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Full Length Research Article

The Effectiveness of Forest Management and Monitoring Implementation under the National Forest Stewardship Standards (NFSS) Scheme in Indonesia

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ABSTRACT

Forest management activities inevitably affect environmental functions and community well-being, necessitating rigorous impact monitoring to improve management practices. The Indonesian National Forest Stewardship Standards (NFSS) provide structured guidelines to balance timber production with environmental protection. This study evaluates the comprehension and application of these standards in forest harvesting planning, implementation, and impact assessment. A quantitative descriptive method was employed, integrating questionnaires, field observations, and interviews with field staff from a Forest Stewardship Council (FSC)-certified forest concession in West Papua, Indonesia. Respondents included staff involved in forest planning, production and logging road construction, silviculture and environmental monitoring, and community development. Data were collected using NFSS-based questionnaires and analyzed using the Likert scale method. In addition, triangulation was conducted via field observations at harvesting sites, document reviews (forest management procedures, High Conservation Value report, Social Impact Assessment report, and Environmental Management and Monitoring Plan report), and interviews to validate questionnaire findings. The results show an average Likert score of 83.91% across five key variables (baseline environmental data, Reduced Impact Logging (RIL) map presence, RIL implementation, human resources, and impact monitoring and adaptation), indicating a strong understanding of NFSS standards. However, challenges remain in enhancing community engagement, implementing best management practices, strengthening supervision and impact monitoring techniques, and developing adaptive strategies for sustainable forest management.

1. Introduction

Forest logging activities inevitably impact environmental functions (Rachmawan et al. 2016), with forestry concessions often exacerbating these effects (Juniyanti and Situmorang 2023). These impacts include increased erosion and sedimentation (Asdak 2023), disruptions to wildlife such as birds (Atikah et al. 2021), reptiles (Asad et al. 2022), and mammals (Carvalho Jr et al.

2021), as well as restrictions on community access to forests, which subsequently impacts livelihoods (Sahoo et al. 2023).

Sustainable Forest Management (SFM) standards in Indonesia are mandated to ensure maximum timber production while minimizing environmental and social impacts. These standards include mandatory certifications such as the Legality and Sustainability Verification Certification - Sustainable Production Forest Management (*Sertifikasi Verifikasi Legalitas Kelestarian-Pengelolaan Hutan Produksi Lestari*, SVLK-PHPL), as stipulated in Indonesia's Minister of Environment and Forestry Decree Number 9895 of 2022. Beyond these mandatory certifications, voluntary certifications are prevalent, such as those established by the Forest Stewardship Council (FSC) and the Programme for the Endorsement of Forest Certification (PEFC) (Cashore et al. 2021). These market-driven certifications frequently exceed legal requirements and are endorsed by non-governmental organizations and third parties (Matias et al. 2024).

Strong forest management standards have been shown to encourage forest managers to implement environmental and social impact mitigation measures beyond minimum regulatory requirements (Urano and Rayadin 2019). One prominent example is Reduced Impact Logging (RIL). This planned, effective, and efficient forest harvesting approach prioritizes optimal production while minimizing environmental, ecological, and social damage (Elias 2001). RIL has demonstrated superior harvesting efficiency (75.30–91.41%) in comparison to conventional logging methods (60.42–84%) while significantly reducing residual stand damage (Dulsalam et al. 2021; Soenarno et al. 2019). Nevertheless, it is crucial to acknowledge that implementing RIL does not entirely mitigate all risks associated with forestry practices. For instance, initiating logging at a minimum diameter of 40 cm has extended harvest rotations to 57.3–63.2 years (Heriansyah et al. 2022). On the other hand, limiting the number of trees harvested per hectare has been demonstrated to reduce forest degradation, minimize impacts on tree species diversity, and promote natural regeneration (Matangaran et al. 2023).

Conversely, conventional logging often leads to negative consequences, including soil erosion, increased sedimentation in water bodies, and restricted community access to forest resources, ultimately diminishing local well-being (Bocci et al. 2018; Lontsi et al. 2019; Sahoo et al. 2023). For example, a study on the impact of forest harvesting on water quality in Sabah, Kalimantan, and Malaysia found that logging near roads increased monthly sedimentation up to fifteen times higher than control sites, with peak sedimentation reaching 12.947 mg/liter following heavy rainfall events (Shah et al. 2022). Such impacts can disrupt communities reliant on rivers for essential resources, potentially leading to conflicts with forest concession managers. Community involvement in forest management can mitigate external disturbances and generate economic benefits (Sulistyowati and Hadi 2018; Wulandari et al. 2024).

According to the Forest Stewardship Council (2020), the National Forest Stewardship Standard (NFSS) Indonesia 2020 (FSC-STD-IDN-02.1-2020 EN) mandates impact monitoring as part of adaptive forest management. Forest managers have the obligation to demonstrate monitoring and evaluation of the progress toward management objectives, the impacts of management activities, and the overall condition of the management unit, proportional to the scale, intensity, and risks of those activities.

If monitoring results indicate non-compliance with FSC standards, the forest management plan must be reviewed and revised accordingly. Hermudananto et al. (2018) reported that 29% of non-compliance cases with FSC environmental standards in Indonesia result from a lack of monitoring data for management improvements, often due to poor data integration into adaptive management strategies. This deficiency may lead to overlooked environmental degradation and inadequate corrective actions. Furthermore, Lima and Azevedo-Ramos (2023) stated that the effectiveness of environmental monitoring is highly supported by clear and strong management standards, which influence the monitoring practices of forest concessions and other stakeholders. Rana and Sills (2024) highlighted that implementing robust forest management certification standards leads forest managers to monitor forest conditions, resulting in lower deforestation rates and reducing the negative impacts of logging activities. Within FSC standard implementation, adaptive monitoring plays a crucial role in mitigating negative environmental and social impacts while enhancing overall forest management effectiveness.

Previous studies on impact monitoring in forest concessions have primarily focused on assessing the effects of harvesting activities on soil, water, and biodiversity. The novelty of this research lies in its emphasis on a quantitative descriptive analysis of the field staff's understanding of NFSS Indonesia implementation. Specifically, this research examines how field personnel perceive the effectiveness of forest management, impact monitoring, and challenges in applying NFSS Indonesia, thereby defining the study's main objective.

2. Materials and Methods

2.1. Study Site

The research was carried out at PT Wijaya Sentosa, located in Teluk Wondama and Teluk Bintuni Regencies, West Papua Province, Indonesia, which has an area of 130,755 ha. The concession started working operationally in 2014 and obtained an FSC certification for Forest Management/Chain of Custody (FM/CoC) in 2016. The topographic conditions of the forest concession area have an altitude of 0 – 1,113 m above sea level. The concession area consists of undulating terrain (67.76%), flat slopes (19.49%), and steep slopes (8.63%). There are 10 villages located within and around the concession area. According to the 10-Year Work Plan (2023–2032), the forest concession has been granted an annual harvesting permit for an average of 3,645 ha. It has gradually implemented Reduced Impact Logging (RIL) since 2016. This research focuses on field staff's understanding of work practices following the NFSS Indonesia 2020 (FSC-STD-IDN-02.1-2020 EN) standards. The research location is shown in **Fig. 1**.

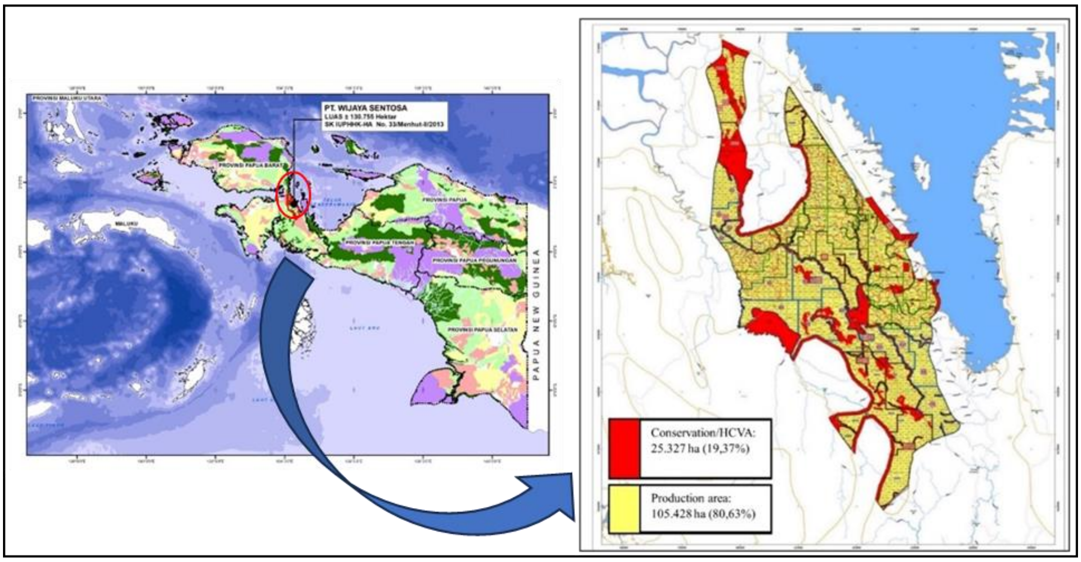

Fig. 1. Map of concession work as research locations at PT Wijaya Sentosa.

2.2. Research Design

This research employs a quantitative descriptive method, incorporating a triangulation approach to ensure data validity and reliability. This research integrates primary and secondary sources through questionnaires – completed by field staff to assess their understanding of NFSS Indonesia implementation, direct observations – conducted on-site to verify consistency between questionnaire responses, document records, and field practices, and interviews – conducted to gain deeper insights into operational challenges and implementation effectiveness. Sugiyono (2016) states that the triangulation method is used in quantitative research to ensure that the data obtained is more valid and trustworthy. In this research, source triangulation is used, which involves comparing and cross-checking the consistency of information obtained from multiple data sources, such as interviews with various informants, documents, and observations.

Interviews were conducted with field staff at various levels, including field officers, foremen, supervisors, managers, and directors, to verify responses from the questionnaire. The selected field staff directly involved in forest harvesting activities include forest planning staff, production and logging road construction staff, silviculture and environmental monitoring staff, and community development staff. The interview scope varied based on the variable context: managerial aspects were discussed with supervisors, managers, and directors; technical field aspects were addressed with foremen and field officers.

Review of supporting documents includes standard operating procedures (SOPs) for forest harvesting planning, forest silviculture, and environmental impact monitoring (water, soil, flora, wildlife, and social impacts). In addition, a review was conducted on documents containing basic planning information, such as the results of high conservation value identification in 2016, the social impact baseline study in 2019, and the Environmental Management and Monitoring Plan report (2015-2023). Site visits were conducted to assess post-harvest forest conditions (soil, water, and biodiversity) by inspecting harvested blocks from 2016 to 2024.

2.3. Data Collection

Field data collection was conducted from October to November 2024. The process began with administering questionnaires to asses the field staff's understanding of the implementation of the NFSS Indonesia 2020 (FSC-STD-IDN-02.1-2020 EN) standard. The questionnaire distribution started with an explanation provided to selected field staff representatives (including field officers, foremen, supervisors, and managers) regarding each questionnaire statement. This approach was necessary due to time constraints and logistical challenges in gathering all respondents in one location or visiting each individually. Subsequently, these representatives conveyed the instructions to other respondents on how to complete the questionnaire. The completed questionnaires were then reviewed to ensure the accuracy and correctness of responses.

The total number of field staff directly related to the research is 195, originating from the Departments of Forest Planning, Production, Social Management, Silviculture, and Environmental Monitoring. The sample size was determined using Slovin's formula with a 5% margin of error (Amirin 2011), resulting in a selected sample of 132 respondents. The Slovin's formula used is as follows:

$$n = \frac{N}{1+Ne^2} \quad (1)$$

where *n* is the number of samples, *N* is the population size, and *e* is the maximum error rate or significance level.

The details of the sample respondents from each department are as follows:

- Forest Planning Department: 30 respondents from a total population of 48 staff members.
- Forest Silviculture and Environmental Monitoring Department: 15 respondents from a total population of 22 staff members.
- SFM Certification Department: 3 respondents from a total population of 3 staff members.
- Community Development Department: 15 respondents from a total population of 22 staff members.
- Production and Road Department: 69 respondents from a total population of 102 staff members.

The questionnaire statements are derived from the indicators outlined in NFSS Indonesia 2020 (STD-IDN-02.1-2020 EN), specifically focusing on aspects directly related to forest management implementation and impact monitoring. These aspects include forest management planning, implementation, impact monitoring, and adaptive management. The questionnaire consists of five variables: (1) Baseline data on environmental function values; (2) RIL maps and field markings; (3) RIL implementation and/or Best Management Practices (BMP) in forest management activities, (4) Human Resources, and (5) Impact monitoring and adaptive management. The list of statements was submitted to obtain confirmation from respondents on a scale: Strongly Agree (4), Agree (3), Disagree (2), and Strongly Disagree (1). Sugiyono (2016) and Riduwan (2023) stated that scale determination can be modified according to data collection needs, provided the scale remains aligned with the measurement objectives. This study's questionnaire deliberately omitted a neutral (zero) option to encourage respondents to express a clear and consistent opinion, ensuring more definitive and reliable questionnaire responses. The list of questionnaire statements is as follows:

Variable 1: Baseline data on environmental function values

1.1 An assessment of the existence of threats to environmental values is conducted prior to management/harvesting activities. This includes the identification of the presence of protected flora and fauna according to CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora), IUCN (International Union for Conservation of Nature) Red List, Indonesian Ministry of Environment and Forestry Regulation P.106/2018 about protected flora and fauna, endemic species, as well as habitats and Intact Forest Landscapes (IFL).

1.2 An assessment of potential environmental impacts from forest management activities is conducted down to the site level.

1.3 Conservation zones (including the availability of representative areas of natural ecosystems) are established within the forest concession area, connected by corridors, and designated for protection as part of the habitat conservation efforts for threatened and rare flora and fauna. The total representative conservation zone area is at least 10% of the total concession area.

1.4 There are verifiable targets in the management plan to ensure the protection of environmental function values.

1.5 Specifically regarding the presence of High Conservation Values (HCV), stakeholders participate in developing management strategies and actions to maintain and/or enhance identified HCVs. (Note: Stakeholders include affected local communities, impacted stakeholders, interested stakeholders, and/or experts).

1.6 The High Conservation Value Areas (HCVA) map illustrates the identified HCV attributes as part of the existing environmental function values.

Variabel 2: RIL maps and field markings

2.1 There are procedures for planning activities prior to management operations (e.g., harvesting planning, field mapping) to optimize management activities and minimize environmental impacts.
2.2 Pre-management planning is conducted with a precautionary approach, and best management practices are applied to prevent adverse impacts on environmental values, ensuring the protection of ecosystem habitats, river networks, riparian zones, and cultural sites.
2.3 RIL operational maps (including topographic information) are prepared to safeguard environmental values and are designed at a scale that allows effective monitoring of management activities and soil and water protection.
2.4 Field markings are in place to support RIL implementation and harvesting techniques, designed to minimize soil compaction and maximize soil nutrient retention in the work areas.
2.5 Stakeholders are involved in the development of management planning before harvesting operations.
2.6 An effective decision-making mechanism is established from the managerial level to the field staff in case of planning modifications.

Variable 3: Implementation of RIL and/or Best Management Practice (BMP) for forest management

3.1 A mechanism is in place to protect wildlife following applicable laws on species protection, hunting, and trade of species or their parts.
3.2 Environmentally friendly harvesting procedures, or Reduced Impact Logging (RIL), aim to protect local communities' soil, water, biodiversity, and social aspects.
3.3 RIL practices (with clear field markings) are fully applied to protect environmental values from degradation, including soil damage, river flow disturbances, forest canopy openings, and cultural heritage sites.
3.4 The use of native plant species to control exotic and alien species is ensured in restoration activities.
3.5 Chemical fertilizers and pesticides are minimized, and hazardous and toxic waste are properly managed.
3.6 There is a significant large-scale conversion of natural forests to other land uses within the concession.

Variable 4: Human Resources

4.1 Adequate training is provided for implementing forest management activities, including planning, RIL, and environmental impact monitoring.
4.2 Effective supervision is in place to ensure that all workers perform their duties efficiently and safely.
4.3 A sufficient number of field workers is available for the harvesting and monitoring systems.
4.4 Implementing Occupational Health and Safety Management Systems (SMK3) ensures a safe working environment, including using personal protective equipment (PPE), risk analysis, and mitigation measures.

4.5 A non-discriminatory work environment (regarding ethnicity, religion, race, and gender) is maintained regarding training opportunities, promotions, transfer/reassignment, and wages.

Variable 5: Impact monitoring and adaptive management

5.1 Environmental impact monitoring is conducted periodically using clear procedures or methods.
5.2 The results of environmental impact monitoring are utilized to assess the effectiveness of management practices and the impact of harvesting on environmental function values.
5.3 Immediate corrective actions are taken to restore environmental values if environmental damage is detected. For example, repairing riverbanks, preventing erosion, addressing uncontrolled forest openings, and mitigating other negative impacts.
5.4 An adaptive management mechanism/procedure is implemented based on monitoring results and conducted periodically to improve planning and harvesting implementation. This includes data analysis procedures and the presentation of monitoring data.
5.5 Stakeholders are involved in forest management impact monitoring activities, such as providing input for management improvement actions. (Note: These stakeholders include local communities with affected rights, impacted stakeholders, interested stakeholders, and/or experts).

2.4. Data Processing and Analysis

Sugiyono (2016) stated that before conducting a comprehensive sample collection, it is necessary to perform validity and reliability tests using the Pearson correlation test to obtain the r-table, calculated using the degree of freedom formula (df = n-2). Meanwhile, the reliability test is conducted using the Spearman-Brown formula. The validity and reliability tests were performed with the assistance of IBM SPSS Statistics 27 software. The Spearman-Brown formula used is as follows:

$$r_i = \frac{2r_b}{1+r_b} \quad (2)$$

where r_i is the internal reliability of all instruments, and r_b is the product-moment correlation between the first and second hemispheres.

Validity and reliability testing were conducted on a random sample of 30 respondents to assess whether the questionnaire was suitable for full-scale research implementation. The validity analysis results were deemed valid as the calculated r-value exceeded the table r-value (0.361). Similarly, the reliability test results indicated that all variables were reliable, as the required Cronbach’s Alpha coefficient (> 0.60) was met: Variable 1 = 0.735; Variable 2 = 0.785; Variable 3 = 0.794; Variable 4 = 0.825; and Variable 5 = 0.747. Thus, the questionnaire could be administered to the 132 respondents for data collection. **Table 1** presents the validity test results for each statement in the variables.

Table 1. Results of validity test for each variable, which r $_{\text{calculated value}}$ > r $_{\text{table value}}$ 0.361)

Variable	Statement	Calculated r-value
Baseline data on environmental function values	1.1	0.674**
	1.2	0.677**
	1.3	0.611**
	1.4	0.735**
	1.5	0.546**
	1.6	0.665**
RIL maps and field markings	2.1	0.664**
	2.2	0.702**
	2.3	0.753**
	2.4	0.662**
	2.5	0.649**
	2.6	0.642**
Implementation of RIL and/or best management practices in forest management activities	3.1	0.683**
	3.2	0.644**
	3.3	0.612**
	3.4	0.707**
	3.5	0.697**
	3.6	0.472**
Human Resources	4.1	0.797**
	4.2	0.724**
	4.3	0.761**
	4.4	0.770**
	4.5	0.681**
	4.6	0.642**
Impact monitoring and management adaptation	5.1	0.642**
	5.2	0.690**
	5.3	0.670**
	5.4	0.716**
	5.5	0.617**

After the validity and reliability tests were conducted and deemed to meet the requirements, the next step was to perform the Likert scale test. Riduwan (2023) and Sugiyono (2016) stated that to measure an individual's or a group's attitudes, opinions and perceptions regarding a particular matter. The Likert scale can be used, which is then established as a research variable. The research variables are measured based on indicators reflecting respondents' perceptions being studied. **Table 2** presents a summary of the Likert scale index calculation for each variable.

Initial information from the Likert scale analysis in this research is as follows:

a. Total sample: 132 respondents.
b. Questionnaire rating scale: 4 (strongly agree), 3 (agree), 2 (disagree), and 1 (strongly disagree).
c. The maximum score is 4 x 132 respondents = 528.
d. The Likert scale interval is calculated as 100 ÷ 4 (sum of scores) = 25, resulting in the following scale intervals used in this study: strongly disagree (0–24.99); disagree (25–49.99); agree (50–74.99); strongly agree (75–100).

Table 2. Example of Likert Scale Index Calculation Summary for Each Questionnaire Variable Statement

Statements from each variable	Score (a)	Respondent frequency (b)	Score value x Respondent (c) = a x b	% (d) =b/total b
Strongly agree	4			
Agree	3			
Do not agree	2			
Strongly disagree	1			
Total		132		
Likert scale index value of the variable			Total amount C / Total highest score value (4 x 132 = 528)	

3. Results and Discussion

3.1. Understanding the Implementation of NFSS Indonesia

The results of the Likert scale analysis for Variables 1 to 5 indicate a score of 83.91%, suggesting that all respondents strongly agree that the forest management activities and monitoring system are well-implemented with high commitment, ensuring the preservation of environmental values and ecosystem sustainability. Consequently, the field staff can consider the understanding and implementation of NFSS Indonesia 2020 (STD-IDN-02.1-2020 EN) well-comprehended and effectively applied. A summary of the Likert scale analysis results for Variables 1 to 5 is presented in **Table 3**.

Table 3. Likert Scale Scoring Summary for Variables 1 to 5

Variable	Likert Score (%)
1. Baseline data on environmental function values	84.97
2. RIL maps and field markings	85.10
3. Implementation of RIL and/or best management practices in forest management activities	81.69
4. Human resources	84.02
5. Impact monitoring and management adaptation	83.79
Average Likert Score	**83.91**

The explanation of the Likert scale analysis results for each variable is as follows: Variable 1 – Baseline data on environmental function values has an average index score of 84.97%, indicating that the protection of environmental values before harvesting has been well implemented. This includes the identification of High Conservation Value (HCV) areas covering 25,327 ha (19.37% of the concession area), which have been designated as conservation zones (as shown in **Fig. 1.**). NFSS Indonesia defines environmental values as a collection of biophysical and human environmental elements, including ecosystem functions (such as carbon absorption and storage), biodiversity, water resources, soil, atmosphere, and landscape values, including cultural and spiritual values. The process of gathering baseline environmental data and formulating protection strategies follows these steps: (a) Identifying the existing environmental values; (b) Identifying potential negative impacts of forest management activities on these environmental values; (c) Identifying methods to prevent negative impacts on environmental values; and (d) Identifying the representative sample area of natural habitats to be protected (Forest Stewardship

Council 2020). A flowchart illustrating the assessment of environmental values and the impacts of forest management within NFSS Indonesia 2020 (STD-IDN-02.1-2020 EN) is presented in **Fig. 2**.

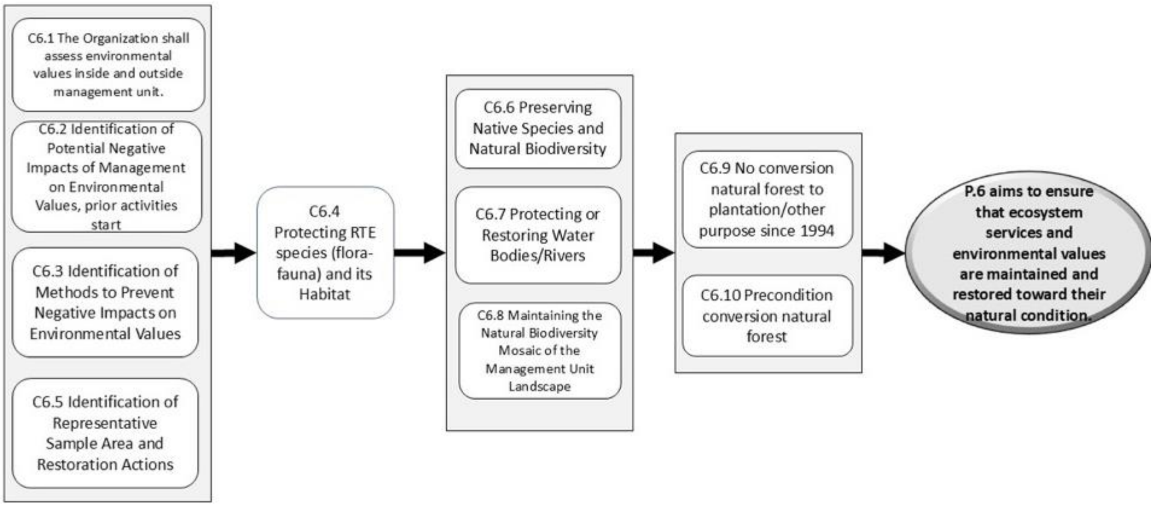

Fig. 2. Flow Principle of Environmental Value and Impact (Principle 6), NFSS Indonesia 2020.

Variable 2 – The average Likert index score for RIL maps and field markings variable is 85.10%, indicating that the planning and implementation of Reduced Impact Logging (RIL) have been carried out effectively. Pre-harvest planning, a key phase of RIL implementation, helps mitigate environmental damage. The implementation of pre-harvest planning has been shown to reduce deforestation rates by 5–74% over 10 years (2000–2010) in the Congo Basin and Kalimantan, Indonesia, within FSC-certified concessions from 2000 to 2008 (Miteva et al. 2015; Tritsch et al. 2020). RIL mapping must include accurate topographic information, rivers and watercourse locations, the positions of harvestable trees, and conservation areas (Elias et al. 2001; Elias 2024). Implementing RIL is considered a best practice and is mandatory, particularly for protecting environmental values, habitat and species conservation, and minimizing timber waste (Forest Stewardship Council 2020). However, 7 respondents (5.3%) indicated concerns about the lack of stakeholder involvement (especially in local communities) and unclear decision-making mechanisms. While this percentage may be small, it is important to investigate further, considering that the forest concession has adhered to FSC standards since 2015 and obtained FSC FM-CoC certification in 2016. Understanding the root causes or specific cases behind these concerns and formulating solutions to prevent recurrence and escalation is necessary for continuous improvement.

Variable 3 - Implementation of RIL and/or BMP in forest management activities has an average index value of 81.69%, indicating that the implementation of RIL and BMP has been carried out effectively. Implementing RIL has proven to yield better outcomes than conventional logging. This has been demonstrated by various studies, including Asad et al. (2022) and Asad et al. (2021) on amphibian reproduction in RIL-logged plots, Lontsi et al. (2019) on the impact of RIL on nutrient loss in forest soils, Dulsalam et al. (2021) on the effects of RIL on residual stand damage, Soenarno et al. (2019) on RIL efficiency levels, Carvalho Jr et al. (2021) on the impact of RIL on mammal populations, and Atikah et al. (2021) on bird life in the RIL-logged forests after 30 years. However, some respondents highlighted concerns regarding the threat of natural forest conversion (69.89%) and the need to minimize the use of hazardous chemicals (79.92%).

Variable 4 - Human Resources has an average index score of 84.02%, reflecting a well-managed human resource system. However, six respondents (4.5%) reported issues related to supervision, the availability of field personnel, and a non-discriminatory work environment. Interviews revealed that training for all staff is conducted regularly according to the department's plan and organized by the Human Resources department. Promotions are carried out transparently, based on a performance assessment system involving supervisors and senior management. Staff transfers, reassignment, and employee rotation are agreed upon in employment contracts, covering movements between departments or within the company's larger corporate group. Wages are set transparently above the provincial minimum wage, ensuring no discrimination. If there are allegations of discrimination, each case should be analyzed individually rather than generalized.

Variable 5 - Impact monitoring and adaptation management have an average index score of 83.79%, indicating that forest management monitoring and adaptation have been effectively implemented. Environmental impact monitoring is conducted periodically following clear procedures, with corrective measures taken when environmental damage is identified. Monitoring of forest management impacts includes observations of erosion and the hydrological conditions of watersheds (Asdak 2023), the condition of remaining stands (Kusmana et al. 2022), and the presence of key species or umbrella species (Konsorsium Revisi HCV Toolkit Indonesia 2008).

A monitoring and impact evaluation system is essential to support adaptive management. Meijaard et al. (2006) stated that impact monitoring by forestry concessions should at least include verification of current and future threat identification and changes in flora and fauna abundance indicators. The monitoring scope should cover both logged and unlogged areas. This is further supported by Coleman et al. (2019), who explained that forests with high biodiversity concentrations face significant pressure from degradation threats due to management or utilization activities. Therefore, evaluating the causes of such pressures is necessary to identify the species and habitats at the highest risk. According to the Forest Stewardship Council (2020), under Principle 8 – Monitoring and Assessment, forest managers must establish a robust impact monitoring system to evaluate management adaptation. This includes the existence of monitoring procedures, result analysis, and the utilization of monitoring data to assess the achievement of forest management targets. The flowchart of environmental impact monitoring and assessment in NFSS Indonesia 2020 (STD-IDN-02.1-2020 EN) can be seen in **Fig. 3**.

Based on the triangulation analysis of data collection, including Likert scale analysis, interviews with field officers, harvest operators, foremen, supervisors, forest planning managers and directors, as well as field observations, several key areas require attention for improved management:

a. Enhancing stakeholder engagement, particularly community involvement, in every stage of forest management planning, harvesting implementation, and impact monitoring. This is crucial to mitigate the negative impacts of forest management on local communities.
b. Improving best management practices through implementing Reduced Impact Logging (RIL), not using hazardous chemicals, and preventing natural forest conversion due to increased accessibility from road infrastructure (e.g., Trans-Papua) within the company's concession.
c. Strengthening managerial governance and human resources through coaching, problem-solving initiatives, continuous training, and stricter supervision to ensure effective implementation in compliance with established standards.

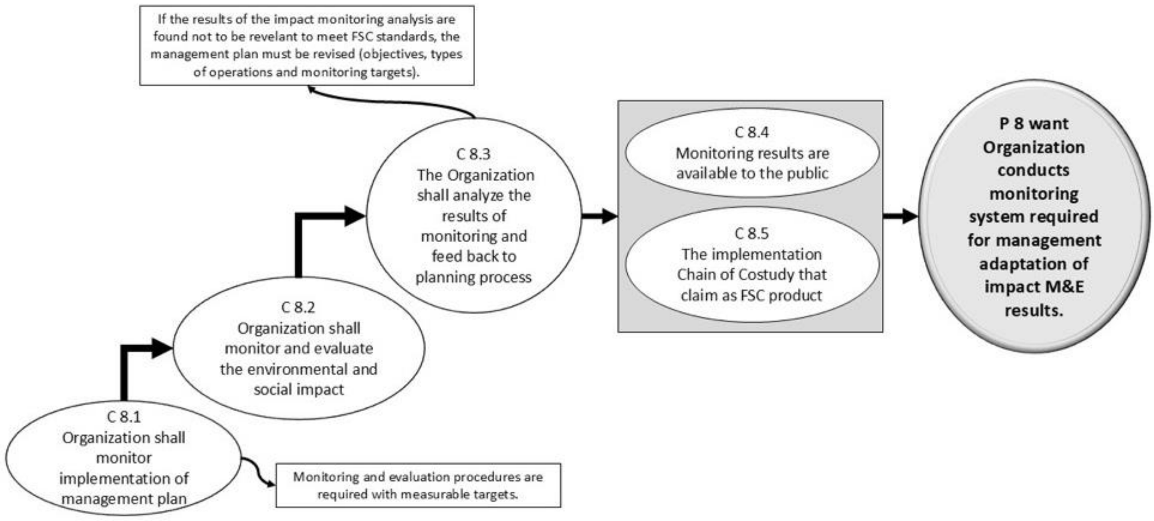

Fig. 3. Impact Monitoring and Management Adaptation Flow in NFSS Indonesia 2020.

3.2. Discussion

Matias et al. (2024) stated that the FSC standards can guide the implementation of sustainable forest management from both conservation, social, and production aspects with high standards. In some cases, it even exceeds the fulfillment of obligations contained in legal regulations, ensuring minimal environmental impact from forest management. The NFSS Indonesia 2020 (FSC-STD-IDN-02.1-2020 EN) directs the implementation of high forest management standards by providing baseline data on environmental and social values, integrating them into planning, implementing best management practices, and developing mitigation and impact monitoring plans. In addition, management must be adaptive if existing strategies fail to meet targets based on monitoring results. Through this approach, forest management is expected to be efficient, achieve optimal production, and minimize environmental and social impacts.

Based on the analysis of the Likert scale scores for variables 1 to 5, it has been determined that the forest concession has implemented the identification of environmental function values as a consideration in the development of harvesting plans. This approach helps minimize the environmental damage caused by harvesting activities. Environmental impacts are monitored, and the results are analyzed to serve as a basis for improving management activities. The analysis of the Likert scale scores indicates the need for improvements in addressing challenges related to enhancing stakeholder participation (particularly the local community) and strengthening field staff's technical and managerial capacities to ensure effective forest management. These challenges are described as follows.

3.2.1. Stakeholder engagement (particularly local communities) in forest management activities

Community involvement in forest management and monitoring is a fundamental characteristic and requirement of FSC standards. Communities surrounding FSC concessions tend to have positive perceptions due to their involvement in forest concession activities, such as forest planning and conflict resolution (Degnet et al. 2022). In addition, the engagement of local communities through Free, Prior, and Informed Consent (FPIC) is a mandatory approach that forest concession should implement to ensure the participation of indigenous and local communities in accordance with their cultural practices, build trust, and encourage active participation from all community members (Forest Stewardship Council 2020). However, this involvement still faces cultural challenges, such as the dominance of male voices in decision-making due to the perception of higher social status compared to women and a low interest in topics beyond the compensation for customary land rights. Tabuni (2023) noted that in Papua, women hold significant cultural value. However, within the socio-cultural (and religious) structures, women often experience subordination in public spaces and are frequently regarded as second-class citizens with limited authority in public domains.

Therefore, more intensive training for field staff in implementing FPIC is necessary with the following objectives:

- Enhancing their ability to serve as facilitators who actively "listen" to community voices, particularly those less dominant, ensures that forest concession programs and activities align with the needs of the entire community, not just specific groups.
- Increasing the participation of community representatives, particularly women, in every stage of the FPIC discussion process.
- Structuring discussion methods and topics in a way that enhances community engagement and encourages greater participation in dialogues with the forest concession.

Bocci et al. (2018) and Mohta et al. (2023) explain that community involvement can potentially increase positive participation despite the heterogeneity of economic benefits across different social groups. Community participation also plays a crucial role in protecting concession areas (such as High Conservation Value areas) from threats such as encroachment, illegal logging, and forest fires.

3.2.2. Improving forest management practices

Enhancing forest management practices should focus on improving existing best practices, such as Reduced Impact Logging (RIL) and impact monitoring, and anticipating the consequences of increased public transportation access within concession areas. Currently, the construction of the Trans-Papua road, which spans 475.81 km from south to north through concession areas, raises concerns about uncontrolled forest clearance due to easier external access. This could lead to encroachment, illegal logging, and other unauthorized activities. Alamgir et al. (2019) found that road development in North Kalimantan, which cuts through vast areas of natural forests, is expected to cause significant ecological damage, especially causing fragmentation of the existing forest stretch. New infrastructure will accelerate expansion in intact areas, leading to illegal logging, encroachment, unauthorized mining, and wildlife poaching. Therefore, environmental, social, and economic/financial risks must be carefully assessed to ensure forests remain protected while maintaining their ecological function. This concern aligns with the findings of Sloan and Sayer (2015), who stated that road construction through forest areas increases pressure due to land conversion for agriculture and settlements, which, unfortunately, is often linked to illegal activities in forest areas.

Another challenge in forest management practices is ensuring consistency in impact monitoring, particularly in determining sample locations and addressing biases in sample size during analysis. Establishing standardized and valid monitoring procedures with relevant references is essential for field staff to follow. Errors in sampling and data processing, especially with small sample sizes, can have significant implications when extrapolated to a larger scale.

Sugiyono (2016) emphasized the importance of accuracy in sample selection, population representation and measurement. In line with this, Asdak (2023) recommended a comprehensive approach to watershed monitoring by considering hydrological representation across upstream, midstream, and downstream zones. This approach can be aligned with the zoning system in the 10-Year Business Work Plan of the forest concession to ensure that hydrological impacts are adequately represented and to support adaptive management if discrepancies with environmental quality standards are identified.

This method enhances the accuracy and effectiveness of monitoring. It assesses the impact of harvesting activities within a specific area or watershed. Impact monitoring results, such as river water's physical-chemical quality, erosion rates, and runoff coefficients, can be integrated into a single descriptive narrative alongside residual stand conditions monitoring results. These include the Important Value Index (INP), Community Similarity Index (IS), Shannon-Wiener Diversity Index (H'), and stand density distribution against diameter or growth trends (inverted "J" curve).

The availability of monitoring data, particularly those indicating negative impacts, forms the basis for adapting and improving management activities to ensure the BMP is met. The forest concession has implemented adaptive and mitigation measures in its management practices. For example, terracing, sediment traps in descending road ditches, and making cuts when the skid trail is no longer used. Pictures of erosion control structures carried out at the research location are presented in **Fig. 4**. This aligns with the findings of Huang et al. (2022), who reviewed conservation techniques in tropical and subtropical forests, which revealed that soil can be protected from the dangers of erosion through several environmental engineering techniques. First: terracing is recommended on moderate to heavy slopes (slope 12%–35%); second: slope hydraulics in the form of sediment traps in water flows/trenches, which have been proven to be able to reduce runoff and sediment by 76.4% and 87.4% respectively; and third: ditch control techniques by creating check dams combined with vegetation planting ensuring effective sediment retaining and soil quality improvement.

Fig. 4. Erosion control buildings as a management adaptation at PT. Wijaya Sentosa.

3.2.3. Effective supervision of management and monitoring implementation

The forest concession needs to implement a Plan-Do-Corrective Action management system, which involves multi-layered supervision to ensure smooth processes and early problem detection. The involvement of higher-level management in supervisory roles is essential to coaching mid- and lower-level managers, enhancing their problem-solving capacity and boosting their confidence in executing their responsibilities. This is crucial, as Novitasari et al. (2021) found that leaders who coach their teams significantly influence the psychological capital and team commitment to fulfilling their responsibilities. Such leadership inspires field managers to improvise and effectively resolve on-site challenges. The NFSS Indonesia 2020 (FSC-STD-IDN-02.1-2020 EN) emphasizes that managerial improvisation and adaptation are necessary for responsible forest management, ensuring that management plans are developed with measurable, realistic, and verifiable targets (Forest Stewardship Council 2020).

4. Conclusions

Based on the research findings, the understanding of the NFSS Indonesia 2020 (FSC-STD-IDN-02.1-2020 EN) implementation among field staff is at a good level, as indicated by the Likert index analysis, which shows an average score of 83.91% (strongly agree) across several variables, including the availability of environmental function data, the presence of RIL maps and field markers, RIL implementation, human resources, impact monitoring, and adaptive management. The challenges include enhancing community engagement, implementing best management practices, strengthening supervision, improving impact monitoring techniques, and developing adaptive management to ensure sustainable forest management. Therefore, the following measures are recommended to improve the effectiveness of management and impact monitoring: enhancing the capacity of field staff as facilitators who actively listen to the community, structuring discussions with stakeholders (particularly local communities) to encourage higher participation, establishing consistent and robust monitoring procedures, and implementing coaching management for field staff to strengthen leadership and problem-solving skills.

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Author Contributions

J.S.: conceptualization, methodology, software, validation, writing – original draft preparation; M.T.S.B., A.H.: data curation, writing – review and editing, visualization, supervision; I.E., R.A.S.W.: data collection, validation.

Conflict of Interest

The authors declare no conflict of interest.

Declaration of Generative AI and AI-Assisted Technologies in the Manuscript Preparation

Not applicable. The authors used only basic tools to check grammar, spelling, and references.

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