoration in South Sumatra, Indonesia*; World Resources Institute: Washington, DC, USA, 2021. [CrossRef]
31. Arisanty, D.; Zaenal, M.; Anis, A.; Porda, H.; Putro, N.; Hastuti, K.P.; Angriani, P. Social Vulnerability of Land Fires in Banjarbaru. In *Advances in Social Science, Education and Humanities Research*; Atlantis Press: Amsterdam, The Netherlands, 2021. [CrossRef]
32. Wicaksono, A. Zainal Peatlands Restoration Policies in Indonesia: Success or Failure? *IOP Conf. Ser. Earth Environ. Sci.* **2022**, *995*, 012068. [CrossRef]
33. Saputra, E. Beyond Fires and Deforestation: Tackling Land Subsidence in Peatland Areas, A Case Study from Riau, Indonesia. *Land* **2019**, *8*, 76. [CrossRef]
34. Sheng, W.; Zhen, L.; Xiao, Y.; Hu, Y. Ecological and Socioeconomic Effects of Ecological Restoration in China's Three Rivers Source Region. *Sci. Total Environ.* **2019**, *650*, 2307–2313. [CrossRef]
35. Wang, J.; Liu, Y.; Li, Y. Ecological Restoration under Rural Restructuring: A Case Study of Yan'an in China's Loess Plateau. *Land Use Policy* **2019**, *87*, 104087. [CrossRef]
36. Urzedo, D.I.d.; Piña-Rodrigues, F.C.M.; Feltran-Barbieri, R.; Junqueira, R.G.P.; Fisher, R. Seed Networks for Upscaling Forest Landscape Restoration: Is It Possible to Expand Native Plant Sources in Brazil? *Forests* **2020**, *11*, 259. [CrossRef]
37. Pratama, I.; Purnomo, E.P.; Mutiaran, D.; Adrian, M.M.; Sundari, C. Creating Peatland Restoration Policy for Supporting in Indonesian Economic in a Sustainable Way. *IOP Conf. Ser. Earth Environ. Sci.* **2022**, *1111*, 012004. [CrossRef]
38. Fahad, S.; Wang, J. Climate Change, Vulnerability, and Its Impacts in Rural Pakistan: A Review. *Environ. Sci. Pollut. Res.* **2020**, *27*, 1334–1338. [CrossRef] [PubMed]
39. Clough, Y.; Kirchweger, S.; Kantelhardt, J. Field Sizes and the Future of Farmland Biodiversity in European Landscapes. *Conserv. Lett.* **2020**, *13*, e12752. [CrossRef] [PubMed]
40. Ren, C.; Liu, S.; van Grinsven, H.; Reis, S.; Jin, S.; Liu, H.; Gu, B. The Impact of Farm Size on Agricultural Sustainability. *J. Clean. Prod.* **2019**, *220*, 357–367. [CrossRef]
41. Ulya, N.A.; Waluyo, E.A.; Nurlia, A.; Rahmat, M.; Martin, E. Alternative Natural Capital-Based Livelihoods in Facing Peatland Degradation in Rengas Merah Hamlet, Ogan Komering Ilir Regency, Indonesia: A Financial Analysis Approach. *IOP Conf. Ser. Earth Environ. Sci.* **2021**, *917*, 012017. [CrossRef]
42. Sakuntaladewi, N.; Rachmanadi, D.; Mendham, D.; Yuwati, T.W.; Winarno, B.; Premono, B.T.; Lestari, S.; Ardhana, A.; Ramawati; Budiningsih, K. Can We Simultaneously Restore Peatlands and Improve Livelihoods? Exploring Community Home Yard Innovations in Utilizing Degraded Peatland. *Land* **2022**, *11*, 150. [CrossRef]
43. Alam, S.; Nurhidayah, L.; Lim, M. Towards a Transnational Approach to Transboundary Haze Pollution: Governing Traditional Farming in Fire-Prone Regions of Indonesia. *Transnatl. Environ. Law* **2023**, *12*, 424–450. [CrossRef]
44. Girkin, N.T.; Cooper, H.V.; Ledger, M.J.; O'Reilly, P.; Thornton, S.A.; Åkesson, C.M.; Cole, L.E.S.; Hapsari, K.A.; Hawthorne, D.; Roucoux, K.H. Tropical Peatlands in the Anthropocene: The Present and the Future. *Anthropocene* **2022**, *40*, 100354. [CrossRef]
45. Indrajaya, Y.; Yuwati, T.W.; Lestari, S.; Winarno, B.; Narendra, B.H.; Nugroho, H.Y.S.H.; Rachmanadi, D.; Pratiwi, P.; Turjaman, M.H.; Adi, R.N.; et al. Tropical Forest Landscape Restoration in Indonesia: A Review. *Land* **2022**, *11*, 328. [CrossRef]
46. Islam, S.; Ghosh, S.; Podder, M. Fifty Years of Agricultural Development in Bangladesh: A Comparison with India and Pakistan. *SN Bus. Econ.* **2022**, *2*, 71. [CrossRef]
47. Rahman Sunny, A.; Jimi Reza, M.; Anas Chowdhury, M.; Nazmul Hassan, M.; Abdul, M.; Ratul Hasan, M.; Mostafa Monwar, M.; Solaiman Hossain, M.; Mosarof Hossain, M. Biodiversity Assemblages and Conservation Necessities of Ecologically Sensitive Natural Wetlands of North-Eastern Bangladesh. *Indian J. Geo-Mar. Sci.* **2020**, *49*, 135–148. Available online: https://www.researchgate.net/publication/333194233_Biodiversity_assemblages_and_conservation_necessities_of_ecologically_sensitive_natural_wetlands_of_north_eastern_Bangladesh (accessed on 3 March 2024).
48. Barua, P.; Rahman, S.H.; Barua, M. Sustainable Management of Agriculture Products Value Chain in Responses to Climate Change for South-Eastern Coast of Bangladesh. *Mod. Supply Chain. Res. Appl.* **2021**, *3*, 98–126. [CrossRef]
49. Hu, F.; Zhong, H.; Wu, C.; Wang, S.; Guo, Z.; Tao, M.; Zhang, C.; Gong, D.; Gao, X.; Tang, C. Development of Fisheries in China. *Reprod. Breed.* **2021**, *1*, 64–79. [CrossRef]
50. Wen, X.; Liu, D.; Qiu, M.; Wang, Y.; Niu, J.; Liu, Y. Estimation of Maize Yield Incorporating the Synergistic Effect of Climatic and Land Use Change in Jilin, China. *J. Geogr. Sci.* **2023**, *33*, 1725–1746. [CrossRef]
51. Ibrahim, L.A.; Shaghaleh, H.; Abu-Hashim, M.; Elsadek, E.A.; Hamoud, Y.A. Exploring the Integration of Rice and Aquatic Species: Insights from Global and National Experiences. *Water* **2023**, *15*, 2750. [CrossRef]
52. Peguero, F.; Zapata, S.; Sandoval, L. Challenges and Opportunities. *Choices* **2019**, *34*, 1–10.
53. Li, H.; Zhu, D.; Cook, M. A Statistical Framework for Consolidating "Sibling" Probe Sets for Affymetrix GeneChip Data. *BMC Genom.* **2008**, *9*, 188. [CrossRef]
54. Ghosh, S.; Das, A. Urban Expansion Induced Vulnerability Assessment of East Kolkata Wetland Using Fuzzy MCDM Method. *Remote Sens. Appl.* **2019**, *13*, 191–203. [CrossRef]
55. Hu, X.; Ma, C.; Huang, P.; Guo, X. Ecological Vulnerability Assessment Based on AHP-PSR Method and Analysis of Its Single Parameter Sensitivity and Spatial Autocorrelation for Ecological Protection—A Case of Weifang City, China. *Ecol. Indic.* **2021**, *125*, 107464. [CrossRef]

56. Coulibaly, B.; Li, S. Impact of Agricultural Land Loss on Rural Livelihoods in Peri-Urban Areas: Empirical Evidence from Sebougou, Mali. *Land* **2020**, *9*, 470. [CrossRef]
57. Depietri, Y. The Social–Ecological Dimension of Vulnerability and Risk to Natural Hazards. *Sustain. Sci.* **2020**, *15*, 587–604. [CrossRef]
58. Eriksen, S.; Schipper, E.L.F.; Scoville-Simonds, M.; Vincent, K.; Adam, H.N.; Brooks, N.; Harding, B.; Khatri, D.; Lenaerts, L.; Liverman, D.; et al. Adaptation Interventions and Their Effect on Vulnerability in Developing Countries: Help, Hindrance or Irrelevance? *World Dev.* **2021**, *141*, 105383. [CrossRef]
59. Ricart, S.; Castelletti, A.; Gandolfi, C. On Farmers' Perceptions of Climate Change and Its Nexus with Climate Data and Adaptive Capacity. A Comprehensive Review. *Environ. Res. Lett.* **2022**, *17*, 083002. [CrossRef]
60. Shrestha, R.; Rakhal, B.; Adhikari, T.R.; Ghimire, G.R.; Talchabhadel, R.; Tamang, D.; KC, R.; Sharma, S. Farmers' Perception of Climate Change and Its Impacts on Agriculture. *Hydrology* **2022**, *9*, 212. [CrossRef]
61. Twecan, D.; Wang, W.; Xu, J.; Mohmmed, A. Climate Change Vulnerability, Adaptation Measures, and Risk Perceptions at Households Level in Acholi Sub-Region, Northern Uganda. *Land Use Policy* **2022**, *115*, 106011. [CrossRef]
62. Eka Suranny, L.; Gravitiani, E.; Rahardjo, M. Impact of Climate Change on the Agriculture Sector and Its Adaptation Strategies. *IOP Conf. Ser. Earth Environ. Sci.* **2022**, *1016*, 012038. [CrossRef]