Criteria and indicators for tropical peatland restoration

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Contents

List of boxes, figures and tables

Boxes

Figures

Tables

Preface

Effective restoration of tropical peatlands is critical for climate mitigation, biodiversity protection and the wellbeing of local communities. This working paper presents a comprehensive framework of **criteria and indicators (C&I)** to monitor restoration efforts. Developed through a consultative process with stakeholders in Indonesia, the C&I framework provides measurable, adaptable tools grounded in field-testing at restoration sites.

By refining and applying these C&I, the working paper aims to support policymakers, implementers and communities in designing, assessing and scaling effective peatland restoration practices in Indonesia and other tropical regions.

We extend our sincere appreciation to all contributors, including partner institutions and local stakeholders, whose knowledge, experience and commitment were integral to this effort. It is our hope that this paper serves as a practical reference not only within Indonesia but also for broader tropical peatland countries.

Bogor, June 2025

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Executive summary

Examination of the success or shortcomings of ecological restoration during the early stages of a project allows practitioners to evaluate progress and make necessary adjustments. A simple and practical approach to conduct such an assessment can be very helpful. Using specific criteria and indicators (C&I) can offer a structured framework for routine monitoring of interventions. Grounded in key principles and validated through field testing, these C&I are intended to serve as a vital tool for tropical peatland restoration.

Peatlands are recognized as crucial ecosystems for climate action and greenhouse gas (GHG) mitigation and offer significant opportunities through rewetting to restore degraded areas. Such efforts can reduce GHG emissions while promoting sustainable, peatland-friendly practices which contribute to local livelihoods. However, demonstrating the success of restoration initiatives requires an effective monitoring system. Our attempt to test a proposed set of C&I aimed to investigate this framework as an effective and functional tool to track progress and outcomes. Covering four key aspects – biophysical, social, economic and governance – the framework was developed to span the multifaceted nature of peatland restoration. Tailored to the Indonesian context, the C&I are designed to be relevant, user-friendly, adaptable and reliable, making them a valuable decision-making tool.

This working paper provides a summary of this collaborative effort and learnings from the verification process, following testing of the identified C&I in the field, in which surveys, group discussions and meetings with local communities helped to determine the practical applicability of the C&I approach for tropical peatland restoration monitoring. It is hoped that the insights of this process will be useful and can guide stakeholders to develop user-friendly, robust, reliable and actionable approaches to assess peatland restoration progress as well as provide the necessary feedback in diverse settings. We hope our learnings will be useful both within Indonesia and globally and can enhance peatland restoration efforts everywhere.

1 Introduction

1.1 Peatlands and peatland restoration

Peatlands are among the world's most carbon-dense ecosystems, storing about 644 Gt of carbon – 21% of global soil organic carbon – despite covering only ~3% of the Earth's surface (IUCN 2017; IPCC 2022). This is nearly twice the carbon stored in all forest biomass. Forming slowly at 0.2–2.0 mm per year, peat deposits can reach over 12 meters, holding more than 7500 Mg C/ha. However, when drained for agriculture or development, peatlands rapidly emit stored carbon as CO_2 and N_2O due to microbial decomposition. If left unmanaged, degraded peatlands are projected to release 80.8 Gt C and 2.3 Gt N over the coming centuries – around 1.91 Gt CO_2-eq annually (Leifeld and Menichetti 2018).

Beyond carbon storage, peatlands also regulate water flows, reduce flood risks, buffer extreme heat and resist wildfires – benefits that are vital for biodiversity and local communities. Their degradation, however, compromises these ecosystem services and threatens food, fibre and water supplies.

Despite their importance, peatlands face intense pressure from drainage, deforestation and agriculture, releasing 2 billion metric tons of CO_2 annually and shifting from carbon sinks to major GHG sources. This undermines both climate goals and essential services like water purification and tourism.

In response, many countries are advancing peatland conservation and restoration to mitigate emissions, protect biodiversity and enhance community resilience. Maintaining healthy peatlands is crucial not only for climate and biodiversity but also for sustaining livelihoods and ecosystem stability into the future (Schulz et al. 2019).

1.2 Criteria and indicators (C&I) for monitoring peatland restoration

Peatland restoration involves deliberate actions to support the recovery of degraded ecosystems, aiming to return them as closely as possible to their natural state by restoring key ecological processes and functions. Criteria and indicators must reflect the realities of restoration outcomes. Their selection must consider site-specific human–ecological contexts, enabling decision-makers to assess the legitimacy, sustainability and desirability of local aspirations and adjust interventions accordingly.

No single criterion or indicator provides a complete measure of restoration; they must be interpreted collectively. Viewed as interconnected information nodes, these indicators offer a comprehensive picture of peatland conditions and restoration progress (Figure 1).

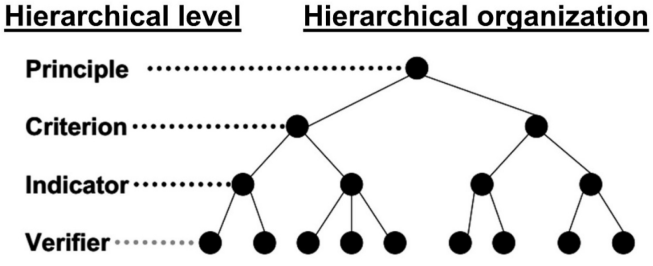

Figure 1. Hierarchical organization of principles, criteria and indicators (Pokorny and Adams 2003)

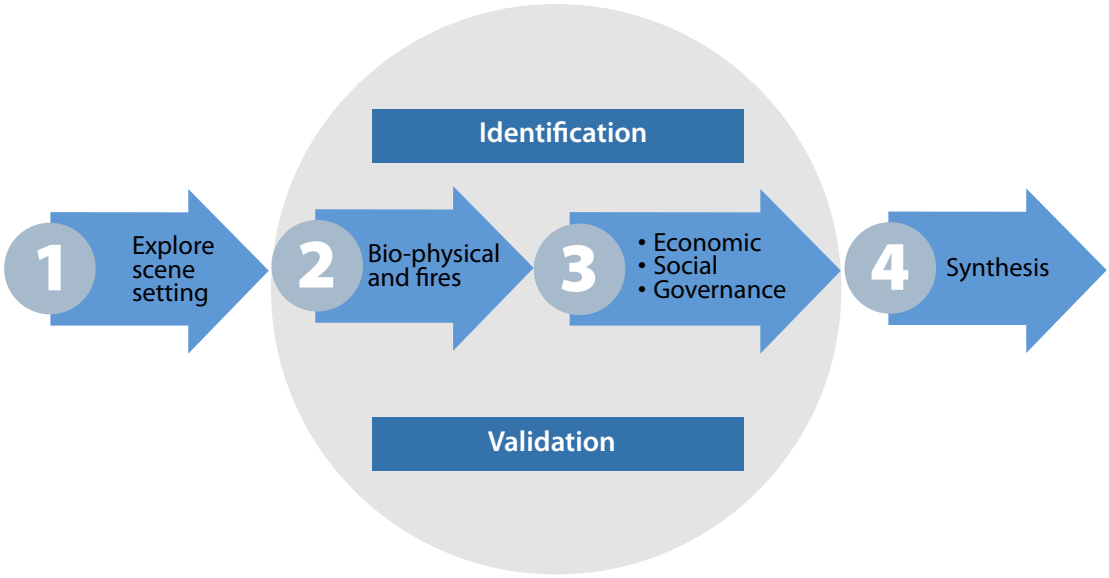

Figure 2. The process of identification and validation of criteria and indicators for peatland restoration in Indonesia. Step 2 and 3 involved a detailed consultative process with participants representing all stakeholders, and validation was done at two different active peatland restoration sites.

In this hierarchy, principles represent fundamental truths, elaborated through criteria – intermediate points where information, conveyed by indicators, can be integrated for meaningful assessment. Indicators are variable components that infer the status of criteria, while verifiers provide specific data to enhance the clarity and ease of indicator assessment.

Beyond the hierarchy, several practical considerations are essential when developing principles, criteria and indicators (PCIs):

- PCIs are adaptable tools, not rigid frameworks
- All landscape stakeholders should be considered 'users'
- Data collected should serve a diverse range of stakeholders
- Implementation costs must be considered
- PCIs should be practical and easy to understand

Before formulating PCIs, the goals and objectives of a site or programme must be defined. PCIs should promote behavioural change, support learning, align with a theory of change, reflect local context, and be designed for evaluation and application by the target audience.

Sustained and effective peatland restoration requires monitoring systems that inform design, strategy, site selection and adaptive management. Standardized tools and tested protocols can guide practitioners in assessing restoration outcomes. Simple, recognizable and measurable indicators are crucial for stakeholders involved in peatland restoration.

1.3 Purpose and use of the C&I approach

The C&I approach integrates attributes from biophysical, social, economic and governance aspects to provide a nuanced understanding of peatlands, particularly in relation to local context and complexity.

This peatland restoration monitoring guide was developed by CIFOR with input from Indonesian peatland stakeholders, including BRGM, Riau University's Disaster Risk Study Centre (PSB), PT Rimba Makmur Utama (PT RMU), and peatland experts through consultations and direct discussions. The contributions of these stakeholders enriched both its the scientific foundations and field-level applicability.

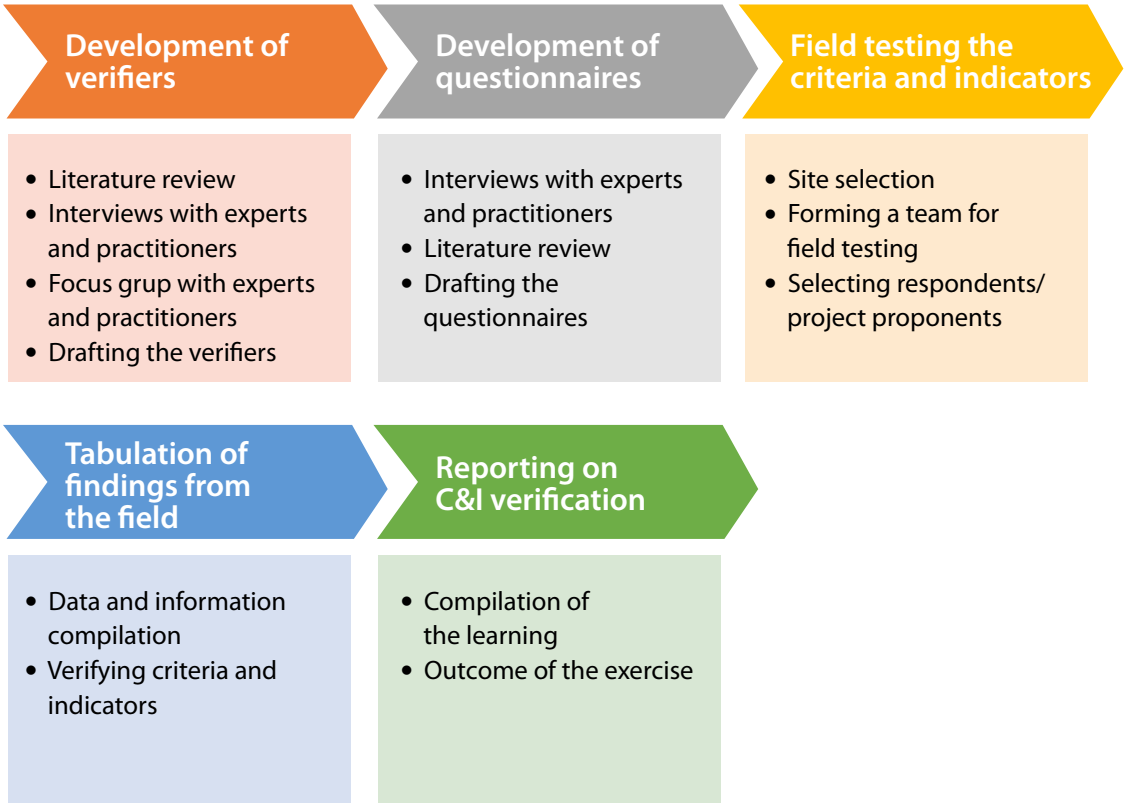

Figure 3. Process of identifying verifiers and field testing to determine the effectiveness of using the C&I approach for monitoring peatland restoration.

The guide outlines the key concepts and scope for establishing criteria, indicators and verifiers to monitor the progress of peatland restoration. It also provides tools for evaluating restoration outcomes through a structured process (Figure 3).

The lessons learned are intended to support peatland restoration stakeholders – especially those in tropical regions – to enable better understanding and application of C&I in peatland restoration monitoring and evaluation frameworks.

Box 1. Identifying principles, criteria and indicators: A demand-driven approach

Identifying principles, criteria and indicators for peatland restoration monitoring followed a demand-driven approach, in line with Peatland and Mangrove Restoration Agency (BRGM) guidance:

- Ensure long-term, comprehensive monitoring is possible based on scientifically sound criteria and indicators.
- Ensure continuous knowledge exchange around the use of C&I for monitoring and evaluation.
- Integrate remote sensing with indicators based on in-situ field data.
- Ensure practical methods for monitoring biophysical, social, economic and governance aspects to provide a holistic overview of ongoing restoration and identify possible corrections where required.
- Strengthen village-level governance, particularly through the Peat Care Village (*Desa Peduli Gambut,* DPG) programme.

2 Measuring biophysical aspects

2.1 Rationale

Peatland restoration aims to rehabilitate degraded areas and conserve ecosystems by minimizing disturbances. One guiding principle – 'wet and vegetated peatlands without risk of drainage or deforestation' – underpins the criteria and indicators identified for monitoring key biophysical aspects like vegetation, hydrology and peat condition. Restoration approaches differ by capacity and may focus on tree planting, rewetting or fire prevention. However, defining success and tracking progress is difficult, especially without early monitoring. This chapter offers practical guidelines to support stakeholders in assessing and reporting on biophysical restoration outcomes.

During planning for biophysical monitoring and evaluation, two approaches can be used for restoration reporting – quantitative (i.e., numerical numbers) and qualitative (i.e., perception, judgment, attitude). These approaches maintain transparency and accountability of the project performance. The key steps suggested for tracking the biophysical performance of restoration activities are as follows:

a. Develop a questionnaire or assessment list to gather relevant data. Much of the qualitative information can be directly observed in the field, so evaluators should document conditions before and after restoration to avoid subjectivity. Additional detailed questions may be included to capture missing information.
b. Establish site-specific biophysical baseline data. Before implementing restoration, project managers should gather baseline data to set realistic targets, anticipate outcomes and track improvements over time.
c. A minimum of two monitoring and evaluation stages, before/early stage of restoration and at the end of the project, is strongly suggested.
d. Differentiate monitoring data by levels. Given the limited resources available in many restoration programmes, biophysical C&I questionnaires can be split into two tiers: Tier 1 for general qualitative data, and Tier 2 for detailed qualitative and quantitative data (see Form 1).
e. Ensure consistent monitoring at the same site. For accurate biophysical data, monitoring should be done within the same location using a consistent evaluation form. See Form 1 and Table 2 for examples.

2.2 Biophysical criteria, indicators and verifiers

Restoration progress is assessed using three main criteria: land cover functionality, hydrology and peat soil condition (Table 1). This guide offers simplified indicators and verifiers, with detailed guidance in Form 1 and Table 2. While detailed verifiers yield better results, they require technical expertise, which many projects lack. To ensure usability, general verifiers are provided, though technically equipped projects are encouraged to generate and report more comprehensive biophysical data.

Table 1. Biophysical criteria, indicators and verifiers to evaluate peatland restoration activities

Criteria	Indicators	Verifiers
Ecosystem/land cover functionality	Dominant land use	• Vegetation cover enhanced following regeneration • No forest loss followed by reduced disturbances • Number of seedling establishment occurrences
	Native vegetation species	• Number of natural regeneration occurrences • Number of native vegetation species (that can adapt to wet peatland conditions) is maintained or increased
	Commercial vegetation species	Commercial vegetation species are introduced or enriched
Restored hydrology	Ground water table	Mean groundwater table increases during the dry season
	Dryness index/soil moisture	Mean soil moisture increases
	Fire susceptibility	Decrease in the number of fire events, particularly during dry season
	Peat subsidence	Mean peat subsidence is reduced
Quality of peat	Peat maturity	Stability of peat maturity condition
	Peat depth	Peat depth is maintained and stable
	Heterotrophic respiration (GHG emissions)	Lowered heterotrophic respiration as response of GW increase
	Organic matter content	Organic matter content is maintained and stable

2.3 Planning and implementing biophysical C&I

Before and during restoration project implementation, it is essential to define the project's criteria, indicators and verifiers, along with its overall goals, which define project performance indicators. For instance, one project focused on carbon credits may prioritize hydrological control and increasing the mean water table so emissions reduction can be achieved. In contrast, a project aiming to conserve peatland biodiversity may focus on species enrichment, nurseries and biodiversity surveys, and may not require hydrological network improvement. Monitoring and evaluation of restoration progress can also be reformulated during implementation if goals or outputs shift, such as adding canal blocking to a revegetation-focused project in a later phase.

To formulate performance indicators for biophysical monitoring and evaluation, the following steps are suggested:

1. Identify relevant indicators and verifiers to measure any change or improvement that is in line with the goal of restoration intervention. **What** are the criteria, indicators and verifiers to be used?
2. Identify literature data based on recent studies or research. **What** literature and data are available?
3. Define the magnitude of the restoration progress that is to be achieved. **How much** progress is intended?
4. Specify the area and scale **where** the restoration will take place.
5. Define the timeframe for monitoring progress. **When** will monitoring take place?

Table 2. Summary of general changes or improvements seen in an implemented peat restoration project

Criteria:	Indicator:	Verifiers:	1st monitoring	2nd monitoring	Improvements or changes (primary indicators)	Time needed for improvement	Score:
Response					*Improved/ Not improved*	*Months*	*0: Not improved 1: Improved*
Ecosystem/ land cover functionality	Dominant land use	• Enhanced vegetation cover resulting from regeneration • No forest loss followed by reduced disturbances • Seedling establishment occurrences					
	Native species	• Natural regeneration occurrences • Number of native vegetation species (that can adapt to wet peatland conditions) is maintained or increased					
	Commercial species	• Commercial species is introduced or enriched					
Restored hydrology	Ground water table	• Mean ground water table increased during dry season					
	Dryness index/soil moisture	• Mean soil moisture increased					
	Fire susceptibility	• Number of fire events decreased, particularly during dry season					
	Peat subsidence	• Mean peat subsidence is reduced					
Quality of peat	Peat maturity	• Stability of peat maturity condition					
	Peat depth	• Peat depth is maintained and stable					
	Heterotrophic respiration (GHG emissions)	• Lowered heterotrophic respiration as response of GW increase					
	Organic matter content	• Organic matter content is maintained and stable					

Box 2. Form 1: Tier 1 information for monitoring and evaluating the biophysical aspects of peatland restoration

General information:

1. Project restoration name
2. Site location name
3. Area of restoration: … ha
4. Date of project establishment: date information
5. Project period: … year(s)
6. Type(s) of restoration approach being applied: (1) rewetting, (2) revegetation (3) revitalization

Box 3. Form 2: Tier 2 information for monitoring and evaluating the biophysical aspects of peatland restoration

For Tier 2 level monitoring, the same form can be utilized to monitor detailed changes in restoration processes, however additional considerations include:

1. Monitoring and evaluation should be conducted under the supervision of a biophysical expert
2. Field sampling locations and assessments should be considered carefully because they will affect results, especially for peat soil qualities.
3. Baseline data are needed so that monitoring data can be compared against this, further biophysical evaluation can be undertaken and errors can be minimized.

3 Measuring social and economic aspects

3.1 Rationale

Economic indicators for peatland restoration align with the principle of a 'Viable and sustainable peatland-based economy', with five economic criteria and indicators. Social aspects follow the principle 'Community well-being and equity is widely demonstrated'. Access to reliable social data is crucial but challenging. Community dynamics are often overlooked, though restoration projects can trigger social and economic change (Barthélémy and Armani 2015) . Studies highlight that local experiences and social benefits are rarely measured. In Talio Hulu community, for example, the Fire Care Community Group patrols lands independently, showing how strong local ownership enhances sustainability. Such initiatives should be studied to inform what community-driven restoration models are replicable and could be used in other areas.

For this reason, criteria and indicators were developed to highlight the extent to which peat restoration interventions had an impact on communities' social and economic conditions. However, due to a lack of data, indicator values have not yet standardized.[1] The criteria and indicators in this guide act as a first step for measuring the economic and social aspects of peat restoration. The verifier of each indicator acts as minimum measurement; adjustment to the needs of each project is needed. Each of the indicators works at different levels. Some indicators have other factors outside of restoration activities that affect their value.

Measurement of economic and social aspects is carried out at the household level, the smallest level in the framework of community involvement in peat restoration activities. This is done with the intention of seeing whether peat restoration activities provide changes in the households involved in the peat ecosystem being restored. Measurement at the household level can be challenging but is necessary to see on the ground how peat restoration affects the lives of surrounding communities. The challenge lies in a lack of detailed data on citizen involvement; this is not typically well documented by project implementers. Reliance on residents' memories for data around their involvement in restoration activities adds complications; memories are subjective and unstructured, so they need to be explored slowly.

3.2 Social and economic criteria, indicators and verifiers

The criteria and indicators presented in the table have been tested in the field. These indicators can help to measure the extent to which restoration activities are progressing. Each indicator works at its own level. Certain conditions produce specific information, and so verifiers need to be adjusted to the assessment objectives of each peat restoration project.

Below we explain what indicators can and cannot measure for each criterion.

1 The varying characteristics of peat ecosystems shape community adaptations, resulting in unique socioeconomic conditions across regions. Collected data to inform this guide is limited to two communities (KHG Katingan-Mentaya and KHG Rokan-Siak Kecil) therefore, standardized values are irrelevant.

3.2.1 Social aspects

The social indicators below can assess the extent to which peatland restoration has an impact on social conditions within a community. The verifier in this case is only initial data; more detailed data needs to adjust to the intended goal for measuring progress.

Table 3. Criteria and indicators for monitoring social aspects of peat restoration

Criteria	Indicators
Social capital	Land ownership and tenure rights
	Community capability
	Gender equality
	Social networks
	Improvements in individual capability
Social welfare	Food security
	Water security
	Access to education
	Access to health services

Social capital

The social capital criteria refer to the way community connect with each other to achieve peatland restoration goals. These criteria are measured using five indicators: 1) land tenure rights; 2) community capabilities; 3) gender equality; 4) social networks; and 5) human capital improvements. Land indicators assess whether restoration has caused conflicts. For respondents involved in multiple activities (e.g., canal blocking, boreholes or revitalization), questions should address each intervention to capture conflict variations.

'Community capability' reflects local peatland knowledge. 'Gender equality' focuses on women's participation in formal roles – for example decision-making and hands-on implementation. Women often contribute informally, and such roles are underrecognized, signalling ongoing gender gaps, however measuring informal contributions is particularly challenging; for this reason, we focus on measurable formal participation as a proxy for gender equality.

'Social networks' measures support from various community groups for restoration, while 'individual capability' indicators assess whether participants gain skills and knowledge aligned with restoration goals.

Social welfare

Social welfare is assessed through four indicators: food security, water security, access to education, and access to health services. However, not all are directly linked to peat restoration. In Riau, education and health access predate restoration, while in Central Kalimantan, improvements in these areas followed restoration efforts. Food and water security depend on the restoration type; for example, rice cultivation in Talio Hulu enhanced food security, but rewetting alone requires time before impacts are measurable. These indicators are influenced by external factors, so assessments must consider broader socioeconomic conditions beyond restoration activities to accurately reflect social welfare outcomes in peatland areas.

3.2.2 Economic aspects

The economic indicators below can assess the extent to which peatland restoration has an impact on the economic conditions of a community. The verifier in this case is initial data; data needs to be adjusted to the desired goal of monitoring progress.

Table 4. Criteria and indicators for monitoring economic aspects of peatland restoration

Criteria	Indicators
Wealth	Household income
	Annual household savings
	Families' basic needs
	Property ownership
Economic incentives for peatland restoration	Access to market
	Access to finance
Sustainable and just value chain	Promotion of local products
	Rate of product innovation
	Technology used in production
	Product certification/standardization
Human resources	Job/workforce creation due to wetland-based enterprises

Wealth

Wealth criteria are measured by assessing 1) household income; 2) household annual savings; 3) the level at which household needs are fulfilled; and 4) ownership of goods. These measurements provide information on the welfare level of households involved at the time of data collection. Indicators can also contain information on changes in welfare levels if measurement is carried out twice: before the project is implemented and several months after the project has commenced. For the 'household income' indicator, we do not consider this only in terms of income amount, but also if sources of household income originate from peat or non-peat land. We then measure which income source (between peat and non-peat) makes the largest contribution to household income. This means we also can calculate how much the household depends on the peat ecosystem.

Economic incentives for peatland restoration

The purpose of these criteria is to measure whether households whose livelihoods depend on peat get benefits from peat management. This is measured by assessing 1) access to the market and 2) access to finance. Measurement of the presence or absence of a market (including the price received by households) and the use of loan credit, needs to be broken down based on the commodities produced/cultivated by each household. Commodity information is obtained from household income indicators relating to welfare.

The measurement of economic incentives can also be used to measure the extent to which SMEs, as implementers of economic revitalization activities, economically benefit from the assistance they receive. Meanwhile, the information obtained from the government is to establish whether the government has facilitated an economically profitable peat utilization ecosystem.

Sustainable and just value chain

This measurement is focused on SME actors and the government, to assess 1) the presence or absence of promotional activities; 2) the level of resulting product innovation; 3) the technology used to produce peat-related products; and 4) whether a final product is certified. Governmental bodies are the intended data source here – this can indicate whether the government has supported SME activities to produce. It also helps assess whether there are government activities or programmes providing training or facilities that support improvements relating to sustainable and just value chain criteria.

Human resources

Human resources here are defined as the number of individuals working in business sectors relating to the peat ecosystem. The verifier is limited to measuring the number of household members involved in small and medium peat-based industries. In the field, especially in economic revitalization activities, many multiplier effects occur (i.e., not the main goals of an intervention). For example, when a group is given capital to revive a craft made of *purun* (*Lepironia articulata*), then another income source emerges as a result – *purun* seekers, including the rental of *jukung* (small boats) to search for *purun*.

3.3 Planning and implementing social and economic C&I

To adequately assess and evaluate, this exercise can be divided into four steps. These are summarized below as exploring the programme profile, determining respondents, finalizing data collection tools, and reporting.

Explore the programme profile

Peat restoration monitoring must closely relate to the form of intervention to be monitored. Details of the programme, such as who is responsible and who is involved, need to be collected first. Some key programme indicators that must be collected are:

a. Title of activity
b. Type of restoration intervention (rewetting, revegetation or economic revitalization)
c. Implementer of activity (community involved at the time the activity was implemented)
d. Year of implementation (budget year)
e. Status of activity sustainability (still running, monitoring stage, not running – adjusted to the form of restoration intervention)
f. Activity details (depending on the type of restoration intervention)

Table 5. Example of a programme profile

Activity title	**'Utilization of degraded peatland for rice production – PEN' programme**
Intervention type	Economy revitalization (R3)
Implementer	1 community group (consist of 6 farmers groups)
Location	Talio Hulu, Pulang Pisau Regency
Year initiated	2020
Status	Ongoing (harvested 3 times)
Activity details	Planting rice in paddy fields that have not been in active use for more than 20 years; using rice seeds from Balitra; rice fields belonging to each group member are located approximately 2 hectares from ex-transmigration land.

The information in Table 5 is based on the *Pemulihan Ekonomi Nasional Food Estate* operational plan, of the Directorate General of Spatial Planning in the Ministry of Environment and Forestry (KLHK 2020).

Determining respondents

The process of measuring economic aspects is carried out with several groups of respondents: 1) residents (households) who are directly involved in restoration activities; 2) small and medium industry actors whose products are related to the peat ecosystem (peatland-based SMEs); and 3) the government body or institution that supports peatland-based SMEs. These respondent groups are selected so that the collected data can highlight the extent to which restoration activities impact on the economic conditions of those connected to the restoration project.

Figure 4. Determining respondents to inform economic monitoring

The number required for each group of respondents depends on field conditions. Household respondents can be selected based on 1) their active involvement in activities organized by the peatland restoration project being monitored; 2) those who undertake activities in peatland; and 3) those who have a peatland-derived source of income. This number may therefore vary depending on how many people are involved in restoration activities, which households are active in peatland, and which households have peatland-related income sources.

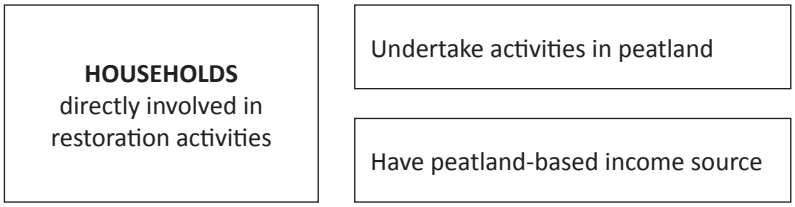

Figure 5. Determining household respondents

Data regarding SME respondents can be collected separately from the project being monitored if: (1) their products relate to peat ecosystems; and (2) SMEs are located in or near the project area. If no such SMEs exist, government data collection is an unnecessary step. This targeted approach helps assess whether peat-based SMEs are supported by local programmes. Government respondents should confirm relevant SME support initiatives.

For the social aspects, we used the same household respondents as in the economic assessments—specifically those who were directly involved in the restoration activities. The number of respondents should reflect project involvement and may be grouped by activity type (e.g., rewetting, replanting, economic revitalization). In the Table 5 example, respondents come from farmer groups engaged in the project, ensuring data aligns with restoration goals and activities.

Table 6. Determining household respondents in the 'Use of degraded peatland for rice production (PEN)' programme

Respondent population	Members of a farmer group involved in rice production in Talio Hulu
Respondent criteria	1. has a peatland-based income source
	2. representing diverse genders (male, female)
	3. representing diverse welfare levels (i.e., rich, poor)

The information in Table 6 is based on the *Pemulihan Ekonomi Nasional Food Estate* operational plan designed by the Directorate General of Spatial Planning, in the Ministry of Environment and Forestry (KLHK 2020).

Data collection tools

Data collection tools can include questionnaires. Questionnaire data can complement more quantitative economic data, especially where this relates to *Incentives for peatland restoration* and *Sustainable and just value chain*. As such, different questions are relevant to different respondent groups.

Table 7. Questionnaires and respondents to measure indicators

No	Respondent group	Economic questionnaire	Social questionnaire
1	Household	V	V
2	Peatland-based SME	V	-
3	Government	V	-

Households were given two questionnaires, relating to economic and social aspects. SMEs and government respondents meanwhile were only given a questionnaire on economic aspects.

If a respondent acts as head of the household and is also head of a SME, then the respondent becomes part of two respondent groups, namely: 1) household respondents; and 2) SME respondents. Thus, the respondent was given three questionnaires: 1) household-related economic questions; 2) SME-related economic questions; and 3) social questions.

Table 8. Illustration of respondents and data needs

Name	Ali
Position	Head of Makmur Jaya Group
Data needed	• Household-related economic information • SME-related economic information • Social information

Reporting

Data processing and presentation should align with the monitoring focus of each restoration project. If the goal is to assess community welfare, then relevant welfare indicators should be prioritized. To measure changes in welfare, data collection should occur at least twice – before and after the intervention. For example, in cultivation projects, the second assessment can follow the harvest period.

Box 4 details welfare monitoring based on data from Peatland and Mangrove Restoration Agency (BRGM)'s economic revitalization activities (2017–2021). In this case, data were collected only once, after the activity began. As a result, the findings are descriptive, reflecting respondent profiles rather than changes in welfare before and after the intervention.

Box 4. Illustrating monitoring results based on welfare criteria

Welfare

Based on BKKBN's Prosperous Family Stage indicators, 69% of respondents fall into the Stage I category, and can meet their basic needs (such as food, clothing, housing, health and education). The remaining 31% (four respondents) are classified as pre-prosperous due to inadequate housing conditions in terms of health and safety.

Peat utilization

About 80% of respondents use the peat ecosystem, mainly for cultivation (rice, rubber, oil palm, sengon, horticulture, rattan and fruit), as well as livestock (chickens, fish) and forest product collection (mushrooms, herbs, vegetables, fish). However, 25% reported that most of their income came from non-peat sources.

4 Measuring governance aspects

4.1 Rationale

The overarching principle for governance is 'Just, fair and strong governance at all levels', supported by three criteria and relating indicators. Governance spans beyond the sociopolitical to include finance, economics, the environment, and both landscape- and jurisdiction-level processes. It focuses not only on the outcomes, but also on how decisions are made. Governance indicators assess institutional capacity, meaningful participation and adaptability of government mechanisms. The goal is to foster inclusive, responsive and effective governance that enables the successful implementation of peatland restoration programmes.

4.2 Governance criteria, indicators and verifiers

An important consideration for governance C&I (criteria and indicators) is to be both specific and practical. As such, these C&I were reviewed, filtered, field-tested and modified according to their relevance and the complexity of field data. Following filtering and modification of criteria and indicators, a set of verifiers were developed to provide data and information that could be used to assess indicators.

The C&I framework highlights stakeholder participation in peatland restoration, making transparency and accountability key. Verifiers assess decision-making processes, participant inclusion, access to public data, monitoring systems and community feedback channels, including grievance mechanisms for livelihood-related impacts.

At Tier 1, progress is measured by the presence, use and awareness of these mechanisms. Tier 2 evaluates stakeholder satisfaction to gauge effectiveness. Field discussions also emphasized the value of including a cost-benefit analysis in decision making to help policymakers enhance impact. This indicator is noted in italics as it is an optional tool for practitioners monitoring governance.

To monitor progress relating to mechanisms that enable peat restoration, verifiers assess both their availability and effectiveness. Regulatory indicators examine the presence of relevant policies and the alignment of enforcement mechanisms. Organizational indicators cover actor roles, responsibilities, budgets and their collaboration in restoration. Customary law indicators evaluate how traditional institutions support restoration, particularly through community engagement. Rule of law indicators focus on the existence and application of enforcement mechanisms, verified through compliance records or documented cases.

To assess adaptive capacity to change criteria, two key indicators can be used: institutional/natural resource governance and knowledge management. For institutions, this includes verifying the presence and use of evaluation mechanisms, as well as systems for updating regulations and involving vulnerable groups in peat restoration. Governance indicators focus on mechanisms and tools, requiring two steps for data collection. First, a desk or legal review is conducted to examine existing frameworks, supported by a literature review to enhance findings. Second, these findings are verified through interviews with relevant respondents to assess how mechanisms function in practice and whether they reflect real implementation on the ground.

Table 9. Criteria, indicators and verifiers for monitoring peatland restoration governance

Criteria	Indicators	Verifiers
Decision-making processes	Level of participation	a. Stakeholder map is available b. Vulnerable group participation is ensured and exercised c. FPIC mechanisms are in use
	Level of transparency	a. Availability of a public information mechanism b. Number of people accessing this mechanism has increased
	Level of accountability	a. Availability of monitoring mechanisms managed by the government b. Availability of monitoring mechanisms managed by the public c. Number of people with access to these mechanisms has increased
	Role of women	a. Types of roles women hold in decision making regarding peatland restoration b. Issues women raise in the decision-making process
	Cost and benefit analysis	a. Use of cost and benefit analysis in policy making
Enabling tools	Formal regulation	a. Specific regulations on peat restoration are in place and there is regular awareness raising around them b. Regulations on peat restoration do not conflict with each other c. Enforcement mechanisms are in place to implement these regulations
	Formal organizations	a. Identification of existing agencies and their scope of work b. Annual budget for peatland restoration programmes c. Restoration programmes at different levels of government are aligned
	Informal organizations	a. Informal organizations that support peat restoration exist b. They make a positive contribution to peatland restoration
	Customary laws	a. Customary laws and institutions that support peat restoration are available b. Customary laws and institutions that support peat restoration are involved and/or considered in implementing formal regulations on peat restoration
	Conflict resolution	a. Conflict resolution mechanisms are available b. Data around the use of these mechanisms is available
	Rule of law / monitoring & compliance mechanisms	a. Mechanisms to monitor compliance on peatland restoration are available b. The mechanisms are being used
Adaptive capacity to change	Institutional/ natural resource governance	a. Evaluation mechanisms regarding peat restoration (or natural resource governance in general) are available and in use b. Mechanisms to revise regulations/policies/ organizations on peat restoration are available and in use c. Representation of vulnerable groups in the mechanisms
	Knowledge management	a. Mechanisms and resources to gather practices, lessons learned and knowledge from peat restoration are available and/or support the revision of regulations/policies b. Practices, lessons learned and knowledge from existing/ previous peat restoration is being used in decision-making processes

4.3 Planning and implementing governance C&I

Legal review

Law research as referred to here is research carried out by collecting relevant regulations relating to the implementation of peat restoration in the location where the assessment is carried out. Law research is conducted to identify the regulatory framework and available mechanisms to carry out restoration and to understand the scope, mechanism and the design of restoration programmes as stipulated by the law. Research on regulations and policies is important because organizations, procedures, mechanisms and funding must typically be regulated.

To enrich this legal research, a literature review will help to find data or information regarding verifiers. Research done by other organizations, which can provide data for the verifiers, can also be useful for monitoring.

Respondent surveys/ interviews

To verify criteria and indicators, interviews are conducted to obtain further information on indicators and to verify information from law research and literature review. This could include obtaining data or information that is not yet publicly available. In planning the interview, start by identifying relevant resource persons in the location where assessment will be conducted, considering the roles and responsibilities, scope of authority and level of government.

To obtain data and information for criteria and indicators, respondents for governance aspects can be categorized into:

a. Law or policymakers, to gather their perspectives and knowledge on the existing laws, regulations and policies regarding peatland restoration.
b. Project proponents or implementing agencies of restoration programmes, to gather their perspectives, knowledge and experience from implementation of restoration programmes.
c. Community groups impacted by peatland restoration, to gain their perspectives and experience from implementation of existing laws, regulations and policies and implementation of restoration programmes.

In the Indonesian context, respondents under the law or policymaker category include: (a) officials from the ministry or agency tasked with managing and supervising the implementation of peat restoration; and (b) officials at provincial or district level where peat restoration activities are carried out.

For project proponents or implementing agencies, two respondent groups should be interviewed, those directly executing restoration work, such as permit holders or contractors responsible for infrastructure or intervention activities.

For the third category, respondents include community members not formally involved in restoration but living near or within restoration sites. In this group, ensuring gender representation is important – at least 30–40% of respondents should be women to ensure a balanced perspective and inclusive data collection.

Table 10. Description of survey respondent categories

Respondent category	Number of respondents required	Description	Survey form
Law maker, policymaker	1 from each organization		1
Implementing actor	2 for each project		1
Community/ villagers	A minimum of 5 per village	Less/inactive in restoration activities; live close to peatland restoration activities	2

Team recruitment

In carrying out data collection to test the criteria and indicators for peatland restoration, a team of researchers with expertise in biophysical, social, economic and governance fields is needed. These researchers must have relevant educational backgrounds and experience in related aspects to ensure they can easily assess and understand the information or data needed for each indicator. To conduct field surveys, a team of enumerators is needed to support data and information collection. Certain standards can be developed for these enumerators to ensure high quality data and information.

Planning to monitor

To conduct monitoring using the criteria and indicators, the team should develop monitoring plans to help identify goals, needs and methods that will be used in the field. The plan will also be useful to inform stakeholders of activities that will be conducted and the contribution that is expected from them. In developing the monitoring plan, the following points are to be considered:

- Where the monitoring will be conducted
- Stakeholders to be involved
- Types of data to be collected
- How this data will be collected
- Types of resources needed.

Equally important is getting the right documents ready. As part of the monitoring plan, list all the documents, permits and letters that will be needed to help the team getting the data, information or interviews they need.

Restoration programme profile

As part of developing the monitoring plan, it is also key to gather information around the peat restoration programme itself. Information relevant to governance includes:

a. Proponent/implementor of the programme
b. Details of the site (eg., what Peat Hydrological Unit (PHU) it belongs to, in what province, what district, area restored)
c. Time/duration of restoration activities
d. Types of restoration activities
e. Sources of funding
f. Villages or community groups that are directly involved in restoration activities.

In addition to the programme profile, governance evaluation should also involve developing a list of government actors involved in that restoration site and developing a profile to better understand their scope of work and roles in peatland restoration programmes. Information should include:

a. Organizations that are tasked with peat restoration duties
b. Their roles and responsibilities
c. Sources of funding for their peat restoration duties.

Reporting assessment

Following completion of this information and data collection via research and interviews, expert questionnaires can be used to verify results. As mentioned earlier, governance verification will also consider the availability of mechanisms or procedures needed to support and strengthen effective restoration programmes. This should provide information on existing governance mechanisms (as a baseline) and steps to be taken to improve on this. This list of verifiers can be extended as progress continues to capture more details relating to the C&I indicators.

5 Lessons learned and way forward

Developing and applying C&I (criteria and indicator) for tropical peatland restoration projects is essential for evaluating project success, yet requires careful adaptation to diverse project scales, objectives and local contexts. Insights from field trials highlight the importance of customized C&I frameworks, direct stakeholder involvement and robust baseline data to ensure practical relevance and effective monitoring of restoration efforts.

The exercise conducted at two sites where tropical peatland restoration projects are being implemented revealed critical insights into the practical application of C&I. These findings emphasize the need for adaptability, context-specificity and robust monitoring systems to effectively guide restoration efforts.

Tailored application of C&I

Restoration projects vary in duration, scope and cost. Applying all C&I uniformly across diverse projects proved impractical. This highlights the need for tailored frameworks, with a minimum set of essential C&I that can be applied universally, complimented by specific indicators that can be used for projects with extended timelines or broader objectives.

Impact of concurrent projects

The presence of multiple projects (‘stacked’ projects) within a given area, such as a PHU (peatland hydrological unit) influenced the application of C&I. Initial designs assumed a project-specific application without considering any overlap of ongoing initiatives. Effective use of C&I must account for and integrate existing projects to ensure coherence and avoid redundancy.

Importance of direct stakeholder involvement

Data reliability depends on engaging directly involved stakeholders. Respondents not actively participating in project activities provided insufficient insights into progress, particularly in short-duration projects. This underscores the need to identify and involve key stakeholders, ensuring that data reflects the true progress and impact of restoration activities.

Challenges with short-term projects

Short-term projects (1–2 years) with specific objectives, such as rewetting, revegetation or revitalization, cannot apply the full suite of C&I effectively. Such projects require a subset of relevant indicators that align with their targeted outcomes. A modular approach to C&I selection ensures efforts are focused on measurable and achievable goals within limited timelines.

Baseline data and periodic evaluation

The absence of baseline data and structured periodic evaluations hampers the utility of C&I. Baseline assessments prior to project initiation and a system for regular monitoring are crucial for tracking progress, enabling course corrections and generating actionable insights. These measures ensure C&I frameworks remain dynamic tools for guiding and assessing peatland restoration efforts.

5.1 Lessons learned

5.1.1 Biophysical

Field testing of verifiers provided valuable insights for improving biophysical monitoring in peatland restoration. A key finding is the need to include marketable species in revegetation efforts to encourage community participation and support economic sustainability. Since large-scale restoration relies heavily on local involvement, engaging communities from the planning phase is essential.

Testing also highlighted significant differences between small-scale (<100 ha) and large-scale (>1000 ha) projects. Large projects, like Katingan-Mentaya, have the resources to meet long-term goals, while small projects often lack funding and data for sustained impact. This points to the need for targeted studies and pilots to support small-scale efforts.

Finally, the biophysical C&I questionnaire should be adapted to reflect resource constraints, project duration and community engagement dynamics specific to different scales of restoration.

5.1.2 Economic

Economic indicators in the C&I framework showed mixed results, with some needing clearer definitions or contextual relevance. The concept of 'wetland-dependent side industries' was poorly understood, as such industries were mostly absent at test sites. Similarly, the 'benefit-sharing mechanism' proved hard to assess, as communities were often unaware of receiving structured incentives, like in Central Kalimantan's RMU project. This highlights the need for better communication and transparency. In Riau, a rare example of a wetland-based SME – ginger processing – was observed. Rather than serving as indicators, such SMEs should be treated as respondents, so that the broader economic impacts of peatland restoration can be assessed.

5.1.3 Social

Land ownership and tenure rights

An important social finding in peatland restoration relates to land ownership and tenure rights. Field testing revealed contrasting outcomes between Riau and Central Kalimantan. In Riau, restoration improved peatland accessibility, prompting increased community interest and competition, highlighting the need for equitable land-use regulations. In contrast, Central Kalimantan saw restricted access, as restoration programmes prioritized existing users through forestry partnerships, encouraging others to pursue alternative livelihoods. These differing outcomes show that 'equal access' may not be a relevant verifier. Instead, indicators should focus on monitoring tenure-related conflicts to support social harmony and the long-term success of restoration efforts.

Access to education and health services

Another key observation relates to the indicators of access to education and health services, under the social welfare criteria. Field testing showed indicator relevance varies by region when measuring social impacts, making them inconsistent measures of restoration impact. In Riau, access to education and health services is already well-established through government programmes, independent of restoration activities. Conversely, in Central Kalimantan, restoration has directly improved service access. For example, communities near the RMU concession have received support like school transportation and mobile health services, including *Posyandu* (integrated health posts). These interventions, implemented as part of the restoration programmes, demonstrate how peatland projects can provide tangible social benefits in areas with limited infrastructure.

Respondent selection: Prioritizing involvement in restoration

Selecting the right respondents is crucial for accurate economic and social impact assessments. Field testing began with village-level sampling, targeting residents in areas with restoration interventions. To diversify the data, factors like socioeconomic status, programme involvement and peatland use were considered. However, in Riau, vehicle ownership – used as a proxy for economic status – was unrelated to restoration, instead reflecting income from existing plantations. This revealed the need to focus on individuals directly involved in restoration activities like rewetting, revegetation or economic revitalization. Refining respondent criteria in this way ensures that data better reflects actual restoration impacts. Sampling should also extend beyond village boundaries to include those engaged in field-level interventions like canal block construction or planting efforts.

Timing and baselines for effective monitoring

Field trials underscore the importance of establishing a systematic timeline for monitoring and evaluation. Monitoring cannot be a one-time activity conducted at the end of a restoration project; instead, it requires baseline data collected before the project's initiation. This baseline data should align with the verifiers outlined for each indicator, ensuring comprehensive documentation of initial conditions.

In cases where baseline data is unavailable, the monitoring tools within this module can serve as a framework to document initial conditions at the project's outset. Subsequent assessments should involve the same respondents and tools, with follow-up measurements conducted at regular intervals, such as every 6 to 12 months. By comparing initial conditions with subsequent evaluations, projects can effectively monitor progress and determine the long-term impacts of restoration interventions.

Expertise in monitoring and assessment

The complexity and variability of social and economic conditions across peatland ecosystems necessitate the involvement of expert assessors in monitoring efforts. Communities in Riau, for example, differ significantly from those in Central Kalimantan in terms of their relationship with the peatlands, making it challenging to standardize the evaluation of outcomes.

To address this, assessors must possess specific expertise, including: at least six months of experience working with peatland communities; and a foundational understanding of the biophysical characteristics of peat ecosystems.

This expertise ensures that monitoring results are contextualized, accurate and reflective of the unique dynamics within intervention areas. The inclusion of additional qualitative data describing community conditions can further enrich the analysis, providing insights that go beyond the predefined verifiers.

Adapting to specific restoration projects

Field trials showed that monitoring frameworks cannot be universally applied, as restoration goals vary by local context. In Riau, where peatlands are actively used by residents, restoration focuses on sustainable use and minimizing further damage. In contrast, in Central Kalimantan where peatlands are located far from the settlement and there is limited direct community interaction, restoration emphasizes preventing exploitation through alternative, non-peatland-based livelihoods.

These regional differences require monitoring approaches tailored to each project's objectives. For instance, if the goal is 'a viable and sustainable peatland-based economy', the criteria used here suit projects like those in Riau. However, projects like RMU in Central Kalimantan, which promote non-peatland-dependent economies, may require a different monitoring framework.

5.1.4 Governance

Governance is a cornerstone of effective peatland restoration, ensuring transparency, accountability and inclusivity in decision making and implementation. The proposed governance C&I for peatland restoration cover a wide range of aspects, including legal frameworks, regulatory mechanisms, participation, transparency and accountability. The following is a summary of our key findings, challenges and recommendations based on field surveys and the applicability of these indicators in the context of Riau and Central Kalimantan.

Key governance indicators and relevant laws

To ensure effective implementation, governance indicators require robust legal foundations. Indonesia already has several laws and regulations aligned with these indicators, as summarized in table 11.

Table 11. Indicators of relevant laws and regulations

Indicator	Relevant laws and regulations
Level of participation	The Indonesian Constitution 1945; Law No. 12/2011; Regulation of Head of BRG No. 3/2016 on Free, Prior and Informed Consent (FPIC)
Level of transparency	Law No. 14/2008 on Public Information; Government Regulation No. 61/2010 on the Implementation of Public Information
Level of accountability	Law No. 25/2009 on Public Services; Regulation of Head of BRG No. 3/2016 on Complaint Handling Mechanisms
Formal regulation	Law No. 32/2009 on Environmental Protection and Management; Government Regulation No. 57/2016; Ministerial Decree No. 60/2019
Conflict resolution	Law No. 41/1999 on Forestry; Law No. 32/2009; Government Regulation No. 44/2004 on Forest Management Plans
Regulatory frameworks for change/adaptivity	Law No. 12/2011; Government Regulation No. 57/2016; Ministerial Decree No. 60/2019

While these laws provide a strong baseline, field surveys revealed gaps in their implementation at the local level. In regions like Riau and Central Kalimantan, several mechanisms mandated centrally have not been established at regional level, limiting community access to governance processes.

Progress framework for governance indicators

It was determined that it was possible to address implementation gaps relating to governance C& I by using a three-tiered framework:

- *Existence of rules*: Confirm whether legal and regulatory frameworks mandate the indicator.
- *Existence of mechanisms*: Determine whether the mandated mechanisms have been established.
- *Effectiveness of mechanisms*: Assess the frequency and quality of use of these mechanisms by stakeholders.

This approach ensures that governance monitoring focuses on both the presence and the functionality of regulatory mechanisms.

Context-specific indicators

Not all governance indicators are universally applicable across restoration sites. For example, customary laws related to environmental management were found to be irrelevant in some areas because the governance frameworks they supported no longer exist. In such cases, it is essential to prioritize C&I that align with the specific context and needs of the restoration project. For better monitoring, selection of C&I that reflect the project's scale, objectives and local conditions could be a preferred approach.

Reformulating complex indicators

Several governance indicators need refinement for easier verification and interpretation:

- *Role of women*: Current indicators capture women's participation through their presence but fail to assess their substantive role in decision making. Women's contributions were evident in economic and social aspects but were not adequately reflected in governance metrics. This can be addressed by creating separate criterion for women's roles, possibly under economic and social aspects.
- *Rule of law*: This indicator is too broad and challenging to verify. This can perhaps be reformulated to focus on monitoring and compliance mechanisms.
- *Natural resource governance*: Similarly broad and difficult to measure. A suggestion would be to replace them with verifiers under the 'Institutions' criterion.

Accountability and utilization of public funds

Accountability indicators should address how restoration activities connect to public budget usage. However, in cases like RMU, where restoration is funded by private entities, public audit mechanisms may not be applicable. This can be addressed by adjusting accountability indicators to reflect the source of funding. For privately funded projects, alternative verifiers, such as third-party assessments or stakeholder feedback, can be used.

Effectiveness beyond formal mechanisms

In some cases, restoration projects have successfully implemented participatory and accountable governance practices despite gaps in formal government mechanisms. For example, RMU's participatory restoration activities in Central Kalimantan demonstrate that community-driven approaches can achieve governance objectives even in the absence of comprehensive regulatory frameworks. For this reason, we felt there was a need to include qualitative assessments of informal or community-based governance practices as supplementary indicators.

5.2 Conclusions

Verification of peatland restoration monitoring highlights the need for flexible application of C&I across diverse contexts. The monitoring of biophysical aspects benefits from community-driven approaches and addressing resource disparities between project scales. Economic indicators meanwhile require clearer definitions – for example around benefit-sharing and wetland-based industries – and improved communication to enhance stakeholder engagement. Social indicators must move beyond access-based measures toward monitoring land tenure conflicts and tailoring welfare indicators like education and health to regional contexts. Adaptive frameworks enable more accurate assessments across varying communities and project conditions. Effective evaluations rely on involving directly engaged respondents, supported by baseline and follow-up data, and guided by skilled assessors using context-specific tools. Governance indicators, while essential, must be simplified and localized, including recognition of informal governance. Refining C&I, particularly for small-scale projects, enhances inclusivity and usability. Ultimately, context-sensitive, adaptive C&I frameworks support better decision making and contribute to more effective, equitable and sustainable peatland restoration worldwide.

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Restoring tropical peatlands is essential for achieving sustainable development goals**.** Yet measuring restoration progress remains a challenge, particularly across diverse landscapes and stakeholder contexts. This working paper presents a structured framework of **Criteria and Indicators (C&I)** by which peatland restoration initiatives can be monitored and evaluated with scientific rigor and practical relevance.

Developed through multi-stakeholder consultations and field validation in Indonesia, the framework encompasses four key dimensions: **biophysical, social, economic and governance**. It enables evidence-based decision-making processes with the aim of fostering inclusive peatland management.

By integrating ecological science with local knowledge and institutional analysis, this paper provides both conceptual grounding and applied guidance for researchers, practitioners and policymakers. Insights generated through applying its framework can help to build more accountable and effective peatland restoration programs – both within Indonesia and beyond.