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Multidimensional Constraints to Native Fish Biodiversity Management: Perceptions of Fishers in North-East India

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HIGHLIGHTS

- Constraint severity differed significantly across states, water bodies and villages.
- Findings highlight the need for context-specific interventions for sustainable biodiversity management.

ARTICLE INFO

Keywords: Native fish biodiversity, Fishers, Constraints, Fisheries extension, Knowledge–action gap, North-East India.

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ABSTRACT

Native fish biodiversity in North-East India is increasingly threatened due to environmental degradation, livelihood pressures, inadequate infrastructure, and weak institutional support. This study assessed the multidimensional constraints fishers perceive in managing native fish biodiversity in selected freshwater ecosystems in Manipur and Tripura. A cross-sectional study was conducted during 2023–2025 among 240 fishers from 12 villages across the Loktak, Pumlen, Rudrasagar, and Dumboor water bodies of Northeast India. Primary data were collected through personal interviews, focus group discussions, and field observations. Constraints were assessed using a five-point severity scale and analysed through Weighted Mean Scores, Kruskal–Wallis H tests and eta-squared (η^2H) for assessing effect size. Significant village-level differences were observed for all constraint dimensions ($p<0.001$), with large effect sizes for physical, environmental, marketing, infrastructural, institutional and overall constraints ($\eta^2H=0.495–0.914$). In contrast, technology-transfer constraints showed a moderate effect ($\eta^2H = 0.120$). Among the lakes, Pumlen recorded particularly high physical, marketing and infrastructural constraints, whereas Rudrasagar showed comparatively lower constraint levels. The findings highlight a clear gap between biodiversity knowledge and its translation into conservation action. Sustainable management therefore requires location-specific, participatory fisheries extension interventions that integrate capacity building, market support, improved infrastructure, information access, and community participation.

INTRODUCTION

Fish biodiversity, a fundamental component of freshwater ecosystems, contributes to ecological stability, ecosystem functioning, food security, and community livelihoods (Reid et al., 2019). However, freshwater ecosystems are increasingly exposed to habitat degradation, pollution, wetland encroachment, hydrological alterations, overexploitation, invasive species, and climate change, threatening native fish populations and ecosystem integrity (Dudgeon et al., 2006; Tickner et al., 2020; Sreeraman et al., 2023; Koreti et al., 2025). The northeastern region of India, with its abundant freshwater ecosystems, is no exception.

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The northeastern region of India is a major centre of freshwater fish biodiversity, hosting diverse aquatic ecosystems and forming part of the Indo-Burma Biodiversity Hotspot (Vishwanath, 2017). It has many fish species, including endemic, threatened, and economically important species, and rivers, wetlands, lakes, and reservoirs serve as habitats for indigenous and ethnic fishing communities, who benefit from them through their livelihoods (Sarma et al., 2018). Traditional fishing practices and indigenous ecological knowledge (IEK) support biodiversity conservation and sustainable fisheries management (Jones et al., 2024). These socio-ecological systems, however, face ever-changing threats from habitat modification, pollution, hydrologic modifications, and overexploitation (Vishwanath, 2017; Sreeraman et al., 2023). The water resources of Manipur and Tripura, i.e. the Loktak and Rudrasagar Ramsar wetlands (Ramsar Sites), and Pumlen Lake and Dumboor Reservoir, are valuable inland fisheries resources and livelihoods for the local fishing communities. Different threats to these ecosystems impact fish habitats, species diversity, recruitment, and fisheries productivity (Dutta et al., 2018; Meinam et al., 2025).

Socio-economic, infrastructural, institutional, and technological conditions also affect biodiversity management, alongside ecological pressures. However, constraints such as limited livelihood opportunities, poor infrastructure, marketing problems, limited access to credit and technology, and weak institutional support and extension services hamper fishers' ability to implement conservation-oriented practices (Allison & Ellis, 2001; Béné et al., 2016; Bayala, 2023). Likewise, poor coordination, minimal stakeholder involvement, and weak co-management reduce the success of conservation programmes (Ostrom, 2009; Masud et al., 2022). Contextually, several studies have focused on fish species diversity and wetland degradation in the wetlands of North-East India, where the multidimensional constraints faced by fishers and their spatial variations due to agroecological specificity remain relatively under-researched (Barman, 2004; Bhattacharjee, 2013; Mandal, 2015; Dauruhi et al., 2025). Thus, an assessment can identify deficiencies that hinder effective biodiversity management and may provide a basis for appropriate community-level interventions.

Against this background, this study assessed the constraints of native fish biodiversity management as perceived by fishers in selected freshwater ecosystems of Northeast India. The study examined physical, environmental, marketing, infrastructural, institutional, and technology-transfer constraints and their spatial variations to provide a comprehensive understanding of the challenges confronting community-linked biodiversity management and to support location-specific extension, participatory management, and policy interventions.

METHODOLOGY

The study was conducted during 2023–2025 in Manipur and Tripura, which were purposively selected for their rich freshwater fish biodiversity and local communities' dependence on them. In Manipur, Loktak Lake (Ramsar site) and Pumlen Lake were selected, whereas in Tripura, Rudrasagar Lake (Ramsar site) and Dumboor Reservoir were selected. Three villages from each selected water body were purposively selected based on the presence of active fishing communities and their relevance to the study, resulting in 12 villages, i.e. Thanga, Karang and Laphupatvillages of the Loktak Lake; Yangbi, Komnao and Tokpa Ching villages of the Pumlen Lake; Rangamura, Kemtali and Chandanmuravillages of the Rudrasagar Lake; and Chaplin Sora, Mandir Ghat and Indrajit Para villages of the Dumboor Reservoir.

A quota sampling approach was used to select respondents, with 20 active fishers selected from each selected village, resulting in a total sample of 240 fisher respondents. Quota sampling was used to select fishers because each lake required adequate representation from specific population subgroups. It also helped select respondents without requiring a complete understanding of population size in the sampling frame. Primary data were collected through personal interviews using a pre-tested, semi-structured interview schedule. A pilot study was conducted with 40 non-sampled respondents to pre-test and modify the interview schedule. The final interview schedule covered six constraint categories: physical, environmental/anthropogenic, marketing and financial, infrastructural, extension/institutional, and transfer of technology. Each constraint was measured using a five-point severity scale: Most Severe (MS) = 5, Severe (S) = 4, Moderate (M) = 3, Less Severe (LS) = 2 and Least Severe (L) = 1. The collected data were coded, tabulated, and analysed using appropriate descriptive and inferential statistical techniques. The Weighted Mean Score (WMS) was used to assess the perceived severity of individual constraints and rank them within each constraint category using the following formula:

$$\text{WMS} = \frac{\Sigma f_i S_i}{N}$$

where, f_i represents the frequency of respondents selecting the i^{th} response category, S_i represents the score assigned to the corresponding response category, and N represents the total number of respondents. The Kruskal-Wallis 1-way ANOVA (k samples) test was used to assess differences in constraint perceptions and their spatial variations among the selected water bodies and villages. Statistical significance was tested at the 5% level ($p< 0.05$). Further, the strength of associations was assessed using bias-corrected eta-squared for Kruskal–Wallis (η^2H) to measure the effect size.

$$\eta^2H = \frac{H - k + 1}{N - k}$$

Where, H = Kruskal-Wallis H, k = No. of Lakes / Villages, N = No. of respondents

The bias-corrected eta-squared (η^2H) value was interpreted using the conventional benchmarks of <.01 = negligible, .01–<.06 = small, .06–<.14 = moderate, and ≥.14 = large (Tomczak & Tomczak, 2014).

RESULTS

Constraints of native fish biodiversity management perceived by the fishers of Manipur and Tripura

The nature and severity of these constraints vary with ecological and socio-economic conditions. Physical constraints, particularly water scarcity (WMS = 4.492), were the most severe problem in Manipur. Fishers of Tripura identified unfavourable climatic factors (WMS = 4.275) as the major constraint. Regarding environmental and anthropogenic constraints, deforestation and overexploitation ranked first in Manipur (WMS = 4.533), followed by weed domination (WMS = 4.517). whereas flooding (WMS = 4.050) and overexploitation (WMS = 3.733) were the major environmental constraints in Tripura. For marketing and financial constraints, intermediaries' domination (WMS = 4.500) emerged as the most serious problem in Manipur, whereas fluctuation in market prices (WMS = 3.992) ranked first in Tripura. For infrastructural constraints, poor landing and marketing infrastructure ranked first in both Manipur (WMS = 4.500) and Tripura (WMS = 2.667). Among extension and institutional constraints, fishers in Manipur identified a lack of training and awareness programmes (WMS = 4.442) as the most critical issue. In contrast, weak extension services ranked first in Tripura (WMS = 4.250). Among technology transfer constraints, lack of awareness of government fisheries schemes ranked first in both Manipur (WMS = 4.567) and Tripura (WMS = 4.408), as shown in Table 1.

Comparative analysis of spatial variations of perceived constraints among the fishers

Table 2 revealed significant differences in perceived constraints among fishers in Loktak, Pumlen, Rudrasagar, and Dumboor lakes. Fishers around Pumlen Lake experienced the highest levels of physical, marketing and infrastructural constraints. Similarly, fishers in Loktak Lake also reported high environmental and institutional constraints. In contrast, Rudrasagar Lake consistently recorded the lowest mean ranks for most constraint categories, while fishers of Dumboor Reservoir exhibited moderate levels of constraints. Thus, fishers in Manipur, particularly at Pumlen Lake, experienced substantially greater constraints than fishers in Tripura.

Table 1. Constraints of native fish biodiversity management as perceived by the fishers of Manipur and Tripura

Constraints	Manipur (n=120)		Tripura (n=120)	
	Weighted Mean Score	Rank	Weighted Mean Score	Rank
Physical Constraints				
Unfavourable climatic factors	4.550	I	4.275	I
Water scarcity	4.492	II	2.750	IV
Skilled labour scarcity	3.975	IV	4.050	II
Non-availability of fish seed material	3.700	V	2.083	V
Inadequate storage facilities	4.392	III	3.933	III
Environment/ Anthropogenic Constraints				
Pollution	4.483	III	3.533	III
Deforestation and Urbanisation	4.533	I	1.917	VI
Drought problem	3.950	IV	3.050	IV
Flood problem	3.516	V	4.050	I
Overexploitation	4.533	I	3.733	II
Under exploitation	2.750	VI	2.633	V
Weeds Domination	4.517	II	1.842	VII
Marketing and Financial Constraints				
Less demand for fish	3.350	VI	2.200	VI
Competition from larger units	3.450	V	3.475	II
Fluctuation in market price	3.958	IV	3.992	I
Intermediaries' domination	4.500	I	3.050	IV
Lack of access to credit facilities and subsidies	4.200	III	3.000	V
Lack of alternate income sources during lean seasons	4.275	II	3.100	III
Infrastructural Constraints				
Community/personal ownership	4.242	II	2.000	III
Inadequate storage and preservation facilities	3.950	III	2.550	II
Poor landing and marketing infrastructure	4.500	I	2.667	I
Extension/ Institutional Constraints				
Weak extension services	4.008	IV	4.250	I
Lack of training /awareness programme	4.442	I	3.867	II
Inadequate technical knowledge in identifying proper solutions	4.233	III	3.600	IV
Weak coordination between agencies/stakeholders	4.425	II	3.775	III
Transfer of Technology Constraints				
Lack of location-specific fishing advisories	3.492	IV	3.425	III
Difficulty in using improved fishing gears and implements	3.508	III	2.483	IV
Limited access to information through mass media platforms	3.725	II	4.400	II
Lack of awareness about government schemes related to fisheries	4.567	I	4.408	I

Table 2. Analysis of fisheries constraints across the lakes

Variable	Lakes Mean Rank (N=240)				H-value	df	η^2H	Effect size*	P-value	Significance
	Pumlen	Loktak	Rudrasagar	Dumboor						
Physical	202.35	153.83	37.51	88.32	197.915	3	0.826	Large	0.000	Significant
Environmental	188.67	172.22	48.33	72.78	185.881	3	0.775	Large	0.000	Significant
Marketing	202.08	148.65	30.87	100.41	200.472	3	0.837	Large	0.000	Significant
Infrastructural	202.78	158.15	30.50	90.58	219.308	3	0.917	Large	0.000	Significant
Institutional	164.10	166.00	88.14	63.76	106.755	3	0.440	Large	0.000	Significant
Transfer of Technology	148.56	121.90	92.06	119.48	21.223	3	0.077	Moderate	0.000	Significant

*<.01 = negligible, .01–<.06 = small, .06–<.14 = moderate, and ≥.14 = large (Tomczak & Tomczak, 2014)

The Kruskal–Wallis test revealed statistically significant differences across the four lakes for all categories of fisheries constraints (H=21.223–219.308, df=3, $p<0.001$). The effect sizes indicated large differences for physical (η^2H=0.826), environmental (η^2H=0.775), marketing (η^2H=0.837), infrastructural (η^2H=0.917), and institutional constraints (η^2H=0.440). Among these, infrastructural constraints showed the largest effect, showing the greatest variation in perceived constraints across the lakes. Transfer of technology constraints showed a moderate effect (η^2H=0.077), indicating comparatively lower spatial variation among the lakes. This shows Pumlen generally recording the highest levels of perceived constraints and Rudrasagar the lowest.

The village-level analysis in Table 3 further demonstrates variation in the perceived severity of fisheries constraints across the selected 12 fishing villages. The H-values ranged from 38.352 for transfer of technology constraints to 219.472 for infrastructural constraints, while η^2H values ranged from 0.120 to 0.914, indicating considerable differences among villages. Infrastructural constraints recorded the highest effect size (η^2H=0.914), followed by physical (0.837), marketing (0.834), environmental (0.773), and institutional constraints (0.526), all representing large effects. Transfer of technology showed a moderate effect (η^2H=0.120), suggesting less spatial variation across villages than other factors. The overall constraint score also showed a large effect (η^2H=0.495), indicating substantial differences in overall perceived constraints among villages.

The mean ranks also showed clear spatial differences, where villages surrounding the Pumlen Lake, namely Topa Ching, Yangbi and Komnao, reported the highest physical, environmental and infrastructural constraints, indicating greater challenges. Similarly, villages around Loktak Lake, particularly Karang, Thanga, and Laphupat Tera, recorded the highest marketing constraints. In contrast, villages around Rudrasagar Lake, i.e., Rangamura, Kemtali, and Chandanmura, experienced the lowest levels of constraints across most dimensions. However, institutional and technology-transfer constraints remained comparatively evident in some villages. Villages around the Dumboor Lake showed moderate levels of constraints, with Chaplin Sora recording comparatively higher technology-transfer constraints.

The overall village-level pattern in Table 3 highlights considerable spatial heterogeneity in the constraints fishers face. These findings emphasise the need for lake- and village-specific

Table 3. Analysis of fisheries constraints across the fishing villages

Villages	Mean Rank						
	Physical	Environmental	Marketing	Infrastructural	Institutional	Transfer of Technology	Overall
Topa Ching	211.74	185.10	145.62	203.05	166.10	157.50	178.19
Yangbi	192.36	190.09	152.95	202.50	158.86	130.07	171.14
Komnao	207.30	189.80	144.13	202.27	167.07	163.23	178.97
Thanga	150.53	171.33	202.93	156.40	165.50	124.90	161.93
Karang	155.83	174.74	208.02	157.36	170.24	122.17	164.73
Laphupat Tera	157.12	173.38	191.98	165.24	163.43	121.26	162.07
Rangamura	38.10	56.70	21.10	30.50	81.18	80.60	51.36
Kemtali	44.20	34.53	36.95	30.50	76.53	88.15	51.81
Chandannura	30.23	53.78	34.55	30.50	106.73	107.43	60.54
Indrajit Para	70.73	71.53	106.68	78.63	13.25	84.03	70.81
Mandir Ghat	89.08	79.38	93.20	95.53	64.63	114.45	89.38
Chaplin Sora	105.15	67.45	101.35	97.58	50.63	159.98	97.02
H-value	201.916	187.143	201.112	219.472	131.019	38.352	123.879
η^2H	0.837	0.773	0.834	0.914	0.526	0.120	0.495
df	11	11	11	11	11	11	11
P-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Effect size*	Large	Large	Large	Large	Large	Moderate	Large
Significance	Significant	Significant	Significant	Significant	Significant	Significant	Significant

*<.01 = negligible, .01–<.06 = small, .06–<.14 = moderate, and ≥.14 = large (Tomczak & Tomczak, 2014)

interventions focusing on habitat restoration, infrastructure, market linkages, extension services, and community-based resource management to conserve native fish biodiversity.

DISCUSSION

The study suggested that conservation and management of native fish biodiversity were influenced not only by fishers' knowledge but also by multidimensional constraints, including physical, environmental, marketing, infrastructural, institutional, and technological factors (Roche et al., 2022). Conservation outcomes are shaped by interactions among ecological conditions, livelihood requirements, institutions, information, and community capacities (Ostrom, 2009). Hamelin et al. (2024) and Sharma et al. (2025) identified a persistent knowledge-action gap. They indicated that knowledge does not necessarily translate into management action because of contextual, institutional, and resource-related barriers.

The higher severity of constraints in Manipur suggested strong links between biodiversity conservation, ecological degradation, and livelihood dependence on wetlands. Pumlen and Loktak reflected multiple pressures experienced by fishing communities. Recent evidence reported *phumdi* proliferation, water pollution, and declining fish species and production as major perceived risks (Singh & Mistri, 2025). Moreover, climatic variability, anthropogenic pressures, and hydrological changeshave been associated with livelihood vulnerability among fishers (Imdad et al., 2025). De and Dwivedi (2024) emphasised environmental management, stakeholder participation, alternative livelihoods, inter-sectoral coordination, and freshwater biodiversity monitoring.

The comparatively lower constraint scores in Tripura, particularly from Rudrasagar Lake's fishers, did not indicate an absence of management concerns. Saha (2018) identified alternative income generation, appropriate land-use practices, and conservation management as important extension needs. He also reported inconsistent attitudes toward consultation with fisheries officials and applying government regulations. In Dumboor Reservoir, moderate constraint levels across most dimensions suggest fishers faced persistent challenges. De and Dwivedi (2024) highlighted similar concerns about stakeholder participation, institutional coordination, and freshwater biodiversity management. Institutional communication, community participation, market access, and fisheries infrastructure remain important for converting awareness into effective management practices (Pomeroy and Rivera-Guieb 2006).

Village-level variation indicated that constraint severity was shaped by local ecological, livelihood, and service-access conditions. Large effect sizes for infrastructural, physical, marketing, and environmental constraints suggested substantial differences in facilities, market access, and local resource conditions. Fishers and fish farmers in Manipur have also reported similar constraints, including poor transportation, inadequate marketing facilities, limited training, and limited financial support (Salam et al., 2020).

In Tripura, inadequate training, extension services, and awareness of government schemes indicated information gaps. Singh et al. (2023) emphasised need-based training, frequent farmer visits, and training evaluation. Niangti et al. (2025) reported similar training gaps among fish farmers, while Periginji et al. (2026) highlighted the need for local-language content, usability, and social and institutional support for digital extension. Extension interventions should therefore combine locally relevant information, digital and interpersonal communication, scheme facilitation, and institutional contact (Reed et al., 2009). Integrating indigenous ecological knowledge with scientific fisheries knowledge is desirable, as fishing communities possess locally developed knowledge of fish species, seasonal changes, fishing grounds, and aquatic environments. Linking these can improve the relevance and acceptability of conservation interventions (Gomes et al., 2025).

CONCLUSION

Barriers included ecological pressures, inadequate infrastructure and market facilities, limited training and awareness, weak extension support, and poor awareness of government schemes. These suggested a gap between biodiversity knowledge and its translation into conservation action, indicating that knowledge alone did not ensure conservation action. Therefore, conservation measures needed to be location-specific and participatory, integrating ecological management, infrastructure, market linkages, extension support and stakeholder coordination. These will enable fishers' conservation knowledge to translate into effective action, supporting sustainable fisheries and livelihood resilience in North-East India. Fisheries extension for native fish biodiversity conservation should move beyond awareness to an integrated approach that combines biodiversity education, capacity building, need-based information, community networks, institutional cooperation, market and livelihood support, and habitat management. Manipur requires greater emphasis on habitat restoration, infrastructure, livelihood diversification, market linkages, and institutional support, whereas Tripura requires stronger fisheries services, flood management, extension support, and institutional communication.

DECLARATIONS

Ethical approval and consent to participate: To protect participant welfare and scientific integrity, we confirm that we conducted this study in accordance with ethical guidelines and with approval from the PME Cell of Central Agricultural University, Imphal, India (Ref. No. 8451 CF/CAU, Date 09/02/2024). To protect individuals' privacy, all data collection and processing procedures adhered to applicable regional laws. We also confirm that all participants consented to participate in the project and to the publication of the manuscript, and that all participants were above 18 years of age during the project period.

The authors confirm that the submitted work has not been published previously (except in the form of an abstract, a published lecture, or an academic thesis, that it is not under consideration for publication elsewhere, that its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere in the same form, in English or any other language, including electronically, without the written consent of the copyright holder.

We also confirm that we did not use generative AI or AI-assisted technologies in the writing process.

Author contributions: Martina Meinam, Biswajit Lahiri, and SoibamKhogen Singh contributed to the study's conception and design. The supervision and project administration were handled by Biswajit Lahiri. Material preparation, data collection and analysis were performed by Martina Meinam, Biswajit Lahiri, and Prasenjit Pal. Martina Meinam, Biswajit Lahiri, SoibamKhogen Singh, and Amitava Ghosh wrote the first draft of the manuscript. Anil Datt Upadhyay and Y Jackie Singh reviewed and edited the manuscript and supported graphical mapping and the incorporation of relevant visualisation to improve clarity. All authors read and approved the final manuscript.

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REFERENCES

Alagappan, M., & Kumaran, M. (2020). Assessment of information seeking behaviour and constraints in obtaining information of public and private aquaculture extension personnel. *International Journal of Farm Sciences, 10*(1), 104–114. https://doi.org/10.5958/2250-0499.2020.00023.3

Allison, E. H., & Ellis, F. (2001). The livelihoods approach and management of small-scale fisheries. *Marine Policy, 25*(5), 377–388. https://doi.org/10.1016/S0308-597X(01)00023-9

Andrachuk, M., Kadykalo, A. N., Cooke, S. J., Young, N., & Nguyen, V. M. (2021). Fisheries knowledge exchange and mobilization through a network of policy and practice actors. *Environmental Science & Policy, 125*, 157–166. https://doi.org/10.1016/j.envsci.2021.08.023

Barman, R. P. (2004). Threatened and endemic fishes of Tripura with comments on their conservation. *Records of the Zoological Survey of India, 104*, 75–81.

Bayala, E. R. C. (2023). Stakeholder perceptions on landscape governance in Northern Ghana: A Q-study to identify common concern entry points for integrated landscape approaches. *Journal of Environmental Management, 351*, 119857.

Béné, C., Arthur, R., Norbury, H., Allison, E. H., Beveridge, M., Bush, S., *et al.* (2016). Contribution of fisheries and aquaculture to food security and poverty reduction: Assessing the current evidence. *World Development, 79*, 177–196. https://doi.org/10.1016/j.worlddev.2015.11.007

Bhattacharjee, P. (2013). *Present status of fish faunal diversity in Tripura, India*.

Dauruhi, P. D. E., Baruah, A., Balange, A. K., Baruah, D., Handique, B., Chaudhary, M., *et al.* (2025). Fisheries and aquaculture in Northeast India: A comprehensive review of status, issues, and sustainable development opportunities. *International Journal of Agriculture Sciences, 17*(3), 13546–13552.

De, K., & Dwivedi, A. K. (2024). Bridging gaps in the Indian freshwater biodiversity conservation through science-based and policy-backed recommendations. *Ecohydrology & Hydrobiology, 24*(1), 169–177. https://doi.org/10.1016/j.ecohyd.2023.06.013

Dudgeon, D., Arthington, A. H., Gessner, M. O., Kawabata, Z. I., Knowler, D. J., Léveque, C., & Sullivan, C. A. (2006). Freshwater biodiversity: Importance, threats, status and conservation challenges. *Biological Reviews, 81*(2), 163–182.

Dutta, R., Bhagabati, S. K., & Baishya, S. (2018). Ichthyo-faunistic diversity of Northeast India–status and future. *Fishing Chimes, 38*(1–2), 54–60.

Gomes, M. A., Alves, C. M., Neto, R., Faria, F., Troncoso, J., & Gomes, P. T. (2025). Fishing beyond the surface: Harnessing local ecological knowledge to improve local fisheries management and conservation. *Marine Policy, 179*, 106763.

Hamelin, K. M., Charles, A. T., & Bailey, M. (2024). Community knowledge as a cornerstone for fisheries management. *Ecology and Society, 29*(1). https://doi.org/10.5751/ES-14552-290126

Imdad, K., Sahana, M., Gautam, O., Chaudhary, A., Misra, S., Dwivedi, S., *et al.* (2025). Anthropogenic and hydroclimatic drivers of livelihood vulnerability in wetland communities: A geospatial and pragmatic assessment. *Water Resources Management, 39*, 2503–2525. https://doi.org/10.1007/s11269-024-04075-5

Jones, B. L., Santos, R. O., James, W. R., Costa, S. V., Adams, A. J., Boucek, R. E., *et al.* (2024). New directions for Indigenous and local knowledge research and application in fisheries science: Lessons from a systematic review. *Fish and Fisheries, 25*(4), 647–671. https://doi.org/10.1111/faf.12831

Koreti, K., Lahiri, B., Singh, S. K., Ghosh, A., Pal, P., Debbarma, R., & Singh, H. P. (2025). Optimal to excessive: Pragmatic use of chemical and biological products and crucial determinants in carp aquaculture in the Northeastern Himalayas. *Environment and Development, 56*, 101271. https://doi.org/10.1016/j.envdev.2025.101271

Mandal, S. A. (2015). Checklist of ichthyofaunal diversity of Khowai River, Tripura, North-East India. *Advances in Bioresearch, 9*, 203–208.

Masud, M. M., Shahabudin, S. M., Baskaran, A., & Akhtar, R. (2022). Co-management approach to sustainable management of marine protected areas: The case of Malaysia. *Marine Policy, 138*, 105010. https://doi.org/10.1016/j.marpol.2022.105010

Meinam, M., Lahiri, B., Ghosh, A., Singh, S. K., Bharati, H., Upadhyay, A. D., *et al.* (2025). Aquatic ecosystem, fish diversity and conservation strategies of the fragile Eastern Himalayas: A comprehensive review with a focus on Loktak Lake. *Wetlands, 45*(7), 96. https://doi.org/10.1007/s13157-025-01978-w

Niangti, W., Singh, Y. J., Lahiri, B., Upadhyay, A. D., Pal, P., Meinam, M., Huirem, B., &Monsang, M. W. (2025). Training needs of fish farmers for the development of fisheries and aquaculture in Meghalaya. *Indian Journal of Extension Education, 61*(2), 45–50. https://doi.org/10.48165/IJEE.2025.61209

Ostrom, E. (2009). A general framework for analyzing sustainability of social-ecological systems. *Science, 325*(5939), 419–422. https://doi.org/10.1126/science.1172133

Periginji, S. K., Prusty, A. K., Tripathy, P., Sahoo, B., & Mishra, N. (2026). Constraints in social media use for agriculture and fisheries in Andhra Pradesh. *Indian Journal of Extension Education, 62*(3), 334–338. https://doi.org/10.48165/IJEE.2026.623RN08

Pomeroy, R. S., & Rivera-Guieb, R. (2006). *Fishery co-management: A practical handbook*. CABI Publishing.

Reed, M. S., Graves, A., Dandy, N., Posthumus, H., Hubacek, K., Morris, J., & Stringer, L. C. (2009). Who's in and why? A typology of stakeholder analysis methods for natural resource management. *Journal of Environmental Management, 90*(5), 1933–1949. https://doi.org/10.1016/j.jenvman.2009.01.001

Reid, A. J., Carlson, A. K., Creed, I. F., Eliason, E. J., Gell, P. A., Johnson, P. T., *et al.* (2019). Emerging threats and persistent conservation challenges for freshwater biodiversity. *Biological Reviews, 94*(3), 849–873. https://doi.org/10.1111/brv.12480

Roche, D. G., O'Dea, R. E., Kerr, K. A., Rytwinski, T., Schuster, R., Nguyen, V. M., *et al.*(2022). Closing the knowledge–action gap in conservation with open science. *Conservation Biology, 36*(3), e13835. https://doi.org/10.1111/cobi.13835

Saha, B. (2018). Livelihood security vis-à-vis extension needs of the fishers inhabiting around Rudrasagar Lake, Tripura. *Indian Journal of Extension Education, 54*(4), 98–105.

Saha, B., Pandit, A., & Datta, M. K. (2021). Knowledge, attitude and practice of fishers on fisheries resource management in Rudrasagar Lake, Tripura. *Journal of the Inland Fisheries Society of India, 47*(2), 44–50. https://doi.org/10.47780/jifsi.47.2.2015.116802

Salam, M. A., Hussain, S. M., Oinam, G., & Debnath, B. (2020). Perceived constraints of fish farmers in adoption of scientific fish farming in Manipur. *Young (Up to 30 yr)*, *46*, 23-0.

Sarma, D., Singh, A. K., & Baruah, D. (2018). Checklist of endemic ichthyofauna of North-East India. *Indian Journal of Fisheries, 65*(3), 1–15. https://doi.org/10.21077/ijf.2018.65.3.60836-01

Sharma, L. K., Lahiri, B., Singh, Y. J., Waikhom, G., Biswas, P., Hoilenting, Pavan Kumar, S. T., Chandegara, A. K., &Meinam, M. (2025). Impact assessment of floating and alternative feeds (*Wolffia globosa*) for fish rearing technologies in Tripura, India. *Indian Journal of Extension Education*, 61(4), 112-119. https://doi.org/10.48165/IJEE.2025.61419

Singh, O. K., & Mistri, A. (2025). Wetland ecology deterioration and livelihood diversification as a coping strategy: A study from Ramsar wetland, Loktak, India. *Discover Sustainability, 6*, 1322. https://doi.org/10.1007/s43621-025-02187-5

Singh, Y. J., Ojha, S. N., Upadhyay, A. D., Ananthan, P. S., Argade, S. D., Meinam, M., Huirem, B., & Mir, S. A. (2023). Identification of indicators for assessing research-extension-farmers linkage in fisheries sectors of Tripura. *Indian Journal of Extension Education, 59*(4), 23–27. https://doi.org/10.48165/IJEE.2023.59405

Sreeraman, B. A., Singh, K. G., & Leichombam, P. (2023). Informing ecosystem values of Loktak Lake in Manipur, India: An application of discrete choice experiments. *Marine and Freshwater Research, 74*(8), 697–711. https://doi.org/10.1071/MF21337

Tickner, D., Opperman, J. J., Abell, R., Acreman, M., Arthington, A. H., Bunn, S. E., *et al.* (2020). Bending the curve of global freshwater biodiversity loss: An emergency recovery plan. *BioScience, 70*(4), 330–342. https://doi.org/10.1093/biosci/biaa002

Tomczak, M., & Tomczak, E. (2014). The need to report effect size estimates revisited: An overview of some recommended measures of effect size. *Trends in Sport Sciences*, 21(1), 19–25.

Vishwanath, W. (2017). Diversity and conservation status of freshwater fishes of the major rivers of northeast India. *Aquatic Ecosystem Health & Management, 20*(1–2), 86–101.

Welcomme, R. L., Cowx, I. G., Coates, D., Béné, C., Funge-Smith, S., Halls, A., & Lorenzen, K. (2010). Inland capture fisheries. *Philosophical Transactions of the Royal Society B: Biological Sciences, 365*(1554), 2881–2896. https://doi.org/10.1098/rstb.2010.0168