

Multi-metric assessment of ecological condition in the Labo River, Philippines using Fishers' Expert Rating (FER)

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<https://doi.org/10.67784/1011>

Abstract. River ecosystems are ecologically, socio-economically, and culturally important, yet assessing their ecological condition remains challenging where long-term monitoring data are limited. Integrating ecological indicators with local knowledge of resource-dependent communities offers a practical and complementary approach to addressing information gaps in freshwater systems. This study assessed the perceived longitudinal ecological condition of the Labo River using the River Ecological Assessment Tool (REAT), while Fishers' Expert Rating (FER) served as a participatory method for quantifying fishers' perceptions. Forty experienced riverine fishers rated the four Nature Function Indicators: Water Quality Index (WQI), Water Temperature Variability Index (WTVI), Aquatic Fauna Living Space Index (AFauSI), and Aquatic Flora Living Space Index (AFloSI). Results revealed an atypical longitudinal pattern of perceived ecological condition. The upstream section recorded the least favorable condition for WQI (6.81 ± 2.41), AFauSI (7.10 ± 1.29), and AFloSI (8.28 ± 2.38), while the downstream section showed the most favorable perceived ecological condition, particularly for WQI (3.14 ± 1.06). Significant longitudinal differences were observed for WQI, AFauSI and AFloSI, whereas perceived WTVI did not differ significantly among river sections. Despite these longitudinal differences, the assessment classified the overall perceived ecological condition of the Labo River as acceptable, although the upstream section was classified as having poor perceived ecological condition based on its composite FER score. This overall classification reflects fishers' perceptions rather than direct measurements of the river's ecological integrity. Fishers also reported perceived declines in catches relative to five years ago, with most anticipating further declines over the next five years (upstream: 100%; midstream: 92%; downstream: 94%). Conservation and rehabilitation (38%) emerged as the leading management priority. Fishers' local ecological knowledge may help identify changes in river conditions that warrant further investigation. Integrating FER with biophysical monitoring, fisheries assessment, and habitat evaluation is recommended to strengthen evidence-based and adaptive management of the river.

Keywords: ecological degradation, fish catch decline, *Gari* sp., river conservation, spatial variation.

Introduction. How can the ecological condition of rivers be assessed when long-term monitoring data are limited? Addressing this question is particularly challenging because river ecosystems are dynamic and interconnected, with ecological conditions varying across space and time under the combined influence of natural processes and human activities. River ecosystems are ecologically, socio-economically, and culturally important systems that support aquatic biodiversity, fisheries productivity, livelihood activities, and downstream coastal ecosystem functions. Despite these important functions, river ecosystems worldwide face increasing physical, chemical, and biological pressures associated with land-use change, pollution, hydrological alteration, and climate variability (Allan & Castillo, 2007; Albert et al., 2021). In the Philippines, environmental pressures vary among watersheds according to local geography, land use, and watershed characteristics (Sarmiento et al., 2022; Grefalda et al., 2024; Nolasco et al., 2024), while pollution inputs impose additional stress on freshwater ecosystems (Replan et al., 2023).

Systematic river assessment is therefore important for identifying ecological stress, prioritizing conservation actions, and informing timely management interventions to prevent further degradation (Martinez, 2018). Conventional water-quality indices provide important physicochemical information but may not fully represent the broader ecological condition of river systems. Zhao et al. (2024) demonstrated that favorable conventional water-quality classifications in the lower Yangtze River coexisted with risks from emerging contaminants and impaired biological integrity which emphasize the importance of multidimensional ecological assessments. However, comprehensive assessments remain difficult in data-limited freshwater systems. This challenge is particularly relevant in the Philippines, where freshwater ecosystems remain comparatively understudied (Magbanua et al., 2017; Papa & Briones, 2017; Gabriel et al., 2023). Jamandre et al. (2026) reported uneven sampling efforts and persistent information gaps across Philippine river catchments, particularly in relation to freshwater fish biogeography. In the Bicol Region, river systems support inland capture fisheries and provide food and livelihoods through the harvest of fishes, crustaceans, and mollusks (Biag & Alberto, 2021). The Labo River in Camarines Norte supports inland fisheries and other livelihood activities, while its upstream, midstream, and downstream sections are characterized by differing environmental and land-use conditions. Environmental disturbances may also extend beyond individual river sections through connectivity with downstream estuarine and coastal ecosystems. Despite the river's local importance, freshwater fauna in Camarines Norte, particularly ichthyofauna, remain understudied, with the fish fauna of the Labo and Bosigon Rivers reported as undocumented (National Irrigation Administration V, 2025). This information gap supports the need for locally grounded baseline assessments to inform further ecological investigations.

In data-limited river systems, local ecological knowledge can serve as a practical complement to conventional monitoring by providing long-term, place-based observations of environmental change. Fishers, through their regular interactions with river ecosystems, can provide experiential information on perceived changes in water quality, fish abundance, aquatic habitats, and conservation concerns. Citizen science and participatory approaches have demonstrated the value of community involvement in aquatic ecosystem assessment (Licuanan & Mordeno, 2021; Requilme et al., 2021). Related studies have further established the contributions of fishers' ecological knowledge to fisheries assessment and conservation (Silas et al., 2023; Silvano et al., 2023; Maliao et al., 2025). Nevertheless, perception-based information is influenced by respondents' experiences and recollections and should be interpreted as complementary to, rather than a substitute for, direct physicochemical measurements and biological surveys. Despite these contributions, a specific research gap remains for the Labo River: the lack of a structured, spatially comparable assessment of fishers' perceptions of ecological conditions across its upstream, midstream, and downstream sections. Addressing this gap can provide preliminary evidence of perceived environmental concerns and identify priorities for subsequent ecological investigation. Accordingly, this study assessed the perceived ecological condition of the Labo River using Fishers' Expert Rating (FER) within the River Ecological Assessment Tool (REAT). The assessment compared upstream, midstream, and downstream sections using four Nature Function Indicators: Water Quality Index (WQI), Water Temperature Variability Index (WTVI), Aquatic Fauna Living Space Index (AFauSI), and Aquatic Flora Living Space Index (AFloSI). The assessment incorporated perceived environmental degradation, pollutant occurrence, and satisfaction with conservation efforts. The study also examined perceived past, present, and anticipated fish catch trends and community-proposed management interventions. By comparing river sections, the study examined longitudinal differences in perceived ecological degradation that a river-wide assessment alone might overlook. The findings provide a perception-based baseline that complements limited ecological monitoring data, identifies priorities for further ecological investigation, and supports participatory, reach-specific conservation planning. The study also provides locally relevant information aligned with Sustainable Development Goal (SDG) 6, particularly Target 6.6 on protecting and restoring water-related ecosystems, and SDG 15, particularly Target 15.1 on the conservation and sustainable use of inland freshwater ecosystems.

Material and Method

Description of the study sites. The study was conducted in April 2024 along the Labo River, located in the municipalities of Labo and Vinzons, Camarines Norte, Philippines ($14^{\circ}11'11''$ N, $122^{\circ}56'22''$ E) (Figure 1). Labo is the largest municipality in Camarines Norte in terms of land area and is located approximately 15 km from Daet, the provincial capital, and about 325 km from Manila (Balce Oco, 2004). The municipality is classified as a first-class municipality and comprises 52 barangays, with agriculture as one of the dominant livelihood activities (Balce Oco, 2004). Geographically, the area is characterized by mountainous terrain and the presence of three inactive volcanoes, namely Mt. Labo, Mt. Bagacay, and Mt. Cadig. It is also traversed by major thrust fault lines that may pose geological risks, particularly in the northwestern portion of the municipality (Capili, 2003). The Labo River originates from the mountainous areas of Labo and flows downstream toward Vinzons, where it discharges into coastal waters. The river supports inland fisheries, irrigation, transportation, and other livelihood activities of nearby riverine communities. Areas along the river are susceptible to flooding during periods of heavy rainfall and increased river flow. Separately, satellite observations documented flooding in agricultural areas along the river in November 2024 (United Nations Satellite Centre [UNOSAT], 2024). This highlights the river's socio-ecological importance to surrounding communities. Based on the 2015 national census, approximately 18,390 residents from five barangays in Vinzons and five barangays in Labo resided near the river (Paringit & Uy, 2017). The river therefore functions not only as an ecological corridor but also as a critical socio-economic resource for surrounding communities. The study covered the upstream, midstream, and downstream sections of the Labo River. The upstream section included Barangays Calabasa and Pangpang and was characterized by headwater conditions, upland land uses, quarrying activities, small-scale riverside resorts, and relatively limited fishing activity that increased during the flood season. The midstream section comprised Barangays Gumamela and Sta. Cruz, which were characterized by residential areas, agricultural and fishing, and a history of quarrying. The downstream section included Barangays Singi and Cagbalogo, situated closer to the river mouth and coastal interface.

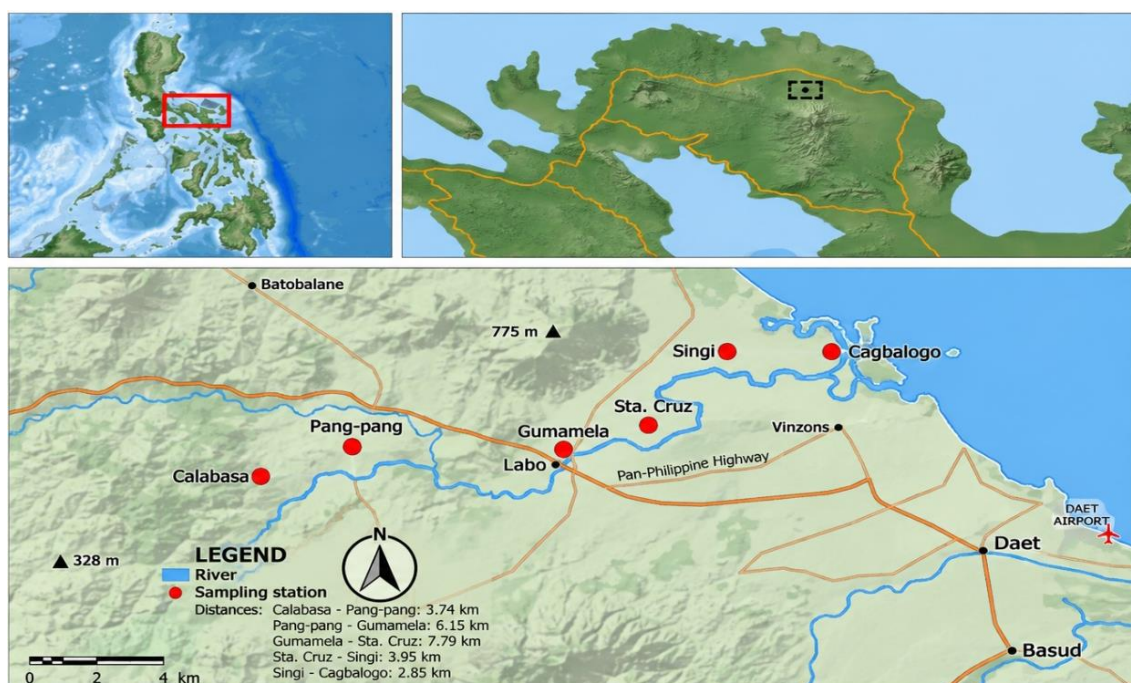


Figure 1. Geographic location of the Labo River in Camarines Norte, Philippines, showing the upstream, midstream, and downstream sections and corresponding sampling areas.

Data collection. The study employed a perception-based ecological assessment of the Labo River using a researcher-structured REAT designed to characterize fishers'

perceptions of river conditions. Purposive and snowball sampling methods were used to identify and recruit experienced small-scale riverine fishers from the upstream, midstream, and downstream sections of the Labo River. These non-probability sampling approaches were used to target respondents with direct and long-term fishing experience in the river. The questionnaire was administered in person. The study focused on fishing communities within the upstream, midstream, and downstream river sections. A total of 40 experienced small-scale riverine fishers from the selected barangays participated: 10 from the upstream, 12 from the midstream, and 18 from the downstream sections. All respondents had at least five years (≥ 5) of fishing experience in the Labo River. This eligibility criterion was intended to ensure familiarity with river conditions and local fishing activities.

River ecological assessment tool and fishers' expert rating. The REAT was operationally defined as the researcher-structured assessment instrument used to organize fishers' local ecological knowledge into measurable perception-based indicators of river condition. The REAT was adapted from river health assessment frameworks described by Wang et al. (2010) and Yu et al. (2019). This involved identifying river health indicators relevant to the Labo River and translating these indicators into observable river conditions. The REAT was not used as a substitute for empirical water quality, habitat, or biodiversity monitoring, but as a complementary early-diagnostic tool for organizing fishers' perceptions in a data-limited river system. The REAT followed a hierarchical structure composed of Main Ecological Indicators (MEIs), Sub-Ecological Indicators (SEIs), and Nature Function Indicators (NFIs). The MEIs represented broad ecological components of river condition, namely physicochemical and biological conditions. The SEIs represented more specific ecological components, including perceived water quality, water temperature variability, aquatic fauna habitat condition, and aquatic flora/riparian habitat condition. The NFIs served as the measurable perception-based indicators: Water Quality Index (WQI), Water Temperature Variability Index (WTVI), Aquatic Fauna Living Space Index (AFauSI), and Aquatic Flora Living Space Index (AFloSI). FER was operationally defined as the scoring method used to quantify the ecological observations of experienced riverine fishers. Respondents rated 21 structured survey items corresponding to the four NFIs using a 10-point negatively oriented scale. The rating scale incorporated three related dimensions: perceived environmental degradation, pollutant occurrence, and satisfaction with conservation efforts. Lower scores represented fewer perceived signs of degradation or environmental change, lower pollutant occurrences, and greater satisfaction with conservation efforts. Higher scores represented greater perceived degradation or negative environmental change, higher pollutant occurrences, and greater dissatisfaction with conservation efforts. Thus, increasing FER scores represented increasing perceived ecological concern, with a score of 1 indicating the most favorable perception and a score of 10 indicating the least favorable perception. FER scores reflect fishers' perceptions and should not be interpreted as direct empirical measurements of water quality, habitat condition, or biodiversity status. For each respondent, the NFI score was calculated as the arithmetic mean of that indicator's item ratings; section-level NFI means and standard deviations were then calculated from respondent scores. At the NFI level, the values were interpreted as perceived degradation categories: low degradation = 0.00-3.33, moderate degradation = 3.34-6.67, and high degradation = 6.68-10.00. At the SEI and MEI levels, the same numerical ranges were expressed as perceived ecological condition categories: good condition = 0.00-3.33, acceptable condition = 3.34-6.67, and poor condition = 6.68-10.00. This distinction was used because NFIs describe the degree of perceived degradation, whereas SEIs and MEIs summarize broader perceived ecological condition. The categories were used only as analytical groupings of FER scores and should not be interpreted as objective ecological benchmarks. The physicochemical MEI was computed as the mean of WQI and WTVI, while the biological MEI was computed as the mean of AFauSI and AFloSI. The section-level ecological condition was computed as the mean of the four NFIs for each river section. When a river-wide overall condition was reported, it was derived from the grand mean of the section-level NFI scores across upstream, midstream, and downstream sections. The study assigned equal weights to all indicators

because no empirical evidence justified differential weighting. The assessment incorporated fishers' local ecological knowledge to complement limited ecological monitoring data.

Statistical analysis. All survey responses were coded and analyzed to assess spatial variation in perceived ecological conditions across the upstream, midstream, and downstream sections of the Labo River. Data normality was assessed using the Shapiro–Wilk test, and nonparametric tests were applied because the data were not normally distributed. FER scores for each Nature Function Indicator (NFI) and river section were summarized using means and standard deviations. Spatial differences were examined using Kruskal–Wallis H tests, followed by pairwise Mann–Whitney U tests with Holm adjustment where significant differences were detected ($p < 0.05$). Fishers' perceptions of past, present, and anticipated future catch conditions were summarized using frequencies and percentages and analyzed separately using the same statistical procedures. Proposed management interventions were summarized as relative frequencies across five thematic categories. Graphical visualizations illustrated longitudinal patterns and variability in ecological perceptions.

Results

Ecological profile of Labo River. The multi-metric ecological profile of the Labo River showed longitudinal variation in FER scores across NFIs (Figure 2).

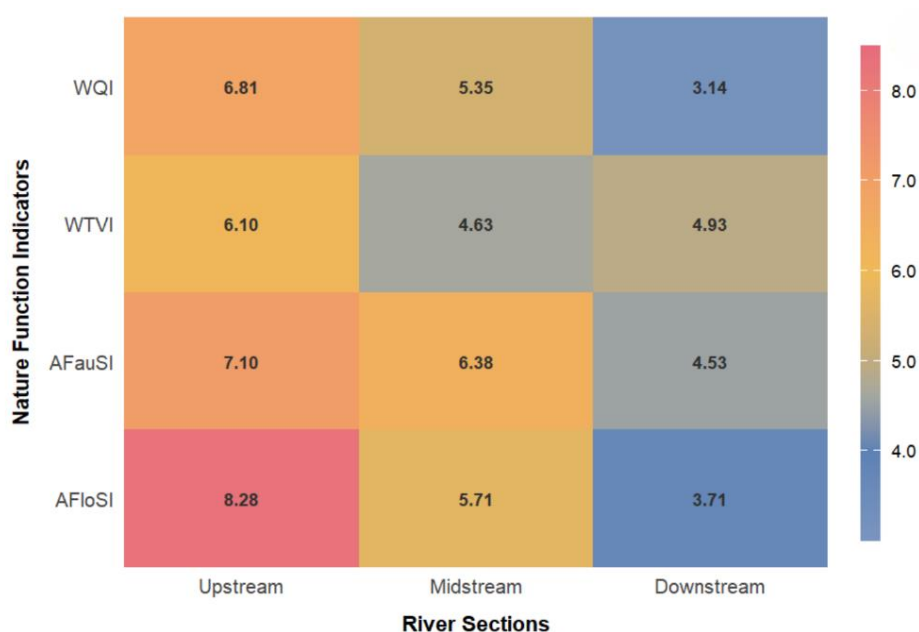


Figure 2. Multi-metric ecological profile of the Labo River based on FER in upstream, midstream, and downstream sections. Higher FER values and warmer heatmap colors indicate poorer perceived ecological conditions.

Higher FER values denote poorer perceived ecological condition. The upstream section exhibited the highest FER values in most NFIs. This shows that perceived ecological stress was substantially more pronounced in this section compared with the midstream and downstream sections. Specifically, AFloSI recorded the highest FER value in the upstream (8.28), followed by the AFauSI (7.10), WQI (6.81), and WTVI (6.10). This observed pattern indicates that habitat-related biological indicators, particularly the perceived living-space conditions of aquatic flora and fauna, were the main factors associated with the poorer perceived ecological condition in the upstream section. The midstream section displayed intermediate FER values, with AFauSI recording the highest score (6.38), followed by AFloSI (5.71), WQI (5.35), and WTVI (4.63). This pattern reflects a transitional zone of moderate perceived ecological concern. In contrast, the downstream section generally recorded lower FER values, particularly for WQI (3.14) and AFloSI (3.71), although WTVI

remained moderately rated (4.93). These results indicate that perceived ecological degradation was not uniformly distributed along the river continuum, with ecological stress concentrated in the upstream section and, to a lesser degree, in the midstream section. Figure 2 provides a visual synthesis of the longitudinal differences in perceived ecological condition. The heatmap shows that water quality and biological habitat indicators were more sensitive discriminators of river condition than temperature variability in distinguishing the three river sections.

Spatial variation in Nature Function Indicators. Fishers' Expert Rating (FER) values varied among river sections and across Nature Function Indicators (NFIs) (Figure 3; Table 1). Higher FER values indicate poorer perceived ecological conditions. For WQI, the upstream section recorded the highest mean FER (6.81 ± 2.41), followed by midstream (5.35 ± 1.09), with downstream recording the lowest mean FER (3.14 ± 1.06). Differences among river sections were statistically significant ($p < 0.001$), with downstream differing significantly from both upstream and midstream, while no significant difference was detected between upstream and midstream. For WTVI, upstream recorded the highest mean FER (6.10 ± 2.12), followed by downstream (4.93 ± 2.32) and midstream (4.63 ± 1.29). However, differences among river sections were not statistically significant ($p = 0.282$). For AFauSI, significant differences were observed among river sections ($p = 0.014$). Upstream exhibited the highest mean FER (7.10 ± 1.29), followed by midstream (6.38 ± 2.24) and downstream (4.53 ± 2.02). Following Holm adjustment, upstream differed significantly from downstream, whereas midstream did not differ significantly from either section. Similarly, AFloSI differed significantly among river sections ($p < 0.001$), with the highest mean FER recorded upstream (8.28 ± 2.38), followed by midstream (5.71 ± 3.11) and downstream (3.71 ± 2.22). Pairwise comparisons revealed significant differences between upstream and both midstream and downstream, while the latter two sections did not differ significantly. Overall, WQI, AFauSI, and AFloSI exhibited significant spatial variation, whereas WTVI did not. The observed pattern indicates greater perceived ecological degradation upstream, intermediate ratings midstream, and comparatively lower ratings downstream, particularly for water quality and aquatic habitat indicators.

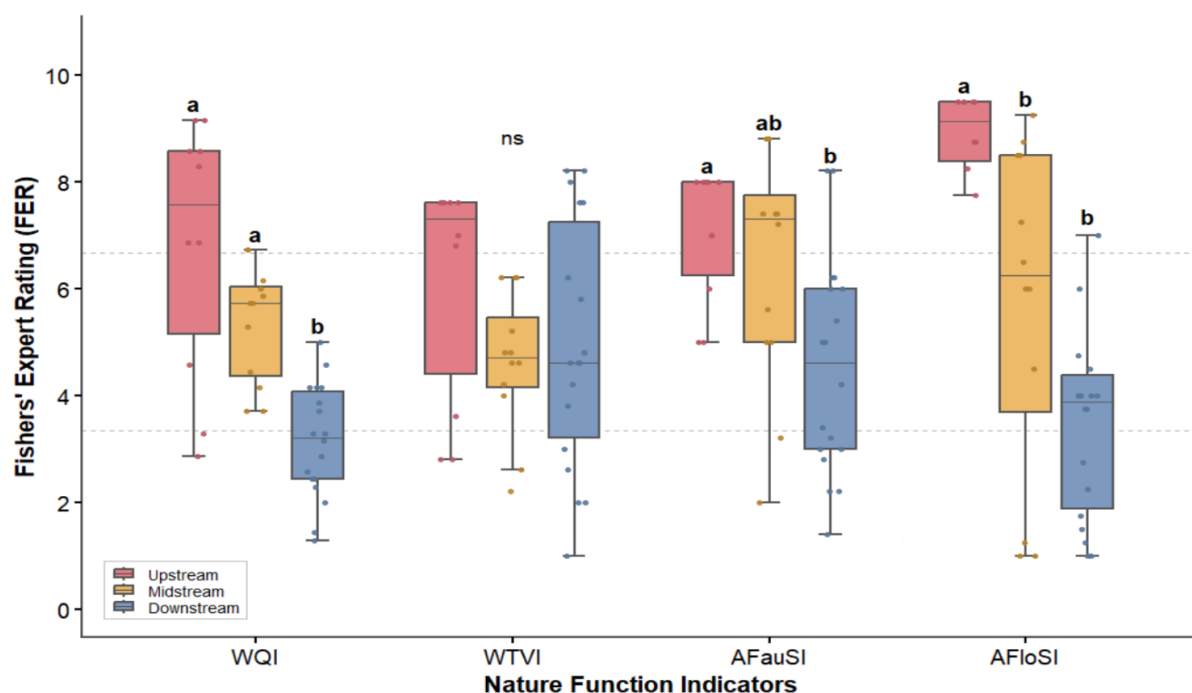


Figure 3. Fishers' Expert Rating (FER) across river sections of the Labo River. Boxes represent the interquartile range, horizontal lines indicate the medians, whiskers show data spread, and points represent individual scores. Dashed lines indicate FER thresholds at 3.33 and 6.67. Different lowercase letters indicate significant pairwise differences based on Mann-Whitney U tests with Holm adjustment; ns indicates no significant difference.

Table 1

Fishers' Expert Rating values and statistical comparison of Nature Function Indicators across river sections

Nature Function Indicators	Upstream	Midstream	Downstream	Kruskal-Wallis
WQI	6.81±2.41 ^a	5.35±1.09 ^a	3.14±1.06 ^b	p < 0.001
WTVI	6.10±2.12	4.63±1.29	4.93±2.32	ns (p = 0.282)
AFauSI	7.10±1.29 ^a	6.38±2.24 ^{ab}	4.53±2.02 ^b	p = 0.014
AFloSI	8.28±2.38 ^a	5.71±3.11 ^b	3.71±2.22 ^b	p < 0.001

Note: Values are mean±SD. Different lowercase superscript letters indicate significant pairwise differences following Kruskal–Wallis tests and Holm-adjusted Mann–Whitney U comparisons. Groups sharing at least one letter are not significantly different; *ns* = not significant.

Categorical classification. To facilitate interpretation, mean FER scores were further classified into low (0.00–3.33), moderate (3.34–6.67), and high (6.68–10.00) categories of perceived ecological degradation (Figure 4). FER integrates fishers' perceptions of environmental degradation and pollutant occurrence, together with their satisfaction with conservation efforts, into a single negatively oriented scale in which higher scores indicate poorer perceived river conditions. The matrix classification demonstrates that the upstream section falls within the high category for water quality, aquatic fauna living space, and aquatic flora living space, while temperature variability remains within the moderate category. In contrast, midstream indicators are predominantly classified as moderate. The downstream section shows comparatively better perceived condition, with water quality categorized as low and biological indicators largely within the moderate range. The matrix complements the continuous FER distributions and statistical comparisons by translating mean scores into ecologically interpretable categories. This categorical distribution highlights the upstream river section with the least favorable perceived ecological condition.

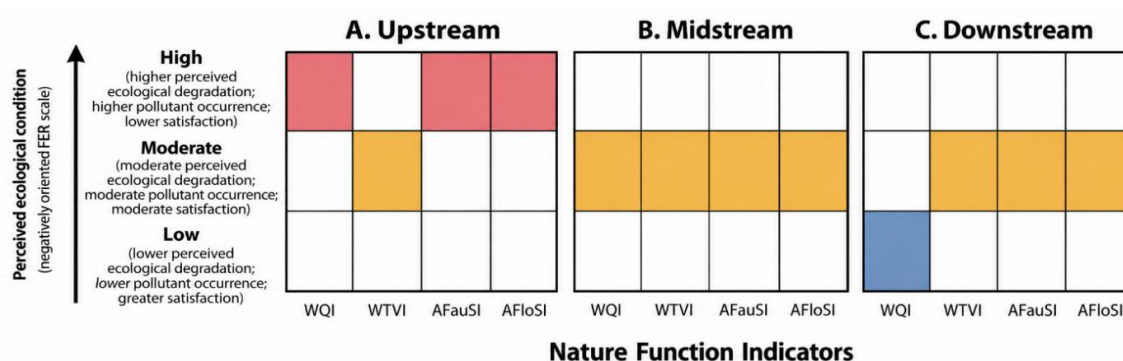


Figure 4. Matrix classification of perceived ecological condition across (A) upstream, (B) midstream, and (C) downstream river sections of the Labo River based on four NFIs. Red, yellow, and blue denote high, moderate, and low levels of perceived ecological degradation, respectively. FER followed a negatively oriented scale (higher ratings represent poorer perceived ecological condition).

Sub- and main ecological condition. The integrated assessment of sub-ecological and main ecological indicators revealed clear spatial variation in the perceived ecological condition of the Labo River (Table 2). At the sub-ecological level, the upstream section recorded the highest mean FER scores for all four indicators. In this section, WQI (6.81), AFauSI (7.10) and AFloSI (8.28) fell within the poor category, whereas WTVI (6.10) was classified as acceptable. This indicates that biological habitat components, particularly aquatic fauna living space and aquatic flora or riparian-related habitat condition, were the components of greatest perceived ecological concern in the upstream river section.

The midstream section showed a more moderate pattern, with all sub-ecological indicators classified as acceptable. Mean values ranged from 4.63 for WTVI to 6.38 for AFauSI, suggesting that perceived ecological condition in this section remained within an acceptable range but still reflected moderate perceived stress, particularly in habitat-related indicators. The downstream section exhibited comparatively better perceived

condition, especially for WQI, which had the lowest mean value (3.14) and was classified as good. Other downstream indicators, including WTVI (4.93), AFauSI (4.53), and AFloSI (3.71), were classified as acceptable. This pattern indicates that perceived ecological stress was most pronounced upstream, intermediate in the midstream section, and comparatively lower downstream.

When sub-ecological indicators were aggregated into main ecological indicators, physicochemical condition was classified as acceptable across all river sections, although the upstream WQI (6.81) was individually classified as poor at the sub-ecological level. However, the upstream section still recorded the highest physicochemical mean value (6.46), followed by the midstream (4.99) and downstream (4.04) sections. A stronger spatial contrast was observed in the biological indicator, where the upstream section was classified as poor (7.69), while the midstream (6.05) and downstream (4.12) sections were classified as acceptable. The main ecological limitation in the Labo River is more strongly associated with biological habitat condition than with physicochemical condition, particularly in the upstream biological indicators. While several ecological components of the Labo River remain within acceptable condition, localized perceived ecological stress is evident, especially in the upstream biological indicators. Despite these differences, the overall perceived ecological condition of the Labo River was classified as acceptable.

Table 2

Integrated sub-ecological and main ecological condition of the Labo River across river sections

Indicator level	Indicator	Upstream		Midstream		Downstream	
		Mean	Condition	Mean	Condition	Mean	Condition
Sub-ecological	WQI	6.81	Poor	5.35	Acceptable	3.14	Good
	WTVI	6.10	Acceptable	4.63	Acceptable	4.93	Acceptable
	AFauSI	7.10	Poor	6.38	Acceptable	4.53	Acceptable
	AFloSI	8.28	Poor	5.71	Acceptable	3.71	Acceptable
Main ecological	Physicochemical	6.46	Acceptable	4.99	Acceptable	4.04	Acceptable
	Biological	7.69	Poor	6.05	Acceptable	4.12	Acceptable

Perceived catch trends. Fishers across the Labo River generally recalled more favorable catch conditions five years ago and anticipated further declines over the next five years (Figure 5). Overall, 32 of the 40 fishers (80%) recalled better catches five years ago, while 38 (95%) anticipated poorer catches over the next five years. Most respondents reported better catches five years earlier than at present (upstream: 80%; midstream: 75%; downstream: 83%). While the present catch trends in midstream section (100%) rated catches as average, whereas a majority in the upstream (60%) perceived conditions as worse than average. In the downstream section, most fishers (89%) reported average conditions and with 11% indicating worse than average catches. Expectations regarding future catches were predominantly pessimistic, with 100% of upstream, 92% of midstream, and 94% of downstream respondents anticipating further declines in fish catches over the next five years. A Kruskal–Wallis test was conducted to assess differences in fishers’ perceptions of catch among the upstream, midstream, and downstream sections in the three time periods: five years ago, the present, and five years into the future. It revealed no significant spatial differences in perceived catch conditions five years ago ($H(2) = 0.15$, $p = 0.926$) and for the next five years ($H(2) = 0.83$, $p = 0.661$). In contrast, perceptions of present catch conditions differed significantly among river sections ($H(2) = 13.54$, $p = 0.001$). Post hoc pairwise Mann–Whitney U tests with Holm adjustment identified significant differences between the upstream and midstream ($U = 24$, adjusted $p = 0.007$) and between the upstream and downstream ($U = 46$, adjusted $p = 0.015$). However, the difference between the midstream and downstream was not statistically significant ($U = 96$, adjusted $p = 0.260$). These findings indicate that spatial variation in perceived catch conditions was most evident for the present period, particularly between the upstream and the other river sections, whereas recalled past and anticipated future catch conditions showed no statistically detectable spatial differences.

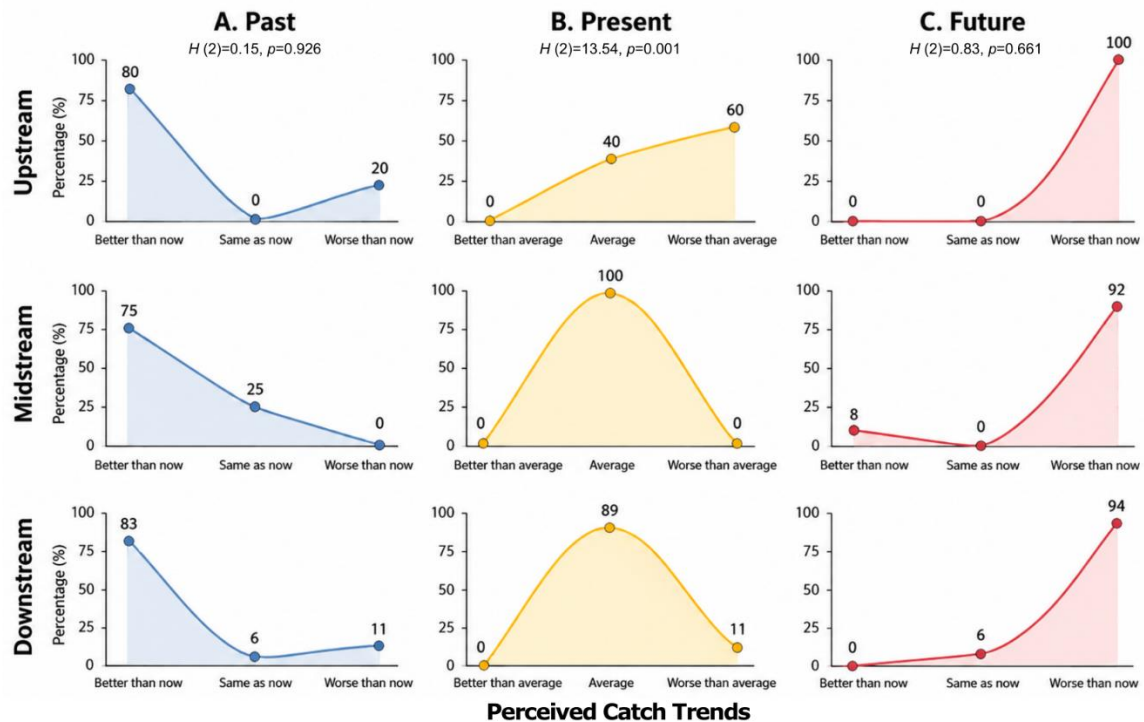


Figure 5. Perceptions of riverine fishers across upstream, midstream, and downstream sections of the Labo River regarding catch trends: (A) perceived catch condition five years ago, (B) perceived present catch condition, and (C) expected catch condition five years into the future. Curves serve as visual guides connecting discrete response categories.

Management priorities. Riverine fishers identified priority programs, projects, and policy areas that relevant agencies could address to strengthen conservation and management of the Labo River (Figure 6). Among the identified priorities, conservation and rehabilitation projects accounted for the largest proportion of responses (38%). Increased patrols and monitoring followed at 26%, while regulatory and enforcement measures (17%), livelihood and support programs (15%), and infrastructure and policy development (4%) were identified as additional areas of concern. More specifically, riverine fishers identified several section-specific management priorities along the river continuum. In the upstream section, fishers emphasized the need for conservation and rehabilitation initiatives, particularly stock enhancement, riverbank tree planting, mitigation of quarrying impacts, and strengthened river monitoring. Concerns regarding illegal fishing and quarrying activities were consistently highlighted as major threats requiring regulatory intervention. In the midstream section, fishers prioritized enhanced patrols and monitoring, stricter enforcement measures, and river rehabilitation efforts. Fishers also emphasized the need for water quality monitoring, riparian restoration, and assessment of river morphology associated with sedimentation and channel alteration. Additional priorities included livelihood diversification and improved river governance policies. Downstream fishers placed greater emphasis on enforcement-related measures, including increased patrol operations, community-based surveillance, and stricter regulation of illegal fishing activities. Conservation concerns in this section focused on aquatic species protection, particularly the sunset clam (*Gari* sp.), locally known as “ngok-ngok,” whose genus-level identification was established through a separate morphological assessment based on diagnostic shell characteristics and taxonomic references. Additional priorities included the continuation of riverbank stabilization measures and the provision of patrol boats to strengthen monitoring capacity. Across the three river sections, monitoring and regulatory enforcement emerged as recurring priorities, while the specific conservation measures reflected differences in the environmental concerns and resource-management needs identified by fishers in each section.

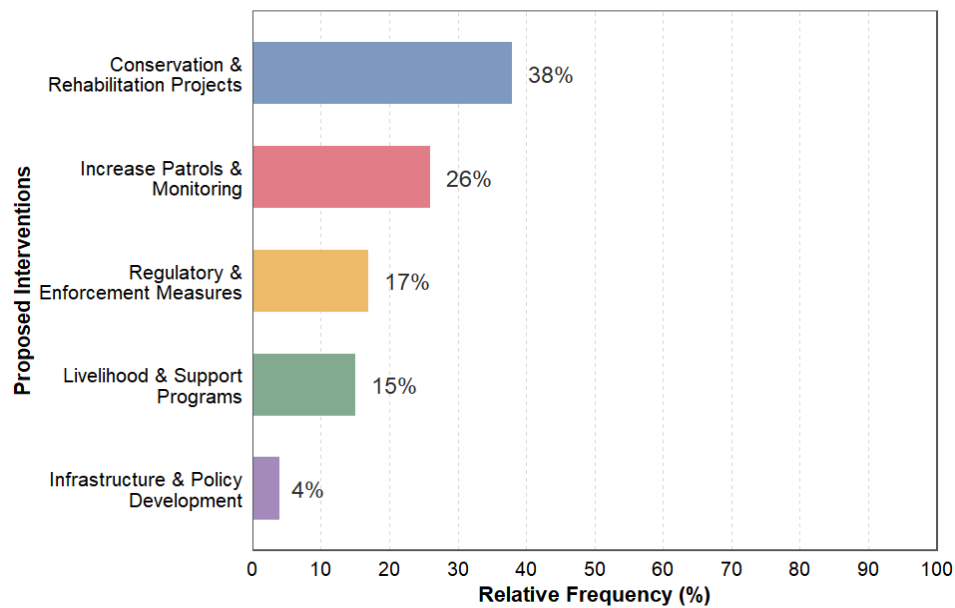


Figure 6. Relative frequency of proposed interventions identified by riverine fishers for priority management attention.

Discussion

Longitudinal ecological condition of the Labo River. The multi-metric assessment indicates that the overall perceived ecological condition of the Labo River was classified as acceptable; however, this classification should be interpreted with caution. At the sub-ecological level, the upstream section exhibited poor perceived ecological condition for WQI, AFauSI, and AFloSI, whereas WTVI remained acceptable. At the main ecological level, the upstream biological indicator was classified as poor, whereas the physicochemical indicator remained acceptable. Thus, the overall acceptable classification should not be interpreted as evidence of ecological stability, as the indicator-level results reveal spatially uneven patterns of perceived degradation, particularly in the upstream section. River ecosystems are increasingly shaped by cumulative anthropogenic pressures, including land-use change, pollution, habitat modification, and hydrological alteration (Best, 2019; Allan et al., 2021). These findings emphasize the importance of examining spatial differences and individual ecological indicators rather than relying solely on an aggregated assessment of river condition. The most notable finding of this study is the atypical pattern in which the upstream section recorded the highest perceived degradation, particularly for water quality, aquatic fauna living space, and aquatic flora living space. This pattern challenges the common assumption that upstream areas are generally less disturbed than downstream sections, where environmental pressures are often expected to accumulate. In the Labo River, the higher upstream FER scores may reflect the direct visibility of localized pressures, including quarrying, riparian disturbance, sediment movement, and perceived habitat alteration. Because the indicators are perception-based, the elevated upstream scores may also reflect fishers' long-term familiarity with this section of the river. Their repeated observations over time may allow them to readily recognize visible changes in water quality, aquatic habitats, and resource condition compared with previous conditions. Similar mechanisms were reported by Nwosu et al. (2021), who found that sand excavation, sand mining, erosional deposits, and illegal waste disposal contributed to elevated turbidity, sediment loading, and high biological oxygen demand (BOD) in the Nworie River. Their findings support the interpretation that physical disturbance near river channels can reduce water clarity, affect submerged vegetation, and threaten aquatic productivity. The upstream degradation signal is also biologically meaningful because the highest FER scores were associated not only with water quality but also with aquatic fauna and flora living space. Habitat condition is a central determinant of river biodiversity and ecological integrity (Allan & Castillo, 2007). Riparian vegetation contributes to bank

stability, shading, sediment control, nutrient regulation, and habitat complexity (Allan & Castillo, 2007). When riparian and substrate conditions are altered, spawning areas, refuge habitats, food resources, and nursery grounds may be reduced. This interpretation is supported by Raphahlelo et al. (2022), who found that macroinvertebrate assemblages in the Mohlalapsi River were strongly associated with water quality differences, with upstream sites showing better conditions while more disturbed midstream and downstream sites were dominated by pollution-tolerant taxa. Although the present study is perception-based, the high upstream FER values for aquatic living space are consistent with ecological evidence that habitat alteration can affect biological communities before system-wide collapse becomes apparent.

Fishers' ratings of water temperature variability showed no significant differences among river sections. Shared climatic and hydrological conditions may partly explain this pattern, although local factors such as riparian vegetation, channel depth, shading, and water flow can influence thermal conditions within individual river sections. Nevertheless, this does not mean that temperature is ecologically unimportant. Temperature affects fish metabolism, reproduction, survival, and distribution, especially when combined with poor water quality and habitat degradation (Albert et al., 2021). Future monitoring should therefore examine temperature together with dissolved oxygen, turbidity, flow velocity, nutrients, and habitat structure. Hydrodynamic conditions may also influence pollutant transformation; in a regulated river, flow velocity was identified as a key control on pollutant degradation dynamics, emphasizing the need to interpret physicochemical water-quality variables together with hydrological conditions (Wang et al., 2025). Similarly, Getachew et al. (2023) found significant associations between macroinvertebrate assemblages and river velocity, phosphate concentration, and substrate conditions in the Awash River Basin. These relationships emphasize the importance of multiple ecological indicators in the Labo River assessment. These highlight the potential role of hydrological, physicochemical, and habitat conditions in longitudinal ecological variation.

The midstream section appears to function as a transitional zone where upstream disturbance interacts with local human activities and cumulative watershed inputs. Although midstream FER scores were generally lower than upstream values, moderate degradation in water quality and aquatic living space shows that ecological stress remains present. This supports the river continuum perspective, where sediments, nutrients, organic matter, and biological responses are transported and transformed along river sections (Doretto et al., 2020). Kabwe & Musenge (2026) similarly reported that downstream and affected river zones may show increased turbidity, nutrients, BOD, COD, electrical conductivity, and reduced dissolved oxygen when pollutant loads accumulate. While the Labo River is not necessarily exposed to the same industrial pressures as the Kafue River, the comparison suggests that the midstream section should be considered a zone of active ecological processing rather than simply a connecting channel.

The lower perceived degradation in the downstream section should also be interpreted carefully. Lower FER scores indicate relatively more favorable perceived conditions, but they may also indicate long-term normalization of disturbance. This aligns with the shifting baseline concept, where gradual ecological decline becomes less noticeable because present conditions are compared with already altered historical baselines (Pauly, 1995). Therefore, the comparatively lower downstream FER scores should not automatically be interpreted as ecological recovery. They may reflect dilution, sediment deposition, habitat heterogeneity, accumulated community familiarity with disturbance, or reduced sensitivity to long-term change (Allan & Castillo, 2007; Doretto et al., 2020). The Labo River should be understood as a functionally intact but ecologically vulnerable river system. The overall acceptable FER classification should not be interpreted as confirmation of the river's ecological integrity. Instead, the perception-based degradation signals can help prioritize locations for ecological verification and potential management interventions. Accordingly, structured fishers' ecological knowledge can help identify spatially differentiated ecological concerns in a data-limited tropical river. In particular, the upstream condition might be overlooked if assessments assume that degradation mainly intensifies primarily downstream.

Anticipated future decline in fisheries. The reported decline in fish catches and the expectation of further declines indicate that riverine fishers perceive continuing pressure on Labo River fisheries. In data-limited fisheries, perceived catch decline is important because fishers are long-term observers of changes in abundance, seasonality, habitat condition, water clarity, and fishing success (Silvano & Begossi, 2012). Similar observations in Philippine fisheries show that fishers often associate declining catches with fishing pressure, habitat degradation, destructive practices, and environmental disturbance (Muallil et al., 2014). A comparable assessment was conducted by Malcolm et al. (2021), who examined artisanal fishers' perceptions of catch conditions five years ago, at present, and five years into the future. Similarly, most fishers in their study recalled better catches five years ago and expected catches to decline over the next five years.

In the Labo River, perceived fisheries decline corresponds with the highest degradation ratings for water quality and aquatic living space in the upstream and midstream sections. This relationship is ecologically plausible because freshwater fisheries depend on suitable water quality, stable substrates, sufficient dissolved oxygen, riparian inputs, spawning habitats, and nursery areas. When sediment disturbance, habitat alteration, and riparian degradation occur together, fish productivity may decline even before severe ecological degradation is reflected in formal classification scores. Studies on macroinvertebrates support this interpretation because benthic organisms respond strongly to habitat and water quality changes and are important components of aquatic food webs. In a Philippine river system, Baclayon et al. (2023) documented longitudinal differences in macroinvertebrate assemblages, with pollution-sensitive taxa dominating the upstream section and pollution-tolerant taxa dominating downstream, alongside anthropogenic modification of riparian and substrate conditions. Raphahlelo et al. (2022) showed that benthic macroinvertebrate abundance and diversity followed water quality differences among river sites, while Getachew et al. (2023) demonstrated that hydrological and nutrient-related variables influenced macroinvertebrate assemblages.

Although perception-based catch assessments may be influenced by shifting baselines (Pauly, 1995), the consistency of perceived decline across respondents suggests that fishers' observations should be treated as an early-warning signal rather than dismissed as anecdotal. The anticipated future decline may reflect the combined effects of fishing pressure, habitat degradation, water quality stress, and broader socio-environmental variability (Medeiros et al., 2024). Therefore, future studies should integrate fishers' perceptions with catch-per-unit-effort, species composition, gear-use patterns, seasonal catch monitoring, habitat assessment, and empirical water quality measurements.

River management and conservation. The management priorities identified by riverine fishers show that ecological degradation is already being translated into community-level concern. Their emphasis on conservation, rehabilitation, monitoring, enforcement, livelihood support, and policy development suggests awareness that river degradation is both an ecological and socio-economic issue. Similar findings from the Baloi River Basin emphasize that fisheries conservation should be linked with appropriate regulation, local stakeholder participation, and protection of fishing livelihoods (Daturanong et al., 2024). River health assessment is essential in such human-dominated systems because ecological integrity and community use are closely connected (Xi et al., 2023). The upstream section requires immediate attention because this reach showed the strongest degradation signal and was associated with concerns over quarrying, riparian disturbance, and habitat alteration. Activities such as stone mining, river modification, and engineering works can rapidly alter aquatic habitats and reduce fish biodiversity (Li et al., 2020). This is further supported by Nwosu et al. (2021), who recommended controlling sand mining, excavation, erosion, and indiscriminate waste disposal to prevent further river degradation. Comparable evidence from the Pansipit River in the Philippines indicates that gravel extraction, land excavation, and unregulated waste disposal can contribute to siltation and deterioration of river ecological condition (Isla et al., 2024). In the Labo River, upstream management should therefore prioritize quarrying regulation, sediment control, riparian buffer restoration, bank stabilization, and protection of aquatic habitats. In the midstream

and downstream sections, monitoring and enforcement should be strengthened to address cumulative pressures. Kabwe & Musenge (2026) emphasized the importance of continuous water quality monitoring, stricter discharge regulation, wastewater treatment, integrated catchment management, and stakeholder engagement in restoring river water quality. Although the pollution sources in Labo River may differ, the management principle remains applicable: rehabilitation alone is insufficient without enforcement, monitoring, and institutional coordination. Management should therefore be reach-specific rather than uniform across the entire river. Upstream interventions should focus on habitat protection, quarrying regulation, sediment reduction, and riparian rehabilitation. Midstream interventions should focus on cumulative stress monitoring, water quality assessment, riverbank restoration, and enforcement. Downstream interventions should emphasize fisheries protection, community-based surveillance, and monitoring of sediment, nutrient, and habitat conditions. This section-based approach aligns with integrated watershed management, which recognizes that ecological, social, economic, cultural, and policy dimensions must be considered together. Integrated river-basin management similarly requires coordination among hydrological, ecological, economic, social, engineering, and institutional dimensions (Yang et al., 2021). Talampas et al. (2025) support this perspective through an Integrated Watershed Health Assessment Framework that incorporates ecological, social, cultural, economic, and policy attributes, with ecological factors receiving the highest priority weight.

Integrating local knowledge into a multi-metric assessment. This study incorporated local ecological knowledge into a structured multi-metric river assessment. The Fishers' Expert Rating (FER) helps translate experiential observations into quantifiable indicators that capture water quality, temperature variability, aquatic fauna living space, and aquatic flora and riparian living space. These ratings allowed comparisons of perceived ecological conditions across the upstream, midstream and downstream sections of the Labo River. This is particularly relevant in data-limited rivers where long-term scientific monitoring is sparse or fragmented. The methodological value of FER lies not in replacing empirical monitoring but in guiding where empirical monitoring should be prioritized. By indicating greater perceived degradation in the upstream and midstream sections, the framework helps identify priority reaches for detailed water quality testing, habitat assessment, and biological monitoring. This is consistent with multi-metric ecological assessment approaches, where composite indicators provide a more comprehensive understanding of river condition than single-variable assessment (Shahraki et al., 2025). Similarly, Soriano (2025) demonstrated that integrated ecological indices can synthesize multiple environmental dimensions into a unified assessment of ecological quality. The framework also has governance value. Fishers are not merely respondents but long-term observers of ecological change. Their knowledge can identify emerging stressors, historically significant changes, and management concerns that may not yet be captured by formal monitoring programs. This supports the broader argument that local ecological knowledge can strengthen fisheries and aquatic science when it is organized systematically and interpreted carefully (Silvano et al., 2023). However, the results should be understood as diagnostic rather than definitive biophysical evidence. FER provides a structured early-warning tool, but its findings require validation through empirical indicators such as dissolved oxygen, turbidity, pH, conductivity, nutrients, BOD, COD, macroinvertebrate indices, fish assemblage structure, riparian vegetation condition, and substrate composition.

Conclusions. This study provides an early diagnostic approach for assessing perceived ecological condition in data-limited freshwater systems through Fishers' Expert Rating (FER). Although the overall perceived ecological condition of the Labo River was classified as acceptable, the assessment revealed spatial variation in FER scores, with the upstream section showing the highest perceived degradation, particularly for water quality and biological habitat indicators. This atypical upstream condition challenges the assumption that headwater reaches are necessarily less disturbed and reinforces the need for reach-specific river assessment and management. Perceived degradation may therefore be

localized rather than progressively increasing downstream. Perceived declines in fish catches further suggest continuing pressure on riverine fisheries. Conservation and rehabilitation emerged as the foremost management priorities identified by riverine fishers, with section-specific concerns that include habitat protection, monitoring, enforcement, and protection of locally important aquatic resources. Among the downstream priorities was “ngok-ngok,” a locally utilized shellfish identified in this study as the sunset clam (*Gari* sp.). A key contribution of the study is the use of riverine fishers’ experiential knowledge through FER as a structured multi-metric assessment of perceived ecological condition, which translates observations of environmental change and degradation, pollutant occurrence, habitat condition, and conservation efforts into quantifiable indicators across river sections. This approach can help identify priority areas and management needs where long-term ecological information is limited, while complementing rather than replacing empirical monitoring. Future studies should validate FER through water-quality measurements, habitat assessment, macroinvertebrate and fish assemblage surveys, catch-per-unit-effort analysis, and assessment of locally important aquatic resources. The Labo River remains insufficiently studied, with much of its ecological condition, biodiversity, fisheries dynamics, responses to human pressures, and other ecological attributes yet to be fully documented. This study provides a starting point for more comprehensive and long-term investigations that can strengthen the scientific basis for conservation and sustainable management. Such evidence can also support the design of strategic management measures that integrate socio-economic, ecological, biological, and policy considerations.

Acknowledgements. The authors acknowledge the assistance of the local government units of Labo and Vinzons, Camarines Norte, Philippines, and the riverine fishing communities during field activities. We also extend our sincere appreciation to our colleagues and friends, Darwin C. Biag, Janine F. Vasquez, Monicalyn V. Borlagdan, Shena Mae D. Opeda, Richmond Hombrilla, and Lucy O. Elep Jr. for their support in the completion of this study.

Author Contributions. SFF led the study development and implementation, data analysis and interpretation, and manuscript preparation; APC, PMN, ABM, and RUB contributed to the development of the study, interpretation of the results, and review of the manuscript.

Conflict of Interest. The authors declare that there is no conflict of interest.

Data Availability. The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Funding. This research received no external funding.

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Received: 13 July 2026. Accepted: 18 September 2026. Published online: 25 October 2026.

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How to cite this article:

Furio, S. F., Camaya, A. P., Nieves, P. M., Mendoza, A. B., & Bobiles, R. U. (2026). Multi-metric assessment of ecological condition in the Labo River, Philippines using Fishers' Expert Rating (FER). *Aquaculture, Aquarium, Conservation & Legislation*, 19(5), 2513-2529. <https://doi.org/10.67784/1011>