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Safeguard Information System (SIS) model for forestry mitigation actions in West Papua Folu Net Sink 2030 Initiatives

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Abstract

Indonesia's FOLU Net Sink 2030 is committed to climate change, particularly in forestry and land use. The Enhanced NDC Indonesia document increased the domestic initiative (unconditional) GHG emission reduction objective from 29% to 31.89% by 2030 and the international support (conditional) goal from 41% to 43.2%. Field supervision is essential to ensure the implementation of these ambitious goals. However, a dedicated Safeguard Information System (SIS) for the FOLU Net Sink 2030 has not yet been established. This study aims to develop the SIS for the West Papua context, using the seven safeguard criteria outlined in the SIS REDD+ framework as a foundation. The mixed-methodologies study included qualitative and quantitative methods. Semi-structured interviews will be conducted to collect qualitative data for the completion of PIC SIS FOLU Net Sink 2030. SPSS, utilizing a Likert scale, will quantify the data through variability, reliability, and factor analysis for the SIS FOLU Net Sink 2030 West Papua model. The SIS FOLU Net Sink 2030 West Papua Model identified five clusters: deforestation and degradation, sustainable forest management, mitigation action, indigenous peoples' forests, and legality. In clusters, mangrove and peat management, reverse risk, emission displacement, and transparency and efficacy values were significantly opposite.

Keywords: FOLU Net Sink 2030; Check; Assessment; Evaluation; Model

1. Introduction

The target of implementing Indonesia's FOLU Net Sink 2030 Operational Plan is to achieve -140 million tons of CO_2e in 2030, increasing to -304 million tons of CO_2e in 2050, so that net emissions at the national level (all sectors) become 540 million tons of CO_2e, or equivalent to 1.6 tons of CO_2e per capita [1,2,3]. Indonesia's FOLU Net Sink 2030 represents a significant commitment and heightened ambition from the Indonesian Government in addressing climate change, particularly within the forestry and land use sectors. The execution of these mitigation measures necessitates engagement and oversight from the community and relevant stakeholders. This document contains information on the execution of Indonesia's FOLU Net Sink 2030 at the provincial and site levels [4, 5, 6].

The operational plan for Indonesia's FOLU Net Sink 2030 encompasses several mitigation strategies within the FOLU sector, including reducing deforestation and forest degradation of mineral lands and peatlands. Additionally, it includes the development of plantation forests, sustainable forest management, both rotational and non-rotational rehabilitation, peat restoration, enhancement of peat water management, mangrove management, and biodiversity conservation [7].

This work plan is an initiative by the Indonesian government to attain carbon neutrality, equivalent to net zero emissions, through the FOLU Net Sink 2030 program, utilizing the LCCP scenario and the LTS-LCCR 2050 framework to establish a net sink objective in the FOLU sector (surpassing net zero emissions). This aim is achieved during

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implementation through the LCCP scenario, reflecting a commitment to reach net-zero emissions in the FOLU sector by 2030. In this context, we persist in evaluating the changing dynamics of project execution, task allocations, policy advancements, and global, national, and local frameworks necessitating oversight (safeguards) that have been largely overlooked, including pertinent research in Indonesia, which is deemed a crucial instrument for the success of Indonesia's and West Papua's Folu Net Sink 2030 [8,9,10,11,12].

Several provinces, including West Papua, are preparing the 2030 FOLU Net Sink mitigation action document at the subnational level. Furthermore, the Central Government has established standard mechanisms for measurement, reporting, and verification (MRV) [13]. The seven primary principles that Indonesia has established to ensure the successful implementation of REDD+ are as follows: legal compliance and consistency with the national forestry program, transparency and effectiveness of national forest governance, rights of indigenous and local communities, effectiveness and participation of stakeholders, conservation of biodiversity-social protection-and environmental services, reverse risk, and reduction of emission displacement. West Kalimantan, West Nusa Tenggara, and Central Kalimantan have effectively implemented the REDD+ Safeguard Information System (SIS). West Papua has not fulfilled its obligation [14,15,16].

The practical understanding of SIS REDD+ is crucial in this study for evaluating the 7 Principles (P), 17 Criteria (C), and 32 Indicators (I). PCI is pertinent for use in West Papua but may require simplification or modifications based on regional requirements [17,18]. This paper examines the issues related to monitoring SIS REDD+ to supervise the execution of the West Papua Folu Net Sink 2030 (MoEF, 2023), assessing PCI in light of regional conditions and disparities in West Papua Province, as well as the SIS West Papua Folu Net Sink 2030 model.

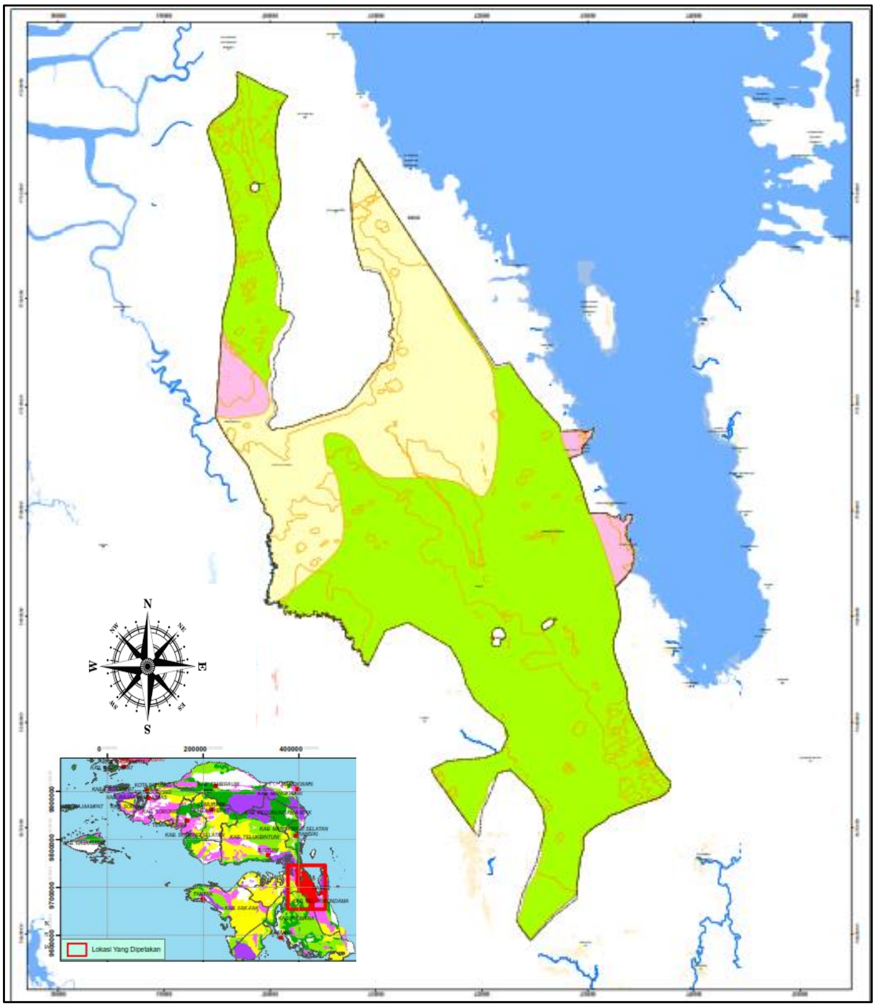
2. Material and methods

2.1. Study area

PT Wijaya Sentosa Management is deeply committed to managing its forest resources appropriately and sustainably, aligning with the company's objectives and vision. To achieve these management objectives, PT Wijaya Sentosa has identified and analyzed various aspects, including the assessment of natural forest resource potential via the Periodic Comprehensive Forest Inventory (PCFI) survey and the formulation of the Forest Utilization Work Plan document (FUWP) for the period 2023 – 2032, identification of high conservation values in the region via the High Conservation Value (HCV) assessment and the presence of intact forest landscapes (IFL), and examination of social conditions via Participatory Rural Appraisal (PRA) survey activities in all villages surrounding the concession area.

The area of PT Wijaya Sentosa includes protected and conservation areas, including a 1,587 Ha protected forest, a 4,934 Ha buffer zone, a 4,393 Ha river border, a 784 Ha Plasma Nutfah Conservation area, a 136 Ha Lake and Spring area, and a Sacred Forest area (Figure 1). According to the NKT identification survey, the PT Wijaya Sentosa concession area has four forest ecosystems: lowland forest, freshwater swamp, karst, and mangrove. The 401 plant species observed can be divided into 102 high-category families. Based on their protection status, 9 flora species are in CITES Appendix II, and 25 are in the IUCN Red List. Wildlife species numbered 211, divided into 67 high-ranking families. 62 species were protected, 51 were on the CITES Appendix II list, and 190 were on the IUCN Red List. The Wowor, Watiri, Naramasa, Yawarone, Waro, Urubati, and Kasar rivers provide drinking water, sanitation facilities, and fishing areas.

Social studies show that PT Wijaya Sentosa's concession villages are 15 villages with 6 customary areas (ulayat): Simei/Dusner, Sombokoro, Werianggi, Nanimori, Obo, and Idore. Most people still rely on the forest and river for sago cutting, non-timber forest product hunting (gaharu, masohi, lawang wood), and fishing. There are also civil servants, traders, and employees of various community companies. PT Wijaya Sentosa enables the community to search for non-timber forest products within the concession area. PT Wijaya Sentosa created a market for residents to trade agricultural and marine items. Markets are held on Wednesday and Saturday. The company purchases local agricultural and aquatic products for employee meals. PT Wijaya Sentosa undertakes an impact study to minimise production-related environmental damage before logging. lessen Impact Logging (RIL) training is also done during road construction to reduce the land impact of manufacturing. PT Wijaya Sentosa exclusively uses wood and does not claim ecosystem services and water [19].



Note: green (conversion production forest), yellow (production forest), pink (limited production forest)

Figure 1 Research Locations to implement the SIS Folu Net Sink 2030 of West Papua Province (red color: protection forest)

2.2. Method of data analysis

The number of samples in this study uses the Slovin formula [20] as follows:

$$n = \frac{N}{1+N(e)^2} \text{ .... } 1$$

with n : rounded sample size, N : population size, and e : 5% significance level.

In 2024, community data from Dusner Village, Kuriwamesa District, was collected from 361 individuals, resulting in a sample size of 190 people using the Slovin formula. Subsequently, five individuals were added from the leadership and personnel of PT Wijaya Sentosa, along with an additional five from the Forest Management Centre and the West Papua Provincial Forestry Service. Therefore, a total of 200 responders were required.

The data analysis, based on the primary variables comprising 10 Principles, 27 Criteria, and 110 Indicators, utilizes the Likert scale [21] to assign weights or scores according to the assertions presented in Table 1.

Table 1 Weight of statement

No	Description	Weight
1	Strongly Agree	5
2	Agree	4
3	Netral	3
4	Disagree	2
5	Strongly Disagree	1

This study uses the Product-Moment Correlation formula by Karl Pearson to assess construct validity for each item using the specified formula:

$$r = \frac{N\sum(XY)-(\sum X)(\sum Y)}{\sqrt{[N\sum X^2-(\sum X)^2][N\sum Y^2-(\sum Y)^2]}} \quad \text{......... 2}$$

with r : validity, x : total score of question items, y : total score of question items, and n : number of samples to be tested. Criteria for decision-making:

- r count > r table, then valid.
- r count < r table, then invalid

The criteria r count > r table indicates validity, and conversely, with degrees of freedom (df = n-2 = 200-2). Conduct a validity assessment for each item of the questionnaire instrument with the SPSS software. A significance level of 5% is employed to ascertain the item's validity. An item is considered valid if the obtained correlation coefficient (rb) is larger than or equal to the correlation value in the table (rt). The item is invalid if (rb) is less than (rt). If the correlation of each item is positive and exceeds 0.1388, the item is considered a robust construct, indicating that the instrument possesses good validity [22,23].

A reliability test must be conducted to assess the dependability of the equipment used in the investigation. An instrument is considered dependable if it possesses a reliability coefficient of 0.7 or above. The dependability coefficient is determined using the Cronbach's Alpha formula. A high reliability coefficient signifies that the instrument consistently measures the same variables across different instances. To evaluate reliability, employing the Cronbach's Alpha formula [24,25], as outlined below:

$$r_{11}=\left(\frac{k}{k-1}\right)\left(1-\frac{\sum\sigma_b^2}{\sigma_t^2}\right) \text{.......... 3}$$

with r_{11}: instrument reliability, k: number of questions or number of questions, Σ σ_b^2: amount of variance per item, and σ_t^2: total variance.

The concluding phase involves developing the SIS FOLU Net Sink 2030 model for West Papua Province using factor analysis, a statistical method that uncovers latent structures from linked data [26,27]. The objective is to diminish dimensionality and construct theoretical models from intricate data sets. Factor analysis aims to categorize variables into representative factors, uncover latent structures (or constructs) underlying observational data, and develop conceptual models based on the interrelationships among these factors. The phases of factor analysis are delineated below:

1. Data Viability Assessment
    a. Kaiser-Meyer-Olkin (KMO) Test

    $$KMO = \frac{\sum r_{ij}^2}{\sum r_{ij}^2+\sum q_{ij}^2} \text{ …….. 4}$$

    with r_{ij} : correlation between variables i and j and q_{ij} : partial correlation

KMO > 0.50 qualifies as feasible

b. Bartlett's Test of Sphericity
Evaluate whether the correlation matrix is an identity matrix. If significant ($p < 0.05$), the data are appropriate for factor analysis

2. Factor Extraction
Principal Component Analysis (PCA) is employed for dimensionality reduction using the following formula:
$KU_{1-n} = \mathbf{a}_1\mathbf{x} = a_{11}x_1 + ... + a_{1p}x_p$ ….. 5
with KU_{1-n} : principal components from 1 to n, $\{X_1, X_2, ..., X_p\}$: independent variable variance matrix and a_{1p} are the coefficients of variables 1 to p.

3. Factor Rotation
To enhance interpretation, rotation was conducted using Varimax (orthogonal), yielding uncorrelated components

4. Factor Loading Matrix
According to the factor loading matrix, variables with a loading of more than 0.5 (or equal to or greater than 0.4, depending on the context) are deemed relevant to the factor.

3. Results and discussion

3.1. Checking PCI FOLU

The variable can be considered valid if r count > r table (0.1603), as illustrated in Table 2. The data indicate that all variables are declared valid by principles 1-7. The 21 invalid variables identified by principle 8 are as follows: 1-5, 7-9, 11-15, 20, 27, 29, 30, 35, 37, 38, and 40. Principle 9 identified three invalid variables (3, 8, and 11), while Principle 10 identified six invalid variables (1, 5, 8, 9, 15, and 18).

Various issues, such as respondent bias, can compromise the accuracy and integrity of research results. This bias occurs when respondents provide answers that do not accurately reflect their actual circumstances or opinions, either due to ignorance, misinterpretation of the questionnaire's content, or the influence of social perception. This phenomenon frequently occurs among respondents from communities with limited comprehension of the subject matter, including indigenous populations or local communities that lack a thorough understanding of technical or policy terminology such as FOLU Net Sink, REDD+, or carbon conservation [28,29]. This deficiency in comprehension may result in conjectural responses, excessive neutrality, or merely fulfilling the enumerator's expectations.

Beyond internal respondent characteristics, external factors also affect data validity, particularly in socially and ecologically fragile regions. Illegal logging activities, tenure conflicts, inadequate law enforcement, and ambiguity in incentive giving and monitoring and evaluation implementation can foster a socio-political context that is detrimental to precise data collection. Under such circumstances, respondents may experience discomfort in providing truthful responses, feel coerced, or even question the survey's intent, resulting in inauthentic replies [30,31].

Supplementary social disputes, particularly those associated with land claims, overlapping governance, or confusion over customary rights, can influence how communities perceive questionnaire questions, directly impacting the quality of the responses provided. Communities tend to respond based on expectations or dissatisfaction rather than reality [32,33]. This is because incentive schemes, such as carbon offsets or payments for environmental services, are not universally recognized or obvious. In line with [34], adopting a participatory approach in the design of instruments, the pretesting of questionnaires, and the involvement of local facilitators familiar with the community's socio-cultural background is essential. This will help to eliminate bias and boost the validity of the research.

Table 2 Evaluate the validity of the SIS FOLU variable

Variable	r count	Variable	r count	Variable	r count
X1.1	**0.509**	X8.11	0.056	X9.11	0.112
X1.2	**0.559**	X8.12	0.098	X9.12	**0.388**
X1.3	**0.450**	X8.13	0.100	X9.13	**0.281**
X1.4	**0.513**	X8.14	0.072	X9.14	**0.236**
X2.1	**0.538**	X8.15	0.112	X9.15	**0.201**

Variable	r count	Variable	r count	Variable	r count
X2.2	**0.633**	X8.16	**0.240**	X9.16	**0.198**
X2.3	**0.620**	X8.17	**0.470**	X9.17	**0.383**
X3.1	**0.377**	X8.18	**0.261**	X9.18	**0.377**
X3.2	**0.420**	X8.19	**0.280**	X9.19	**0.239**
X3.3	**0.489**	X8.20	-0.011	X9.20	**0.184**
X3.4	**0.374**	X8.21	**0.434**	X9.21	**0.393**
X3.5	**0.556**	X8.22	**0.292**	X10.1	0.122
X4.1	**0.273**	X8.23	**0.251**	X10.2	**0.341**
X4.2	**0.300**	X8.24	0.147	X10.3	**0.349**
X4.3	**0.407**	X8.25	**0.276**	X10.4	**0.187**
X4.4	**0.503**	X8.26	**0.233**	X10.5	0.022
X4.5	**0.439**	X8.27	-0.028	X10.6	**0.321**
X4.6	**0.405**	X8.28	**0.342**	X10.7	**0.314**
X5.1	**0.496**	X8.29	-0.095	X10.8	0.058
X5.2	**0.392**	X8.30	0.100	X10.9	0.009
X5.3	**0.526**	X8.31	**0.292**	X10.10	**0.336**
X5.4	**0.229**	X8.32	**0.276**	X10.11	**0.389**
X5.5	**0.289**	X8.33	**0.405**	X10.12	**0.511**
X5.6	**0.427**	X8.34	**0.477**	X10.13	**0.399**
X6.1	**0.568**	X8.35	0.087	X10.14	**0.177**
X6.2	**0.657**	X8.36	**0.326**	X10.15	0.132
X6.3	**0.657**	X8.37	0.111	X10.16	**0.255**
X6.4	**0.621**	X8.38	-0.005	X10.17	**0.349**
X7.1	**0.573**	X8.39	**0.231**	X10.18	0.159
X7.2	**0.659**	X8.40	0.066	Y1	**0.255**
X7.3	**0.613**	X9.1	**0.528**	Y2	**0.470**
X8.1	0.064	X9.2	**0.209**	Y3	**0.508**
X8.2	0.106	X9.3	0.063	Y4	**0.536**
X8.3	0.022	X9.4	**0.494**	Y5	**0.354**
X8.4	-0.041	X9.5	**0.388**	Y6	**0.497**
X8.5	0.123	X9.6	**0.257**	Y7	**0.405**
X8.6	**0.190**	X9.7	**0.178**	Y8	**0.197**
X8.7	-0.045	X9.8	-0.024		
X8.8	-0.028	X9.9	**0.164**		
X8.9	0.145	X9.10	**0.195**		
X8.10	0.147				

Note: bold value, r count > r table (0.1603)

3.2. Assessing SIS FOLU

The PCI FOLU Net Sink 2030 assessment of West Papua Province was conducted using a reliability test analysis. This was accomplished by observing the Cronbach's Alpha value > 0.6. The results of this analysis are presented in Table 3. Based on the findings, it can be concluded that principles 1-7 for each variable are dependable. Only one of the variables, number 22, was found to be unreliable by Principle 8. Compared to the implementation of Principle 9, a total of 21 variables were identified, nine of which were the most frequently selected items and therefore required removal to make the data more credible. The previous version of Principle 10 had 18 variables, 12 of which were the most often chosen items and therefore needed to be removed to make the data more credible.

The unreliability of data in a study can result from multiple sources, one of which is the inconsistency of respondents' responses. In the discipline of social and environmental research, this frequently takes place due to respondents' insufficient comprehension of the subject matter, particularly within local or indigenous communities that have not been sufficiently acquainted with concepts such as deforestation, forest degradation, sustainable forest management, and the conservation of mangrove and peat ecosystems [35,36,37]. Respondents with limited comprehension of the language or significant context within the questionnaire can provide inconsistent, unclear, or contradictory responses to similar yet varied questions.

Besides the comprehension aspect, unreliability worsens due to the fluctuating nature of the variables examined, particularly in forestry and coastal ecological matters. Changes in deforestation and degradation rates can occur rapidly, influenced by external factors such as infrastructure development, illegal logging, or land conversion [38]. Sustainable forest management and the protection of peat and mangrove ecosystems are frequently impacted by evolving policies, institutional instability, and climate variability, including extreme weather events [39, 40]. These variables exhibit non-static and unpredictable characteristics, and interpreting data obtained at a single point in time is insufficient for representing larger or long-term situations.

More importantly, in numerous instances, community participation in surveys lacks an ongoing dialogue or engagement mechanism that enables people to comprehend the goal and purpose of each queried indication. This leads them to offer responses based on assumptions or inaccurate views, rather than on validated experience or knowledge [41,42]. Consequently, a more participative and contextual methodology in instrument design and survey execution is essential to enhance the dependability of the acquired data.

Table 3 Examination of the reliability of the SIS FOLU variable

Principle	Cronbach's Alpha	N items
X1	0.720	4
X2	0.620	3
X3	0.790	5
X4	0.650	6
X5	0.610	6
X6	0.750	4
X7	0.850	3
X8	0.615	18
X9	0.601	12
X10	0.648	6
Y	0.740	8

3.3. Model SIS FOLU

The SIS FOLU Net Sink 2030 model for West Papua Province was executed through factor analysis, indicated by a KMO value > 0.50 and a significance value < 0.05, as presented in Table 4. The table demonstrates that the KMO value exceeds 0.50 and the significance value is below 0.05, indicating that the data satisfies the prerequisites for factor analysis [43,44].

Table 4 KMO test and significant value

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		**0.574**
Bartlett's Test of Sphericity	Approx. Chi-Square	91.753
	df	28
	Sig.	**0.000**

The total variance indicates eigenvalues > 1 [45] and highlights the formation of up to 5 clusters, as illustrated in Table 5 and Figure 2.

Table 5 Total variance, eigenvalues and clusters

Component	**Initial Eigenvalues**			**Extraction Sums of Squared Loadings**			
	Total	% Variance	Cumulative %	Total	% Variance	Cumulative %	Total
1	1.762	16.014	16.014	1.762	16.014	16.014	1.528
2	1.684	15.308	31.323	1.684	15.308	31.323	1.444
3	1.513	13.754	45.077	1.513	13.754	45.077	1.440
4	1.203	10.932	56.009	1.203	10.932	56.009	1.438
5	1.061	9.645	65.654	1.061	9.645	65.654	1.372
6	0.970	8.821	74.475				
7	0.790	7.185	81.660				
8	0.596	5.415	87.076				
9	0.543	4.937	92.013				
10	0.495	4.502	96.515				
11	0.383	3.485	100.000				
Extraction Method: Principal Component Analysis.							

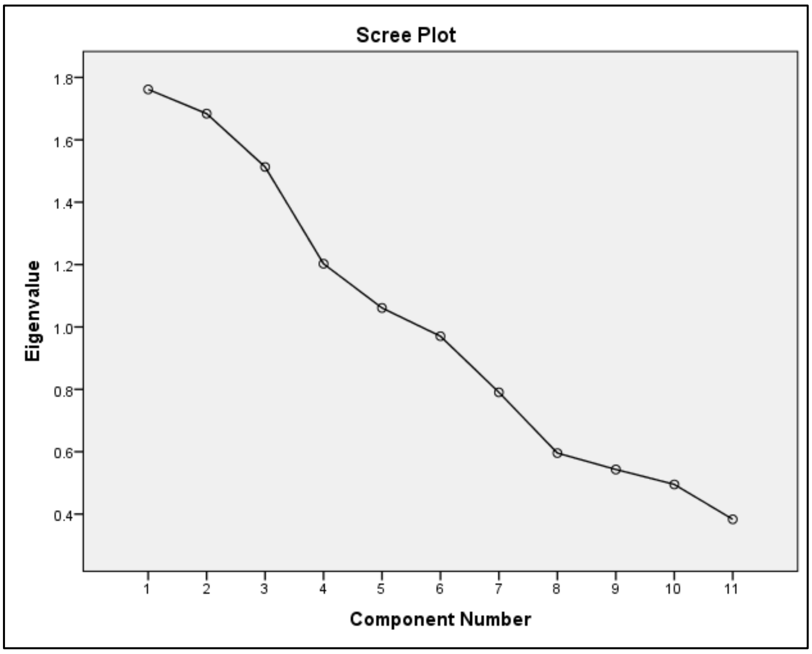


Figure 2 Scree plot of clusters based on eigenvalues

The SIS Folu Net Sink 2030 West Papua model is derived from the SIS REDD+ module and integrates the 2030 FOLU Net Sink West Papua Renja. The SIS REDD+ principles encompass seven elements: legality, transparency, and efficacy, indigenous peoples' forests, stakeholder engagement, mitigation strategies, risk reversal, and emission displacement. According to FOLU, this includes deforestation and degradation, as well as sustainable forest management and the management of mangroves and peatlands.

Principal Component Analysis (PCA) using SPSS factor analysis generated 5 clusters, as shown in Table 6, with the most significant component value > 0.50, indicating strength and influence [46,47]. According to Table 5, cluster 1 is dominated by deforestation and degradation, cluster 2 by sustainable forest management, cluster 3 by mitigation activities, cluster 4 by indigenous peoples' forests, and cluster 5 by law.

Table 6 Rotated Component Matrix

	Component				
	1	**2**	**3**	**4**	**5**
Law	0.339	-0.050	-0.017	0.170	**0.760**
Transparency	0.167	-0.065	-0.099	0.230	-0.760
Community	0.203	0.141	0.032	**0.835**	-0.102
Participation	0.035	0.375	0.752	-0.056	0.153
Mitigation	0.144	-0.262	**0.791**	0.078	-0.056
Risk	-0.183	-0.543	-0.102	0.619	0.086
Emission	-0.242	0.472	-0.248	-0.031	0.346
Deforestation	**0.716**	0.166	0.025	-0.025	0.172
Management	0.030	**0.750**	0.060	0.123	-0.026
Mangrove	-0.718	0.147	-0.187	-0.116	0.145
Safeguard	-0.449	0.281	0.356	0.486	-0.045
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.					

Cluster 1 suggests that managing mangroves and peat involves divergent strategies, highlighting persistent challenges in field implementation. Respondents expressed concerns regarding information asymmetry and restricted data access, insufficient involvement of local communities in monitoring deforestation and degradation, exclusion of indigenous communities from data verification, absence of monitoring indicators aligned with evolving local conditions, lack of community comprehension of indicators and criteria, minimal integration of socio-spatial-policy data, and ineffective institutions executing SIS safeguards at the regional level [48,49,50,51].

Respondents' concerns regarding the periodic monitoring and evaluation of the risk of reversal from forest fire activities, encroachment, illegal logging, and other external impacts, as well as risk mitigation actions to address significant risks of reversal, have resulted in conflicting issues concerning the risk of reversal in Cluster 2 [52,53].

Cluster 3 identified that emission transfer changed in the reverse direction and encountered impediments in the field. This is due to the ongoing deforestation and land destruction, which relocate activities and perpetuate carbon emissions. Challenges faced in emission transfer include the insufficient integration of regional spatial planning, which neglects adjacent areas, alongside the encroachment of oil palm farms, mining, and other activities into different zones; and constraints in monitoring the 2030 SIS FOLU. The Net Sink has failed to comprehensively identify emission leaks, and field activities remain neither real-time nor integrated across districts and provinces. Contributing factors include economic pressures and the mobility of stakeholders, deficiencies in multi-level governance, and inadequate engagement of indigenous communities through incentives for forest protection and initiatives that could enhance community income via the downstreaming of Non-Timber Forest Products (NTFPs) [54,55].

Similar to Cluster 1, Cluster 4 encountered conflicting mangrove and peat management principles and obstacles in the field. In the interim, Cluster 5 identified conflicting concerns, specifically transparency and the effectiveness of activities. The challenges encountered in preparing SIS include a lack of transparency and effectiveness, as evidenced by the limited access to public information that prevents the disclosure of data on emissions, deforestation, reverse risks, emission transfers, and mangrove and peat management. Documentation and reports are not publicly available, and the SIS REDD+ reports have not been published regularly. The absence of an effective feedback mechanism regarding complaints and leaks is a concern, as is the low multi-party involvement and minimal involvement of local universities in preparing SIS [56,57].

3.5. Recommendation SIS FOLU

Recommendations to enhance mangrove and peat management (clusters 1 and 4) in implementing SIS Folu Net Sink 2030 in West Papua include conducting a participatory inventory and mapping customary areas, accompanied by field data verification in collaboration with local groups. Develop a specialized module within SIS REDD+ to document mangrove and peat restoration and protection initiatives; provide incentives to communities safeguarding mangroves and peat based on restoration outcomes and green economic development through the downstreaming of non-timber forest products (NTFPs); enhance the capacity of indigenous community institutions or groups in managing and legalizing territories; improve regulation and prevention of mangrove and peat conversion; and incorporate SASI in conservation zones while documenting local knowledge through SIS as part of social safeguards [58,59,60,61,62,63].

Improvements for mitigating reversal risks (cluster 2) encompass the establishment of enduring monitoring and early warning systems related to fires, deforestation, reversed risks, emission transfers, and the management of forests, mangroves, and peatlands; enhancement of tenure governance to avert encroachment through the reinforcement of customary institutions and community-based monitoring; prioritization of critical landscape restoration and adaptive management strategies to assess restoration outcomes and avoid failures; implementation of a permanent moratorium on forest and land conversion, integrated into provincial and district spatial planning; risk-based funding; and the formation of a rapid response team comprising indigenous communities to anticipate vulnerable areas [64,65,66,67,68,69].

Requests for mitigating emission transfers (cluster 3) include the development of integrated spatial maps and cross-border monitoring systems utilizing satellites and field surveys; enhancing intersectoral and interregional collaboration while incorporating emission reduction strategies into the RPJMD and RTRW; augmenting the capacity of indigenous communities in sustainable forest management; implementing green economic incentives and results-based payments (RBP); intensifying oversight and law enforcement against illegal forest encroachment and alterations in forest and land functions; and providing training for indigenous community-based law enforcement [70,71,72,73,74].

The best practices to enhance transparency and efficacy (cluster 5) consist of open digitalization and real-time online public data access; national and local standardization of SIS FOLU Net Sink 2030; engagement of indigenous communities in monitoring and verification; independent audits and periodic reporting; and the augmentation of regional human resources and the SIS FOLU Net Sink 2030 facilitator team in West Papua [75,76,77,78,79].

4. Conclusion

The validity test (r count > r table) was evaluated for PCI SIS FOLU Net Sink 2030 in West Papua. The check identified 21 variables, namely 1-5, 7-9, 11-15, 20, 27, 29, 30, 35, 37, 38, and 40, which were deemed invalid due to deforestation and degradation (X8). Three variables were invalid on the principle of sustainable forest management (X9): 3, 8, and 11. Six variables were invalid on the principle of mangrove and peat management (X10): 1, 5, 8, 9, 15, and 18. Data invalidity was caused by respondent bias, which included responses from people who did not understand the contents of the questionnaire, as well as external factors such as illegal logging, conflict-prone areas, law enforcement, incentives, and monitoring and evaluation.

The PCI SIS FOLU Net Sink 2030 West Papua assessment is predicated on the reliability test analysis (Cronbach's Alpha > 0.6). The verification yielded a re-evaluation of variables, resulting in 18 remaining variables from the original 40 for the X8 principle, specifically numbers 6, 10, 16- 19, 21, 23-26, 28, 31-34, 36, and 39. The X9 principle includes six remaining variables: 1, 4, 17-19, and 21, while X10 has six remaining variables: 2, 11, 12, 13, 17, and 18. The unreliable data resulted from the respondent's inconsistency in answering due to a lack of prior understanding, particularly regarding community dynamics and the mutable principles of deforestation, degradation, sustainable forest management, and managing mangroves and peatlands.

Factor analysis generated the SIS FOLU Net Sink 2030 West Papua model (KMO > 0.50 and eigenvalue > 1). The model identified five key clusters: deforestation and degradation, sustainable forest management, mitigation action, indigenous peoples' forests, and law. Highly opposing values were discovered in clusters 1, mangrove and peat management, 2, reverse risk, 3, emission displacement, and 4 and 5, transparency and effectiveness. To support the SIS FOLU Net Sink 2030 West Papua model, recommendations include participatory customary area inventory and mapping with data verification in the field with indigenous communities; developing a special module in SIS REDD+ to record forest restoration and protection activities; incentivising forest guard communities based on restoration achievements and green economic development by downstreaming HHBK; and strengthening.

Compliance with ethical standards

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Disclosure of conflict of interest

There is no conflict of interest.

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