

**A SET OF MANAGEMENT EFFECTIVENESS INDICATORS
FOR BIOSPHERE RESERVES IN VIETNAM: A CASE STUDY
OF THE WESTERN NGHE AN BIOSPHERE RESERVE**

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Abstract: This study develops and applies an enhanced management effectiveness evaluation (MEE) framework for Biosphere Reserves (BRs) in Vietnam. Building on an existing 58-indicator evaluation system, five new indicators were added to reflect emerging strategic priorities and international commitments relevant to biosphere reserve governance, encompassing the integration of the Hangzhou Strategic Action Plan (HSAP 2026-2035), gender equality, indigenous knowledge of ethnic minority communities, youth participation, and systematic reporting against the Sustainable Development Goals (SDGs) and Kunming-Montreal Global Biodiversity Framework (GBF), bringing the total to 63 indicators across 20 criteria and the six management elements of the IUCN MEE framework. The evaluation combined document review with a two-stage participatory expert consultation process and descriptive statistical analysis. The expanded framework was applied to the Western Nghe An Biosphere Reserve (WNABR), the largest BR in Vietnam. The overall MEE score was 70.2/100 (indicating moderate management effectiveness), with Planning (73.8/100) and Context (73.5/100) performing best, whereas Process (65.4/100) and Outputs (66.1/100) require priority attention. The five newly introduced indicators averaged 49.0/100, underscoring critical governance gaps in international policy alignment and social inclusion. The study proposes an “open system with a fixed core” methodological approach and seven priority actions for the WNABR in the 2026-2030 period. These findings are based on expert assessment at a single site and require further multi-site validation before national generalization.

Keywords: Biosphere Reserve, Vietnam, management effectiveness, sustainable development, Western Nghe An.

1. Introduction

Biosphere Reserves (BRs) are territorial management models recognized by UNESCO under the Man and the Biosphere (MAB) Program, designed to fulfill three core functions simultaneously: conserving biodiversity, promoting sustainable socio-economic development, and supporting research and education across three functional zones-core, buffer, and transition zones [1]. As of June 2026, the World Network of Biosphere Reserves (WNBR) comprises 797 sites in 145 countries [2]. In Vietnam, as of 2026, 12 BRs have been recognized by UNESCO, covering approximately 5.17 million ha (authors' calculation based on official BR nomination dossiers and periodic review reports) and representing diverse ecosystem types and governance models.

Management effectiveness evaluation (MEE) is an essential tool for measuring the degree to which management objectives are achieved, identifying operational constraints, and supporting policy planning [3]. However, existing tools such as the Management Effectiveness Tracking Tool (METT) [4] and the Biosphere Reserve Management Effectiveness Index (BREMi) [5] primarily focus on conservation functions or were developed for specific governance contexts, and therefore do not fully reflect the multi-functional nature and complexity of BR management in Vietnam.

To address this gap, T.Q. Hoc et al. (2024) [6] developed a set of 58 MEE indicators based on the IUCN framework, assessed its applicability and feasibility at the Cu Lao Cham-Hoi An (CLC-HA) BR, yielding an overall score of 78.2/100 (indicating high effectiveness). This raises three unresolved questions that motivate the present study: (i) Can the 58-indicator framework, validated at one small coastal BR with a centralized governance structure, be extended to a large, multi-level BR with contrasting ecological, socio-economic, and institutional conditions; (ii) Are additional indicators needed to capture governance dimensions absent from the original set; and (iii) What principal management gaps would an expanded framework reveal? Moreover, UNESCO's issuance of the Hangzhou Strategic Action Plan (HSAP) for 2026-2035 [7] and requirements to strengthen the contributions of the WNBR to the Kunming-Montreal GBF [8] have introduced new strategic priorities to update the evaluation indicators, including gender equality, the promotion of indigenous knowledge, the empowerment of youth roles, and the strengthening of inclusive governance - priorities explicitly reflected in GBF Targets 22-23 [8] and contributions to global sustainable development goals.

The Western Nghe An Biosphere Reserve (WNABR) was selected as the case study. Recognized by UNESCO in 2007, the BR covers 1,299,795 ha [9] - the largest BR in Vietnam as of 2026-comprising three core zones (Pu Mat National Park, Pu Huong and Pu Hoat Nature Reserves), spanning 65 communes in Nghe An Province (following the administrative adjustments of July 1, 2025), with a population of 1,038,956 [10]. The study pursues two primary objectives: (i) to enhance the MEE indicator system from 58 to 63 indicators by incorporating criteria that reflect emerging UNESCO governance requirements and international commitments; and (ii) to apply the enhanced framework to evaluate the MEE of the WNABR, thereby validating the applicability of the framework in a multi-level, multi-actor, and multi-objective governance context.

This study provides three key contributions: (i) operationalizing HSAP 2026-2035 and the Kunming-Montreal GBF into measurable indicators; (ii) disaggregating participatory governance into gender, youth, and indigenous knowledge components-elements absent

from METT [4] and BREMi [5]; and (iii) proposing an “open system with a fixed core” design logic that is replicable across multi-ethnic, multi-level governance contexts.

2. Methods and data

2.1. Developing and refining the indicator set

The study builds on the IUCN MEE framework [3], which structures management effectiveness across six elements: Context, Planning, Inputs, Process, Outputs, and Outcomes. It adapts the set of 58 indicators across 20 main criteria developed by Hoc et al. [6] as its foundation baseline, adhering to six methodological principles: (i) fully reflecting BR objectives and functions; (ii) compatibility with Vietnam's legal and institutional framework; (iii) scientific rigor and verifiability; (iv) simplicity and ease of application and interpretation; (v) feasibility within existing management resource constraints; and (vi) consistency with the six-element IUCN evaluation cycle.

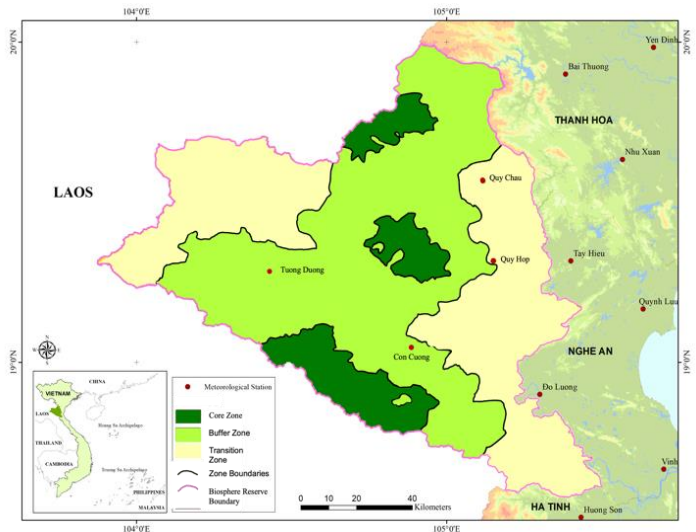


Figure 1. Location of the Western Nghe An Biosphere Reserve on the Vietnam's map

Candidate indicators were identified through four steps: (1) reviewing literature, the HSAP 2026-2035 and GBF priority targets; (2) gap mapping against the existing 58 indicators; (3) drafting indicator descriptions, wording and 5-level descriptors; and (4) refinement via the Panel A content-validity review (Section 2.3.2).

Table 1. Five indicators added to the BR MEE evaluation framework

Indicator code	Content	Management element	Basis for addition
2.1.5	Degree of integration of the HSAP 2026-2035 into BR management strategy	Planning	The HSAP needs to be officially implemented and requires clear evaluation criteria
4.2.4	Gender equality and gender mainstreaming in management	Process	Role of ethnic minority women in conservation and livelihoods
4.2.5	Conservation and integration of indigenous knowledge of ethnic minority communities	Process	Co-management principles
4.2.6	Participation and leadership role of youth (18-35 years, [11])	Process	Youth promotion direction of the WNBR
6.2.3	Degree of contribution and reporting of results against multilateral agreements: SDGs and Kunming-Montreal GBF	Outcomes	Vietnam's international multilateral commitments; MAB/UNESCO reporting requirements

Five new indicators were added across three thematic focus areas: (i) aligning with new international requirements and directions from UNESCO and the Kunming-Montreal GBF [8]; (ii) reflecting the multi-level, multi-ethnic governance characteristics of the WNABR; and (iii) strengthening the assessment of social inclusion in BR management. Their content, position, and rationale are presented in Table 1.

Following these additions, the evaluation framework comprises 63 indicators across 20 criteria and six management elements (Table 2). The full indicator set, including scoring rubrics and supporting evidence for each of the 63 indicators, is available in Supplementary Annex 1 of [12].

Table 2. Structure of the BR management effectiveness evaluation criteria set

Management Element	No. of Criteria	No. of Indicators	Notes
1. Context	4	11	Retained from T.Q. Hoc et al. (2024)
2. Planning	2	8	Indicator 2.1.5 added
3. Inputs	4	11	Retained from T.Q. Hoc et al. (2024)
4. Process	2	8	Indicators 4.2.4, 4.2.5, 4.2.6 added
5. Outputs	5	16	Retained from T.Q. Hoc et al. (2024)
6. Outcomes	3	9	Indicator 6.2.3 added
Total	20	63	

2.2. Data collection

Data were collected through a comprehensive document review encompassing: (i) normative legal documents, strategies, plans, and policies at the central, provincial, and district/local levels; (ii) the 2007 WNABR nomination dossier, the first periodic review report in 2017 [9], and preparatory materials for the second periodic review in 2027; (iii) WNABR management documents, including the Management Strategy 2017-2027; the Environmental Management and Protection Plan 2023-2027; and Management Plan 2026-2030; and (iv) thematic reports on biodiversity, natural resources, socio-economics, environment, and conservation management issued by the BR Management Board and core area management units.

2.3. Methods

2.3.1. Indicator scoring and management effectiveness assessment

Indicators were scored on a 0-100 scale using a five-anchor ordinal rubric (0, 25, 50, 75, and 100), each anchored to a qualitative descriptor (Supplementary Annex 1 [12]. Five-point interpolation between anchors was permitted to allow finer expert judgement while preserving comparability across the 10-member panel. Criterion scores were calculated as the mean of their component indicators; element scores were the mean of their constituent criteria; and the overall MEE score was the mean of the six elements. MEE effectiveness levels followed Hoc et al. (2024) [6], for comparability with the CLC-HA baseline: Very Low (0-<25, no evidence or functioning mechanism), Low (25-<50, initial/ad hoc implementation), Moderate (50-<75, substantially established but with residual institutional or coordination gaps), and High (75-100, appropriate to very appropriate, consistently and effectively implemented)-directly mirroring the five qualitative anchors (0, 25, 50, 75 and 100) used at indicator level (Supplementary Annex 1, [12]).

2.3.2. Content validity assessment of the five newly added indicators (Panel A: 15 Experts)

Prior to application at the WNABR, the five newly added indicators underwent a structured content validity assessment conducted by a separate expert group (Panel A), distinct from the scoring panel described in Section 2.3.3. Panel A comprised 15 experts - 11 representatives from Vietnam's biosphere reserves and 4 academic specialists in BR science and governance (see Supplementary Annex 2, [12]) tasked with validating the indicator set prior to application.

Each of the five newly added indicators was independently assessed by Panel A experts using a five-point Likert scale across five dimensions: necessity, appropriateness, independence from the existing 58 indicators, feasibility, and added value. Mean scores and standard deviations (SD) were calculated for each indicator and assessment dimension. Content validity was evaluated using the Item-level Content Validity Index (I-CVI), calculated as the proportion of experts assigning a score of 4 or 5 to each item. The Scale-Level Content Validity Index based on the average method (S-CVI/Ave) was calculated as the mean of the I-CVI values across the five newly added indicators. Qualitative comments were also reviewed to identify issues requiring clarification of indicator definitions, scoring criteria, and evidence requirements. Feedback from Panel A was consolidated and used to finalize indicator wording, scoring levels, and documentary evidence requirements before application at the WNABR (see Supplementary Annex 2, [12]). Panel A experts did not participate in the subsequent WNABR scoring process.

2.3.3. Participatory scoring at WNABR and sensitivity analysis (Panel B: 10 Experts)

WNABR management effectiveness was scored by a separate expert panel (Panel B), comprising 10 specialists with direct knowledge of the WNABR, including biodiversity conservation scientists, BR governance practitioners, and WNABR Management Board representatives. Panel B was selected based on criteria distinct from Panel A: (i) at least five years of experience in protected area or BR management; (ii) direct knowledge of the WNABR's ecological, social, or institutional context; and (iii) familiarity with IUCN MEE frameworks. Scoring was conducted from May 1 to 23, 2026, through independent individual assessments followed by structured group discussions to reconcile divergences exceeding 20 points. For indicators with a coefficient of variation (CV) exceeding 25%, a second consensus round was held. Final scores were calculated as the arithmetic mean after consensus adjustment (see Supplementary Annex 3, [12]).

Sensitivity analysis under three alternative weighting scenarios (equal weighting within elements, element-weighted, and indicator-count-proportional) yielded overall scores ranging from 69.9 to 70.2/100 - all within the "Moderate" band, confirming the stability of the results.

3. Results

3.1. Overall management effectiveness of WNABR

The aggregate evaluation results (Table 3) show that the WNABR achieved an overall score of 70.2/100 (indicating moderate management effectiveness), indicating that most BR objectives and functions have been implemented with relative effectiveness, whereas persistent limitations remain regarding inter-sectoral coordination mechanisms, resource mobilization, and governance implementation across a large spatial extent with multiple stakeholders. Compared with the CLC-HA BR (78.2/100, indicating high effectiveness) [6],

the WNABR's score is 8 points lower, reflecting specific challenges of a large-scale, multi-administrative, ethnically diverse BR. By contrast, the CLC-HA BR has a more concentrated management scope, a smaller population, and relatively favorable administrative coordination mechanisms. The WNABR's score considerably exceeds the average for Arab BRs (62/100 [5]). It is important to emphasize that this comparison serves an illustrative, rather than evaluative, purpose. The WNABR and the CLC-HA BR differ substantially in spatial scale (1,299,795 ha versus 33,475 ha), governance complexity, and the number of indicators applied (63 vs. 58). The score gap therefore reflects structural differences in governance context rather than a simple performance deficit. To control for indicator incomparability, the WNABR's score was recalculated using the original 58-indicator set, yielding 71.7/100—confirming that structural scale disadvantages, rather than the added indicators alone, drive the observed score variance.

Table 3. Scores of the 20 main criteria of WNABR

No.	Element	Criterion	Score
1	Context	1.1. Organization and management	61.7
		1.2. Functional zoning	82.5
		1.3. Biodiversity conservation	80.0
		1.4. Threats to biodiversity	70.0
2	Planning	2.1. Sustainable development vision	66.0
		2.2. Management planning	81.7
3	Inputs	3.1. Resource mobilization	73.8
		3.2. Resource inventory	72.5
		3.3. Biodiversity resource utilization	67.5
		3.4. Information and BR branding	63.3
4	Process	4.1. Inter-sectoral coordination and cooperation mechanisms	70.0
		4.2. Stakeholder participation	60.8
5	Outputs	5.1. Trends in ecosystem and species change	60.0
		5.2. Conservation function	73.8
		5.3. Development function	69.2
		5.4. Logistic function	67.5
		5.5. Corporate social responsibility	60.0
6	Outcomes	6.1. Functional connectivity	76.7
		6.2. BR network and branding	63.3
		6.3. Management review and improvement	78.3
	Overall		70.2

3.2. Management effectiveness by element

Context (73.5) included two standout criteria, Functional Zoning (1.2 = 82.5) and Biodiversity Conservation (1.3 = 80.0), both anchored in the effective conservation record of the three core zones, whose boundaries and forest-protection work underpin these criteria. The primary structural weakness is Organizational Management (Criterion 1.1 = 61.7): the BR Management Regulation indicator scored 0/100 because this document has not yet been promulgated, thereby undermining binding authority in inter-sectoral coordination, despite high scores for organizational structure (Indicator 1.1.1 = 95.0) and Management Board operating regulations (Indicator 1.1.3 = 90); a single missing regulation therefore substantially depresses the criterion mean. Biodiversity threats remain moderate (Criterion 1.4 = 70.0).

Planning (73.8/100) scores strongly due to the well-established, formally approved planning system (Criterion 2.2 = 81.7; medium-term, annual and local sustainable development plans), while the primary constraints are in incipient HSAP 2026 - 2035 integration (Indicator 2.1.5 = 25, referenced only in the draft 2026 - 2030 Management Plan), which lowers the Sustainable Development Vision score (Criterion 2.1 = 66.0). Inputs (69.3/100) reflect a persistent gap between management scale and resource capacity: human, financial, and equipment inputs (Criterion 3.1 = 73.8) rely on concurrently assigned or seconded staff and external project funding, while BR branding is held back specifically by low uptake of the label among tourism products (Indicator 3.4.3 = 50, compared to 70 for agricultural/forestry products). Outputs (66.1/100): sustainable livelihood development is the most notable strength (Indicator 5.3.1 = 85, via forest-protection contracts and Payment for Forest Environment Services (PFES) to buffer-zone households), while ecosystem recovery trends remain merely stable rather than improving (Criterion 5.1 = 60.0), and the corporate sector role is limited (Indicators 5.3.3 = 5.5.2 = 50), consistent with the absence of any enterprise seat on the Management Board.

Process (65.4/100) was the lowest-scoring element (10.9 points below the CLC-HA BR [6]), reflecting the governance burden of coordinating conservation, development and support functions across 65 communes and three core-zone management authorities. Inter-sectoral coordination mechanisms exist (Criterion 4.1 = 70.0) but substantive effectiveness remains limited in practice. Stakeholder participation (4.2 = 60.8) among the three lowest criteria (5.1 and 5.5 = 60.0)-enterprise participation is its lowest sub-indicator (Indicator 4.2.2 = 50, again reflecting the absence of an enterprise seat on the Board)-with all three new indicators performing at moderate levels: gender equality (Indicator 4.2.4 = 65), indigenous knowledge (Indicator 4.2.5 = 60), and youth empowerment (Indicator 4.2.6 = 55). Outcomes (72.8/100): functional connectivity was high (Criterion 6.1 = 76.7, particularly the application of research results to conservation: Indicator 6.1.1 = 80) and management review capacity was strong (Criterion 6.3 = 78.3, built on regular reporting to the Provincial People's Committee and UNESCO MAB Secretariat since 2014), whereas the main limitation was limited SDG/GBF reporting (Indicator 6.2.3 = 40), as no system currently yet cross-references BR results against specific international targets.

3.3. Evaluation results for the five newly added indicators

The five newly added indicators averaged only 49.0/100 (Table 4). The two lowest-scoring indicators-HSAP 2026-2035 integration (Indicator 2.1.5 = 25) and SDG/GBF reporting (Indicator 6.2.3 = 40)-indicate that international policy framework integration represents the most critical gap. The remaining three reached moderate levels: youth empowerment (Indicator 4.2.6 = 55), indigenous knowledge (Indicator 4.2.5 = 60), and gender equality (Indicator 4.2.4 = 65). These results suggest that the additional indicators capture governance dimensions that were not sufficiently explicit in the original framework. These patterns reflect an early stage of institutionalization rather than measurement error; combined with the high content validity scores reported in Section 3.4, this indicates that the five indicators do not require content revision but do highlight the need for the priority actions proposed in Section 4.3.

Table 4. Evaluation results for the 5 newly added indicators at WNABR

Indicator Code	Added Indicator	Score (/100)	Classification	Notes / Evidence
2.1.5	Integration of HSAP 2026-2035 into BR management strategy	25	Low	HSAP not yet integrated into overall strategy; initial reference in Management Plan 2026-2030
4.2.4	Gender equality and gender mainstreaming in management	65	Moderate	Women participate in livelihoods and conservation but lack a gender budget and formal empowerment mechanisms.
4.2.5	Conservation and integration of indigenous knowledge of ethnic minority communities	60	Moderate	Indigenous knowledge documented but not yet systematically integrated into management mechanisms.
4.2.6	Participation and leadership role of youth (18-35 years)	55	Moderate	No BR Youth Network established; youth participate in movements but not in decision-making processes.
6.2.3	Contribution and reporting against SDGs and GBF	40	Low	Initial awareness of SDGs; no system for cross-checking results against GBF

3.4. Expert validation and content validity assessment

Expert assessments demonstrated strong content validity for all five newly added indicators. Mean scores ranged from 3.87 to 4.87 on the five-point Likert scale, while I-CVI values ranged from 0.933 to 1.000. The overall S-CVI/Ave reached 0.979, indicating a high level of expert agreement regarding the relevance and applicability of the proposed indicators. Feasibility received comparatively lower scores -particularly for Indicator 6.2.3 (3.87±0.74)- reflecting the need for clearer reporting guidance and standardized evidence requirements.

Table 5. Expert validation of the five newly added indicators

Indicator	Necessity	Appropriateness	Independence	Feasibility	Added value	I-CVI
2.1.5 HSAP 2026-2035	4.67±0.49	4.87±0.35	4.87±0.35	4.73±0.46	4.53±0.52	1.000
4.2.4 Gender equality	4.73±0.46	4.73±0.46	4.73±0.46	4.47±0.64	4.33±0.49	0.987
4.2.5 Indigenous knowledge	4.73±0.46	4.73±0.46	4.71±0.47	4.53±0.64	4.29±0.47	0.986
4.2.6 Youth participation	4.60±0.51	4.53±0.52	4.80±0.41	4.40±0.63	4.27±0.46	0.987
6.2.3 SDGs/GBF reporting	4.60±0.51	4.60±0.51	4.67±0.49	3.87±0.74	4.40±0.51	0.933
S-CVI/Ave						0.979

Note: n=15, Panel A experts; scores on a 5-point Likert scale, mean ± SD.

4. Discussion

4.1. Scalability of the indicator set

The study results demonstrate the initial applicability of the BR MEE indicator set beyond its original baseline context when applied to the WNABR. Despite significant differences in scale, governance structures, and socio-ecological conditions between the CLC-HA BR and the WNABR, the six-element structure combined with the five-level scoring system enables a structured assessment and facilitates comparability across biosphere reserves (Table 6), which is consistent with the findings of previous studies [13]. The five additional indicators all scored substantially below the overall average, confirming that expanding the indicator set enables the identification of important governance gaps not previously captured by existing tools. This aligns with international trends towards incorporating culture-and context-specific indicators, such as in the BREMi framework [5] for Arab BRs, and highlights the necessity of principled customization when applying the IUCN framework to diverse governance contexts.

These results support the adoption of an "open system with a fixed core" approach: the six-element framework and five-level scoring scale serve as a standardized core that ensures comparability and longitudinal data accumulation, while component indicators can be flexibly adapted to specific socio-ecological contexts, prevailing international policy directions, and comprehensive governance requirements. Direct score comparisons must, nevertheless, be interpreted cautiously; the recalculated 58-indicator score (71.7/100) isolates structural scale effects from indicator-set differences [13].

The expert validation results further support the inclusion of the five newly added indicators, demonstrating high content validity and strong agreement among experts. However, the relatively lower feasibility score assigned to Indicator 6.2.3 highlights the need for clearer reporting protocols and standardized evidence requirements. Further application across diverse BRs will be essential to assess the robustness and transferability of these enhanced indicators.

Table 6. Comparative analysis of management effectiveness by six elements: CLC-HA BR and WNABR

Management Element	CLC-HA BR (2023) [6]	WNABR (2026)	Causes / Remarks
Overall Score	78.2/100 (High)	70.2/100 (Moderate)	8-point gap; reflects institutional and governance-scale differences
Context	85.8 (High)	73.5 (Moderate)	WNABR lacks a Management Regulation (Indicator 1.1.2 = 0); CLC-HA has issued one
Planning	83.5 (High)	73.8 (Moderate)	Both BRs have sound planning systems; WNABR scored lower for not yet integrating HSAP
Inputs	73.4 (Moderate)	69.3 (Moderate)	Similar; both lack equipment and stable long-term financing
Process	76.3 (High)	65.4 (Moderate)	10.9-point gap; WNABR multi-district/ commune structure is difficult to coordinate
Outputs	68.3 (Moderate)	66.1 (Moderate)	Similar; biodiversity trends are a common challenge for BRs
Outcomes	81.9 (High)	72.8 (Moderate)	WNABR scored lower for absence of SDG/GBF reporting (new criterion)

4.2. WNABR in the context of BR management in Vietnam and the region

With a score of 70.2/100, the WNABR achieved a moderate level of management effectiveness, which is numerically higher than the average for Arab BRs (62/100, as re-tabulated in [6] from BREMi element-level data [5]), but remains lower than that of the CLC-HA BR (78.2/100; [6]) and highly effective BRs in South Africa [14]. This gap is attributable primarily to two structural factors, rather than to management capacity deficiencies per se: (i) scale and multi-level governance disadvantages, which increase coordination costs compared with smaller, more centralized BRs; and (ii) critical institutional gaps, as most clearly evidenced by the absence of a BR Management Regulation (Indicator 1.1.2 = 0/100)-an institutional constraint also identified in the CLC-HA BR and prior studies as driving lower scores across the Process and Outputs elements [6], [13].

Three core strengths were identified: (i) a clearly established functional zoning system; (ii) a relatively complete management planning system spanning multiple planning horizons; and (iii) strong sustainable livelihood development capacity for local communities (Indicator 5.3.1 = 85.0). Conversely, three priority gaps must be addressed: (i) an institutional gap-the absence of a BR Management Regulation, which limits the inter-sectoral coordination effectiveness; (ii) an international integration gap-low levels of HSAP and GBF integration, thereby weakening the link between local management and global commitments; and (iii) an inclusive governance gap-the roles of women, youth, and indigenous knowledge, which are recognized in practice but have not been institutionalized into legally binding participation and co-management mechanisms.

4.3. Proposed priority actions for WNABR

Based on the evaluation results, seven priority actions are proposed. At the highest priority level: (i) the competent provincial authority should formalize and issue the WNABR Management Regulation (2026-2027) as the legal foundation for all other actions; and (ii) the Management Board should establish a long-term biodiversity monitoring program to detect trends and support recovery (2026-2030). At high priority: (iii) integrating HSAP 2026-2035 into the new management strategy (2026-2027); (iv) developing a co-management mechanism that recognizes the indigenous knowledge of ethnic minority communities (2026-2028); and (v) building a system to cross-reference results against the SDGs and GBF Targets (2027-2030). At moderate priority: (vi) establishing a WNABR Youth Network (2027-2028); and (vii) mainstreaming gender into livelihood and conservation programs with a dedicated gender budget (2027-2029).

5. Conclusions

This study presents the first comprehensive MEE assessment of Vietnam's largest biosphere reserves as of 2026, yielding four main conclusions. First, the 63-indicator set built on the IUCN six-element framework [3] and adapting the 58-indicator set from Hoc et al. (2024) [6] provides preliminary evidence supporting the applicability of the framework across BRs with varying scales and governance structures and socio-ecological contexts. The five newly added indicators fill substantive evaluation gaps and provide clear action signals for the subsequent management period. The proposed "open system with a fixed core" model-standardizing the framework while allowing component-

indicator adjustment-constitutes an appropriate methodological approach for BR MEE indicator framework design in Vietnam.

Second, the overall score of 70.2/100 (moderate management effectiveness) indicates that WNABR surpasses the reported Arab MAB average (62.0/100 [5]) but remains below CLC-HA BR (78.2/100 [6]), primarily due to governance complexities associated with its large spatial scale and multiple administrative tiers and the absence of a formal BR Management Regulation. The Context (73.5), Planning (73.8), and Outcomes (72.8) elements reflect a solid foundation, whereas Process (65.4) and Outputs (66.1) require priority interventions.

Third, the successful application at the WNABR demonstrates that the enhanced framework can be effectively applied to large-scale, multi-level BRs in Vietnam with complex socio-ecological and governance environments. However, further empirical application across other BRs is required to fully validate its transferability. The systematic comparison between the CLC-HA and the WNABR provides an initial basis for comparative assessment across Vietnam's BR network and supports the development of a national MEE reporting system aligned with the HSAP 2026-2035. The five newly added indicators reflect critical governance gaps at the WNABR and convey explicit policy implications. Expert validation further confirmed their content validity, with high agreement among the 15 Panel experts. However, their operational validity and scoring criteria require empirical testing across three to five BRs with contrasting socio-ecological conditions before they can be recommended for inclusion in a national standard indicator set. The present study therefore constitutes a first-generation assessment that requires ongoing, iterative refinement.

Fourth, the primary limitations of this study include its reliance on secondary documentation and expert assessment without independent field surveys, as well as its application within a single BR case study. Broader validation of the five added indicators will necessitate pilot testing across three to five additional BRs representing diverse socio-ecological contexts before proposing their inclusion in a national standard indicator set.

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