Insights on Human Dimensions of Freshwater Fish Conservation in Jharkhand and Bihar, India

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Abstract

Conservation outcomes in the socio-economically disadvantaged regions are strongly influenced by human behaviour, social norms, and existing governance mechanisms. This study examined stakeholder attitudes, perceptions, values, norms and decision-making processes associated with the conservation of freshwater fishes in two neighbouring states in Eastern India - Jharkhand and Bihar. An approach integrating the Conservation Planning Framework (CPF) with the Theory of Planned Behaviour (TPB) and Social Values (SV) enabled the development of four interlinked themes: "livelihood and economic prioritisation over conservation", "constraints on participation", "values and conservation willingness" and "erosion of social and cultural memories of mahseer", indicative of a process of dual extinction faced by these iconic freshwater fishes. Despite the widespread positive attitudes of the stakeholders towards native fishes and freshwater ecosystems, conservation intentions and actions in both states were found to be negatively influenced by feeble communication, prioritisation of aquaculture, institutional rigidity, inadequate conservation education, limited actual behavioural control (ABC) and subjective norms-driven livelihood pressures. However, the presence of active fishermen cooperative societies and stronger relational

values among the local communities makes Jharkhand better equipped to implement participatory governance and stakeholder-involved conservation engagement plans. By strategically linking CPF, TPB, and SV, this study demonstrates how human attitudes, behaviour, social norms, and institutional structures interact to shape freshwater fish conservation outcomes in regions where livelihood needs intersect with conservation priorities, thereby offering actionable insights for managing the native freshwater fish diversity.

Keywords: Aquaculture, Communication, Conservation Planning Framework, Freshwater Ecosystems, Human-Fish Interaction, Mahseer, Native Fishes, Participatory Decision-making, Social Values, Societal Extinction, Stakeholder Perceptions, Theory of Planned Behaviour.

Funding

Human Resource Development Group (HRDG) - Council of Scientific and Industrial Research (CSIR), New Delhi, India (09/1320(0001)/2020-EMR-I).

1. Introduction

Freshwater ecosystems, lifelines for both biodiversity and human societies, are among the most imperilled and threatened habitats on earth (He et al. 2017; Reid et al. 2019; Arora et al. 2024; Raghavan et al. 2025). Despite occupying a relatively small fraction of the earth's surface, they support a disproportionately high share of global biodiversity and underpin food security and livelihoods for millions. Amongst the countless species surviving in these water-bodies, fishes are particularly vulnerable. Freshwater fishes are recognised as the most threatened vertebrate group, with extinction rates estimated to be five times higher than those of terrestrial fauna and three times higher than those of marine mammals (Duncan and

Lockwood 2001; Dias et al. 2017; Vardakas et al. 2025). Decline in the freshwater fish diversity is accelerated by multiple interacting pressures - climate change and human induced habitat degradation and fragmentation, river regulation and flow alteration by dams and barrages, water pollution, overexploitation, and introduction of invasive alien fish species (IAFs; Lakra et al. 2010; Dudgeon 2011; Reid et al. 2019).

In the densely populated river basins of the Global South, both ecosystems and fishes are subject to sustained and intensive human exploitation (Dudgeon 2011; Kelkar 2014; Barletta et al. 2015). The rapid and extensive transformations happening in the rivers and its watershed over the last many decades (Welcomme et al. 2010; Lynch et al. 2016) has led to the degradation of the quality of these aquatic resources and the hence the strength and diversity of fish populations. The limited availability or absence of long-term records of fish catches, fishing intensity, gear types used, and population trends of the exploited species (Arthington et al. 2004; Bartley et al. 2015) and the need for considering numerous human factors manifolds the complexity of the conservation efforts in these socio-ecosystems. The Gangetic River basin in India, one of the world's largest and most heavily utilised river systems (Kelkar 2014; Tandon and Sinha 2018), supports remarkable freshwater biodiversity and offers many essential natural resources and livelihood for millions (Sarkar et al. 2012; Kelkar 2014; Bharati et al. 2016). The eastern region of the Gangetic basin, encompassing the Indian state of Bihar and parts of neighbouring Jharkhand, is of particular ecological and economic significance due to its dense network of rivers and tributaries such as the Ganga, Kosi, Sone, Bagmati, Gandak, Burhi Gandak, Damodar, Barakar, Ajay, Punpun, North Koel, etc. (Kelkar 2014; Dey et al. 2020; Kumari and Sharma 2022; Kumar, V. et al. 2025). Additionally, several other rivers originating in Jharkhand, such as the Kharkai, Subarnarekha, and South Koel, flow eastward and drain into separate basins, namely the Subarnarekha and Brahmani river basins, respectively (Tudu and Maji 2025).

The floodplains, wetlands, streams, hill and upland rivers, and reservoirs constitute a dynamic freshwater landscape that historically supported high levels of native fish diversity (Kumar, V. et al. 2025). Several commercially important piscine species such as rohu (*Labeo rohita*), catla (*Catla catla*), mrigal (*Cirrhinus mrigala*), magur (*Clarias magur*; State Fish of Jharkhand), stinging catfish (*Heteropneustes fossilis*; State Fish of Bihar) support local communities through riverine capture and inland fisheries contributing to livelihoods, income, employment, and food security (Kumar et al. 2019; Kumari and Sharma 2022; Kumar, V. et al. 2025; Tudu and Maji 2025. The presence of the mahseer (*Tor* spp. and *Neolissochilus* spp.) iconic freshwater fish with ecological, socio-cultural, religious and economic importance (Bhatt and Pandit 2016; Pinder et al. 2019; Sarma et al. 2022; Froese and Pauly 2025) heightens the conservation importance of this region. Archival literature, gazetteers, research articles, and historical records document the presence of four species of mahseer in these two states, viz. *T. putitora* (Himalayan or golden mahseer; Endangered), *T. tor* (red-fin or deep-bodied mahseer; Data Deficient), *T. mosal* (mosal mahseer; Data Deficient), and *N. hexagonolepis* (chocolate mahseer; Near Threatened) (O'Malley 1906, 1910, 1924, 1926; Roy Choudhury 1957; Kumar 1970; Das 2005; Srivastava and Singh 2014; Sinha Ray 2016; Tudu and Maji 2025). Additionally, the Kosi River in Bihar is recognised as the type locality of *T mosal* (Raghavan et al. 2017), a species for which no recent voucher specimens are available from the region (Dahanukar et al. 2018; Pinder et al. 2019).

Despite their high conservation value, increasing habitat degradation and fragmentation, freshwater ecosystems of Bihar and Jharkhand and the fish diversity present there received relatively little conservation attention (Srivastava and Singh 2014; Kelkar 2014; Das et al. 2018; Arora et al. 2024; Pandey and Bharti 2024). Over the recent decades, embankment construction (*bandh*), river regulation, sand, boulder and river-bed mining, pollution,

destructive fishing practices such as the illegal gear use, netting, dynamiting, electrocution, poisoning, and the spread of invasive alien fish species (IAFs) has ended up in habitat simplification, loss of spawning grounds, disruption of migratory pathways, etc. igniting widespread declines in the native riverine fish populations in these states (Singh and Lakra 2006; Sarkar et al. 2012; Kelkar 2014; Goswami 2023; Das and Khan 2024; Pandey and Bharati 2024; Prasad 2025). The local fishing communities depend on subsistent fishing of species such as climbing perch (*Anabas testudineus*), snakeheads (*Channa* spp.), and bronze featherback (*Notopterus notopterus*), Indian featherback/Indian knifefish (*Chitala chitala*), minor carps and barbs (*Puntius* spp.), eels such as Indian Mottled Eel (*Anguilla bengalensis*), minnows, and Sucker head fish (*Garra gotyla*) for livelihood are also suffering from decline in fish populations. Although ecological surveys, distributional analyses, and taxonomic studies have generated valuable insights into fish diversity and habitat degradation in several areas of Bihar and Jharkhand (Kumar, V. et al. 2025; Tudu and Maji 2025) very little attention has been given to the human dimensions shaping people's interaction with freshwater fishes and ecosystems, and their responses to conservation initiatives in these states.

It is well known, in human-dominated ecosystems including freshwaters, conservation outcomes are strongly influenced by the attitudes, perceptions, values, norms, and behaviours of numerous stakeholders involved (Johannes et al. 2000; Silvano and Valbo-Jørgensen 2008; Bennett et al. 2017; Pascual et al. 2023). While some studies from Bihar have highlighted the value of incorporating fishermen's knowledge in understanding fish declines and environmental changes (Dey et al. 2020), its translation into conservation action requires data of the mindset of a spectrum of actors, nature of power relations existing between them, subjective norms, values, economic drivers and institutional constraints prevailing in the society. This imbalance present in the essential information serves as a

major barrier for designing conservation strategies that are ecologically effective, socially acceptable and livelihood-linked (Kareiva and Marvier 2012; Marchini 2014; Dacks et al. 2025). Addressing this gap the present study examined different facets of freshwater fish conservation in Jharkhand and Bihar through a socio-behavioural lens focusing on the stakeholders' perceptions, attitudes, values, and behaviours related to freshwater ecosystems and fish conservation. In order to get an illustrated picture, we followed an approach integrating Conservation Planning Framework (CPF; Marchini et al. 2019), the Theory of Planned Behaviour (TPB; Ajzen 1985; 1991), and Social Value systems (SV; Chan et al. 2016; Pascual et al. 2023; Das and Binoy 2025b). Here, the CPF provides a well-structured, system-wide approach for assessing the present conservation context, identifying problems, setting objectives, and evaluating management options within the complex socio-ecological systems. The second element TPB, elucidates how attitudes, subjective norms, and perceived and actual behavioural control shape conservation-relevant behaviours (Ajzen 1985; 1991), while the Social Value (SV) captures the intrinsic (valuing wildlife and nature for their own sake and inherent worth, independent of human use or benefit), instrumental (valuing wildlife and nature based on human material needs and usefulness; valuing them for tangible benefits like livelihoods), and relational values (values for wildlife developed through cultivated human-nature relationships and meanings, encompassing a sense of morality, spirituality, identity, belonging, and personal as well as cultural connections with wildlife) underpinning human-fish relationships, including moral, stewardship and responsibility-based aspects for effective human-animal coexistence (Chan et al. 2016; Pascual et al. 2023). Such an integrated approach has been successfully utilised to get insights into the conservation of freshwater fishes mahseers in the states of Karnataka, Assam and Uttarakhand very recently (Das and Binoy 2025b) In this scenario by keeping

the selected districts of the Indian states of Jharkhand and Bihar in focus, the present study aims to:

1. Understand the attitudes, values, perceptions of various stakeholders towards freshwater fish species, their conservation and ecosystem management in Jharkhand and Bihar using the integrated CPF-TPB-SV framework.
2. Explore the implications of these findings to develop recommendations for context-specific, socially informed freshwater fish conservation strategies for these states.

2. Methodology

2.1. Study Areas

This study was conducted across two adjoining states in Eastern India, Jharkhand and Bihar. Bihar encompasses extensive lower reaches of the River Ganga, as well as a major portion of the River Kosi, a key tributary within the Gangetic River Basin. Additionally, the Eastern and Northern regions of Jharkhand fall within the Gangetic River Basin, while other catchments originating in the Chota Nagpur Plateau region of Jharkhand drain into multiple river systems, including the Gangetic, Subarnarekha, and Brahmani River Basins (Jain et al. 2007; Singh and Giri 2018; Tudu and Maji 2025). The fieldwork was undertaken in eight districts of Jharkhand viz., Dhanbad, Dumka, Gumla, Hazaribagh, Koderma, Latehar, Lohardaga and Ranchi (Fig. 1), and in three districts of Bihar viz., Patna, Saharsa and Supaul (Fig. 2). These districts were selected to capture the geographical, ecological, hydrological, socio-cultural, and economic heterogeneity present across the two states. Major rivers flowing through the districts studied were Son, North Koel, South Koel, Sankh, Damodar, Barakar, Subarnarekha, Mayurakshi, and Ajay in Jharkhand and Ganga, Kosi, Son, and Punpun in Bihar.

2.2. Data Collection

Key stakeholder groups were identified using purposive sampling, followed by snowball sampling to reach additional resource persons with relevant experience and knowledge of freshwater fishes and ecosystems. In-depth, semi-structured, discursive, one-on-one interviews of the stakeholders were conducted following a list of questions reflecting multiple aspects of the integrated CPF-TPB-SV framework (SM 1), which lasted between 15-30 minutes. Perceptions and attitudes towards freshwater fishes and riverine ecosystems, environmental changes observed in such habitats, attitudes and values toward conservation, conservation communication, environmental decision-making strategies, determinants of the behavioural control, subjective and social norms, and barriers of pro-conservation and pro-environmental actions were the topics covered during the stakeholder interaction. In total, 69 and 84 interviews were conducted in Jharkhand and Bihar respectively (Table 1). In Jharkhand the languages used for the communication were Khortha, Hindi and Bangla, while stakeholders were comfortable with Hindi, Urdu and English in Bihar Interviews were audio recorded, written notes taken and photographs captured after acquiring oral/audio-recorded informed consent from the participants. The participants were assured of the anonymity of their names, personal details and designations to protect their identity and privacy. We ensured that all interviews adhered to the required ethical guidelines for conducting non-invasive human research.

2.3. Data Analysis

The interviews conducted in local languages were transcribed verbatim into English through manual transcription, while interviews conducted in English were transcribed using Rev.ai. All transcripts were subsequently cross-checked manually against the original audio recordings and supplemented with field notes to correct inconsistencies in transcription and to

retain contextual nuance (Nkansah-Dwamena 2023). The qualitative data collected were analysed using Reflexive Thematic Analysis (RTA) with a hybrid deductive-inductive coding strategy to enhance analytical depth and rigour (Fereday and Muir-Cochrane 2006; Braun and Clarke 2013, 2019, 2021, 2023a, 2023b; Braun et al. 2014, 2022; Byrne 2022; Proudfoot et al. 2022; Das and Binoy 2025b). Following Braun and Clarke's (2006) six-step framework, the RTA involved data familiarisation, initial code generation (combining deductive and inductive codes), organisation of codes into meaningful themes, review and refinement of themes, and final definition of themes. Deductive codes were guided by the constructs from the integrated conceptual framework, whereas inductive codes captured the additional, context- and stakeholder-specific insights. This reflexive approach centres the researcher's subjectivity, knowledge, and contextual expertise and thoughtful qualitative interpretation. Accordingly, RTA, unlike the more conventional qualitative data coding approaches, does not rely on inter-coder reliability or replicability as measures of validity (Braun and Clarke 2019, 2021). Consequently, the entire dataset was coded by a single researcher (PD) with extensive familiarity with the methods of the RTA and the topic of enquiry.

3. Results

The first theme developed at the juncture of CPF's situation assessment with the components of TPB (attitude, subjective norms, PBC and ABC; Das and Binoy 2025b), was "livelihood and economic prioritisation over conservation." Across both states, the majority of the stakeholders viewed the fishes primarily through a lens of livelihood (Jharkhand - J: 69; Bihar - B: 82). Words of a member of the local fishermen cooperative society in Jharkhand capture this situation precisely.

Quote 1: "*We mostly breed and farm IMCs and other fishes like common carp, grass carp, silver carp. We grow them in our ponds and lakes. Once they are big enough, we sell them.*

This is our livelihood. Yes, all native fishes should be conserved. We are tribal people, who worship nature and consider fishes to be a part of nature, but who has so much time to invest in such activities completely? We have to earn; we have to feed our families. We make a living by selling the fishes we grow."

Although respondents were aware of the negative impact of the IAF on native species (J: 69, Fig. 3; B: 84, Fig. 4), many still considered these fishes (e.g. common carp, Thai magur, and tilapia, etc.; Canonico et al. 2005; Singh and Lakra 2006), along with other aquaculture species such as Indian Major Carps (IMC) to be their economic backbone (J: 64; B: 82). While Jharkhand banned wild stocking of the IAF tilapia in 2012–2013, controlled cage culture (16) of mono-sex Genetically Improved Farmed Tilapia (GIFT) strains with apt biosecurity measures (Press Information Bureau, Government of India 2024) is currently allowed in the state.

For the fisheries departments of both states also conservation remained second to aquaculture promotion and livelihood enhancement (J: 9; B: 5).

Quote 2: "*We primarily promote aquaculture and farming of Indian Major Carps, as well as other fishes like pangasius, common carp, grass carp, etc., and encourage local people to take up fish cultivation. Over the years, fish production has increased, and fish farming has become one of the most important income-generating activities in Jharkhand, significantly reducing poverty levels. It is helping many local people earn a livelihood and is also boosting the state's economy.*" – said one of the fisheries department staff from Jharkhand.

Poor economic conditions and the vulnerability of people dependent on fishes for their income, visible across both states, may be contributing to the popularisation of strong subjective norms (a component of TPB), creating social pressure at the individual level to prioritise livelihood security over fish conservation (J: 53; B: 77). Such conditions, which

reinforce attitudes supporting a "production-over-protection" approach, can constrain stakeholders' behavioural intentions. Perceived inadequate institutional and governmental support for conservation, along with the absence of alternative livelihood opportunities for those engaged primarily in conservation activities, is reflected in limited actual behavioural control (ABC-TPB). Consequently, involvement in conservation activities are often viewed as economically risky and a luxury rather than a necessity by many respondents (J: 64; B: 82). This perception was further compounded by the limited exposure to conservation-focused education and training in both states (J: 69; B: 84), where capacity building is centred around aquaculture, breeding techniques and production-enhancing technologies, possibly promoting a more utilitarian outlook towards freshwater fish species.

The decision-making and implementation elements of CPF with the attitude and PBC of TPB led to the next theme: "constraints on participation". A top-down decision-making and governance structure with minimal possibility for stakeholder participation and communication between them hindered inclusive fish conservation in the focal states. We noticed significant communication gaps existing between fishermen, and fisheries department staff (J: 52; B: 73) and researchers and fisheries department (B: 4). Many fishermen from both states complained of their exclusion from decision-making processes (B: 77; Fig. 4) and neglect of their suggestions (J: 48; Fig. 3) by the authorities. The words of the member of a local fishermen's cooperative society in Bihar vouch for it.

Quote 3: "*We have requested meetings multiple times. I have even personally sent letters to the Fisheries head office, offering our help to address the issue of destructive illegal fishing. But to this day, there has been no response from them.*"

However, instances of limited collaboration and joint activities, though restricted to aquaculture-related training and IMC breeding (J: 18; B: 7), particularly between researchers

and the fisheries department staff were observed in both states. Unfortunately, many respondents who participated in such initiative were dissatisfied with the lack of interest for continued collaboration and bidirectional communication shown by the participants from other departments, as exhibited in the statement by a member of the fisheries department staff in Bihar:

Quote 4: "*I have told the senior officials many times that researchers from central institutes should consult us, the local government officials, on how to undertake breeding ground revival and habitat restoration, and how to protect rivers and their biodiversity by removing the bandhs/bunds. We know these things better; we have both the ground-level experience as well as knowledge from the fisheries research books we have read. But who cares? They just hear us as an obligation and never implement anything we suggest. So, we have stopped providing recommendations anymore.*"

Such a situation can catalyse distrust between the departments (2), suppress conversation intentions among stakeholders, further weaken collaborations (7) and ultimately impact conservation actions as observed in Bihar.

Reduced availability of human and monetary resources also constrained actual behavioural control (ABC) of many stakeholders in both Jharkhand (16) and Bihar (7). For instance, many government staff expressed anguish over lesser time available to focus on conservation due to their heavy workload (J: 12; B: 5). Formally involving fishermen who hold pro-conservation and relational values for native fishes in the conservation intervention could fill this gap, and such communities acknowledged availability of the suitable human resource with them for this purpose in both Jharkhand (48) and Bihar (77). Unfortunately members from fishermen communities failed to join such activities due to lack of conservation education (J: 69; B: 84), limited exposure to conservation breeding initiatives (J: 69; B: 84),

and exclusion from institutional decision-making and planning processes. In Bihar, caste bias and political influences affected fishermen's access to the government schemes (*yojanas*) and benefits (25). This inequity in the resource distribution was found emerging as a major barrier for participation in the fish conservation activities by many stakeholders. Hence, strengthening government support mechanisms, fulfilling needs, and addressing livelihood concerns (PBC; J: 64; B: 77) of the local populations may improve their willingness to join such activities. The following words of a member of the local fishermen cooperative society in Bihar reflected the same.

Quote 5: "*If proper benefits from the government schemes like fish feed, medicines, tube well, pump, aerators equipment, subsidies on pond construction and infrastructure, etc. are provided to us; then of course, why would we not help them in whatever conservation activity they ask us to do. All fishes should be conserved, but if we are unable to earn and don't receive the benefits from the schemes, why should we invest our time in something that does not feed our families? They should stop this caste- and politics-based distribution and provide equal benefits to everyone.*"

Insights from the monitoring and evaluation stages of CPF, combined with stakeholder's perceived and actual control of behaviours and subjective norms (TPB), and the 3 components of social values (SV) resulted in the theme "values and conservation willingness." Across both states, all stakeholders consistently expressed strong intrinsic and relational values for fishes, underpinned by the belief that "*jungli*' (native wild species) are integral components of nature (J: 69; Fig. 3; B: 84; Fig. 4) requiring protection (J: 69; B: 84). Interestingly these perspectives coexisted with instrumental value - viewing fishes also as a source of food, livelihood, and income (J: 69; B: 84) - reflecting a pluralistic value orientation ascribed by the stakeholders toward native fishes. In Jharkhand, fishermen

disclosed elements of the local and tribal identity, culture, and traditional belief systems (35) emphasising respect for and promoting safeguarding native fishes (35). Consistent with these value orientations, a much lower number of reports of destructive fishing received from this state (69). Here, the fishermen's cooperative societies, possibly reinforced by the stewardship virtues and relational outlook towards fish and nature (48) monitored and protected the aquatic resources, as indicated by one of their members.

Quote 6: "*Here, destructive fishing practices in the rivers and streams are very less. We do hear about such things happening in other states, but we are traditional fishermen, and as a cooperative society, we feel that it is our duty and responsibility to look after and protect our water bodies. Our livelihoods have come from these waters for generations. All fishes are part of nature; and nature has been providing us with food for generations. That is why we actively make sure that no one puts dynamite, poisons or chemicals into the rivers. Yes, there have been one or two small instances of fine-mesh or prohibited netting that happens sometimes, but otherwise, such cases are rare here.*"

By contrast, despite the fishermen in Bihar expressing strong relational values towards native fishes (77), destructive fishing practices were widely reported (84). These practices included poisoning, use of chemicals, fertilizers, fine-mesh nets, dumping of sewage and solid waste along approximately 35-40 km stretches of the Kosi River, (84) which were allegedly carried out by the local non-traditional fishermen. Additionally, in both states staff of the government department (fisheries department in both states and forest department in Jharkhand) had an 'instrumental' outlook towards fishes (J: 11; B: 5) and many described aquaculture as their prior duty.

Despite widespread relational values and pro-conservation orientations, in both states stakeholder's reported familiarity with native fishes was largely restricted to aquaculture- and

livelihood-relevant species (Table 2). Interestingly, ecologically important but economically less-significant native species (Ayyappan and Raman 2003; Bhakta 2020; Baitha et al. 2024; Sahil et al. 2024), such as mustached danio (*Danio dangila*), finescale razorbelly minnow (*Salmostoma phulo*), large razorbelly minnow (*Salmostoma bacaila*) Indian flying barb (*Esomus danricus*), sucker-head fish (*Garra gotyla*), cotio (*Osteobrama cotio*), etc. were rarely recognised or reported by most of the participants, except managers of Damodar Valley Corporation fish hatchery in Jharkhand (Table 2). This knowledge gap was at its peak in the case of a socio-culturally significant but threatened group of fishes, the mahseer (*Tor* and *Neolissochilus spp*.). Across both states, lion's share of stakeholder groups interviewed had never heard of mahseer or were familiar with their vernacular names - *mahasol, turiya, mansir, masal* and *kajur* and failed to identify the fish from the images shown (J: 62; Fig. 3; B: 80; Fig. 4). However, mahseers were widely distributed in the freshwaters of the two focal states as mentioned and documented in the British Gazetteers during the colonial period and Bihar and Bengal Gazetteers post-independence (O'Malley 1906, 1910, 1924, 1926; Roy Choudhury 1957; Kumar 1970; Talwar and Jhingran 1991; Sugnnan 1995; Desai 2003; Das 2005; Srivastava and Singh 2014; Sinha Ray 2016). This loss of collective knowledge and lived experience associated with mahseer led to the development of another theme - "erosion of social and cultural memories". The message conveyed in the following statement by a member of the fishermen co-operative society in Bihar, was a representation of the stakeholder response regarding mahseers across Bihar and Jharkhand.

Quote 7: *"I have never heard of mahseer fish. (After looking at the picture) No sir, this type of fish is not found in the rivers here. I have never seen or caught any fish like this"*.

Only a small number of respondents from both states were aware of mahseers as freshwater fish in general, and even among these, perceptions regarding their presence varied considerably. In Jharkhand, respondents believed that the mahseer was either absent (4),

endangered or possibly extinct in the rivers of the state (2; Fig. 3). Meanwhile, respondents in Bihar predominantly perceived mahseers to be absent (4) or present only in the cold-water rivers of the neighbouring country of Nepal (4; Fig. 4). Furthermore, the staff of the state fisheries (J: 9; B: 5) and forest departments (J: 3), and the Damodar Valley Corporation (DVC) fish hatchery (J: 2) reported that they did not possess any official records regarding the landing of the mahseers, though the possibility of occasional unofficial catch going unrecorded and unreported due to the protected status of these fish cannot be ruled out (Fisheries Dept. Jharkhand: 1).

As articulated in the following statement by a staff of the forest department from Jharkhand, the lack of systematic documentation of aquatic biodiversity and its distribution in the state (2) acts as a barrier for designing effective programmes for the conservation of native fish species.

Quote 8: *"Even though Jharkhand has so many jungles, rivers and wild animals, very little wildlife biodiversity research has been conducted here as compared to the other states of the country. On top of that, there has been even less research focused on aquatic biodiversity distribution or conservation. It is very important to undertake such kinds of studies to know the fish's distribution. We are also willing to support researchers in doing so."*

These findings point towards an on-going process of "societal extinction" (Jarić et al. 2022), wherein species vanish not only from ecosystems but also from cultural memory. Because people no longer recognise or remember mahseer, there is little motivation to support its conservation (J: 64; B: 82). This result serves as a warning to the managers of aquatic ecosystems and conservators of biodiversity in Jharkhand and Bihar and other Indian states. If proper actions are not taken immediately other important fish species also may join mahseer in the journey towards "societal extinction" soon, since they seldom attract the notice of the public or policy makers due to the cryptic nature of their habitat and reduced

opportunity for interaction. Therefore, strengthening the knowledge of diverse stakeholders and socio-cultural memory is essential to reinforce public interest, governmental support, policy attention and long-term conservation of native freshwater fishes including mahseers which may require restocking or reintroduction in Jharkhand and Bihar.

4. Discussion

Jharkhand and Bihar are among India's economically poorer states, where riverine and inland fisheries remain central to livelihoods, food security, and nutrition for millions (Dey et al. 2020; Kumar, V. et al. 2025). Hence, conservation in these regions is not driven solely by ecological decline, environmental challenges, or data gaps, but by the interlinked and deeply embedded socio-economic, institutional and behavioural dynamics that shape stakeholder priorities, decision-making and actions. Bihar has emerged as one of the leading inland fish-producing states with the largest population of inland fishermen in India, through the rapid expansion of pond aquaculture and hatchery-based seed production (Kumar et al. 2018; Rupala, Parliament of India 2023; Prasad 2025), while Jharkhand has promoted reservoir fisheries and cage culture, including large-scale installations such as those in Chandil reservoir in the Seraikela-Kharsawan district (Pandit et al. 2021; Kumari and Sharma 2022). Although, these interventions have enhanced fish yields, improved food security, and generated employment opportunities, it also reinforced instrumental values towards freshwater ecosystems and shifted management priorities towards production-oriented goals rather than conservation-centred actions (Kumari and Sharma 2022; Raut et al. 2020; Arora et al. 2024). As a result, long-term ecological sustainability and native fish biodiversity are frequently marginalised within governance frameworks, receiving limited conservation attention compared to aquaculture-driven development (Béné 2003; Deb 2009; Leite and Gasalla 2013; Lynch et al. 2016; Dey et al. 2020; Arora et al. 2024).

This production-centric approach, coupled with the expansion of aquaculture through the seed-production of non-native fishes, has led to significant ecological consequences. It has contributed to the widespread introduction and establishment of exotic IAFs, including tilapia (*Oreochromis* spp.), African catfish, common carp (*Cyprinus carpio*), grass carp (*Ctenopharyngodon idella*), silver carp (*Hypophthalmichthys molitrix*), and bighead carp (*Hypophthalmichthys nobilis*) across the freshwater-bodies in Jharkhand and Bihar (Canonico et al. 2005; Singh and Lakra 2006). These species often outcompete native fishes for resources, alter food chains and webs, and reduce ecosystem resilience (Khan and Panikkar 2009; Martin et al. 2010). Despite widespread declines in populations of native fish species, aquaculture-driven development has emerged as the dominant policy (Narayanan 2016; Kumari and Sharma 2022) over the sustainable management of natural fish populations (Arora et al. 2024; Kumar, V. et al. 2025) leaving conservation interventions for native fishes disjointed, less prioritised, with limited emphasis on ecosystem restoration, stakeholder participation, or long-term sustainability.

The prioritisation of livelihoods and economic benefits expressed by the fishermen, hatchery managers, and fisheries department staff does not reflect that they are against conservation per se, but rather highlights a mismatch between conservation goals and livelihood realities. Although stewardship values, positive attitude towards conservation and willingness (conditional) were present their conservation intentions remained weak because of the low perceived behavioural control (PBC). Stakeholders questioned the feasibility of investing time and resources in conservation due to the absence of social support or compensation for the time spent in such activities which may jeopardise their income. Such livelihood-first norms are not unique to Jharkhand and Bihar; similar patterns have been documented across many economically marginal regions, where conservation is often perceived as a luxury rather than a necessity (Béné 2003; Deb 2009; Haque 2009; Kiwango and Mabale 2022; He and Jiao

2023; Lyakurwa et al. 2025). Evidence from Asia (India, Bangladesh, rural China), Sub-Saharan Africa (Cameroon, Congo, Nigeria, Chad), and South America (Brazil) have consistently shown that livelihood insecurity compels local communities to prioritise short-term subsistence and income security over long-term ecological and resource sustainability. In such contexts, conservation interventions are often viewed as externally imposed rather than locally relevant and a threat to immediate food access and livelihoods, thereby leading to low compliance and limited long-term support (Béné 2003; Deb 2009; Haque 2009; Kiwango and Mabale 2022; He and Jiao 2023; Lyakurwa et al. 2025).

Despite the popularity of the relational and intrinsic values, as well as a sense of responsibility for protecting fishes and freshwater ecosystems in both states, local fishermen expressed willingness to support conservation activities provided their livelihood needs are met, benefits are equitably distributed and they are included in the decision-making processes. The coexistence of positive conservation values with the prioritisation of the fish based livelihood underscores a classic attitude-behaviour gap (Barr 2006; Muller et al. 2025). While attitudes and values are broadly supportive of conservation, actual behaviour is constrained by limited resources, weak institutional support, non-inclusion of inputs and no autonomy in decision making, social norms prioritising income, and governance failures (TPB components), thereby leading to limited pro-conservation behaviour (Ullah et al. 2021; Karimi and Ataei 2022). These observations highlight the need for conservation approaches that align ecological goals with livelihood incentives, rather than framing them as competing priorities (Pimid et al. 2022; Newing et al. 2024), especially in economically poor but biodiversity-rich regions (Salafsky and Wollenberg 2000; Nepal and Spiteri 2011; Mandoloma et al. 2025). Failing to do so risks making the subjective norms that support short-term economic viability over the coexistence and conservation of indigenous and native (fish) species the mainstream

narrative in the society, thereby making future changes increasingly difficult (Hutton et al. 2005; Bennett et al. 2017).

Although the study areas are blessed with numerous native fishes, the majority of the stakeholders we contacted were familiar largely with the species of aquaculture and fisheries importance. This observed absence of native fish diversity in respondents' knowledge base may lead to gradual erosion of the ecologically important but economically less significant fish species from the public discourse and their memory (Jarić et al. 2022; Soga and Gaston 2022), as observed in the case of mahseers. The presence of these charismatic megafishes - *T. putitora*, *T. tor*, *T. mosal* and *N. hexagonolepis* - has been reported from 15 of the 24 districts of Jharkhand and 12 of the 38 districts of Bihar. Historical records, including the British-era Gazetteers of Bihar and Bengal (1906-1926), the Government of Bihar Gazetteers, and several books and research articles dating back to the early 1900s, provide descriptions of mahseers from the focal states (O'Malley 1906, 1910, 1924, 1926; Roy Choudhury 1957; Kumar 1970; Talwar and Jhingran 1991; Sugnnan 1995; Desai 2003; Das 2005; Sinha Ray 2016). Furthermore, drawing on extensive archival and repository-based research on hunting, wildlife and conservation in colonial Bengal (1850-1947), Sinha Ray (2016) reported that mahseers occurred in the Damodar and Subarnarekha rivers of Jharkhand (then part of Bengal) as early as the 1850s, highlighting the long historical distribution of these species in the eastern Indian river systems. However, poor species recognition by the stakeholders, meager representation of these fishes in conservation education, minimal breeding programmes, and negligible representation in the social and conventional media (Das and Binoy 2024, 2025a) point towards a potential "dual (societal and biological) extinction" of mahseers in both states. This argument is reinforced by the absence of mahseers in the catch records of the last decades, unavailability of their distributional references in the recent research, and nonexistence of research programmes focusing these fishes since the late 1990s

(Tudu and Maji 2025; Raghavan et al. 2017; Dahanukar et al. 2018; Pinder et al. 2019; Das and Khan 2024; Sarmah et al. 2024). When human interactions with a species decline, it loses societal salience and gradually disappear not only from the ecosystem but also from the cultural (art, literature, digital records) as well as communicative (lived experiences, local names, folklores; Assmann 2011; Candia et al. 2019; Jarić et al. 2022) memories. Such societal extinction can further diminish the possibility of getting support from public and policy makers for conservation efforts, such as the ecological exploration to know the presence, or undertake restocking programmes for, red-fin or deep-bodied mahseer (*T. tor*), mosal mahseer (*T. mosal*), golden mahseer (*T. putitora*), and chocolate mahseer (*N. hexagonolepis*), once common in the waters of Bihar and Jharkhand. These results offer an important lesson and a warning for other regions in India, as well as other nations harbouring natural populations of mahseer - if timely conservation interventions are not implemented, a similar situation is not far away!

Our results point towards an urgent need for the targeted communication and collaborative interventions in Jharkhand and Bihar to ensure the conservation of freshwater fish diversity, and counter the on-going erosion of socio-cultural memory associated with mahseer. Differing from the terrestrial organisms, due to the cryptic nature of their habitat and the reduced opportunity for interaction available to a major section of the human population, extermination of many freshwater fish species could happen silently (Cambray and Bianco 1998; Reid et al. 2019; Vardakas et al. 2025). Hence, starting ecological surveys, in-depth distribution studies, conducting multi-stakeholder workshops and awareness programmes, and establishing collaborations are the need of the hour to save this important component of biodiversity. In this context, the social extinction faced by the mahseers in these two states could be projected as a compelling example to convince the public and policymakers to prioritise and participate in fish conservation programmes. Notably, attempts to reintroduce

mahseer were undertaken twice in the late 1990s in the North Koel River of Jharkhand (then part of undivided Bihar). However, these efforts were not successful due to unsuitable ecological conditions, in terms of elevated river water temperatures, as well as the lack of adequate scientific guidance and planning (Singh *personal communication*). Scientifically-backed reintroduction programmes, alongside the promotion and dissemination of historical and cultural narratives, could help revive public interest and collective memory of mahseer (Jarić et al. 2022), and potentially extend the enthusiasm to other native fish species. Furthermore, the presence of an active communication system will preserve local knowledge, promote community involvement, improve compliance of conservation norms and laws (Ostrom 2009; Bennett et al. 2017), and reduce human-human conflict (Huang et al. 2020; Wu et al. 2020). Although The Bihar Fisheries Bill, 2013 (draft) was envisaged as a comprehensive legislative framework to promote conservation of aquatic biodiversity, sustainable utilisation of fish stocks, establishment of advisory committees for recommendations, declaration of fish sanctuaries, prohibition of destructive fishing gears and practices, scientific development of fisheries, streamlining licensing mechanisms, and improving the quality fish seed (Narayanan 2016; Kumar et al. 2019), thereby addressing the gaps existing in the Bihar Fish Jalkar Management Act, 2006 (Bihar Act, 13 of 2006, amended in 2018, thereby called The Bihar Fish Jalkar Management (Amendment) Act, 2018), it remained at the draft stage. The enactment of this bill as a stand-alone Act (Kumar et al. 2019), along with the development of similar fisheries legislative acts and policy frameworks for Jharkhand, was also recommended by several stakeholders to reduce the loss of fish diversity.

Targets 21 and 22 (Section H) and Section K of the Kunming-Montreal Global Biodiversity Framework (CBD 2022), emphasise participatory and inclusive decision-making, and recognise the critical role of communication strategies that extend beyond just

awareness-raising to foster positive and sustained behavioural change towards the biodiversity (CBD 2022). Unfortunately, across both states, governance structures were characterised by top-down decision-making, minimal stakeholder participation and limited communication and collaboration among government departments, researchers and local fishermen communities. The *Matsya Mitra* ('Friends of Fishes') initiative undertaken by the Jharkhand State Government in 2007, offers a distinct example of how community-based intermediaries can improve communication, trust, and knowledge transfer (Shweta 2024). The *Matsya Mitra* are people from the local communities appointed on a voluntary basis to work as bridges and communicators between the fisheries department and local community fishermen (NITI Aayog n.d.; Shweta 2024). Although, their primary focus is the promotion of aquaculture, including conservation education and creating awareness of the native fish diversity in their mandates, and empowering them to lead the monitoring and restoration of the freshwater habitats, could help to enhance stakeholder ownership and trust amongst the local community members (Schultz and McGinn 2013).

Taken together, freshwater fish conservation in Jharkhand and Bihar appeared to be constrained less by the dearth of positive attitude and more by governance and communication gaps, limited stakeholder and community participation, misaligned incentives, and critical weaknesses in the decision-making systems, as revealed during the decision-making and implementation stages of CPF. From a TPB perspective, these institutional barriers significantly curb the perceived behavioural control, even among stakeholders keen to participate in conservation activities (Zolait 2014; Dong et al. 2024). Active fishermen's cooperative societies in Jharkhand curbing illegal destructive fishing practices suggests that collective action and involvement of local groups can translate relational tribal values (Jolly et al. 2022; Iqbal et al. 2025; Jolly and Stronza 2025; Kumar, A. et al. 2025) into conservation positive behaviour and endorse human-animal coexistence if

proper supports are provided. Our observations resonate with emerging literature emphasising the role of relational values in conservation, where people's sense of responsibility, care, and connection to nature and wildlife motivates stewardship when structural barriers are addressed (Tsing 2012; Ingold 2013; Chan et al. 2016; Haraway 2018; Pascual et al. 2023; Murali et al. 2024; Jolly and Stronza 2025). Hence, strengthening the co-management of freshwater ecosystems, and recognising local ecological knowledge along with the lived experiences of tribal and local community members, can help translate the strong pro-conservation attitudes present among the stakeholders into sustained pro-environmental behaviours (Kelkar and Arthur 2022; Kura et al. 2023; Newing et al. 2024; Das and Binoy 2025b). However, unequal distribution of the benefits from the government *yojanas* (schemes) reported from the Bihar, if not managed effectively, could not only erode the legitimacy and acceptance of the policies (Bavinck et al. 2018; Owusu and Adjei 2021) but will also intensify the caste and politics based negotiations for traditional fishing rights and other forms of human-human conflict (Bagchi 2018; Kelkar and Arthur 2022), thereby weakening fish conservation efforts.

Stakeholder Recommendations

In Jharkhand and Bihar, stakeholders' recommendations focused on practical, on-ground actions. These included organising regular meetings and encouraging discussions between fishermen and the fisheries department staff to address the challenges faced at the local level, and undertaking more scientific studies to document aquatic biodiversity distribution and support conservation. The declaration of fish sanctuaries and no-fishing zones, the promotion of conservation education and awareness programmes with a focus on native fish species, and the inclusion of inputs from the fisheries departments into research initiatives undertaken by the central government were also emphasised by many. Incorporating mahseer ecology and the socio-cultural significance of these species into the curricula of educational institutions

focused on fisheries and aquatic sciences, as well as the role of such institutions in collecting and preserving voucher specimens of important native species also emerged during the discussion. Additional measures for protecting native fish populations proposed by numerous stakeholders included reviving breeding grounds and restoring habitats for native fish species, removing obstructions such as *bunds* (or *bandhs*) from the rivers, and ensuring that the benefits of government schemes reach all fishermen. These actions were seen by the respondents as essential for strengthening livelihood opportunities and fostering long-term local support for the conservation efforts.

5. Conclusion

While many stakeholders expressed positive attitudes towards conserving native fishes in the resource-limited Indian states of Jharkhand and Bihar, dominant subjective norms prioritising livelihood security over conservation combined with low perceived behavioural control curtailed its translation into meaningful conservation actions. Our findings underscore the need to move beyond purely ecological and taxonomic approaches, prominent in the conservation research, toward planning grounded in the socio-cultural uniqueness of the focal species or ecosystems. In both the focal states, freshwater fish conservation must be embedded within livelihood systems, inclusive institutional and decision-making structures, and local value frameworks. The integrated CPF-TPB-SV framework revealed that enabling conservation of the freshwater fishes will require interventions across multiple levels: (i) reshaping subjective norms by linking conservation with livelihoods, (ii) enhancing perceived behavioural control through incentives (monetary or non-monetary in terms of daily grocery and kitchen-related items or symbolic recognition (public visibility, media coverage); Kipkeu et al. 2014; Rode et al. 2015; Ewane 2024), capacity-building, and inclusive governance and decision-making, (iii) leveraging existing stewardship and relational values through

bottom-up partnerships, acknowledgement and resolution of local needs and concerns, and transparent and equitable benefit-sharing, (iv) promoting collaborations between locals and researchers, and (v) rebuilding societal memory (cultural and communicative) of the mahseer, through targeted distribution research, historically-linked awareness and education. Any efforts to protect the native fish diversity in Jharkhand and Bihar that fail to address these socio-cultural and economic dimensions are less likely to succeed and risk remaining just symbolic, fragmented and ineffective, regardless of ecological urgency.

Author Contributions

Prantik Das: Conceptualisation; methodology; investigation; data curation; formal analysis; visualisation; funding acquisition; writing - original draft; writing - review and editing. **V. V. Binoy:** Conceptualisation; methodology; visualisation; writing - review and editing; supervision.

Acknowledgments

Prantik acknowledges the Human Research Development Group (HRDG) - Council of Scientific and Industrial Research (CSIR), New Delhi, India (09/1320(0001)/2020-EMR-I) for providing the research fellowship and the annual contingency grant for field-work related expenses. He extends his sincere appreciation and gratitude to all the respondents who took part in the interviews across districts in both study states. He also expresses his gratitude to Mrs. Bubu Sarkar Das and Mr. Subhashis Das for their assistance in facilitating stakeholder contacts and data collection in Jharkhand, and to Mr. Shivaditya Aich, Mr. Asad Bilal and Ms. Anjali Bharati in Bihar.

Conflict of Interest Statement

The authors declare no competing or conflicting interests.

Ethical Statement

All interviews were undertaken in compliance with the institutional ethical guidelines for conducting non-invasive research involving human participants, as approved by the Institutional Ethics Committees (IEC) of The University of Trans-Disciplinary Health Sciences and Technology (TDU; Protocol Number: TDU/IEC/16E/2025/PR72) and the National Institute of Advanced Studies (NIAS; Letter Number: NIAS-EC-11/03/2022).

Informed Consent Statement

Prior to the participation, all respondents were made fully aware about the objectives of the study, and it was emphasised that their participation was completely voluntary, with the option to withdraw from interviews at any stage. The data collection through audio-recordings, note-taking and photography was carried out only after obtaining oral/audio-recorded informed consent. The participants were also assured that their names and other personal details that could be used to identify them, would remain confidential and anonymous to protect their identity and privacy.

Data Availability Statement

In order to maintain the respondent's privacy, the datasets have not been made publicly available, as they contain information that could compromise research participant consent. Accordingly, the data used in this study remain confidential.

References:

Ajzen, I. (1985). From intentions to actions: A theory of planned behavior. In Action control: From cognition to behavior (pp. 11-39). Berlin, Heidelberg: Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-69746-3_2

Ajzen, I. (1991). The Theory of planned behavior. Organizational Behavior and Human Decision Processes. https://doi.org/10.1016/0749-5978(91)90020-T

Arora, R., Balachander, T., Agrawal, I., Panda, R., Gupta, D., Kasturirangan, A., ... and Kiesecker, J. (2024). Conserving Freshwater Ecosystems in India: A call to action. Aquatic Conservation: Marine and Freshwater Ecosystems, 34(5), e4165. https://doi.org/10.1002/aqc.4165

Arthington, A.H., Lorenzen, K., Pusey, B.J., Abell, R., Halls, A.S., Winemiller, K.O., Arrington, D.A., and Baran, E. (2004). River fisheries: ecological bases for management and conservation. pp. 21-60. In Welcomme, R.L.; Petr, T. (Eds.) Proceedings of the second international symposium on the management of large rivers for fisheries, volume 1. Food and Agriculture Organisation (FAO), Bangkok. 356 p. https://hdl.handle.net/20.500.12348/2027

Assmann, J. (2011). Communicative and cultural memory. In Cultural memories: The geographical point of view (pp. 15-27). Dordrecht: Springer Netherlands. https://doi.org/10.1007/978-90-481-8945-8_2

Ayyappan, S., and Raman, R. P. (2003). Status of Fisheries Development in Bihar: Challenges and Strategies in the 21st Century. Dimensions of Society and Culture of Bihar. Part IV, 343-353. https://www.researchgate.net/profile/Ram-Raman/publication/324779466_Status_of_Fisheries_Development_in_Bihar_Challenges_and_Strategy_in_the_21st_Century/links/5ae815b745851588dd7f98bb/Status-of-Fisheries-Development-in-Bihar-Challenges-and-Strategy-in-the-21st-Century.pdf

Bagchi, S. (2018). Post-Mandal politics in Bihar: changing electoral patterns. Commonwealth & Comparative Politics, 56(4): 563-565. DOI.org/10.1080/09584935.2019.1689669

Baitha, R., Borah, S., and Sinha, A. (2024). Significance, Threats, Conservation, and Management of Indigenous Small Fish (ISF) of Gandak River (Bihar), India. In: Sinha, A., Roy, A., Gogoi, P. (Eds.) Perspectives and Applications of Indigenous Small Fish in India. Springer, Singapore. https://doi.org/10.1007/978-981-97-1586-2_19

Barletta, M., Cussac, V. E., Agostinho, A. A., Baigún, C., Okada, E. K., Carlos Catella, A., ... and Fabré, N. N. (2015). Fisheries ecology in South American river basins. Freshwater fisheries ecology, 311-348. https://doi.org/10.1002/9781118394380.ch27

Barr, S. (2006). Environmental action in the home: investigating the 'value-action' gap. Geography, 91(1), 43-54. https://doi.org/10.1080/00167487.2006.12094149

Bartley, D. M., De Graaf, G. J., Valbo‐Jørgensen, J., and Marmulla, G. (2015). Inland capture fisheries: status and data issues. Fisheries Management and Ecology, 22(1), 71-77. https://doi.org/10.1111/fme.12104

Bavinck, M., Jentoft, S., and Scholtens, J. (2018). Fisheries as social struggle: a reinvigorated social science research agenda. Marine Policy, 94, 46-52. https://doi.org/10.1016/j.marpol.2018.04.026

Béné, C. (2003). When fishery rhymes with poverty: a first step beyond the old paradigm on poverty in small-scale fisheries. World development, 31(6), 949-975. https://doi.org/10.1016/S0305-750X(03)00045-7

Bennett, N. J., Roth, R., Klain, S. C., Chan, K., Christie, P., Clark, D. A., ... and Wyborn, C. (2017). Conservation social science: Understanding and integrating human dimensions to

improve conservation. Biological conservation, 205, 93-108. https://doi.org/10.1016/j.biocon.2016.10.006

Bhakta, D. (2020). A review of food and feeding habits, reproductive biology of *Osteobrama cotio* (Hamilton, 1822). Research Biotica, 2(4), 141-144. DOI:10.32383/RB.2018.33.3-4.9

Bharati, L., Sharma, B. R., and Smakhtin, V. (Eds.) (2016). The Ganges River Basin. Status and Challenges in Water, Environment and Livelihoods. Taylor & Francis. Routledge, United Kingdom.

Bickford, D., Posa, M. R. C., Qie, L., Campos-Arceiz, A., and Kudavidanage, E. P. (2012). Science communication for biodiversity conservation. Biological Conservation, 151(1), 74-76. https://doi.org/10.1016/j.biocon.2011.12.016

Braun, V. and Clarke, V. (2006). Using thematic analysis in psychology. Qualitative research in psychology, 3(2), 77-101. https://doi.org/10.1191/1478088706qp063oa

Braun, V., and Clarke, V. (2013). Successful qualitative research: A practical guide for beginners. London: Sage.

Braun, V., Clarke, V., and Rance, N. (2014). How to use thematic analysis with interview data. The counselling and psychotherapy research handbook, 3, 183-197.

Braun, V., and Clarke, V. (2019). Reflecting on reflexive thematic analysis. Qualitative research in sport, exercise and health, 11(4), 589-597. https://doi.org/10.1080/2159676X.2019.1628806

Braun, V., and Clarke, V. (2021). One size fits all? What counts as quality practice in (reflexive) thematic analysis?. Qualitative research in psychology, 18(3), 328-352. https://doi.org/10.1080/14780887.2020.1769238

Braun, V., Clarke, V., and Hayfield, N. (2022). 'A starting point for your journey, not a map': Nikki Hayfield in conversation with Virginia Braun and Victoria Clarke about thematic analysis. Qualitative research in psychology, 19(2), 424-445. https://doi.org/10.1080/14780887.2019.1670765

Braun, V., Clarke, V., Hayfield, N., Davey, L., and Jenkinson, E. (2022). Doing Reflexive Thematic Analysis. In: Bager-Charleson, S., McBeath, A. (eds) Supporting Research in Counselling and Psychotherapy. Palgrave Macmillan, Cham. https://doi.org/10.1007/978-3-031-13942-0_2

Braun, V., and Clarke, V. (2023a). Thematic Analysis. In: Maggino, F. (eds) Encyclopedia of Quality of Life and Well-Being Research. Springer, Cham. https://doi.org/10.1007/978-3-031-17299-1_3470

Braun, V., and Clarke, V. (2023b). Thematic analysis. In Encyclopedia of Quality of Life and Well-Being Research. (2nd). Springer'. https://doi.org/10.1007/978-3-319-69909-7_3470-2

Byrne, D. (2022). A worked example of Braun and Clarke's approach to reflexive thematic analysis. Quality & quantity, 56(3), 1391-1412. https://doi.org/10.1007/s11135-021-01182-y

Cambray, J. A., and Bianco, P. G. (1998). Freshwater fish in crisis, a Blue Planet perspective. Italian Journal of Zoology, 65(S1), 345-356. https://doi.org/10.1080/11250009809386845

Candia, C., Jara-Figueroa, C., Rodriguez-Sickert, C., Barabási, A. L., and Hidalgo, C. A. (2019). The universal decay of collective memory and attention. Nature human behaviour, 3(1), 82-91. https://doi.org/10.1038/s41562-018-0474-5

Canonico, G. C., Arthington, A., McCrary, J. K., and Thieme, M. L. (2005). The effects of introduced tilapias on native biodiversity. Aquatic Conservation: Marine and Freshwater Ecosystems, 15(5), 463-483. https://doi.org/10.1002/aqc.699

Chan, K. M., Balvanera, P., Benessaiah, K., Chapman, M., Díaz, S., Gómez-Baggethun, E., ... and Turner, N. (2016). Why protect nature? Rethinking values and the environment. Proceedings of the national academy of sciences, 113(6), 1462-1465. https://doi.org/10.1073/pnas.1525002113

Conference of the Parties to the Convention on Biological Diversity. (2022). COP-CBD. Decision 15/4: Kunming-Montreal Global Biodiversity Framework (CBD/COP/DEC/15/4). https://www.cbd.int/doc/decisions/cop-15/cop-15-dec-04-en.pdf

Dacks, R., Yadav, S., and Mawyer, A. (2025). Emerging human dimensions research in coastal and nearshore Oceania. Conservation Biology, 39, e14455. https://doi.org/10.1111/cobi.14455

Dahanukar, N., Pinder, A. and Harrison, A. (2018). *Tor mosal*. The IUCN Red List of Threatened Species 2018: e.T188106A1855151. https://dx.doi.org/10.2305/IUCN.UK.2018-2.RLTS.T188106A1855151.en. [Accessed January 3, 2026].

Das S. M. (2005). The fishes of Jharkhand. Bishen Singh Mahendra Pal Singh. Dehradun.

Das, M. K., Rao, M. R. K., and Kulsreshtha, A. K. (2018). Native larvivorous fish diversity as a biological control agent against mosquito larvae in an endemic malarious region of Ranchi district in Jharkhand, India. Journal of vector borne diseases, 55(1), 34-41. DOI: 10.4103/0972-9062.234624

Das, H.K., and Khan, K.M. (2024). Study on the ichthyofaunal diversity of Jumar River of Ranchi District in Jharkhand. Biospectra, 19(1), 13–18. https://doi.org/10.5281/zenodo.13989514

Das, P., and Binoy, V. V. (2024). Insights on the distribution, catch and release and public sentiment towards recreational angling of mahseers—A study of YouTube videos from India. Aquatic Conservation: Marine and Freshwater Ecosystems, 34(5), e4176. https://doi.org/10.1002/aqc.4176

Das, P., and Binoy, V. V. (2025a). 'Crafting Fishy News': Framing and Attitudinal Positioning in English Newspaper Articles on Mahseer from Their Endemic Range. bioRxiv, 2025-05. https://doi.org/10.1101/2025.05.22.655491

Das, P., and Binoy, V. V. (2025b). From Attitudes to Actions: Bridging Conservation Planning Framework, Theory of Planned Behaviour and Social Values to Protect Charismatic

Freshwater Fishes, the Mahseer. bioRxiv, 2025-12. https://doi.org/10.64898/2025.12.26.696566

Deb, A. K. (2009). 'Voices of the Fishantry': learning on the livelihood dynamics from Bangladesh. Doctoral Dissertation. University of Manitoba, Manitoba, Canada.

Desai, V. R. (2003). Synopsis of biological data on the tor mahseer *Tor tor* (Hamilton, 1822) (Vol. 158). Food and Agriculture Organisation (FAO)

Dey, S., Choudhary, S. K., Dey, S., Deshpande, K., and Kelkar, N. (2020). Identifying potential causes of fish declines through local ecological knowledge of fishers in the Ganga River, eastern Bihar, India. Fisheries management and Ecology, 27(2), 140-154. https://doi.org/10.1111/fme.12390

Dias, M. S., Tedesco, P. A., Hugueny, B., Jézéquel, C., Beauchard, O., Brosse, S., and Oberdorff, T. (2017). Anthropogenic stressors and riverine fish extinctions. Ecological indicators, 79, 37-46. https://doi.org/10.1016/j.ecolind.2017.03.053

Dong, Q., Zhang, B., Cai, X., Wang, X., and Morrison, A. M. (2024). Does the livelihood capital of rural households in national parks affect intentions to participate in conservation? A model based on an expanded theory of planned behavior. Journal of Cleaner Production, 474, 143604. https://doi.org/10.1016/j.jclepro.2024.143604

Dudgeon, D. (2011). Asian river fishes in the Anthropocene: threats and conservation challenges in an era of rapid environmental change. Journal of Fish Biology, 79(6), 1487-1524. https://doi.org/10.1111/j.1095-8649.2011.03086.x

Duncan, J. R., and Lockwood, J. L. (2001). Extinction in a field of bullets: a search for causes in the decline of the world's freshwater fishes. Biological conservation, 102(1), 97-105. https://doi.org/10.1016/S0006-3207(01)00077-5

Ewane, E. B. (2024). Understanding community participation in tree planting and management in deforested areas in Cameroon's Western Highlands. Environmental Management, 73(1), 274-291. https://doi.org/10.1007/s00267-023-01902-0

Fereday, J., and Muir-Cochrane, E. (2006). Demonstrating rigor using thematic analysis: A hybrid approach of inductive and deductive coding and theme development. International journal of qualitative methods, 5(1), 80-92. https://doi.org/10.1177/160940690600500107

Goswami, B. (2023). Mining, lower water levels affecting Damodar's ecosystem. Bengal. The Statesman. https://www.thestatesman.com/bengal/mining-lower-water-levels-affecting-damodars-ecosystem-1503240600.html

Haque, C. E., Deb, A. K., and Medeiros, D. (2009). Integrating conservation with livelihood improvement for sustainable development: The experiment of an oyster producers' cooperative in Southeast Brazil. Society and Natural Resources, 22(6), 554-570. https://doi.org/10.1080/08941920802271761

Haraway, D. (2018). Staying with the trouble for multispecies environmental justice. Dialogues in Human Geography, 8(1), 102–105. https://doi.org/10.1177/2043820617739208

He, F., Zarfl, C., Bremerich, V., Henshaw, A., Darwall, W., Tockner, K., and Jaehnig, S. C. (2017). Disappearing giants: a review of threats to freshwater megafauna. Wiley Interdisciplinary Reviews: Water, 4(3), e1208. https://doi.org/10.1002/wat2.1208

He, S., and Jiao, W. (2023). Conservation-compatible livelihoods: An approach to rural development in protected areas of developing countries. Environmental Development, 45, 100797. https://doi.org/10.1016/j.envdev.2022.100797

Huang, J., Tang, Z., Liu, D., and He, J. (2020). Ecological response to urban development in a changing socio-economic and climate context: Policy implications for balancing regional development and habitat conservation. Land Use Policy, 97, 104772. https://doi.org/10.1016/j.landusepol.2020.104772

Hutton, J., Adams, W. M., and Murombedzi, J. C. (2005). Back to the Barriers? Changing Narratives in Biodiversity Conservation. Forum for Development Studies, 32(2), 341–370. https://doi.org/10.1080/08039410.2005.9666319

Ingold, T. (2013). Anthropology beyond humanity. Suomen Antropologi: Journal of the Finnish Anthropological Society, 38(3).

Iqbal, S., Desai, R., Kumar, U., Ilyas, O., and Qureshi, Q. (2025). Den site selection by Indian gray wolves in tribal landscapes of Mahuadanr Wolf Sanctuary considering ecological and cultural factors. Scientific Reports, 15(1), 10060. https://doi.org/10.1038/s41598-025-94417-z

Jain, S.K., Agarwal, P.K., and Singh, V.P. (2007). Mahanadi, Subernarekha and Brahmani Basins. In: Hydrology and Water Resources of India. Water Science and Technology Library, Vol 57, pp 597-639. Springer, Dordrecht, Netherlands. https://doi.org/10.1007/1-4020-5180-8_13

Jarić, I., Roll, U., Bonaiuto, M., Brook, B. W., Courchamp, F., Firth, J. A., ... and Correia, R. A. (2022). Societal extinction of species. Trends in Ecology & Evolution, 37(5), 411-419. DOI: 10.1016/j.tree.2021.12.011

Johannes, R. E., Freeman, M. M., and Hamilton, R. J. (2000). Ignore fishers' knowledge and miss the boat. Fish and Fisheries, 1(3), 257-271. https://doi.org/10.1111/j.1467-2979.2000.00019.x

Jolly, H., Satterfield, T., Kandlikar, M., and T.R. Suma. (2022). Indigenous insights on human–wildlife coexistence in southern India. Conservation Biology, 36(6),e13981. https://doi.org/10.1111/cobi.13981

Jolly, H., and Stronza, A. (2025). Insights on human−wildlife coexistence from social science and Indigenous and traditional knowledge. Conservation Biology, 39, e14460. https://doi.org/10.1111/cobi.14460

Kareiva, P., and Marvier, M. (2012). What is conservation science?. BioScience, 62(11), 962-969. https://doi.org/10.1525/bio.2012.62.11.5

Karimi, H., and Ataei, P. (2022). Farmers' cultural biases and adaptation behavior towards drought: a case in Sistan plain. Journal of Agricultural Science and Technology. 24, 793–809. doi: 10.1016/j.jrurstud.2020.11.003

Kiwango, W. A., and Mabele, M. B. (2022). Why the convivial conservation vision needs complementing to be a viable alternative for conservation in the Global South. Conservation and Society, 20(2), 179-189. DOI: 10.4103/cs.cs_45_21

Kelkar, N. (2014). River fisheries of the Gangetic basin, India: A primer. SANDRP, New Delhi, India. https://sandrp.in/wp-content/uploads/2018/03/river_fisheries_of_the_gangetic_basin0914.pdf

Kelkar, N. and Arthur, R.I. (2022). A review of governance and tenure in inland capture fisheries and aquaculture systems of India. FAO Fisheries and Aquaculture Circular No. 1230. Chennai, FAO and ICSF. https://doi.org/10.4060/cb8615en

Khan, M. F., and Panikkar, P. (2009). Assessment of impacts of invasive fishes on the food web structure and ecosystem properties of a tropical reservoir in India. Ecological modelling, 220(18), 2281-2290. https://doi.org/10.1016/j.ecolmodel.2009.05.020

Kipkeu, M. L., Mwangi, S. W., and Njogu, J. (2014). Community participation in wildlife conservation in Amboseli Ecosystem, Kenya. Journal of Environmental Science, Taxicology and Food Technology, 8(4), 68-75.

Kumar, N. (1970). Ranchi. Bihar District Gazetteers. Government of Bihar, Superintendent, Secretariat Press, Gulzarbagh, Patna, Bihar.

Kumar, D., Mehta, R., Yadav, R., Kumar, S., and Kumar, M. (2018). Studies on fisheries status and socio-economic conditions of fisher community in Dholi region, Muzaffarpur, Bihar, India. J Entomol Zool Stud, 6(3), 76-80.

Kumar, R. S., Kumar, D. K., Prakash, S., Krishnan, M., and Ojha, S. N. (2019). Status of small-scale inland fisheries in Bihar, India. SSRG International Journal of Economics and Management Studies, 6(8), 224-229. https://doi.org/10.14445/23939125/IJEMS-V6I8P124

Kumar, A., Kumar, A., and Kumari, S. (2025). Cultural ecology and conservation: Indigenous knowledge systems in Jharkhand. Journal of Native India & Diversity Studies, 2(01), 22-34. https://doi.org/10.62656/

Kumar, V., Sharma, A., Ram, R. K., Kumar, S., and Singh, S. K. (2025). Assessment of Fish Diversity Associated with Water Quality Parameters of Burhi Gandak River, North Bihar, India. Uttar Pradesh Journal of Zoology, 46(6), 6-17. https://doi.org/10.56557/upjoz/2025/v46i64839

Kumari, S., and Sharma, A. (2022). Sustainable livelihood through fish cage culture: Case of chandil reservoir in Jharkhand. Indian Journal of Ecology, 49(3), 879-887. https://doi.org/10.55362/IJE/2022/3610

Kura, Y., Mam, K., Chea, S., Eam, D., Almack, K., and Ishihara, H. (2023). Conservation for sustaining livelihoods: Adaptive co-management of fish no-take zones in the Mekong River. Fisheries Research, 265, 106744. https://doi.org/10.1016/j.fishres.2023.106744

Lakra, W. S., Goswami, M., and Sarkar, U. K. (2010). Conservation biology of Indian mahseers. The Indian Journal of Animal Sciences, 80(4), 98-108.

Leite, M. C., and Gasalla, M. A. (2013). A method for assessing fishers' ecological knowledge as a practical tool for ecosystem-based fisheries management: Seeking consensus in Southeastern Brazil. Fisheries Research, 145, 43-53. https://doi.org/10.1016/j.fishres.2013.02.013

Lyakurwa, G. J., Chepkwony, M. C., and Sabuhoro, E. (2025). Community Perceptions on Conservation, Livelihood Vulnerability and Quality of Life Around Tanzania's Kilimanjaro National Park. Land, 14(2), 334. https://doi.org/10.3390/land14020334

Lynch, A. J., Cooke, S. J., Deines, A. M., Bower, S. D., Bunnell, D. B., Cowx, I. G., ... and Beard Jr, T. D. (2016). The social, economic, and environmental importance of inland fish and fisheries. Environmental reviews, 24(2), 115-121. https://doi.org/10.1139/er-2015-0064

Mandoloma, L., Clark, M., Coad, L., Hughes, K., and MilnerGulland, E. J. (2025). Implications of human‐nature interactions for livelihoods and conservation in Kasungu, Malawi. People and Nature, 7(3), 700-714. https://doi.org/10.1002/pan3.70008

Marchini, S. (2014). Who's in conflict with whom? Human dimensions of the conflicts involving wildlife. In Applied ecology and human dimensions in biological conservation (pp. 189-209). Berlin, Heidelberg: Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-54751-5_13

Marchini, S., Ferraz, K. M. P. M. B., Zimmermann, A., Guimarães-Luiz, T., Morato, R., Correa, P. L., and Macdonald, D. W. (2019). Planning for coexistence in a complex human-dominated world. Human–wildlife interactions: Turning conflict into coexistence, 414-438.

Martin, C. W., Valentine, M. M., and Valentine, J. F. (2010). Competitive interactions between invasive Nile tilapia and native fish: the potential for altered trophic exchange and modification of food webs. PloS one, 5(12), e14395. https://doi.org/10.1371/journal.pone.0014395

Muller, A., Bacs, Z., Fenyves, V., Kovacs, S., Lengyel, A., and Bácsne, E. B. (2025). Demographic influences on environmental attitudes and actions: An analysis of the attitude-behavior gap. Geo Journal of Tourism and Geosites, 60, 1028-1040. https://doi.org/10.30892/gtg.602spl01-1477

Murali, R., Lliso, B., Mannetti, L. M., Filyushkina, A., Amaruzaman, S., Amin, A. M., ... and Yiu, E. (2024). Assessing multiple values of nature in National Biodiversity Strategies and Action Plans. People and Nature, 6(3), 1355-1365. https://doi.org/10.1002/pan3.10645

Narayanan, S. (2016). Inland fisheries, food security and poverty eradication: A case study of Bihar and West Bengal. ICSF Occasional Paper. International Collective In Support of Fishworkers. https://www.icsf.net/wp-content/uploads/2016/08/930.ICSF077.pdf

Nepal, S., and Spiteri, A. (2011). Linking livelihoods and conservation: an examination of local residents' perceived linkages between conservation and livelihood benefits around Nepal's Chitwan National Park. Environmental Management, 47(5), 727-738. https://doi.org/10.1007/s00267-011-9631-6

Newing, H., Brittain, S., Buchadas, A., del Giorgio, O., Grasham, C. F., Ferritto, R., ... and Ghoddousi, A. (2024). 'Participatory'conservation research involving indigenous peoples and

local communities: Fourteen principles for good practice. Biological Conservation, 296, 110708. https://doi.org/10.1016/j.biocon.2024.110708

NITI Aayog (n.d.). Best Practices. Explore Best Practices. Agriculture and Allied Services. Jharkhand's Matsya Mitra Initiative Promotes Aquaculture and Increases Fish Production. https://www.nitiforstates.gov.in/best-practice-detail?id=104000

Nkansah-Dwamena, E. (2023). Lessons learned from community engagement and participation in fostering coexistence and minimizing human-wildlife conflict in Ghana. Trees, Forests and People, 14, 100430. https://doi.org/10.1016/j.tfp.2023.100430

O'Malley, L. S. S. (1906). Bengal District Gazetteer: Gaya. Concept Publishing Company, Logos Press, Delhi

O'Malley, L. S. S. (1910). Bengal District Gazetteers: Sinhbhum, Saraikela and Kharsawan. India: Logos Press, Delhi

O'Malley, L. S. S. (1924). Bihar and Orissa District Gazetteers: Patna. Concept Publishing Company, Logos Press, Delhi

O'Malley, L. S. S. (1926). Bihar and Orissa District Gazetteers: Monghyr. Concept Publishing Company. Logos Press, Delhi

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

Owusu, V., and Adjei, M. (2021). Politics, power and unequal access to fisheries subsidies among small-scale coastal fisherfolk in Ghana. Ocean & Coastal Management, 214, 105920. https://doi.org/10.1016/j.ocecoaman.2021.105920

Pandey, A., and Bharti, V. (2024). Wetlands in Bihar: a comprehensive analysis of extent socio-economic significance, ecological benefits, and associated risks. Journal of Community Positive Practices, (1), 122-138. DOI: https://doi.org/10.35782/JCPP.2024.1.07

Pandit, A., Das, B. K., Chandra, G., Roy, A., Debroy, P., Yadav, A. K., Chakraborty, L., and Biswas, D. K. (2021). Impact of cage culture in reservoir on the livelihood of fishers: A case study in Jharkhand, India. Indian Journal of Fisheries, 68(1). https://doi.org/10.21077/ijf.2021.68.1.93390-09

Pascual, U., Balvanera, P., Anderson, C. B., Chaplin-Kramer, R., Christie, M., González-Jiménez, D., ... and Zent, E. (2023). Diverse values of nature for sustainability. Nature, 620: 7975 620 813–823. https://doi.org/10.1038/s41586-023-06406-9

Pimid, M., Mohd Nasir, M. R., Krishnan, K. T., Chambers, G. K., Ahmad, A. G., and Perijin, J. (2022). Understanding social dimensions in wildlife conservation: Multiple stakeholder views. Animals, 12(7), 811. https://doi.org/10.3390/ani12070811

Pinder, A. C., Britton, J. R., Harrison, A. J., Nautiyal, P., Bower, S. D., Cooke, S. J., ... and Raghavan, R. (2019). Mahseer (*Tor* spp.) fishes of the world: status, challenges and opportunities for conservation. Reviews in Fish Biology and Fisheries, 29(2), 417-452. https://doi.org/10.1007/s11160-019-09566-y

Prasad, S.C. (2025). On the banks of Bagmati River: Bihar's Forgotten fisherfolk. People and Culture. India Water Portal. https://www.indiawaterportal.org/people-and-culture/conflicts/on-the-banks-of-bagmati-river-bihars-forgotten-fisherfolk

Press Information Bureau. (2024, February 28). Secretary, Department of Fisheries, Dr. Abhilaksh Likhi visits Getalsud Dam at Ranchi, Jharkhand for reviewing of cage farming. Government of India. https://www.pib.gov.in/PressReleaseIframePage.aspx?PRID=2009753&reg=3&lang=2

Proudfoot, K. (2023). Inductive/deductive hybrid thematic analysis in mixed methods research. Journal of mixed methods research, 17(3), 308-326. https://doi.org/10.1177/15586898221126816

Raghavan, R., Dahanukar, N., and Britz, R. (2017). The type locality of *Tor mosal* (Hamilton, 1822) (Teleostei: Cyprinidae). Zootaxa, 4317(3), 593-596. https://doi.org/10.11646/zootaxa.4317.3.12

Raghavan, R., Mohamed, K. S., Kumar, A. B., Balasubramanian, C. P., Dubey, S. K., Ranjeet, K., ... and Zacharia, P. U. (2025). Fisheries and aquaculture in India: Past, present and future. Fisheries, vuaf092. https://doi.org/10.1093/fshmag/vuaf092

Raut, S., Gupta, N., Everard, M., and Singh, I. S. (2020). Commercially and medicinally significant aquatic macrophytes: potential for improving livelihood security of indigenous communities in northern Bihar, India. Journal of Threatened Taxa, 12(13), 16819-16830. https://doi.org/10.11609/jott.5640.12.13.16819-16830

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

Rode, J., Gómez-Baggethun, E., and Krause, T. (2015). Motivation crowding by economic incentives in conservation policy: A review of the empirical evidence. Ecological Economics, 117, 270-282. https://doi.org/10.1016/j.ecolecon.2014.11.019

Roy Choudhury, P. C. (1957). Bihar District Gazetteers / by P.C. Roy Chaudhury. Patna: Printed by the Superintendent, Secretariat Press, Bihar.

Rupala, P., Parliament of India (2023, August 1). Answer to Unstarred Question No. 1937: "Welfare Schemes for Fishers." Lok Sabha. Available at: https://sansad.in/getFile/loksabhaquestions/annex/1712/AU1937.pdf?source=pqals

Sahil, Mogalekar, H.S., Lal, J., Nayak, S.K., and Kumar, S. (2024). Indigenous Small Fish Diversity from Selected Wetlands of Eastern India. In: Sinha, A., Roy, A., Gogoi, P. (Eds.) Perspectives and Applications of Indigenous Small Fish in India. Springer, Singapore. https://doi.org/10.1007/978-981-97-1586-2_3

Salafsky, N., and Wollenberg, E. (2000). Linking livelihoods and conservation: a conceptual framework and scale for assessing the integration of human needs and biodiversity. World development, 28(8), 1421-1438. https://doi.org/10.1016/S0305-750X(00)00031-0

Sarkar, U. K., Pathak, A. K., Sinha, R. K., Sivakumar, K., Pandian, A. K., Pandey, A., ... and Lakra, W. S. (2012). Freshwater fish biodiversity in the River Ganga (India): changing pattern, threats and conservation perspectives. Reviews in Fish Biology and Fisheries, 22(1), 251-272. https://doi.org/10.1007/s11160-011-9218-6

Sarmah, R., Das, U. K., Sarma, D., and Shahi, N. (2024). Morphometric and Molecular Assessment of *Tor putitora* and *Neolissochilus hexagonolepi*s Population in Jia Bhoroli river Ecotone Zone, Assam. Indian Journal of Animal Research, 1, 8. DOI: 10.18805/IJAR.B-5156.

Schultz, K., and McGinn, K. C. (2013). "No One Cares About This Community More Than Us" The Role of Listening, Participation, and Trust in a Small Urban District. Urban Education, 48(6), 767-797. https://doi.org/10.1177/0042085912462709

Sharma, B., Khatoon, A., and Jaiswal, M. (2023). Freshwater Fish biodiversity of Indrapuri Dam, Rohtas, Bihar. Journal of Fisheries Research; 7 (6): 177 1 J Fish Res 2023 Volume 7 Issue 6 Research Article https://www. alliedacademies. org/journal-fisheries-research.

Shweta, S. (2024). Extension approach for an effective fisheries extension services by governmental and non-governmental organizations in Jharkhand. International Journal of Advanced Biochemistry Research, 8(2S), 51-58. DOI: 10.33545/26174693.2024.v8.i2Sa.525

Singh, A. K., and Lakra, W. S. (2006). Alien fish species in India: Impact and emerging scenario. Journal of Ecophysiology & Occupational Health, 6(3and4), 165-174.

Singh, A.K., and Giri, S. (2018). Subarnarekha River: The Gold Streak of India. In: Singh, D. (Eds) The Indian Rivers: Scientific and Socio-Economic Aspects. Pp. 273-285. Springer Hydrogeology. Springer, Singapore. https://doi.org/10.1007/978-981-10-2984-4_22

Silvano, R. A., and Valbo-Jørgensen, J. (2008). Beyond fishermen's tales: contributions of fishers' local ecological knowledge to fish ecology and fisheries management. Environment, Development and sustainability, 10(5), 657-675. https://doi.org/10.1007/s10668-008-9149-0

Sinha Ray, K. (2016). Ordering the wild: shikar, wildlife and conservation in colonial Bengal (1850-1947)

Soga, M., and Gaston, K. J. (2022). Towards a unified understanding of human–nature interactions. Nature Sustainability, 5(5), 374-383. https://doi.org/10.1038/s41893-021-00818-z

Srivastava, A., and Singh, R. (2014). Threatened and endemic ichthyofauna of the river Kharkai, Jharkhand with suggestions for their conservation. Biospectra, 9(1), 59-62. https://mset-biospectra.org/wp-content/uploads/2021/03/59-62.pdf

Sugnnan, V. V. (1995). Reservoir fisheries of India. FAO Fisheries Technical Paper. No. 345. Rome, FAO. 1995. 423 p.

Talwar, P. K., and Jhingran, A. G. (1991). Inland fishes of India and adjacent countries (Vol. 2). CRC press.

Tandon, S.K., and Sinha, R. (2018). The Ganga River: A Summary View of a Large River System of the Indian Sub-Continent. In: Singh, D. (Eds.) The Indian Rivers: Scientific and

Socio-economic Aspects (pp. 61-73). Springer Hydrogeology. Springer, Singapore. https://doi.org/10.1007/978-981-10-2984-4_5

The Bihar Fish Jalkar Management (Ammendment) Act, 2018 (Bihar Act 13 of 2006). Government of Bihar, India. https://faolex.fao.org/docs/pdf/IND196906.pdf [Accessed November 27, 2025].

Tsing, A. (2012). Unruly edges: Mushrooms as companion species: For Donna Haraway. Environmental Humanities, 1(1), 141–154. https://doi.org/10.1215/22011919-3610012

Tudu, A. K., and Maji, D. (2025). Ichthyofaunal checklist and its conservation status with special focus on identifying threatened and indigenous ichthyo-species in the Kharkai River: A lesser-known tributary River of Swarnarekha, Jharkhand, India: A Preliminary approach. International Journal of Fisheries and Aquatic Studies. 13(2), 218-222. https://doi.org/10.22271/fish.2025.v13.i2c.3068

Ullah, S., Abid, A., Aslam, W., Noor, R. S., Waqas, M. M., and Gang, T. (2021). Predicting behavioral intention of rural inhabitants toward economic incentive for deforestation in Gilgit-Baltistan, Pakistan. Sustainability 13, 1–17. https://doi.org/10.3390/su13020617

Vardakas, L., Perdikaris, C., Freyhof, J., Zimmerman, B., Ford, M., Vlachopoulos, K., ... and Kalogianni, E. (2025). Global Patterns and Drivers of Freshwater Fish Extinctions: Can We Learn From Our Losses?. Global Change Biology, 31(5), e70244. https://doi.org/10.1111/gcb.70244

Welcomme, R. L., Cowx, I. G., Coates, D., Béné, C., Funge-Smith, S., Halls, A., and 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

Wu, J., Guo, Y., and Zhou, J. (2020). Nexus between ecological conservation and socio-economic development and its dynamics: Insights from a case in China. Water, 12(3), 663. https://doi.org/10.3390/w12030663

Zolait, A. H. S. (2014). The nature and components of perceived behavioural control as an element of theory of planned behaviour. Behaviour & Information Technology, 33(1), 65-85. https://doi.org/10.1080/0144929X.2011.630419

Tables and Figures:

Table 1. List of stakeholders from the two Indian states interviewed for the study.

Jharkhand			
S. No.	**Stakeholders**	**Participants**	**Number of Participants**
1.	Fisheries Department	Staff of State Fisheries Head Office (*Matsya Bhavan*)	1
		Staff of Fish Farmer Training and Research Centre	1
		Staff of District Fisheries Office (DFO)	7
2.	Forest Department	Staff of Divisional Forest Office (DFO)	3
3.	*Matsya Mitra* (Friends of Fishes)	Local Community Volunteer Members working as *Matysa Mitra*	5
4.	Research and Educational Colleges/Universities	Researchers from Fisheries College	2
5.	Damodar Valley Corporation (DVC) Hatchery	Managers of Aquaculture-based Fish Hatchery at DVC	2
6.	Fishermen Co-operative Societies	Fishermen from Local Community	48

Bihar			
S. No.	**Stakeholders**	**Participants**	**Number of Participants**
1.	Fisheries Department	Staff of State Fisheries Head Office (*Meen Bhavan*)	1
		Staff of District Fisheries Office (DFO)	4
2.	Research and Educational Colleges/Universities	Researchers from Fisheries College and Agricultural University	2
3.	Fishermen Co-operative Societies	Fishermen from Local Community	77

Table 2. Vernacular and scientific names of the freshwater fish species reported by different stakeholder groups as occurring or present in the water bodies of Jharkhand and Bihar.

S. No.	**Vernacular Name (s)**	**Scientific Name**	**Stakeholder Groups Reporting the Species**
1.	Koi (Jharkhand) Kowai, Kawai, Kabai (Bihar)	*Anabas testudineus*	All
2.	Baamacchh	*Anguilla bengalensis*	Staff of the Fisheries Department, Bihar Members of the Fishermen Co-operative Society, Bihar
3.	Baghair, Baghar	*Bagarius* spp.	All
4.	Katla	*Catla catla*	All
5.	Garai	*Channa punctatus*	All
6.	Shol, Saur	*Channa striatus*	All
7.	Chital, Bhuna	*Chitala chitala*	All
8.	Mrigal	*Cirrhinus cirrhosus*	All
9.	Magur	*Clarias magur*	All
10.	Bachwa, Garua	*Clupisoma garua*	All
11.	Grass carp	*Ctenopharyngodon idella*	All
12.	Pahari (Jharkhand) Common carp	*Cyprinus carpio*	All
13.	Pathhar chatta	*Garra gotyla*	Managers of Aquaculture-based Fish

			Hatchery at DVC, Jharkhand
14.	Singhi	*Heteropneustes fossilis*	All
15.	Silver carp	*Hypophthalmichthys molitrix*	All
16.	Bighead, Briket, Brigate	*Hypophthalmichthys nobilis*	All
17.	Bata	*Labeo bata*	All
18.	Kalbas, Kalbos	*Labeo calbasu*	Staff of the Fisheries Department, Jharkhand Members of the Fishermen Co-operative Society, Jharkhand
19.	Rohu, Rui	*Labeo rohita*	All
20.	Baami, Baam	*Mastacembelus armatus*	Staff of the Fisheries Department, Bihar Members of the Fishermen Co-operative Society, Bihar
21.	Tengra, Tangra	*Mystus tengara*	All
22.	Patra, Falat, Pholui	*Notopterus notopterus*	All
23.	Tilapia, Telapia, Jalebi	*Oreochromis* spp.	All
24.	Pangaas, Bachua, Basa	*Pangasius pangasius*	All
25.	Roopchand	*Piaractus brachypomus*	All
26.	Punthi, Puthi	*Puntius* spp.	All
27.	Ritha, Rita	*Rita rita*	Staff of the Fisheries Department, Bihar Members of the Fishermen Co-operative Society, Bihar

28.	Gagari	*Sperata seenghala*	All
29.	Hilsa	*Tenualosa ilisha*	All
30.	Mahseer	*Tor* and *Neolissochilus* spp.	Two Staff Members of the Fisheries Department, Jharkhand One Researcher from Jharkhand
31.	Boal, Bual, Buari	*Wallago attu*	All

Fig. 1 The districts in the Indian state of Jharkhand where the study was carried out. Map not to scale.

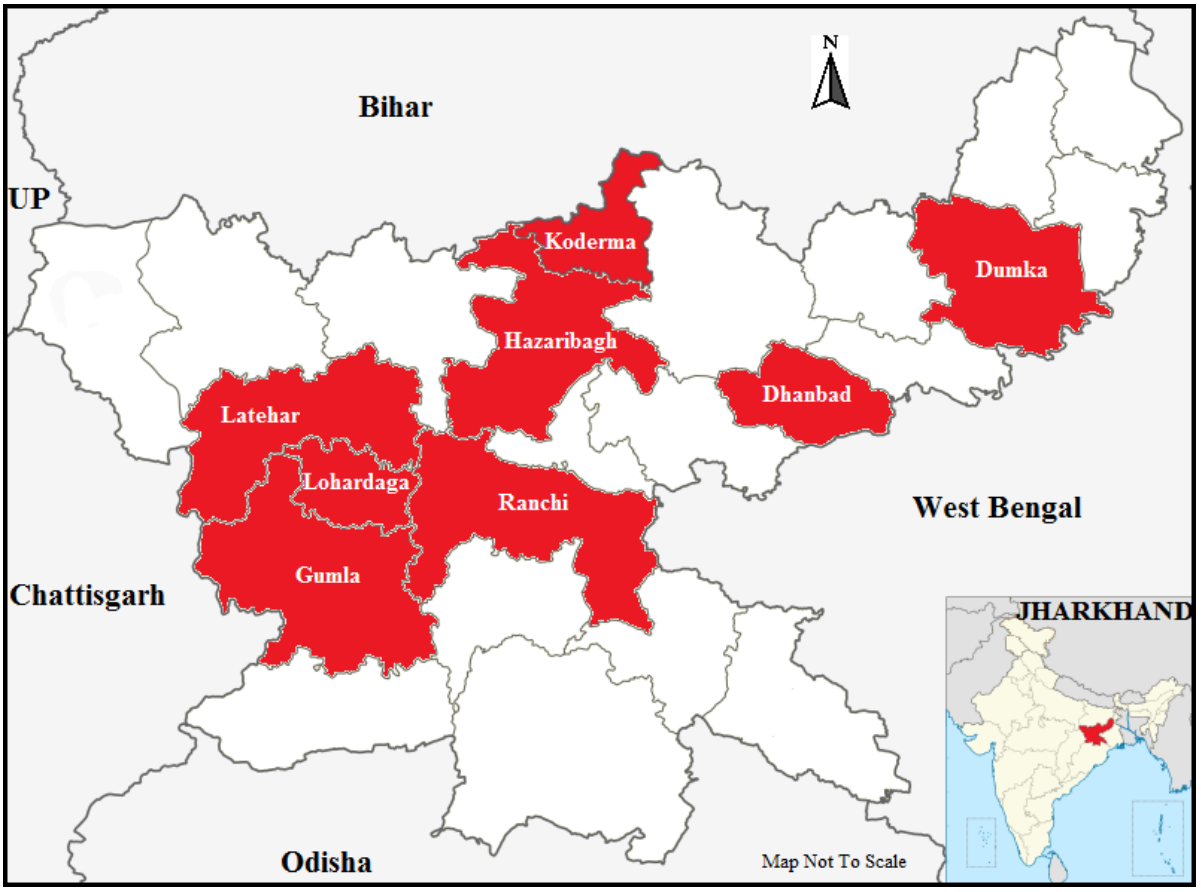


Fig. 2 The districts in the Indian state of Bihar where the study was carried out. Map not to scale.

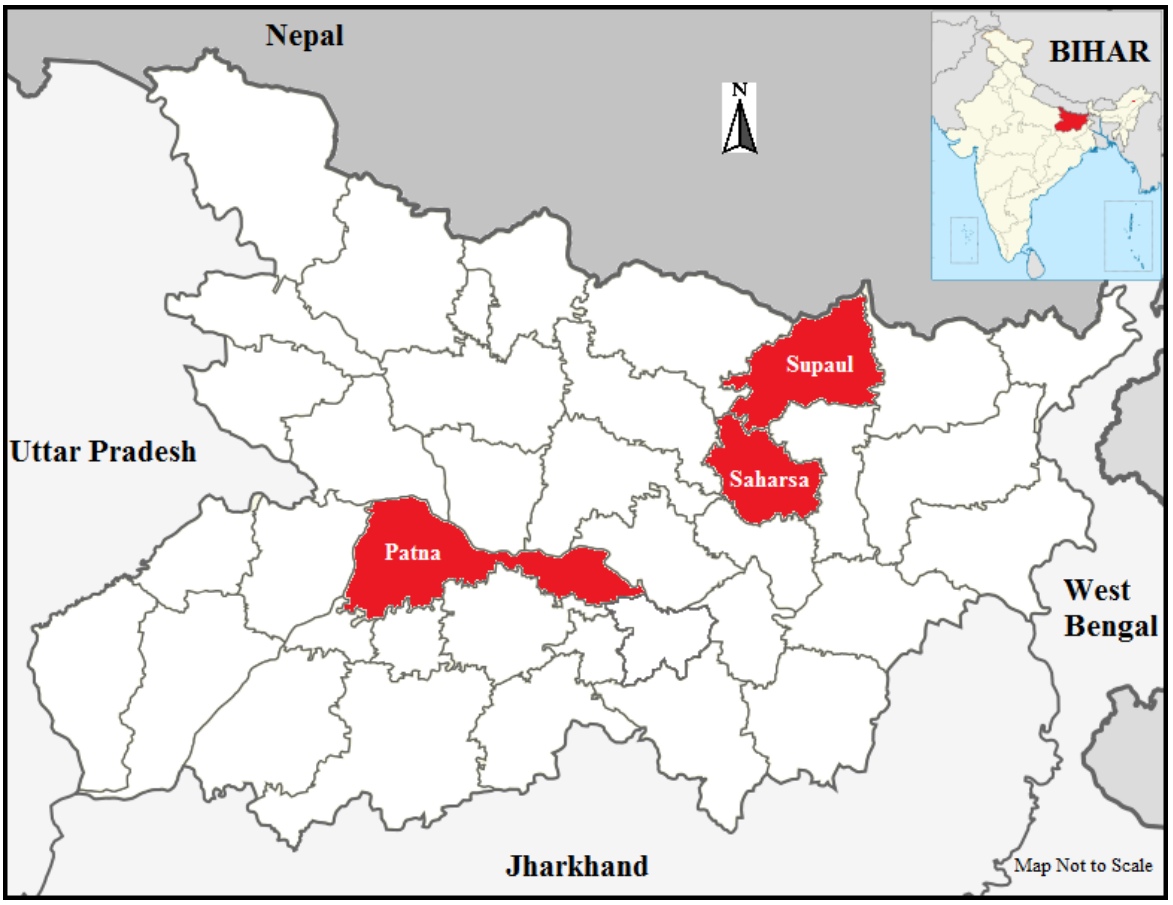


Fig. 3 Radar chart depicting the frequency of codes obtained from the reflexive thematic analysis conducted on the interviews from Jharkhand.

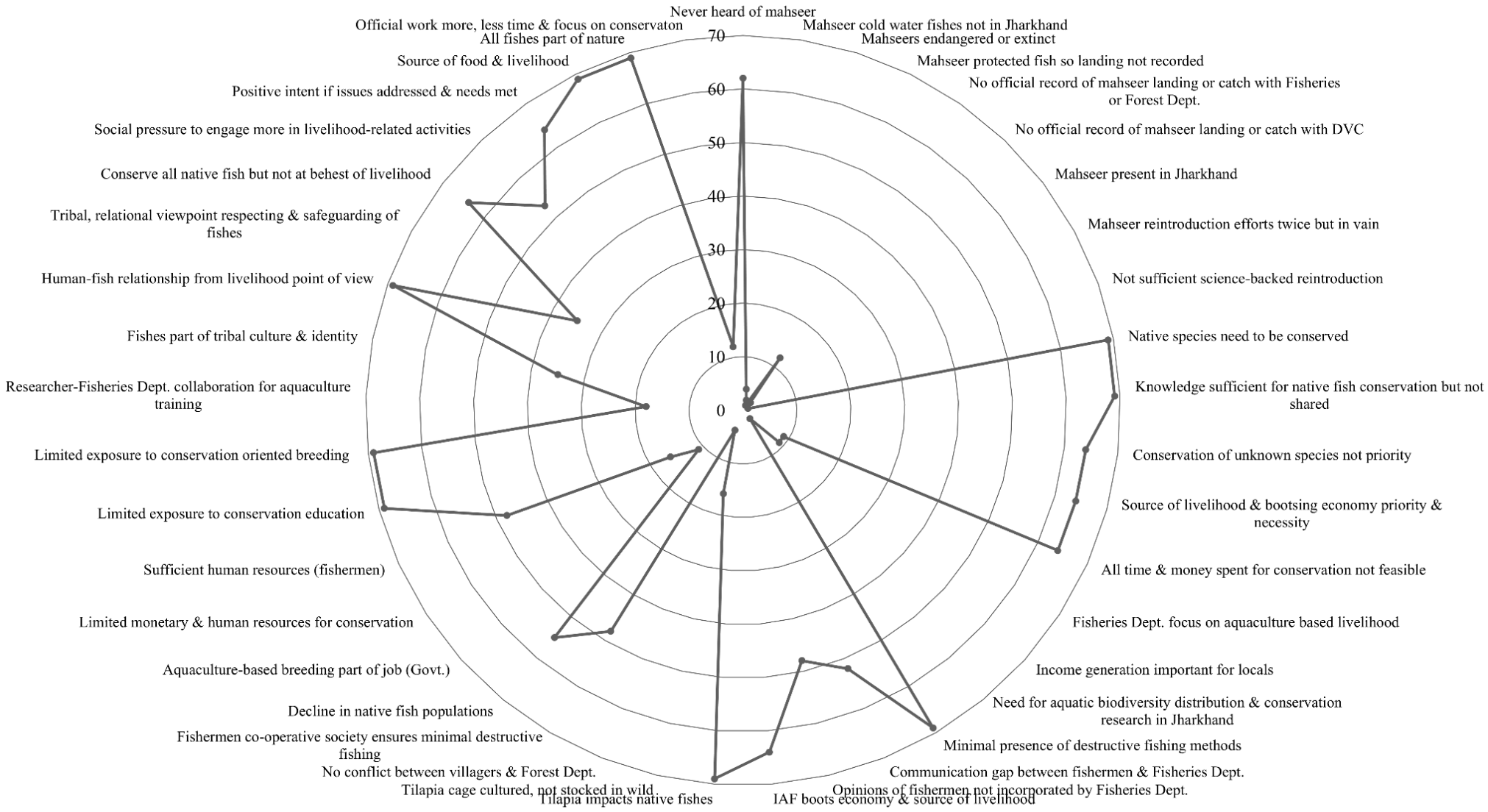
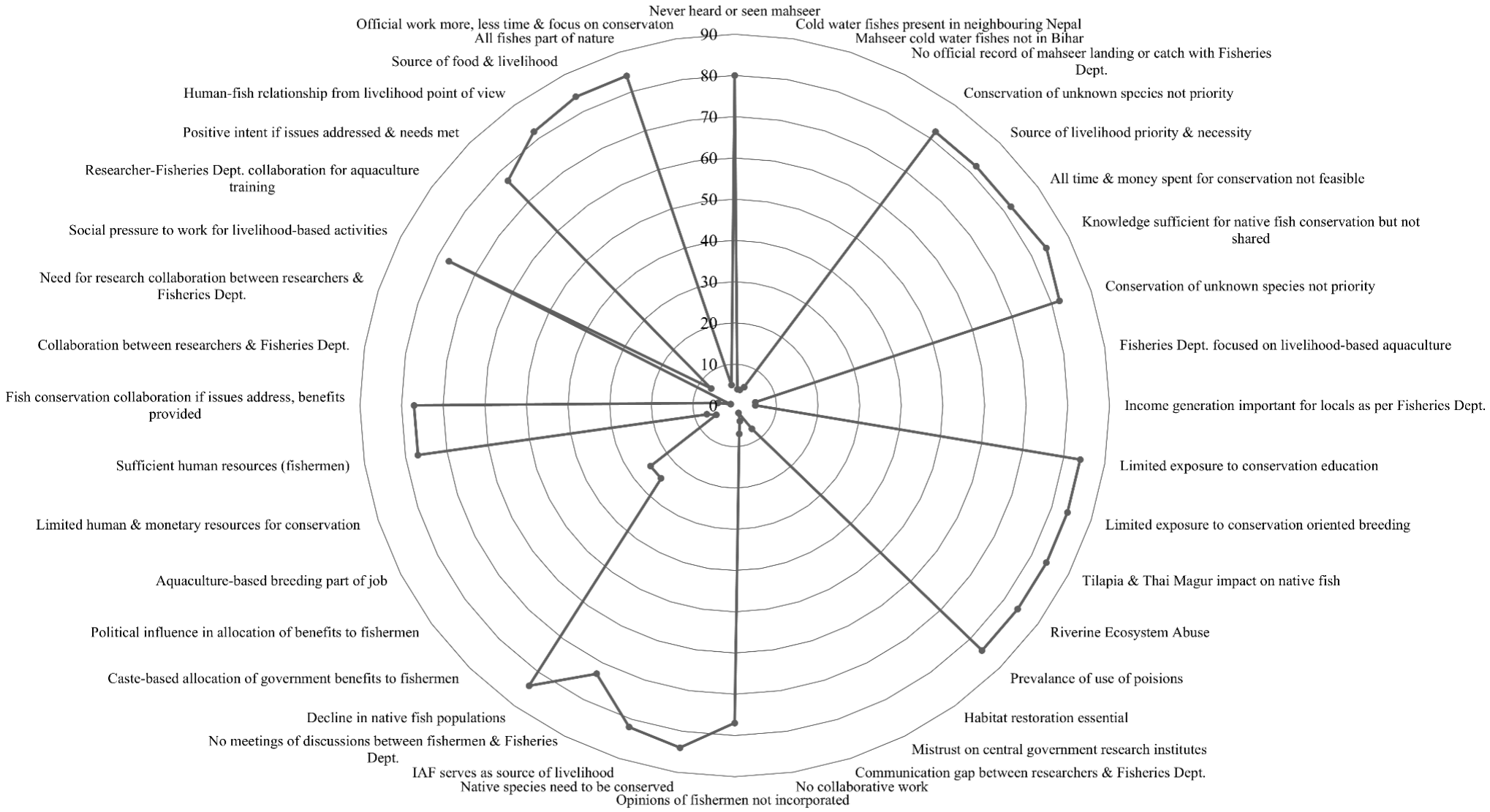


Fig. 4 Radar chart depicting the frequency of codes obtained from the reflexive thematic analysis conducted on the interviews from Bihar.



Supplementary Materials (SM):

SM 1. Stakeholder Interview Questions:

Section 1: Conservation Planning Framework (CPF)

1. Are you aware of the different fish species found in your state?
2. What threats do you think that the freshwater fishes face in your locality?
3. Do people practice any destructive fishing methods here? What are those?
4. Do you know what the Invasive Alien Fishes (IAFs) are? Do you think that IAFs have any effect on the native fish populations in your locality?
5. Should there be stocking of IAF in rivers where native fish population thrives for the economic benefit? Why/Why not?
6. Do you think that there is a need to conserve the native fish species? If so, any opinions on which species need more attention?
7. What are the existing freshwater native fish population management programmes that are being undertaken by the Department (Fisheries and Forest) in the state?
8. Do you think these have been effective in leading to a positive outcome? Do you feel any need for change in these programmes?
9. Do you think interventions are required for the conservation of the native fish populations? What interventions can be done to bolster the stock in the wild?
10. Is subsistence fishing allowed for the locals within the National Park/Wildlife Sanctuary/protected area?
11. Have the local community members or other stakeholders (such as researchers, fishermen) been involved in the decision making process related to native fish conservation plans and strategies?
12. Does the Department (Fisheries and Forest) hold open discussions regarding fish conservation with the local community members?
13. Does the stakeholder hold discussions with the local community members or involve them in awareness activities?
14. Does the Department (Fisheries and Forest) work in association with other government Departments with respect to fish conservation programmes?
15. Does the stakeholder work in association with the other stakeholders such as research institutions, NGOs?
16. Are there sufficient resources (human and monetary) for dedicated fish conservation?
17. What are the conservation communication and awareness activities being undertaken by the stakeholders? Do the locals support these activities?
18. How important do you think conservation communication is for native fish conservation activities to be successful?
19. Does the local media focus on the conservation of native fish species?
20. Do you think social media can be used as a tool for communication?
21. What is your opinion on the creation of fish sanctuaries or no fishing green zones?
22. Are you aware of the mahseer fish species found in your state? What are they called in the local language?

23. (If unfamiliar with the term 'mahseer,' photographs of different mahseer species were shown). Do you recognise these fishes?
24. (If unaware) Based on historical records, they were present in this region in the past. Is it correct that they occurred here earlier but are not found currently?
25. Do you think the number of mahseer (species name changed according to the state where the interview is being conducted) is declining in the rivers in your locality?
26. Are you aware about the IUCN status of the mahseer species?

Section 2: Theory of Planned Behaviour (TPB)

1. In your view, do the stakeholders possess adequate knowledge and information to effectively undertake fish conservation efforts on their own? Is that knowledge shared with other stakeholders?
2. Is there any kind of social pressure from your colleagues/government/family members/head of the community to involve in native fish conservation or other activities regarding fishes?
3. In your opinion, does the existing official workload limit the capacity of the staff to focus specifically on native fish conservation efforts? (For Government stakeholders)
4. What do native fishes mean to you, do you either see it from the point of view of conservation or a way for economic benefits or a combination of both?
5. Are you involved with conservation activities? If not, how willing would you be to get involved in conservation initiatives in your area?
6. Do you collaborate with other stakeholders in such activities?
7. What personal needs, interests, or motivations might drive you to get involved in these kinds of initiatives?
8. What would you say, in your opinion, are the barriers to native fish conservation?

Section 3: Social Values (SV)

1. Are the local native fishes a part of any mythological stories?
2. Do fishes in your locality have any socio-cultural or religious significance?
3. (If yes) In your view, should such cultural values be integrated into the design of region-specific fish conservation plans, such as temple fish sanctuaries? How effective would those be?
4. What kind of socio-economic benefits do native fishes provide to the community over generations?
5. Why do you think that the native fishes should be protected and conserved?
6. What kind of non-tangible, non-monetary benefits, in your opinion, do these native fishes provide to you and the society?
7. How do you think stakeholders view fish conservation — as a personal commitment to nature and biodiversity conservation, a livelihood opportunity, a reflection of cultural or religious identity, a job responsibility (professional obligation), or a combination of these?

8. Do you think that the stakeholders should feel that they have a duty towards the fish conservation?
9. Are there any additional recommendations you would like to suggest to enhance the effectiveness and efficiency of the existing native fish conservation protocols and strategies?

Additional questions for Fisheries Department staff:

1. (For Bihar) Are there any provisions for the declaration of Fish Sanctuaries in accordance with the Bihar Jalkar Management Act, 2006 or any other fisheries Acts or rules? Have they been declared?
2. If yes, what are those stretches? Who manages them?
3. What kind of human activities are allowed here?
4. (For Jharkhand) Have there been any provisions to declare river stretches as Fish Sanctuaries?
5. What are the activities done in the hatchery? (breeding, rearing, selling, distribution without cost)
6. Which species are being bred in the hatchery?
7. Are mahseers being bred in the hatchery? Have they been bred in the past? Any future plans to breed them?
8. Do the officials train the fish farmers regarding fish conservation or only for IMC aquaculture?
9. Do you provide fingerlings to local people? For what purpose?
10. Is there fish conservation related breeding that is being undertaken? (If no) Why not?
11. (For Jharkhand) What is the role of *Matsya Mitra*?

Additional questions for Forest Department staff:

1. Are there any targeted native fish conservation plans or are they protected as part of the forest and biodiversity?
2. Do you conduct a creel census to determine the number of individuals?
3. Are the forest guards consulted during discussions with the ranger or DFOs?
4. Do the forest guards face any kind of conflict from the local residents of the buffer zone?
5. Are the local community members invited for discussions over decision making?
6. Are the buffer zone residents permitted to subsistence fish with rod without any destructive methods? Were the rules the same before or have they changed?
7. Do you provide any licenses to local fishermen for fishing in the buffer zone of the protected areas? If yes, how many licenses are provided? Who are they provided to?
8. Is there any closed season for fishing?
9. What are punishments for illegal destructive fishing or poaching?

Additional questions for researchers:

1. Are you invited to discussions over native fish conservation and management decision making?
2. Are you involved in native fish conservation research?
3. Does your research have a component of intervention as well?
4. Have you conducted any intervention? How effective have those been?
5. Are there any barriers in breeding native fish species?
6. Have you been consulted during breeding or reintroduction or stocking programmes for conservation purposes?
7. Have you faced any conflict with any stakeholder during your research work which included field-work?

Additional questions for fishermen:

1. What kind of fishes do you generally catch?
2. What kind of fishes do you farm for aquaculture?
3. Are you entirely dependent on fishing and aquaculture for your livelihood?
4. Do you need a license to fish in certain stretches of the river? What are these stretches? Who issues the license?
5. Have the number of native fish caught declined over the years? Do you get IAFs in your catch? Have they increased?
6. Do you catch mahseer? If yes, do you land them frequently?
7. What do you do if you land a mahseer? Are they taken for consumption purposes?
8. Are you consulted by the fisheries department officials on what kind of fish to be bred?
9. Do discussions happen with the fisheries department?
10. Are you involved in any native fish conservation related activities?
11. How important is involvement in conservation activities for you along with the livelihood based fishing and aquaculture?
12. Have you seen destructive illegal fishing being undertaken? Have they declined or increased over time?
13. Along with training regarding IMC breeding and aquaculture, are you provided with training or education regarding conservation of native fish species?
14. In case you are asked to involve yourself in conservation activities, will you be willing to do so? Are there sufficient people for undertaking such activities?
15. Do you receive regular benefits from the government-based schemes (*yojanas*) that are in place for the welfare of the fishermen community?
16. Do you face any barriers in receiving them?
17. In your opinion, how can the native fish conservation and livelihood-based aquaculture activities go hand-in-hand and promote sustainability?