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Socio-Economic Profile and Vulnerabilities Assessment in Small-Scale Fisheries of Lower Gangetic Flood Plain Wetland: An Initiative Towards Achieving Wetland Ecosystem Sustainability and Community Well-Being

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Abstract: ICAR-CIFRI has been continuously working to develop wetland fisheries in a transdisciplinary knowledge-to-action mode to upscale the livelihood of vulnerable small-scale fishermen communities. The integrated development approach was initiated in different lower Gangetic floodplain wetlands of North 24 Parganas, West Bengal, India, to increase the fish production and socio-economic development of small-scale fishermen communities of the wetlands. Duma is one of the most extensive horseshoe-shaped wetlands in Asia. To augment the fish production from this wetland, the pen culture system was adopted by the fishers under the supervision of ICAR-CIFRI in 2021. Within a year, they received 15 tons of commercial fish, valued at around 30 lakhs apart from the small indigenous fish. It has recently been advised that auto-stocked, high-value minor carp in the wetland be adopted to improve income and conserve small indigenous species. In this article, SDG 14 (Life below water) addresses sustainable ecosystem management and livelihood enhancement for the wellbeing of the local people (SDG 3). Nutritional security of the local people is maintained through the small indigenous fish species which is crucial for addressing 'No hunger' as per SDG-2. The research also proves that women can play a crucial role in small-scale fisheries and they can economically stand alone, which is the main aim of SDG-5 (gender equality). However, significant issues such as lack of jurisdictional coordination, ecological changes, inequitable distribution of benefits, and income reduction persist in wetland management. The need for urgent reformation of policy and resource management systems is crucial to boost the economic efficiency of the SSF in the wetland. Training for more knowledge on fishing and fish farming, acquiring alternative livelihood and education on financial management should be brought to the fishermen's communities. These could develop a resilient community that is more equipped to respond to future crises.

Keywords: technology; participatory approach; production enhancement; reformation

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Citation: Bhattacharya, S.; Das, B.K.; Roy, A.; Nayak, P.K.; Saha, A.; Parida, P.K.; Lianthuamluaia, L.; Mondal, K.; Chakraborty, S. Socio-Economic Profile and Vulnerabilities Assessment in Small-Scale Fisheries of Lower Gangetic Flood Plain Wetland: An Initiative Towards Achieving Wetland Ecosystem Sustainability and Community Well-Being. *Sustainability* **2024**, *16*, 9583. https://doi.org/10.3390/su16219583

Academic Editors: Gioele Capillo and Idiano D'Adamo

Received: 23 July 2024
Revised: 28 October 2024
Accepted: 29 October 2024
Published: 4 November 2024

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1. Introduction

Fisheries are a crucial livelihood and food security source for over half a billion people, as reported by Bennett [1]. Small-scale fisheries, also known as artisanal, are labour-intensive and characterised by low catch capacity, small boats (≤10–15 m), short travel distances, small crews, and limited capital investment, according to Cánovas-Molina et al. [2]. These types of fisheries represent more than 99% of the world's 51 million fishers and account for over 50% of the total global fisheries production, as mentioned by Jones et al. [3].

Artisanal small-scale fisheries are diverse and have a firm root in family income. They depend on fish stocks from many natural water resources.

The Food and Agriculture Organization of the United Nations (FAO) reported that global inland fishery catch was 11.9 million tonnes, representing 12.7% of the total global capture fisheries in 2019 [4]. Inland fisheries play a significant role in food and nutritional security, poverty alleviation, gender empowerment, socio-economic development of small and marginal fishers, ecosystem services, and biodiversity conservation, according to Funge-Smith and Bennett and Zhang et al. [5,6].

Wetlands are considered a great gift to humanity due to their ecosystem services. They are one of India's most important fishery resources, with 525,028 hectares of water area and a high production potential of 2000–2500 kg/ha/year [7–11]. Bihar has the largest area of floodplain wetlands (209,000 ha), followed by Uttar Pradesh (153,000), Assam (100,872 ha), West Bengal (42,500 ha), and Manipur (16,500 ha) [7,12]. The lower Gangetic wetlands in West Bengal are diverse, with closed and open wetlands of freshwater and brackish water origin. These wetlands, known locally as beel, baor, or jheel, serve ecological functions and provide livelihood and nutritional security [7,13] to a large population of wetland-dependent fishers, agri-farmers, livestock rearers, and other residents, both actively and passively. Wetlands are also the habitat for many small indigenous fish species (SIFS) and many endangered fish species that support subsistence fisheries and meet the nutritional requirements and hidden hunger of the local population [14]. Fisheries play a significant role in the socio-economic sustainability of rural communities by generating revenue, creating employment, and contributing to food security [15]. Despite covering a vast area, fish yield in wetlands is generally much lower than their potential. Only 12.5 percent of the vast area (0.42 lakh ha) of wetlands in the state has been brought under scientific fisheries management.

The changes in land use patterns, ecological alterations, other human activities, and the increasing demand for fish have led to the destruction of fish habitats [11,16]. This has significantly impacted ecosystem health, human livelihoods, and employment opportunities [17,18]. It has also influenced fishing effort levels and the income of rural people [19]. Furthermore, climatic variability and uncertainties have worsened the threats to fisheries production and profitability [20,21]. The eutrophication process, which reduces water flows, leads to sedimentation, depth reduction, macrophyte infestation, and area shrinkage. These factors, in turn, negatively affect fish production [11]. Consequently, rural communities have faced numerous challenges, including low living standards, limited resources, lack of basic food security, entitlement, deprivation, exclusion, inequality, and dependence [22]. As the population grows, the demand for wetland resources from various users increases, leading to conflicting levels of demand that are detrimental to entire aquatic ecosystems and their dependent fisheries [23]. Small-scale fisheries (SSF) are crucial in achieving sustainability goals, as they are better aligned with such goals than industrial fisheries. Small-scale fisheries are environmentally friendly as traditional craft and gears are used, discard less fish, have a lesser carbon footprint than industrial fisheries SSF, and have socio-cultural importance. Indian fisheries (about 81%) are composed of small-scale fisheries that provide employment, income, food, and nutritional security to the rural populace of India [24]. Religious and community belief often foster fish biodiversity conservation in India [25] as in Hinduism 'Matsya'(Fish) is the first 'Avatara' of Lord Vishnu [26].

SDGs significantly contribute to the sustainability movement, serving as a framework for many organizations across various sectors worldwide [27]. The significance of SSFs lies in their potential to provide multiple contributions to other policy imperatives that underlie the Sustainable Development Goals (SDGs), such as biodiversity conservation and human rights. The quest for equitable, sustainable development needs the identification of SDGs and the promotion of equitable and sustainable well-being for everyone [28]. This view is supported by various studies conducted by experts in the field [29–31]. Sustainability is an overarching goal with considerable long-term weight in fisheries and a long-term, overarching, and legal norm, as pointed out by Jentoft and Bosselman, respectively [32,33]. The key

challenge of sustainability is to overcome selfishness, as this is essential for safeguarding ecosystems and fulfilling the goals of economic performance, environmental protection, and social advancement [34].

ICAR-CIFRI has been working with the small-scale inland fishing community in Duma to improve their livelihood opportunities. This involves addressing the challenges and opportunities related to inland fishing. The institute is translating its technological research knowledge into place-based livelihood solutions by addressing the challenges and opportunities related to inland fishing in the area. This transdisciplinary approach involves collaboration among experts from diverse disciplines, stakeholders, and local communities to address complex socio-ecological challenges [35]. The institute has engaged with the wetland for the past four years, providing technical support with a transdisciplinary understanding of the knowledge–action interface.

It is worth mentioning that the Duma wetland's fishery is the backbone of the local community's economy. Therefore, ensuring the sustainable management of the wetland and its resources is vital to secure the community's livelihoods. This study aims to provide valuable insights into the current state of the fishery and suggest constructive ways to maintain its sustainability while supporting the local community. It also aims to explore the opportunities available to enhance the social resilience of the vulnerable community in the area. Furthermore, it emphasises the importance of transdisciplinary engagement in better understanding and addressing the existing challenges.

2. Materials and Methods

2.1. Study Area

This study focused on the Duma wetland in Gaighata block under the Bongaon Subdivision of North 24 Parganas, West Bengal, India (Figure 1), locally known as the Duma baor. The Duma baor has immense socio-economic and socio-ecological importance. It acts as a habitat of numerous wetland flora and fauna and a source of livelihood for the local community through SSF S. The Duma baor is one of the most extensive horseshoe-shaped wetlands in Asia, with an area of 257 hectares along the international border of India and Bangladesh and was created at the interface of the Ganga-Ichhamati River. The wetland gradually transformed into an oxbow lake after a 15-kilometre cut-off from the Ichhamati River. A total of 11 villages surround the wetland and are the economic backbone of the fisherfolk communities living adjoin the wetland (Table 1). Out of a total 25,675 adult population, the society has 1081 members, including 30 women with fishing rights in the baor.

Table 1. Demographic profile of the Duma Wetland surrounding villages (As per Census, 2011) [36].

Village	Total Population	Adult Population	Families
Diangamanik	1490	1343	355
Duma	2976	2639	684
Gadadharpur	2380	2164	600
Chhota Sehana	1275	1158	309
Barnagaria	4789	4361	1151
Jhikra	1968	1808	476
Noradaha	888	806	238
Byasati	325	305	85
Jhaudanga	3476	3212	839
Angrail	6978	6315	1682
Goal Bathan	1712	1564	410

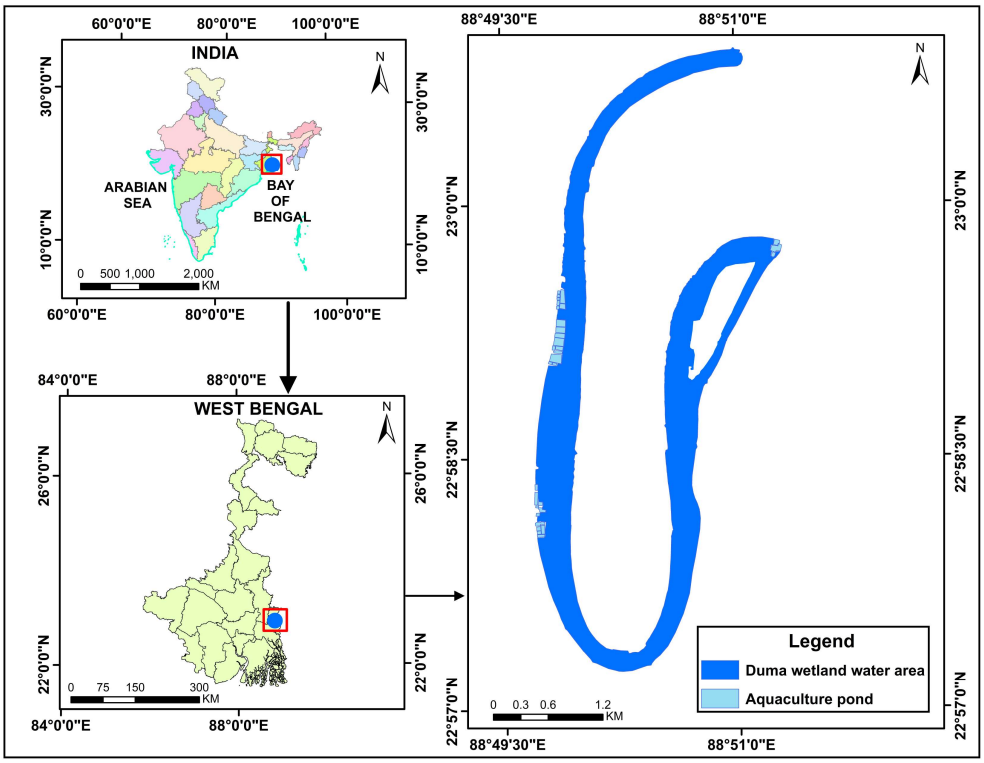

Figure 1. GIS mapping of the Duma wetland showing the total wetland area along with aquaculture ponds in the catchment area of wetland. The red box identify the position of the wetland in India and West Bengal map.

2.2. Intervention Strategy

ICAR-CIFRI has developed a strategic plan for wetland development under the SCSP project by collecting baseline data on the socio-economic profile, constraints perceived by the fisherfolk, and opportunities (Figure 2). This plan was built on a transdisciplinary approach, which involves working with the fisherfolk, community member experts, scientific resource persons, and society at large. By a participatory-transdisciplinary approach, effective location-specific management practices can be implemented, leading to sustainable and equitable outcomes for all stakeholders involved.

2.2.1. Capacity Building (Strengthening Fisher Organisations)

Capacity building involves enhancing critical aspects of knowledge and skills to develop capabilities [33]. It helps people adapt, survive, and prosper in a changing world and is a crucial element of sustainable development. ICAR-CIFRI conducted skill development and capacity building for the fisherfolk community, covering various topics like wetland fisheries management, pen culture, production enhancement techniques, feeding management, disease management, and economic management (Figure 3).

2.2.2. Community Mobilization (Mobilising Fishers to Confront Power)

Community mobilisation has two key components: participation and self-reliance. Azizan and Lyndon et al. have identified participation as one of the crucial components, while Fawcett et al. have emphasised self-reliance. Community mobilisation is a dynamic process that can influence the targeted segment of society for desired social change [37–39]. Exploring the problems and setting priorities is the most critical part of community mobilisation. Accordingly, a plan should be prepared with people's participation. Mobilisation methods can help participants work independently on fisheries management issues and actively participate in formulating management plans in their region (Figure 3).

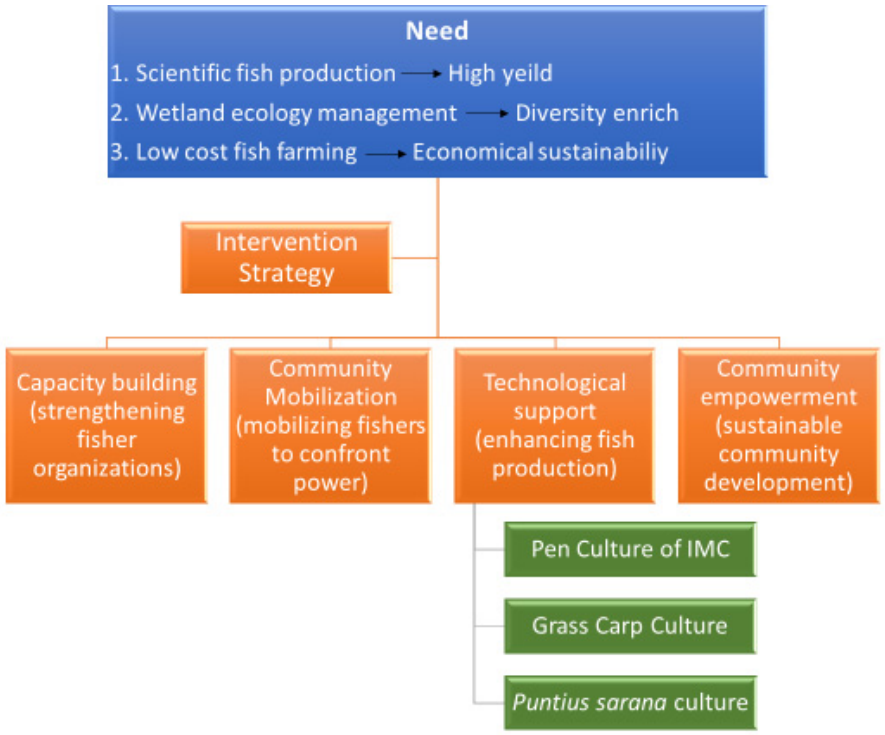

Figure 2. Intervention strategy for wetland small-scale fisheries management.

Figure 3. Community mobilisation and capacity building through a participatory approach.

2.2.3. Technological Support (Enhancing Fish Production)

Pen culture is a highly effective strategy for adapting to climate change and creating sustainable fisheries in India's floodplain wetlands. This technique involves raising fish in situ and is ideal for both culture-based fisheries (CBF) and table fish production [10,40,41]. By raising fish in situ conditions, seedlings can be grown without rearing facilities near open water bodies, and the risk of mortality during transportation of larger fingerlings for CBF can be avoided. Additionally, in situ fish rearing improves survival rates when released into the wetlands [42]. The fingerling of Rohu (*Labeo rohita*), Katla (*Catla catla*), and Mrigal (*Cirrhinus mrigala*) raising in pen up to table size and then release them into the wetland can increase the production and lower the seed raising cost also the mortality.

The grass carp (*Ctenopharyngodon idella*) is a large herbivorous fish native to eastern Asia. These fish can consume up to 100% of their body weight in macrophytes daily [43]. When they digest these plants, about 65% is broken down, and the rest is excreted as dense pellets that act as "green manure" for the water body [44]. Management of macrophytes using grass carp is effective and affordable [45]. Macrophytes are commonly available in floodplain wetlands supporting aquatic diversity, including fish. However, heavy infestation of macrophytes adversely impacts the ecosystem [46] by competing with other primary producers like phytoplankton, which is the main food for many plankton feeder

fish, and disturbing fishing operations. Due to the infestation of macrophytes in the wetlands of India, it is often necessary to remove macrophytes for the successful operation of fisheries. Biological control is preferred over manual removal for its economic and environmental benefits. Grass carp are widely used in aquaculture and culture-based fisheries (CBF) to control macrophytes and enhance fish production [47]. The grass carp will not be able to further disturb the native fish diversity as the grass carp are unable to breed in stagnant water including wetlands. They control emergent, submerged, and floating macrophytes in wetlands as a biological control mechanism. Furthermore, utilising the weed biomass, the fish protein can increase profit by 50%.

Small indigenous fish (SIFs) are an excellent source of nutrition since humans usually consume the entire fish, which is rich in nutrients [48]. The Olive Barb, *Systomus sarana*, locally known as Sar Punti, is an auto breeder and climate-smart small indigenous fish rich in micronutrients. The term "recruitment" refers to the stage where the fish reaches reproductive or marketable size. Auto-recruiting species is a sustainable way to manage wetland productivity and fisheries, which is better for livelihood security than the IMC model. SIF is crucial in reducing malnutrition and safeguarding rural communities' nutritional and economic security [49,50]. Promoting the 'Sarana Model' in wetland fisheries to increase SIF production and provide additional nutritional security to rural households.

Six Pen HDPE®, each of 0.1 ha, were installed in the wetland, and four pens were stocked with the fingerlings of Indian major carp, i.e., Rohu, Katla, Mrigal (120,000 nos. about 710 kg), and one with grass carp (12,000 nos. about 70 kg). One pen was stocked with fish seeds of climate-smart SIF *S. sarana* (19,250 nos, about 55 kg). Furthermore, with technical support and guidance, the institute provided inputs like fish feed (about 9.0 tons) and fish seed to the society (Figure 4). The institute also provided an FRP coracle (round-shaped boat) and an FRP engine boat for easy management of pens and transportation of live fish.

Figure 4. Seed stocking at the wetland.

2.2.4. Community Empowerment (Sustainable Community Development)

The small-scale inland fisheries sector is crucial to communities worldwide. A system for effective communication and collaboration is necessary to build leadership and foster cooperation. This system will help community members identify challenges, plan, implement, monitor, and improve inland fisheries management, and strengthen the community as well. "Active participation" is key to the success of this system, as it involves community members in all aspects of community mobilisation and will help create a brighter future for small-scale fisheries [51].

2.3. Data Collection Method

The study was conducted between January 2021 and July 2021 using a semi-structured interview schedule to collect primary data (Figure 5). The data collection process included interviews, focus group discussions (FGDs), and participatory observation (Table 2). After the intervention, regular monitoring and data collection continued from July 2021 to September 2023. Data were collected from 153 respondents using the personal interview method. The study focused on the socio-economic profile of the fisherfolk community and fishermen's activities, including fish harvesting, seed stocking, fish selling, and repairing

nets and boats. The interviews were held at the fishermen's house, by the side of the wetland, or at the FCS, where they spent most of their time. The collected data were necessary to obtain valuable insights about the wetland and the activities of the fishermen.

Figure 5. Data collection from the fishers.

Table 2. Different events of field research.

Techniques	Fishermen	Remarks
Participatory Rural Appraisal	25 Nos.	Each KI duration of 30–35 min
Focus group discussion	15 Nos. with 10 participants	Each FGD duration of 75–90 min
Direct observation of harvesting	Five days	Duration of each netting 3–4 h
Baseline survey	153 families	Socio-economic attributes

2.3.1. Participant Observation

Data regarding the fishing practices and characteristics of the wetland fishers were obtained through participant observation. The fieldwork in the chosen fishing village started with observing the fishermen's way of life and economic development. This observation method proved the most practical, helpful, and comprehensible way of gaining direct and confident knowledge in a natural or social environment by immersing oneself in the local cultural environment, including people's livelihood dynamics, values, beliefs, interests, and local knowledge.

2.3.2. Participatory Rural Appraisal (PRA)

A multidisciplinary team conducted open-ended interviews using a semi-structured questionnaire. The interviews lasted 30 to 45 min and were conducted with the heads of society in the wetland area and key knowledgeable people from the community. These interviews aimed to gather information on various factors such as coping strategies, livelihood diversities, fisheries resources, indigenous knowledge, conflicts, and local institutions.

2.3.3. Focus Group Discussion (FGD)

During the study, 15 focus group discussions (FGDs) were conducted with 10 participants in each group, each lasting up to 1.5 h. FGDs proved to be an effective method of collecting and verifying data related to production, changes in livelihood, coping mechanisms, ecological changes, aquatic diversity, social and economic transitions, and indigenous knowledge.

2.4. Data Analysis

The survey data were collected and organised according to the study's objectives and parameters. The information was carefully organised and interpreted according to our

objectives and parameters. Garrett's Ranking Technique [52] was applied to identify the perceived constraints of the wetland fishers using the following formula:

$$\text{Percent position} = (100\ (\text{Rij} - 0.5))/\text{Nj}$$

where Rij = Rank given for the ith variable by jth respondents; Nj = Number of variables ranked by jth respondents. Garrett's Table helps to convert the estimated percent position into scores by referring to the table given by Garret and Woodworth [52].

SWOT Analysis was performed to show the wetland fisheries' possible strengths, weaknesses, opportunities, and threats to small-scale fishermen's livelihoods. Then, statistical tools such as graphical analysis and MS Excel version 2019 were used to analyse the quantitative data collected from interviews. The resulting findings provide a comprehensive and detailed understanding of the subject under investigation.

3. Results

3.1. Socio-Cultural Characteristics of the Fishers

3.1.1. Age Structure

Understanding the age structure of fishermen is crucial for estimating the potential productive human resources in the industry. In this study, the fishermen were divided into five age groups: below 30 years, 30–40 years, 40–50 years, 50–60 years, and above 60 years (Figure 6). The results showed that fishermen in the 40–50 age group were the most active and made up the most significant percentage (30.06%) of both male and female fishermen. Conversely, the age group below 30 had the smallest number of active fishermen, as many had shifted to other occupations.

Figure 6. Gender-wise age distribution of the fishers.

3.1.2. Religion

Religion plays a vital role in shaping the social and cultural environment of different regions. According to this study's findings, the majority of respondents in the area practice Hinduism, while only a tiny percentage (0.65%) were identified as Muslim.

3.1.3. Caste

Caste is another critical factor influencing people's occupation and skill sets in rural economic activities. The study found that most respondents (86.27%) belong to the Scheduled Caste, while only 13.73% are from the general caste. As the wetland is located in the transboundary region, many of the East Bangla refugees belong to the Namo-sudra caste (scheduled caste community), especially the Kaivarta community (traditionally known for fishing occupation) from Pubra-Pakisthan/Bangladesh settled in the proximity of the wetland just after partition in 1947 and also during 1972.

3.1.4. Gender

The traditional aquaculture sector is predominantly male dominated, especially regarding essential tasks such as preparation, fingerling stocking, harvesting, watch and ward, and wholesale marketing. Women continue to bear the primary responsibilities for domestic affairs like homemaking, child rearing, and collection of resources for home consumption. The study found that women are indirectly involved in wetland fisheries and support fishing activities by preparing and mending nets (27%) and vending fish to markets (7.18%). About, 12% of women in the sampled households were involved in subsistence fishing by keeping traditional fishing traps like ghuni, chero, and banka to collect small indigenous fishes (SIFs) to feed their families. It was also revealed from the analysis of the data that 39% of the women of the sampled households used to collect aquatic organisms like molluscs, crabs, and also aquatic plants from the wetland for their household consumption and to earn their livelihoods. Thus, the women contribute to household income and food and nutritional security. In other words, women's involvement in fishing activities may likely be higher than traditionally understood since much of their activity providing for the household is invisible (Figure 7). Moreover, women's access to financial institutions, cooperative organizations, wholesale markets, policies, and schemes is often restricted, and they are subject to violence.

Figure 7. Women's involvement in SSF.

3.1.5. Educational Background

Discovering the educational background of respondents is a crucial aspect of conducting social research. According to the latest findings, only a mere 3.27% of respondents held a higher secondary and graduate-level education. In contrast, the majority, 56.86%, can read or write only, i.e., they do not have any formal education. About 9.25% were illiterate; however, the illiteracy percentage was lower than the country average (Census, 2011) (Table 3). These results emphasise the importance of providing accessible education to the masses and highlight the need to focus on increasing access to higher education opportunities.

3.1.6. Marital Status

The above study explains the marital status of the respondents, the majority, 98.03%, were married (Table 3). Among the married, 1.3% were widowers. Only 1.96% were unmarried. Arranged marriages among close relatives or sects were common in a village setting, but in the recent era, nearly a quarter of them received love marriages and love with arranged marriages.

3.1.7. Family Size

Family size is an essential socio-economic indicator that affects household income, food consumption, and socioeconomic well-being. The average family size of the respondents was four–five members (Table 3). Due to household expenses and conflicts, the respondents preferred nuclear families (head of household with spouse and children) over joint families (head of household with spouse and children, father, mother, brothers, and sisters).

Table 3. Demographic characteristics of the fishers of Duma Wetland (N—153).

Characters	Features	Frequency	Percentage (%)
Gender	Male	11	7.18
	Female	142	92.81
Educational Qualification	Illiterate	14	9.15
	Can write the name only	86	56.20
	Primary	31	20.26
	Secondary	17	11.11
	HS and above	5	3.26
Marital status	Married	148	96.73
	Unmarried	3	1.96
	Widow	2	1.3
Family member	Up to 5	100	65.35
	5 to 7	50	32.67
	>7	3	1.96
Housing Condition	Katcha	80	52.28
	Semi-pucca	53	34.64
	Pucca	20	13.07
Boat Possess	Yes	87	56.8
	No	66	43.1
Net Possess	Yes	117	76.47
	No	36	23.52
Wetland involvement	Yes	136	88.88
	No	17	11.12
Family members involved in fishing	Yes	40	26.14
	No	113	73.85
SHG Members	Yes	25	16.34
	No	128	83.66

3.1.8. Housing Condition

The type of materials used in housing can indicate the people's standard of living, social status, and financial capacity. In the study area, there are three types of houses: (1) Katcha, which are made of bamboo and tree leaves with a mud floor; (2) Semi-pucca, which are partially made of brick, either in the floor or wall, but the roof is made of wood or tin; and (3) Pucca, which are made entirely of brick (Figure 8). According to Table 3, it was found that 52.28% of the fishermen's housing conditions were Katcha and without permanent toilet facility.

3.1.9. Craft and Gear Possess

Fishermen catch fish using different types of gear, which vary by type of fishing operation and targeted species. Over half of the fishers, 56.86% have their boat. Not only that, but an overwhelming majority of fishers 76.47% have their fishing gear (Cast net, traditional trap, or Gill net) (Table 3). Sometimes hook and line are also used for small fish catch. In this wetland society, people have their own FRP (Fibre-reinforced plastic) engine boat.

Figure 8. Demographic view of the fishermen's community.

3.1.10. Livelihood Characteristics

Nine crucial factors are considered when evaluating the economic status of fishermen. These include sources of livelihood, average monthly income per individual, income generated from fishing and related activities, household expenses, land ownership, residential ownership, type of housing, assets acquired by the fishermen, source of lighting, and their standard of living. However, for this analysis, we will only focus on the sources of livelihood and the average monthly income.

To deal with the unpredictable fluctuations in the fish catch, many individuals in the wetland community have diversified their livelihoods by engaging in other income-generating activities. However, a significant portion of the community (86.92%) still depends on small-scale wetland fisheries-related sectors for their livelihoods (Figure 9). During the season maximum number of compared to the off-season fishing was the primary source of income. During the off-season, in addition to fishing, households engage in various other income-generating activities such as working as rail contractors, running grocery shops, operating as decorator businessmen, farming, and working as agricultural labourers, among others (Table 4). Some individuals (32 in total) depend partially on fisheries as a secondary source of income.

Table 4. Primary and secondary occupations other than fisheries.

Occupation	Primary (Percentage)	Secondary (Percentage)
Contractor	0.65	Nil
Grocery shopkeeper	2.61	1.31
Decorator	1.31	2.61
Agri-farmers	1.31	4.57
Agri-labours	3.27	11.12
Contract labours	0.65	8.49
Auto driver	1.31	2.61
Carpenter	0.65	1.96
Masonry	1.31	7.19
Migratory labours	Nil	3.92
Other	-	1.31

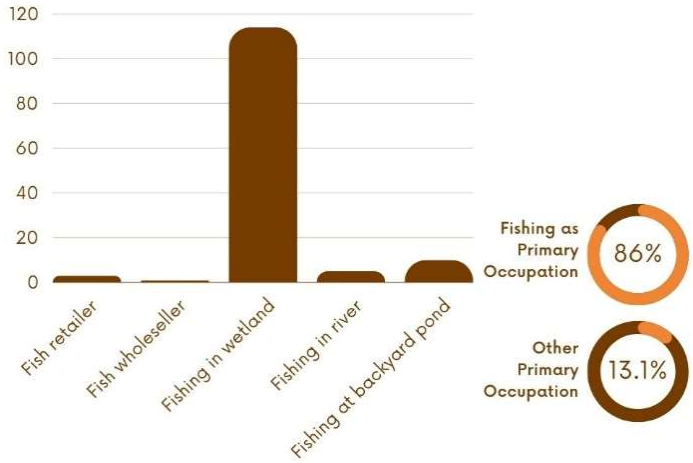

Figure 9. Small-scale fisheries-related livelihood.

3.1.11. Family Earnings and Expenditure

A family's financial well-being is heavily reliant on the income of its members. Table 5 shows a relationship between the number of earning members and the household's economic status. Shockingly, only one member contributes to the family's income in most households, 69 out of 153, to be exact. That is 45.09% of families that are solely dependent on one earner (Table 5). Another 17 households (11.11%) have three members contributing to the family income. This data emphasizes the importance of increasing financial literacy and developing multiple income streams to ensure financial stability for families. The annual income structure of the wetland fishers from fishery as a primary and secondary occupation showed that the maximum income comes from fishing as a primary along with any other secondary occupation (Table 6). But we also noticed that the maximum average income that comes from a fish marketing business is better than other occupations.

Table 5. Number of Earning Members and Family Income.

Earning Members	Frequency	Annual Income	
		Max	Min
Single-Member	69	15,000	440,000
2 Members	67	21,000	810,000
3 Members	17	28,000	844,000

Table 6. Annual income structure of different stakeholders.

Primary Occupation	Secondary Occupation	Avg. (Rs.)	Std. Dev. (Rs.)	Min (Rs.)	Max (Rs.)
Fishing	Fishing	44,164.71	29,320.01	10,000.00	115,000.00
	Others	37,802.72	24,920.79	22,000.00	180,000.00
Others	Fishery	37,500.00	24,805.75	25,000.00	124,000.00
	Fish marketing	94,500.00	57,231.98	15,000.00	110,000.00
Fish Marketing	Others	53,809.52	34,693.24	35,000.00	90,000.00

Household expenditure of fishermen refers to the annual expenses spent by each household. It includes both food and non-food expenditure. According to Figure 10, a whopping 43% of their total income is spent on daily consumption purposes alone. But that is not all, the majority of their remaining income is spent on agriculture and aquaculture inputs, including electricity and loan repayment costs. It is impressive to note that this

individual prioritized their children's education by dedicating 12% of their income towards it. Not only that, but they also managed to spend the minimum amount possible on clothing and luxury items.

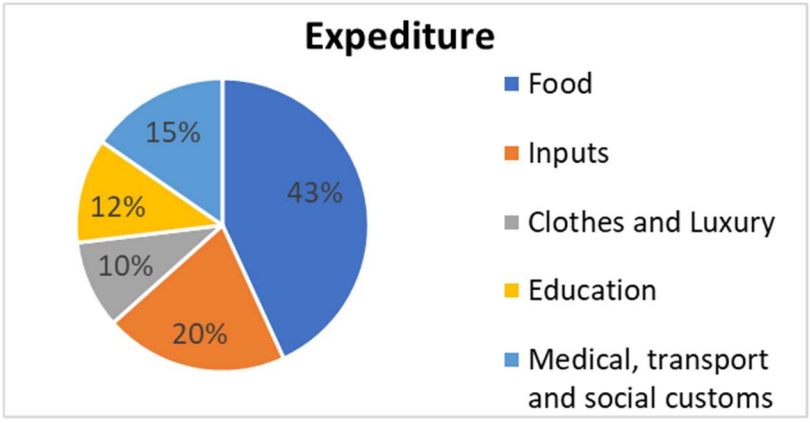

Figure 10. Annually expenditure percentage of the fishers.

3.2. Fish Production, Harvesting and Marketing

With the support of CIFRI and the help of a cooperative society, the fishermen of Duma have found ways to increase their income by raising fish in pens and releasing them into the wetland. Their hard work and perseverance have paid off, as they have harvested an impressive 64 tons of fish worth around Rs. 52 lakhs in July 2021. They have been able to harvest fish throughout the year, with peak seasons between March and May, and November and January. Their dedication has resulted in an average fish yield of 58 tons/year over the last two years. Despite facing challenges such as excessive rainfall and flooding, the fishermen have harvested 15 tons of commercial fish worth around 30 lakhs between March and May 2022, bringing their total to an impressive 79 tons of fish, giving them a benefit of Rs. 82 lakhs (Figure 11). While they could not harvest during the post-monsoon season in November 2021, their annual growth rate of fish production is around 24.19%.

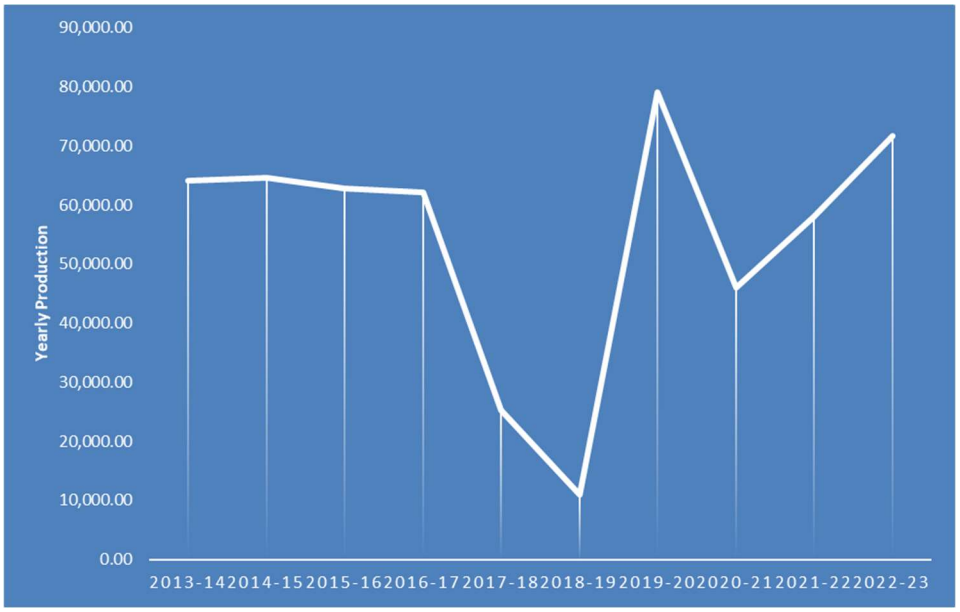

Figure 11. Annual fish production of the last 10 years.

For individual or small-scale fishing, locals rely on either a cast net, known as Khepla, or traditional traps such as Ghuni, Bitti, and others. However, for harvesting large fish like

IMC, a seine net, called Berjal, is used (Figure 12). Group fishing is often conducted using wooden plank boats, known as Donga. In addition to that, an FRP-engine boat is also used for harvesting.

Figure 12. Fish harvesting at the wetland.

There are over 500 active fishermen who regularly catch small indigenous fish. Each person catches 3–4 kg of fish, which they can sell for Rs. 600–800 ($7–9) (Figure 13). Around 16% of the small indigenous fish catch for household nutritional security, while the remaining 84% is marketed at local markets for Rs. 100–250/kg. Among these small indigenous fish species, *Puntius* spp., *Gudusiachapra*, *Mystus* spp., *Anabas testudineus*, and *Amblypharyngodon mola* hold the maximum catch. Apart from that large commercial indigenous fish species i.e., snakeheads (*Channa* spp.), *Notopterus* spp., and catfishes also form a good number of catches.

Figure 13. Catching small indigenous fish species.

Based on a survey of local retail and wholesale markets and interviews with fishermen and the general public, it can be concluded that after catching indigenous fish, fishermen keep it for their household consumption, and the rest they sell to the local market. Consumption of SIF ensures adequate nutritional security to the fishermen's community living adjoining the Duma baor. The commercial fish are sent directly to the wholesale market, known as 'Arat' in the local language. The process of getting fish from the fishers to the consumers involves passing it through a local agent or 'paiker', who then takes it to the local market, where the fish is sold by retailers to the consumers.

3.3. Challenges and Drivers of Wetland Fisheries Vulnerability

The wetland is a precious natural resource that is currently facing a severe threat. The ecosystem is degrading, resulting in a significant loss of biodiversity. Unfortunately, the high population density around the wetland has put undue pressure on the environment, and anthropogenic activities have only worsened the situation. Macrophyte infestation, jute retting, and agricultural pesticide use in the wetland water are also posing a significant challenge to the ecosystem (Figure 14). It is crucial to take urgent action to protect this valuable natural resource, and everyone is working together to preserve the Duma wetland and ensure its sustainability for future generations. However, modern aquaculture practices face significant challenges due to the non-availability of fund support and technological assistance from the government and NGOs. The Garrett Ranking tool (Table 7) categorizes the constraints wetland aquaculture practices face. The constraints are ranked between

one and ten based on data collected from the wetland fishers. Jute retting and sedimentation resulting in water depth reduction are the critical constraints for wetland fisheries management.

Figure 14. Constraints in wetland fishery.

Table 7. Rank of all constraints observed for wetland fishing (n = 153).

Sl. No.	Constraints	Total Score	Avg. Score	Rank
1.	Climate change	6290	62.9	IV
2.	Land use conflict	6272	62.72	V
3.	Lack of management policy	5045	50.45	VIII
4.	Sedimentation	7403	74.03	II
5.	Agriculture waste deposition	5514	55.14	VI
6.	Macrophyte infestation	6697	66.97	III
7.	Jute retting	7684	76.84	I
8.	Non-availability of fund	4193	41.93	IX
9.	Income reduction	5245	52.45	VII
10.	Social and political conflict	3331	33.31	X

SWOT analysis (Figure 15) highlighted small-scale wetland fisheries' strengths, weaknesses, opportunities, and threats, helping to make decisions. With this information, one can capitalise on the strengths and opportunities, while minimising the weaknesses and threats to ensure sustainable and profitable fisheries. While it may not be possible for all situations to apply simultaneously, going through the mentioned points can help identify the situation that is unique to an individual. SWOT (strength, weakness, opportunity, and threat) analysis was also conducted through a focused group discussion method in the presence of community leaders and experts [53]. Strength is an aspect that makes the situation more promising, and weakness is a limitation within the situation that will prohibit it from accomplishing its objectives. Opportunities are any favourable perspective, and threats are unfavourable conditions that are harming its capacity. Through focused group discussion, seven areas were identified for strength, seven areas for weakness, seven areas for opportunity, and eight areas for threats were identified.

Small-scale fisheries in the wetland are facing significant challenges that threaten the livelihoods of the fisherfolk. A decline in fish catches, marginalisation, high dependence on fisheries, and environmental changes are the most common drivers of vulnerability (Table 8). The drivers were identified through a stakeholder's approach, where the stakeholders analyse the major drivers of ecological, anthropogenic, social-ecological, and technological vulnerabilities related to small-scale wetland fisheries and their impact.

Table 8. Main drivers of vulnerabilities of small-scale wetland fisheries.

Types of Drivers	Drivers of Vulnerability	Description	Impact on Fisheries
Ecological	Sedimentation	Water depth reduction A thick layer of bottom sediment Accumulation of bio-waste	• High BOD • Biogas formation • Reduce production • Fish disease outbreak • Flood occurrence
	River dis-connectivity	No connection with the original river	• Biodiversity loss
	Aquatic weed proliferation	Water area decrease	• DO decrease • Bio-waste creation • Small fish gill chocked • Less access to fishing grounds
Anthropogenic	Pollution	Plastic Agricultural waste/pesticide pollution Jute retting	• Water quality degradation • Energy depletion • Slower growth • Decrease ova count and fertilisation rate • Fish mortality
	Habitat destruction	Changes in water and soil quality	• Loss of breeding ground • Reduce production
	Human habitat expansion	Changing the land use pattern	• Catchment area reduction • Human activity increase
	Climate change	Flood Drought High temperature Late monsoon	• Breeding problems • Low survivability • Loss of fish stock • Water quality changes
Social and economical	Marginalisation	Prioritising other activities than SSF	• Governance issues • Conflict over resources • Management issues
	High dependence on fisheries	Fishing is the primary source of nutrition and employment	• Over-exploitation • Loss of bio-diversity • Low income
	Lack of fund	No proper funding support	• Obstructions on high production • Obstructions on modern aquaculture practices
	Increasing input costs	Feed cost Fish seed cost Medicine cost Labour cost Fish raising cost	• Less feed used • Less growth • Low production
	Increase seasonal fishers	Migrant fishers for a particular season	• Lower income • Increase in fishing pressure
	Property rights	Fishers remain underrepresented	• Conflict over the natural asset
Technological	Policy and regulations	No proper wetland conservation rules	• Management issues
	Poor infrastructure	Poor access to knowledge Poor access to technology	• Less production • Decreasing biodiversity

Traditional fishers face the risk of losing their source of income and food security due to the decline in fish catches. Environmental changes, such as temperature anomalies and variations in the duration of rainy/dry seasons, have shifted the patterns of fish species abundance and distribution, leading to a decrease in the productivity of fish stocks. This has resulted in poor governance over resources and feelings of powerlessness among the fishing community.

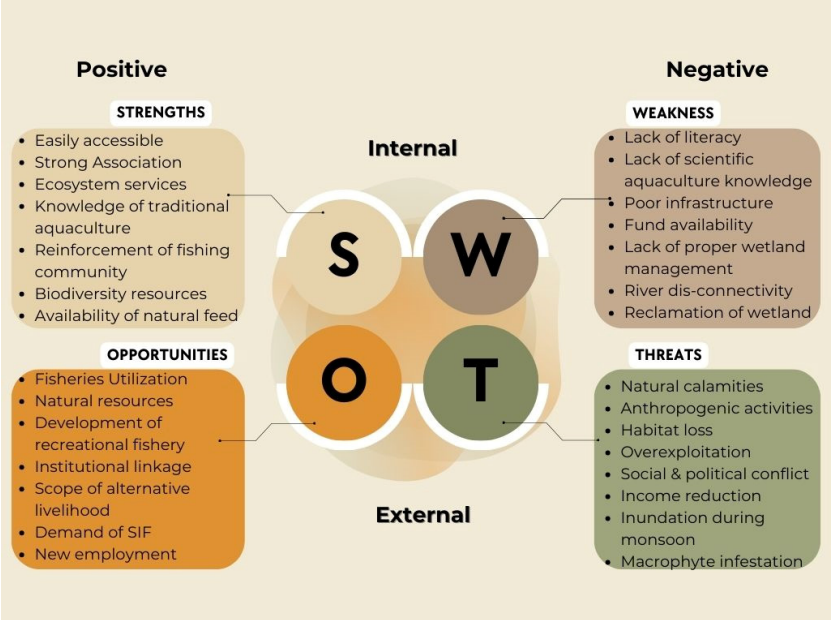

Figure 15. SWOT analysis of wetland fisheries.

Moreover, high dependence on fisheries makes fishing households more vulnerable to the effects of these challenges. They rely heavily on fisheries for income, employment, and nutrition and lack of assets or savings, makes them more reliant on daily fish catches to secure their livelihoods. It is crucial to address these challenges by creating alternative livelihood opportunities, promoting sustainable fishing practices, and improving governance over resources. Failure to perform so could have severe consequences for the fishing communities and the broader ecosystem they depend on.

Coping strategies, or different ways to tackle difficulties in SSF, were documented in Figure 16). All coping strategies were associated with the adaptive capacity dimension of vulnerability.

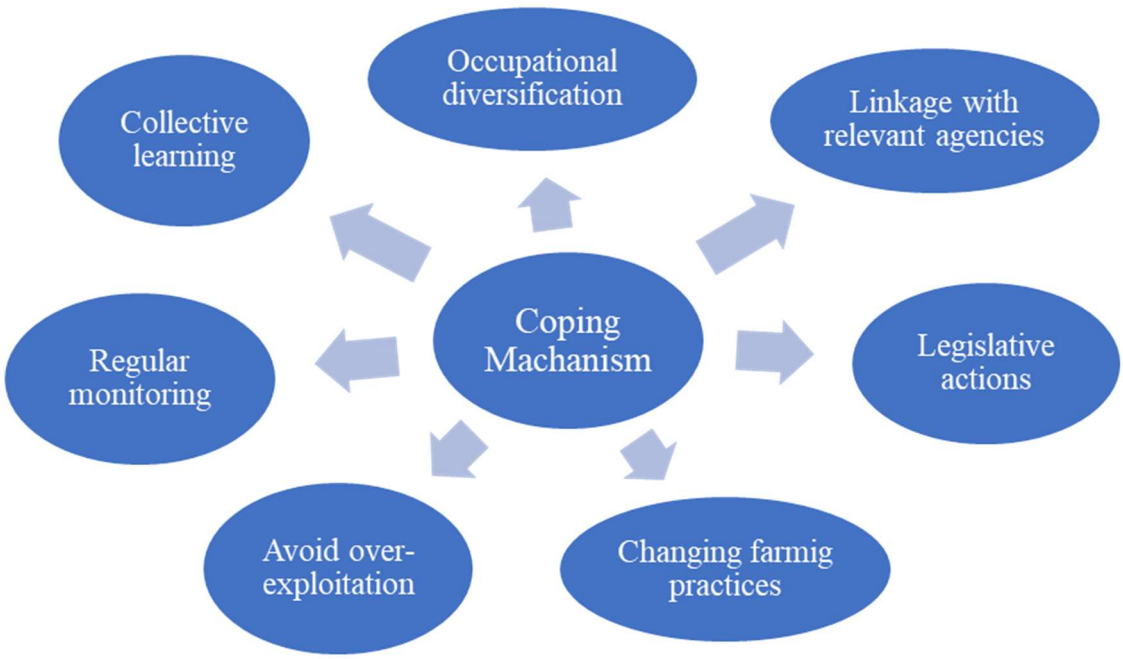

Figure 16. Main coping strategies for Small scale fisheries vulnerability.

4. Discussion

4.1. Approach Need for Community Participation in Wetland Fisheries Management

The participatory approach to wetland fisheries management is crucial in ensuring this vital ecosystem's sustainability and conservation. This approach involves working alongside local fishermen communities who rely on the wetlands for their livelihoods. By encouraging community participation and involvement, outside organisations can develop and implement effective management strategies that benefit both the environment and the people who depend on it. In this wetland, the local fishermen have taken it upon themselves to install pens and release fingerlings, contributing significantly to aquaculture production enhancement (Figure 17). They have also played a vital role in raising awareness amongst the local population about wetland conservation. Additionally, they have made it a point to use separate areas for jute retting, demonstrating their commitment to sustainable and eco-friendly practices. Therefore, it is essential to prioritise this approach as it fosters a sense of ownership, accountability, and responsibility toward the conservation and sustainable use of wetlands resources.

Figure 17. Participatory approach to wetland fisheries development.

4.2. Probable Wetland Conservation Strategies

- It is essential to achieve a balance between the environment and the population for sustainability.
- Local communities should be more aware of proper waste disposal methods, including agricultural and domestic waste, and avoid practicing jute retting.
- The cooperative society should focus on sustainable fishing and aquaculture that allows for maximum profit while maintaining the fish population properly.
- Regular monitoring and analysis of water quality, and hence, developing a database for risk evaluation, are essential for wetland water.
- Banning the use of plastics to protect the environment.
- Awareness should be raised about ecosystem services or biodiversity that exist in wetlands for the general public.
- Enhanced collaboration among communities, fishing associations, and stakeholders is crucial for better management and as well as economic upliftment.

According to a recent survey, most people engage in fishing due to their family traditions, the practice of collecting traditional food for home consumption, and the provision of cheap food options. However, the depletion of fisheries resources due to human and natural factors is a pressing concern [54]. The floodplain wetlands of India are productive ecologically as well as economically and provide vast amounts of goods and services to the population inhabiting the wetland ecosystem [10,16,55,56]. Despite being a highly productive ecosystem for fisheries and livelihood support, wetlands are vulnerable and facing challenges due to severe human activities and climate change [10]. Loss of habitat, breeding, and spawning grounds have led to a reduction in fish catches, resulting in people being forced to change their livelihoods and migrate away from their homes. Extreme climate changes are projected to profoundly impact wetland fisheries [9]. The geographical isolation supports biodiversity against anthropogenic activities despite being vulnerable to

natural disasters [57]. Anthropogenic pressure on wetlands is direct and indirect, leading to over-exploitation, pollution, denitrification, etc. [58,59]. Stakeholders from all walks of life must come together to address these challenges and ensure the long-term preservation of this natural treasure. The future of our communities and our planet depends on it. The anthropogenic impacts remain significant challenges in many parts of the world [60]. The fishermen of the cooperative society's hard work and dedication have paid off, and their success story inspires others. By working together and finding innovative ways to increase their income, they have created a sustainable livelihood for themselves and their families.

Women have significant contributions in small-scale fisheries activities including production role (net repairing, SIF collection, fish seed collection, marketing, etc.), reproduction role (household chores, caregiving to old and children), and community role (SHG group activities, social participation, etc.) [61]. The fisheries sector has a long-standing issue of gender inequality, where women have been denied equal opportunities to participate in all aspects of the industry. Despite women making up approximately 11% of fishers in small-scale fisheries (SSF) and 46% of the total SSF workforce, their contributions are often overlooked and not reflected in fisheries statistics [62–64]. Despite playing a crucial role in strengthening household resilience through their food security and income contributions, women are frequently excluded from decision-making processes [65,66]. The fourth Principle of "Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries" by FAO, 2015 states "Gender equality and equity are fundamental to any development. . . [and] Recognizing the vital role of women in SSF, equal rights and opportunities should be promoted". Therefore, to attain SDG 5, gender barriers should be identified, and gender mainstreaming should be included in SSF development strategies, discrimination should be eradicated, equal rights and opportunities should be promoted, and women involved in SSF should be acknowledged [67,68].

The study highlights the glaring issue of illiteracy rampant in fishing families. Fishermen are now sending their children to school, recognising the importance of education. Their commitment to investing in their children's future is a true inspiration. Sadly, poverty still poses a significant challenge, preventing most children from completing their education beyond the Secondary level. Social participation is a vital component of the fishing industry's success. The study defines it as the degree to which respondents are involved in formal organisations as members or office bearers, attending meetings regularly. The fishers attended meetings regularly organized by their respective cooperative societies. Building and maintaining stakeholder relationships is crucial for establishing trust, commitment, respect, leadership, and shared values. These qualities, in turn, lay the foundation for effective governance [69]. Most fishermen have no formal training in fish farming. The fishery is a specialised profession that requires skill and experience. While traditional knowledge passed down from ancestors is valuable, embracing better management practices, scientific culture-based fisheries, and inland water management is crucial. It is time for the fishing industry to invest in training programs to equip fishermen with the necessary skills and knowledge to thrive in the modern world.

5. Conclusions

Fisheries is undoubtedly a profitable sector that requires proper skills and business strategies. This article mainly emphasizes the importance of SDGs 14 and 12, addressing the key challenges of small-scale fisheries, ecosystem vulnerabilities, and the necessity of sustainable fishing practices. The healthy ecosystem not only nurtures rich aquatic diversity but also enhances the well-being of communities reliant on wetlands (SDG 3). The socio-economic condition of the fishers significantly influences wetland fisheries management and fishing practices. Therefore, educating and engaging fishers, particularly in wetland fisheries management, can contribute to developing wetland fisheries. It is crucial to preserve and sustain the wetland for the benefit of future generations. The active participation of all stakeholders is vital for the ecosystem conservation of the Duma wetland. Working together, will not only protect this invaluable biodiversity but also enhance the

livelihoods and nutritional security of the local people directly supporting the goals of SDG 2. Furthermore, it actively promoted the sustainable use of fish resources, ensuring long-term health and enhancing food security for future generations. Promoting gender equality in the small-scale fisheries sector, as outlined in SDG 5, requires comprehensive strategies that involve policy reforms, community sensitisation, and specific initiatives to recognise and support the crucial roles women play in this sector. Capacity building of wetland stakeholders is vital for the success of this process. In conclusion, increased government involvement is necessary to provide better incentives to the fishing community, allowing them to support themselves and contribute to the nation's well-being.

Author Contributions: Conceptualization, B.K.D.; methodology, A.R. and P.K.P.; formal analysis, S.B. and A.S.; data curation, K.M., A.S. and S.C.; writing—original draft preparation, A.R. and S.B.; writing—review and editing, P.K.N.; visualization, A.R., P.K.N. and S.B.; supervision, P.K.P. and L.L.; project administration, B.K.D. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Acknowledgments: The authors acknowledge the Indian Council of Agriculture Research for supporting the work.

Conflicts of Interest: The authors declare no conflicts of interest.

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