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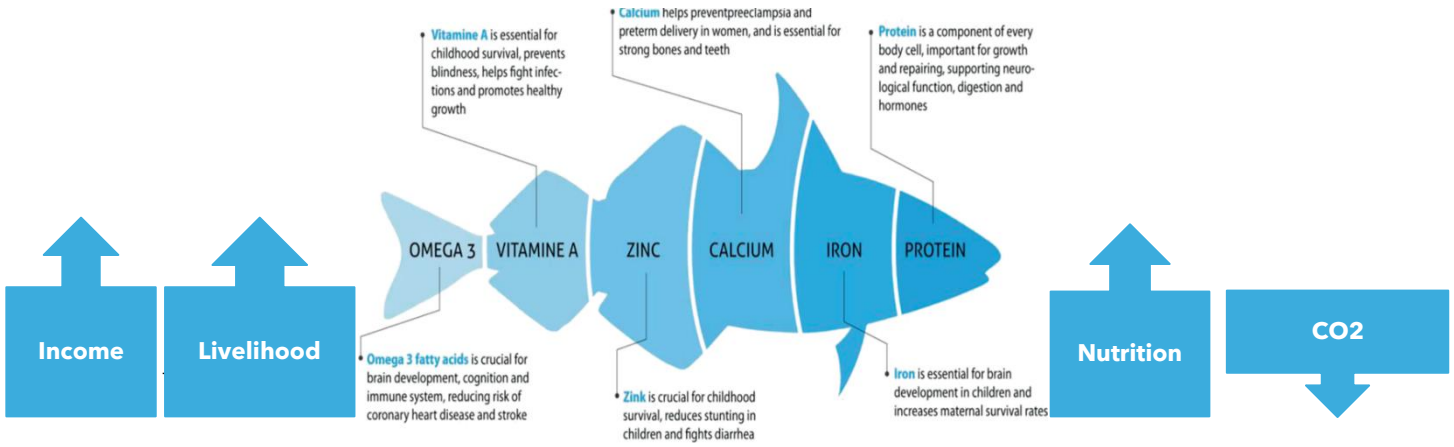
December 2024



Authors

Ayan Samaddar[1], Meghajit Shijagurumayum[2], Smitha Krishnan[2], Nirmallya Mandal[3], Sudharsan Malaiappan[4], Gulshan Borah[4], Arun Padiyar Panemangalore[1], Gopal Kumar[4]

[1] WorldFish, India
[2] Alliance Bioversity International – CIAT, India
[3] Ecociate Consultants Private Limited
[4] International Water Management Institute, India

Contents

Overview

Malnutrition is a serious issue in Madhya Pradesh since the state has one of the highest rates of undernutrition in India. Here, some of the main threats to people's health and nutritional security are dietary deficiencies in iron, calcium, zinc, protein, and vitamin A. In Mandla, these problems are likewise at an alarming stage. This district is regarded as one of the least economically developed area in India and relies mostly on a variety of rainfed agricultural and forest goods for its livelihood and household nourishment. Aquatic foods (especially animal-based), might be a helpful way to address challenges related to economic development and malnutrition. The increasing fish production and shifting dietary preferences within the community, particularly the inclusion of non-vegetarian food items, indicate a favourable opportunity to enhance the aquatic food system in Madhya Pradesh. Hence, comprehending the aquatic food systems rooted in the diverse water resources of Mandla, a distinctive landlocked region, could unveil a novel and previously underexplored avenue for development.

Study design

A qualitative survey and a knowledge-sharing workshop were held to collect data from 167 pertinent stakeholders of Mandla's aquatic food systems, while a quantitative survey method was used to collect data from 400 households directly involved in capture fisheries or aquaculture. The primary goal is to gather and examine data regarding the following issues:

(i) Types of aquatic food systems and involved resources

(ii) Impact on human nutrition and livelihood of diversified aquatic food systems

(iii) Involved techniques

(iv) Associated problems

(v) Human responses to stresses, and motivational forces

(vi) Recommendations

Key outcomes

Fisheries have long been a fundamental aspect of Mandla's cultural heritage. The district has 50 reservoirs and 1321 ponds, minor water bodies, and tanks, totalling an effective water area of 2864.43 hectares, which facilitate the production of aquatic food. Furthermore, the region contains 325 km of the river Narmada used for capture fisheries, which is Mandla's main source of aquatic food. A total of 72,000 individuals (F: 32400, M: 39600) were involved in pisciculture and capture fisheries.

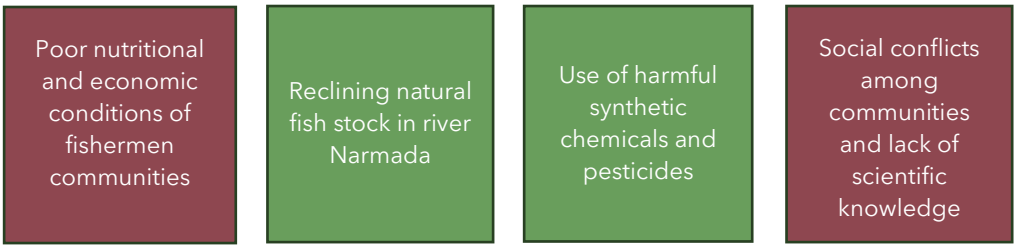


Figure 1 Key challenges with Mandla's aquatic food systems

In the investigated area, 27 different aquatic foods and 8 different types of aquatic food production systems were found. Every type of the many aquatic food systems faces unique difficulties. The current findings show that fishermen's communities are facing significant challenges in securing their basic household income and nourishment while contending with environmental catastrophes like floods and droughts. The productivity and general performance of pisciculture producers are negatively impacted by inappropriate practices due to lack of scientific knowledge and the unavailability of standard-grade farm inputs, particularly fingerlings (Table 1). Water chestnut producers and others engaged in synthetic chemical-based farming were putting the environment at risk and rendering the system entirely unsustainable due to the continually increasing cost of pesticides. Significant female involvement is a positive sign of gender parity; however, their methods are incorrect because they use artificial inedible chemicals during fish, threatening human health directly. Community-based aquaculture is also suffering because of social strife. This highlights several areas that require strong developmental backing (Figure 1). Engagement of women is significant in the district in fish selling and post-harvest management, and often in capturing fish in some villages. Nonetheless, it is evident from the evidence currently available that the ecosystem of Mandala has enormous potential for a productive aquatic food system, and with scientific direction, it can realize its full potential and assist people in improving their nutrition and livelihoods while also supporting sustainable development with need for a Gender Equality and Social Inclusion (GESI) and youth based focus to internalize the marginalized. This typology could be a helpful piece of evidence for researchers, decision-makers, and development organizations who wish to leverage Mandla's abundant water resources to construct a multifunctional landscape shortly.

Key words: Economics, Nutrition, Aquatic Foods (AF), Resources, Opportunities

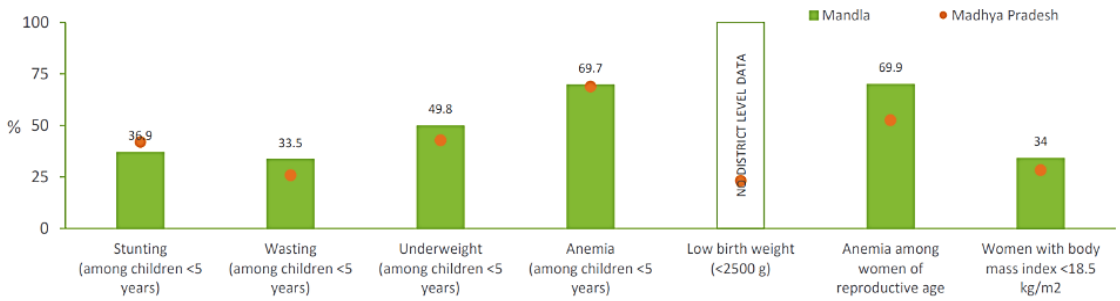


Figure 2 : Undernutrition related major issues in Mandla (Nishmeet et al. 2022)

1. Introduction

Aquatic food systems hold great promise as a catalyst for change in the direction of a more sustainable global food system. Over 800 million people in developing nations depend on aquatic foods for their livelihoods, food, and nutrition security. Plants and animals raised in or collected from water, as well as their synthetic by-products, are considered aquatic foods. Compared to crops and livestock cultivated on land, aquatic foods produce lesser quantities of CO2, making them more environmental friendly. Utilization of aquatic foods to combat the malnutrition-related problem that is becoming prevalent in many developing nations (Golden et al. 2021) involves leveraging their rich nutrient profile, including omega-3 fatty acids, essential vitamins, and high-quality proteins, to address dietary deficiencies and improve overall food and nutrition security for vulnerable populations. The aquatic food system encompasses the intricate network of components and activities related to aquatic foods, as well as elements of the larger social, economic, and environmental contexts in which they are entrenched (Hicks et al. 2022). Addresses issues such food security, public health, nutrition, social and economic prosperity, and environmental sustainability, ultimately covering the full production to consumption cycle. The complexity of this system arises from the interplay of various components and procedures involved in the production, processing, distribution, marketing, preparation, and consumption of aquatic foods. These processes vary depending on geographical location, resource availability, and usage processes over time and across spatial scales (Fanzo et al., 2017).

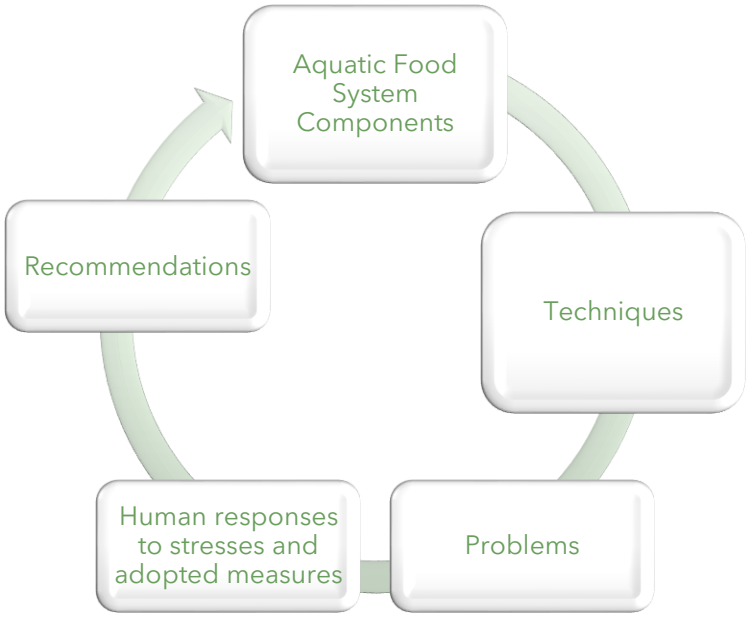
Madhya Pradesh has among of the highest rates of undernutrition in India, making malnutrition a critical concern of the state. Dietary deficits in iron, calcium, zinc, protein, and vitamin A poses major risks to people's health and nutritional security (Negi et al. 2024). Among the several consumable non-vegetarian food items, aquatic foods (especially animals) offer a promising solution to address these problems. The state's rising non-vegetarian diet consumption rate (53.6% of women and 66% of men) indicated potential for incorporating aquatic animal-based foods into diets (Ferry 2024). This increased demand and changing dietary preferences might have pushed the state's fish production, which has grown from 43,419 tonnes to 2,93,008 tonnes between 2017–18 and 2021–22 (Government of India 2022).

Mandla represents a unique land-locked regions in Madhya Pradesh with significant potential for aquatic food systems. The district, one of the least economically developed locations in the state relies on rain-fed agriculture, forest product sales, and wage labour for livelihood including labour migration. Malnutrition is prevalent in Mandla the prevalence of anaemia, stunting, wasting, and underweight children under the age of 5 years (Chourasia 2020) (Figure 2). According to the National Family Health Survey, 2019-21, 33% of children under the age of 5 years are malnourished and underweight and 32.1% show growth delay (Maliappan et al. 2024). Among the Baiga tribe about 76% of people had a BMI below 18.5, a sign of a long-term energy deficit (Chakma et al. 2009). These issues are linked to dietary deficiencies, socioeconomic status and literacy rate (Jhariya 2019). These health problems may certainly be resolved by emphasizing local food production and nutrition through climate-resilient landscape management techniques.

In Mandla, aquatic foods (especially fish) have long been regarded as a staple diet. Mapping the diversity, availability, involved resources, linked economics, and social intricacy of the aquatic food system may help us to gain a better understanding of their potential for addressing nutritional and economic security and inform policies and interventions. Typologies provide a framework for classifying and arranging things based on their commonalities, by considering key elements (described earlier) of a food system. This approach helps to pinpoint areas with interconnected food systems and related resources that might be more susceptible to similar institutional or technological advancements or policy initiatives, as well as shared drivers of nutritional, social, economic, and environmental change. Additionally, it can assist in defining the limits beyond which learnings in one context may not transfer well to another, thus enabling systematic ordering of regional adaptation knowledge to benefit developmental initiatives centered on aquatic food systems (Marshall 2021). However, considering Mandla's increasing interest in alternate farming systems for addressing the region's environmental, socioeconomic, and malnutrition-related issues, this might be an appropriate situation to construct aquatic food systems typologies. Since this study is the first of its kind in the area, it will create a vital baseline by identifying pertinent resources, production characteristics, and obstacles-related information, that is currently missing in the region.

2. Design of the study

The study's design began with the identification of the aquatic food system components, involved technique, associated problems, human responses to stresses, and motivational forces, recommendations and methodology used to evaluate the impact, has been portrayed in Figure 3.



Methods

- **FGD**
- **KII**
- **KAP**
- **Workshop**

Figure 3 Design of the study

3. Study area

The study area was chosen by locating places with a wealth of water resources that could sustain a variety of aquatic food systems. Approaches based on GPS navigation and literature search have been used for this. The CGIAR Initiative on Agroecology's partner organizations, PRADAN, FES, and Ecociate, as well as local stakeholders, including government departments and non-governmental organizations, later corroborated this to verify that all system components of aquatic foods were available in the selected region. Narayanganj (Latitude 22.76354/ Longitude 80.29352), Mandla (Latitude 22.72196/ Longitude 80.34237), and Bichiya (Latitude 22.5792/ Longitude 80.71503) blocks have been selected for this study based on such search and verification (Figure 4). The specific rationale behind selecting these regions is depicted in Figure 5.

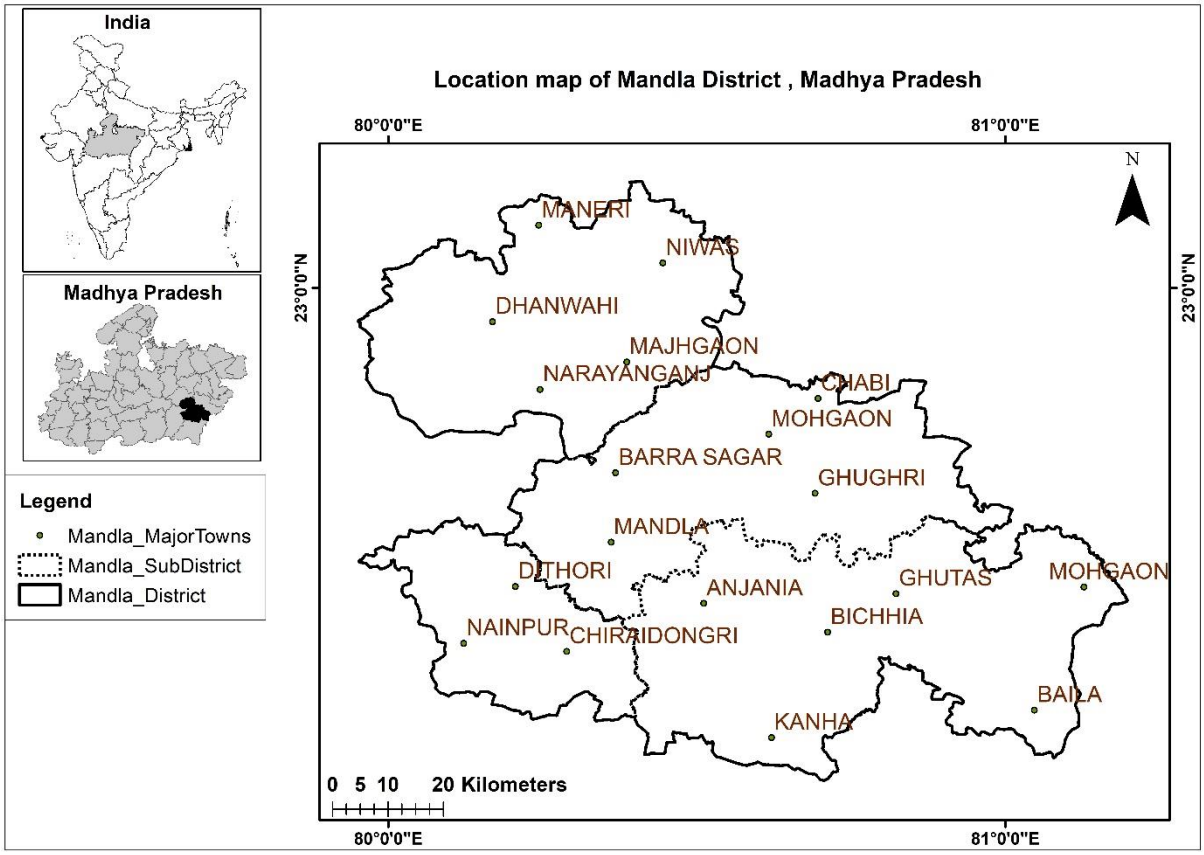


Figure 4 Study locations in Mandla

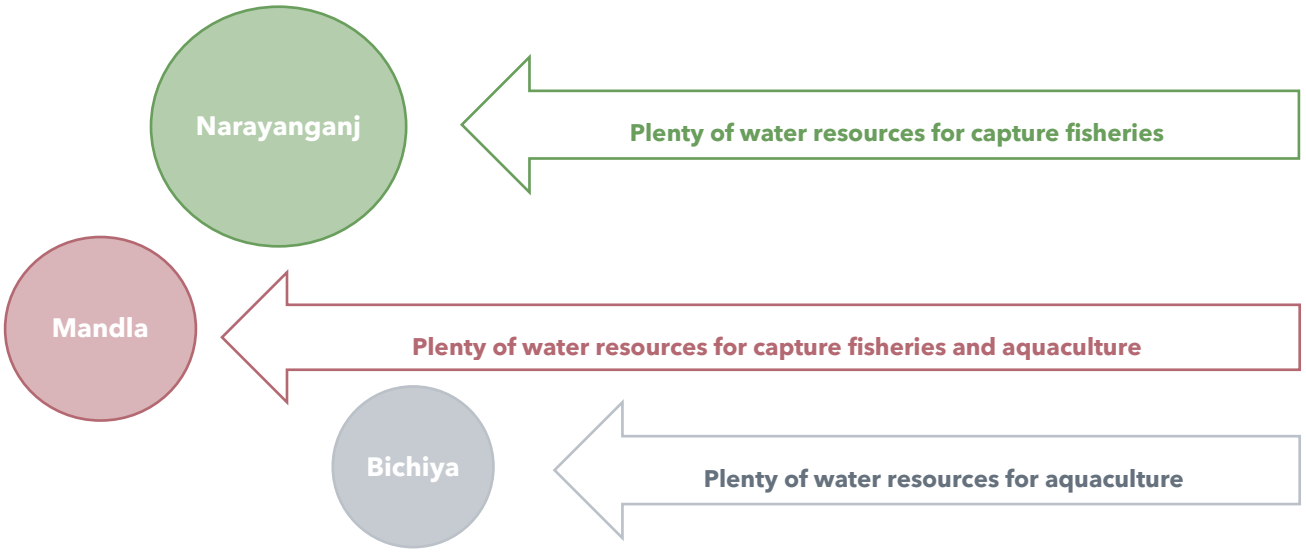


Figure 5 Reason for selection of study region

7.1 Demography

Mandla is located between longitudes 80°18' and 81°50' East and latitudes 22°02' and 23°22' North. The district is 5800 square kilometers and is situated between 443 and 1,100 meters above sea level. Mandla is made up of 1,221 villages, 6 Tehsils, and 9 blocks. The district's literacy rate is 68.28% on average (men 79.49% and women 59.20%). The district has 10,54,905 population, which is 1.45 percent of the state's total population (https://mandla.nic.in/en/about-district/). Approximately 87% of the people lived in rural areas, among which 58% of the population was classed as a scheduled tribe (ST), and another 4.6% as a scheduled caste (SC). Mandla is one of the state's tribally dominated districts, and the ethnic tribes of the Gond and Baiga coexist here alongside other social groups that are economically disadvantaged (census 2011). Mandla was listed as one of the 250 most backward districts in the nation (out of 640) by the Ministry of Panchayati Raj in 2006 (Prasad 2023).

7.2 Environment

The district has a continental climate, meaning that summer temperatures are high and winter temperatures are extremely low. Mandla receives an average of 1427.7 mm of rainfall a year, with the monsoon season, which runs from May to August, having the highest total. Summer (March to April) is the driest time of year, with relative humidity often falling below 25%, compared to over 75% in other seasons. The year is divided into four separate seasons: the southwestern monsoon season, which lasts from mid-June to September; the post-monsoon or retreating monsoon season, which lasts from October to November; the cold season, which lasts from December to February; and the hot season, which lasts from March to mid-June. In general, January is the coldest month of the year. The temperature starts rising from February and summer season, which runs from March to June, May is the hottest month, with average daily maximum temperature of 42.3 °C, the highest daily temperature reaching up to 47.7 °C (Maliappan et al. 2024).

Climate change is likely to increase the unpredictability of weather patterns, including the increased frequency of extreme seasonal variations. An investigation based on the Climate Vulnerability Index (CVI), which considered social, economic, agricultural, water resource, forest, and climatic aspects, found Mandla among the badly affected regions. The district's vulnerability is primarily caused by drought, increased temperatures or extreme heat events, and untimely precipitation. The prolonged drought is the most urgent of these problems, in some specific regions of Mandla. Crop losses, damages to houses, limited availability of drinking and irrigation water, and increased vulnerability to household food security are some of the ensuing consequences of climate stress in the region. Mandla faces a challenging situation due to climate change that impacts several areas that are essential to the well-being of its residents (Sushant, 2013).

7.3 River system

Fortunately, the Narmada River and its tributaries almost entirely encompass the district and known as the Mahakoshal region, which guarantees Mandla's seasonal water supply. The Narmada River basin, which includes the south-western portion of the Wainganga sub-basin, the south-eastern portion of the Son sub-basin, and the south-eastern portion (Seonath sub-basin) of the Godavari basin, occupies a significant portion of Mandla District. The Narmada collects water from its tributaries, Banjar, Burhar, Kharmer, Kikara, and the Gour, and flows through the majority of the district. The Tar, Seoni, Chakar, and Machrar are significant southern tributaries. The Narmada typically flows between high, rocky banks along its winding journey through the district, except for a brief stretch close to Mandla, when it passes across fertile, rich plains. Thawar and Alone are two of the rivers that drain the southwest part of the district and are not part of the Narmada system. The Johilla, which empties into the Rewa plains, the Mahanadi, which rises from close to Shahpura, and the Wainganga unite to supply water to the district's north and northwest. Figure 6shows the mosaic created by the river system of the Mandla.

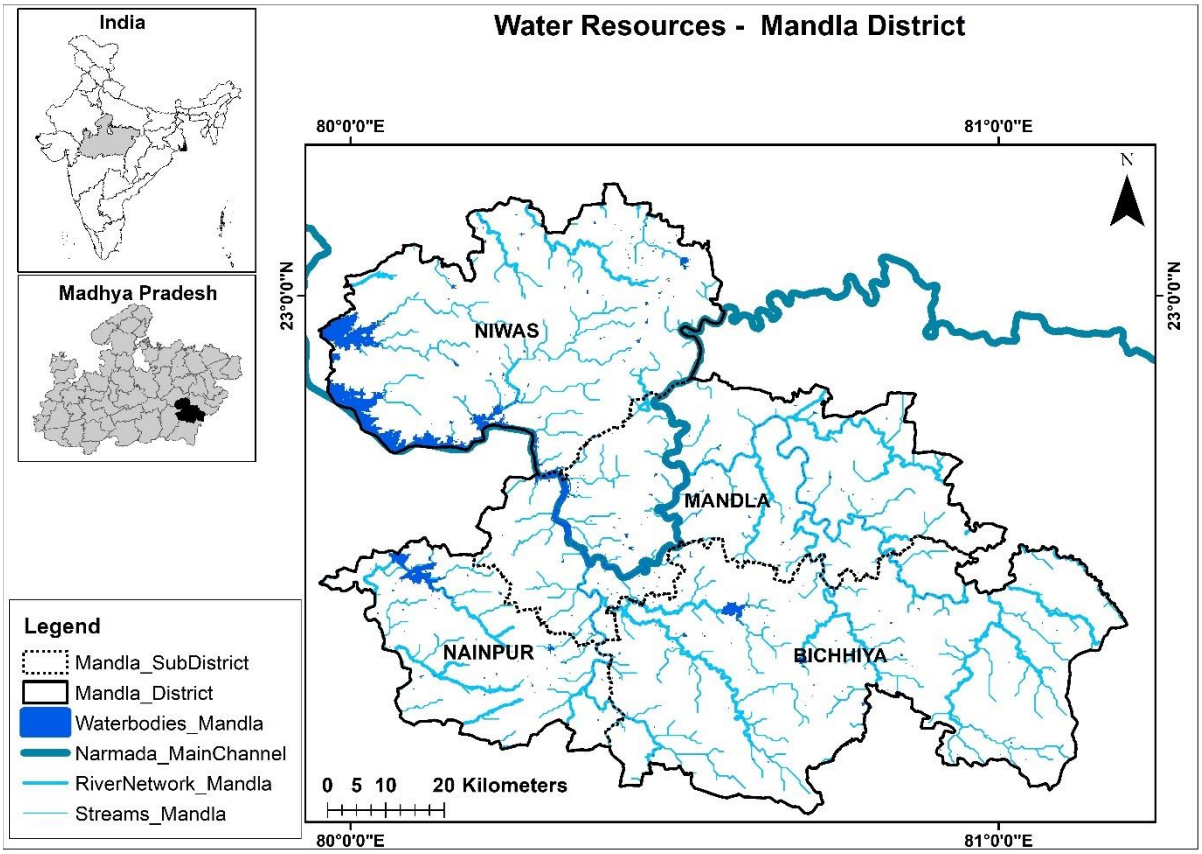


Figure 6 Map of water resources in Mandla (Maliappan et al. 2024)

7.4 Livelihood

In Mandla, 30% of farmers are marginal, 16% are small, and 54% are landless and poor. It is one of the few districts in Madhya Pradesh where 40% of the workforce is employed in agricultural labor, with only 15% of the workforce engaged in non-agricultural labor among the farming communities. For a certain period in a year, rain-fed farming provides the necessary food to the communities. And for the other period, residents rely on selling forest products and other jobs, including daily waged labor often outside their settlements. Approximately 28% of overall revenue comes from the sale of forest products, the second largest income generation source in Mandla after agriculture. Among agriculture cultivation of coarse millets, pulses, cereals, groundnuts, and cash crops such as cotton, sugarcane, and oil seeds are prominent. Other auxiliary activities including fisheries, dairy, goatery, poultry, piggeries, and other related businesses significant contribute to rural livelihood and the food system. While non-tribal communities are primarily involved in paddy, wheat, maize, and vegetable cultivation, fisheries, goatery, dairy, etc., tribal communities are primarily involved in NTFP (non-timber forest product) collection, paddy and maize cultivation, goatery, backyard poultry, piggery, etc. Mahua, Tendu leaves, Tikhur, Harra, Chironji Bel Guda, Palash, Lakh, Amla, Bahira, Bhelma, Chirota, Safed Musli, Kali Musli, are the primary NTFPs that the communities collect. (https://www.nabard.org/auth/writereaddata/tender/2009161010Livelihood_mapping_in_Mandla_MP.pdf).

7.5 Fisheries context

Fisheries have long been a fundamental aspect of Mandla's cultural heritage, wherein fish are traditionally caught or harvested by both male and female family members from various water sources using indigenous knowledge techniques. The 325-kilometer network of rivers (11 rivers) in Mandla is used for capturing fish and about 1338 numbers of impounded water resources (ponds, tanks etc.) totalling an effective water spread area of 2864.43 hectares, are being used for aquaculture. Additionally, there are 52 minor dams, two medium dams, and one large dam where community organizations and cooperatives conduct fishing operations. There were 98 numbers of cooperative societies called Sehkari Sangh/Samiti involving around 3195 people in fisheries activities. A total of 72,000 individuals (F: 32400, M: 39600) were involved in pisciculture and capture fisheries. Rural communities, particularly Dhimar, Kewat, and tribal depend on fishing for both self-consumption and revenue. Mandla's overall average fish productivity is only 60 kg/ha, which is significantly less than the usual productivity in other pertinent Indian locations. Nonetheless, the region was able to produce 6138 metric tons of fish annually on average (2022–2023). Furthermore, the government has supported climate-resilient and creative programs, and as of now, the district has three Bio-Floc schemes, three carp seed hatcheries, and four fish seed farms. Despite the district's 19 fish markets and high demand for aquatic foods, most of

the captured and cultivated fish are sold directly to the public or at the farm gate. Table 1 shows relevant important information linked to fisheries activity.

Table 1: Key highlights on Mandla's aquatic food systems (Source: NABARD Potential Credit Linked Plan 2023-24 and District Contingency plan of Mandla district).

Area under intervention	**No. of Pond/ Water bodies/Tank: 1338** **No. of reservoirs: 50** **Total area: 2864.43 ha** **Yield: 60kg/ ha** **Additionally 325 km stretches of Riverine system are also in use**
Average annual production of fish	Fish - 6138 metric tonnes (2022-23)
Institutional framework available	Cooperative societies or Sehkari Sangh/ Samiti for capture fisheries: 98 (where approx 3195 persons associated with fisheries are enlisted).
Number of aquatic food farming communities / groups available and their structure/type. (Eg. SHGs, Fish Farming Communities, Village based communities etc.)	Total No. of persons associated with fisheries: 72000 (F: 32400, M: 39600) Bio-Floc: 3 Sehkari Sangh/ Samiti: 98 (where approx 3195 persons associated with fisheries are enlisted) Fish Market: 19 Hatcheries: 3 Fish Seed Culture Farm: 4

4. Methods

In February 2024, the WorldFish, International Water Management Institute (IWMI), Alliance of Bioversity International and CIAT collaborated to organize a survey team under the auspicious CGIAR Initiative on Agroecology. The rationale and necessity for the survey have been created in consultation with the Department of Fisheries, Mandla, Government of Madhya Pradesh, and local partner agencies 'Professional Assistance for Development Action' (PRADAN) and 'Foundation for Ecological Security' (FES), based on field-level research and observations that have been conducted before. Based on that, a survey strategy was created to first investigate the qualitative aspects of Mandla's aquatic food systems., followed by a quantitative analysis of primary practitioners' performance. An independent enumerator agency known as 'Ecociate Consultants Private Limited' (Ecociate) was hired for field-level survey tasks including standardization and trial. Following ethical clearance from CMS IRB India (Reference ID CMS-IRB/Ag/2014/019 & IRB number IRB00006230, dated August 26, 2024), field-level data collection was completed.

The non-experimental method has been adopted for formative and scoping studies. Using in-depth interviews, the method was mainly used to identify qualitative traits. Stakeholders in aquatic food systems make up the study population. In addition to focusing on the groups with the most expertise and local knowledge of aquatic food production techniques, these stakeholders were chosen to represent a variety of groups, including genders and the many activities associated with aquatic food production (Figure 7). For this, the snowball sampling technique has been used (Kirchherr and Charles 2018).

Figure 7 Different modes of surveys to explore Mandla's aquatic food system typology

The quantitative research zone and respondents have been chosen based on information obtained from respondents and experiences gained during qualitative sampling. In the chosen area, 400 sample sizes were maintained throughout the quantitative data collection procedure. Only relevant survey data based on their most recent production cycle was collected from respondents who had been involved with aquatic food production systems for three years, either through catch fishing or aquaculture (cultivation of aquatic plants/animals). Depending on practicality, in-depth interviews have been done in person or remotely over the phone (but only if the participants are available, comfortable, and willing to participate). By sampling a variety of players (government, NGOs, and producers) and demographics (women, men, and youth), the sampling strategy seeks to reduce the danger of bias and loss of accuracy. Figure 8 provides detailed information about the survey team, methods, instruments, and participants. Table 2 shows the study's timeline.

[NB: During the survey process engagement of children (below 18 years of age) were avoided. During interview process of women representatives' special attention was given to employ women enumerators and choosing convenient places where women participants feel comfortable]

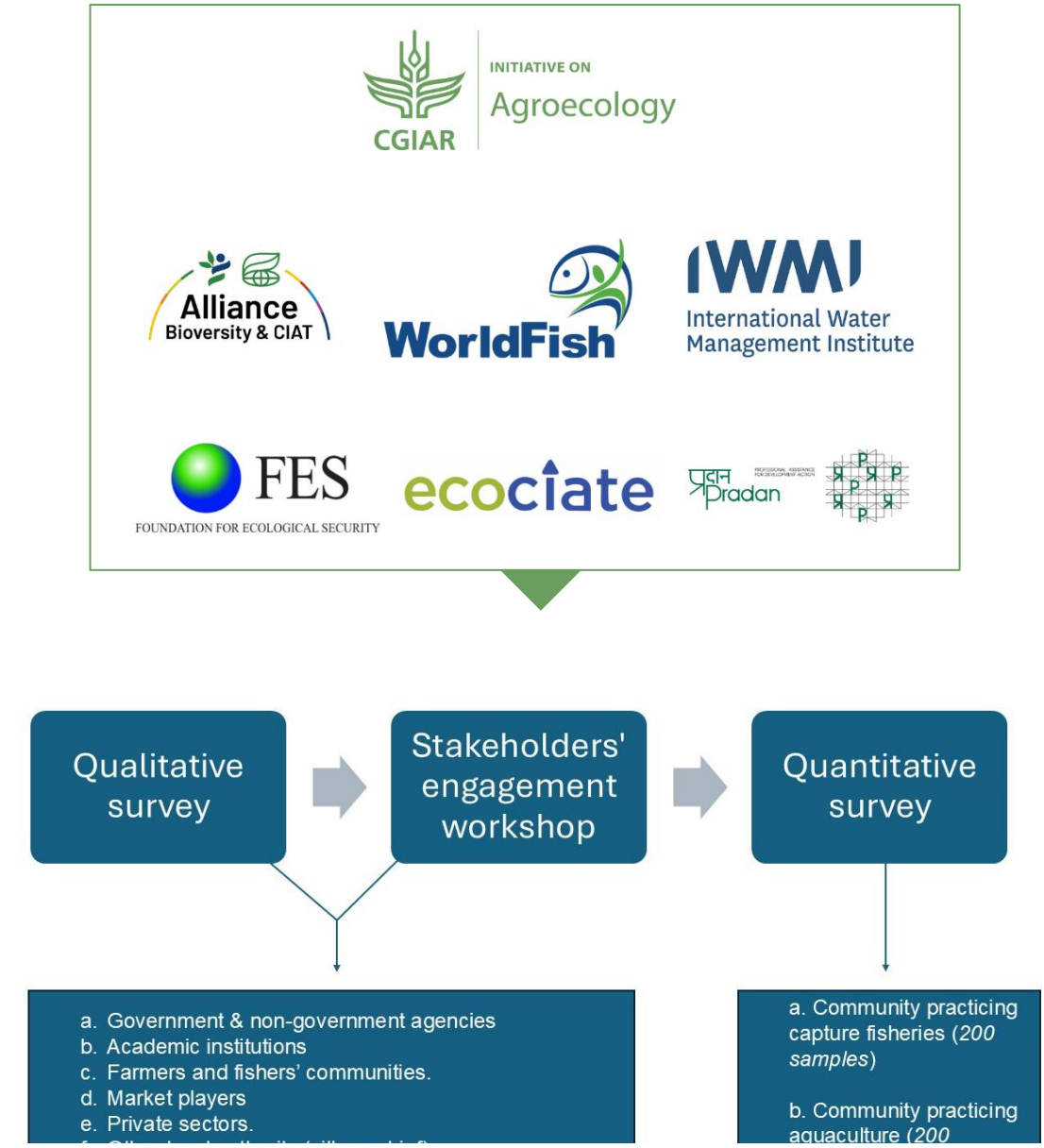


Figure 8 Study team and methods used

Table 2 Details about the study period

Activity	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
	2024										
Conceptualization of the study											
Questionnaire design											
Translation of questionnaire											
Digitisation of questionnaire											
Pilot testing of the questionnaire											
Revision of questionnaire and pilot testing											
Ethical clearance from CMS-IRB India											
Revision of questionnaire											
Engagement and training to the enumerators											
Qualitative survey-based data collection											
Quantitative survey based data collection											
Data cleaning and collating the survey data											
Survey completion report with collated survey data											

5. Principal findings

9.1 Aquatic food system resources

Water Resources:

Eight distinct types of water resources have been utilized, either for aquaculture (ponds, small dams and bioflock tanks) or fish capture (rivers, dams, canals, streams, paddy fields). The most prevalent of them is riverine catch fishing. However, the use of medium-sized dams and community ponds is more common in the Bichia and Mandla blocks, respectively. Figure 9 shows some related types of water resources.

Figure 9 Some important types of water resources utilized for aquatic food production in Mandla

Types of Aquatic Foods:

The local market offers about 27 different forms of freshwater aquatic organisms (plants and animals) treated as food items, including 93% fish and freshwater shrimp, 7% aquatic plants. In addition, tribal communities typically eat a variety of other molluscs, such as different kinds of snails, and crabs that are found naturally in the nearby water sources. Figure 15 shows a variety of aquatic food resources and a glimpse of the local fish market in Mandla block. Details of food types with high demand are displayed in the Table 3.

Table 3: Aquatic food varieties that are highly sought for in the local market of Mandla

Local / Common name	Scientific Name	Products produced
Padan	Ompok bimaculatus	Fresh, Smoked
Rohu	Labeo rohita	Fresh, Smoked
Kalvat		Fresh
Jhinga	Fenneropenaeus indicus	Fresh, Smoked, Dry
Baam	Mastacembelus armatus	Fresh, Smoked
Cotia		Fresh, Smoked
Chalar		Fresh, Smoked
Suar		Fresh, Smoked
Morale	Amblypharyngodon mola	Fresh, Smoked, Dry
Common Carp	Cyprinus carpio	Fresh, Smoked
Catla	Labeo catla	Fresh, Smoked
Darai		Fresh, Smoked, Dry
Bighead	Hypophthalmichthys nobilis	Fresh
Tilapia	Oreochromis sp.	Fresh, Smoked
Pangus	Pangasius pangasius	Fresh
Grass Carp	Ctenopharyngodon idella	Fresh
Singi	Heteropneustes fossilis	Fresh, Smoked
Rupchanda	Piaractus brachypomus	Fresh
Naren	Cirrhinus mrigala	Fresh, Smoked
Singhara	Trapa natans L.	Fresh, Boiled, flour

The data provides an overview of the types of fish harvested by aquaculture farmers from local ponds, tanks, mini dams (irrigation tanks), highlighting the diversity of fish types involved in local aquaculture practices. Among the various fish types, Catla stands out as the most harvested from aquaculture, with 21% of farmers reporting its cultivation. This suggests that Catla is a popular species, likely due to its high market demand or adaptability to the local environment. Following closely are Rohu and Narain, with 19% and 15% of farmers harvesting these respectively. These fish are staples in many freshwater aquaculture systems and are well-regarded for their economic value and popularity in local cuisine. Bighead and Grass carp are harvested by 8% and 10% of farmers, respectively. Common carp also represents 15% of the harvest, showing its continued significance in aquaculture. Other fish like Karot (4%), Gohoriya (4%), and Kheola (3%) are harvested by smaller portions of the farmers. While these fish types make up a lesser percentage, they may still hold cultural or niche market value, contributing to biodiversity in the large tank ecosystem. Finally, Chital and Karchakari, with 2% and 5% of farmers respectively, represent more specialized or less common fish types within the aquaculture practices in the region (Figure 10).

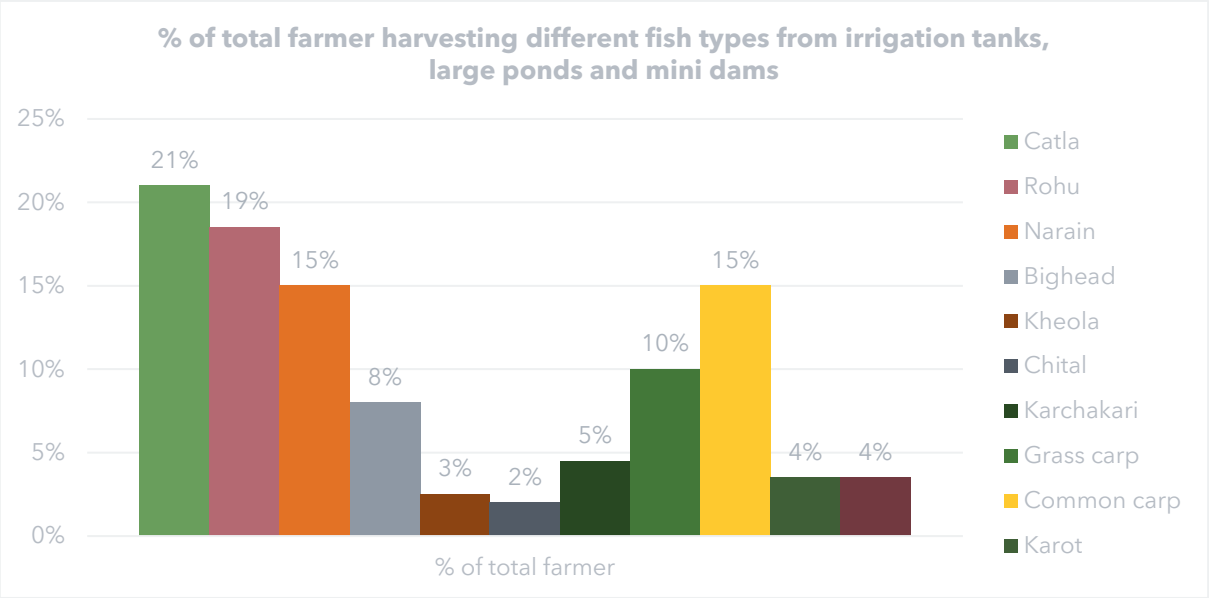


Figure 10 An overview of aquatic food resources from medium sized water bodies

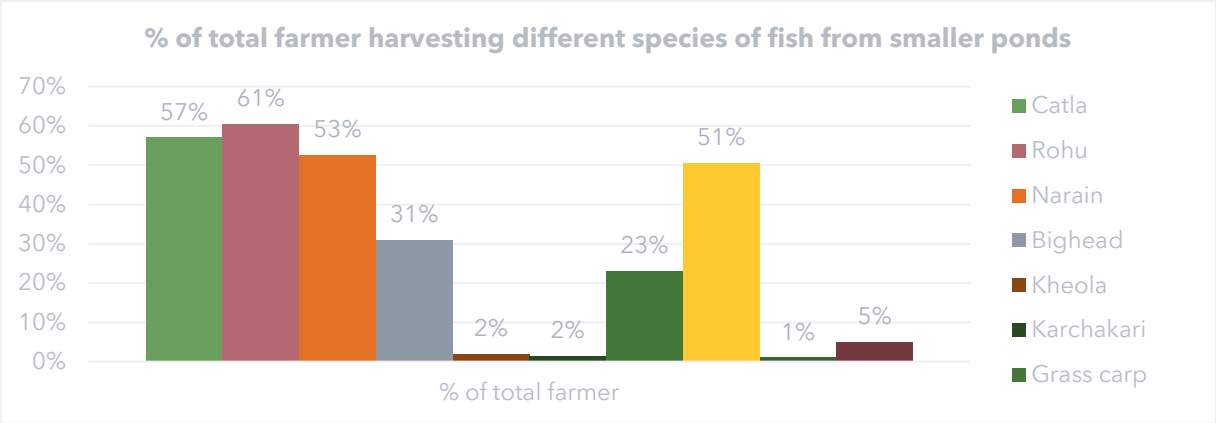


Figure 11 An overview of aquatic food resources from small sized water bodies

Overall, the diversity of fish types harvested from ponds and tanks underscores a varied approach to aquaculture, with different species chosen based on factors such as market preferences, environmental suitability, and farming practices. In smaller aquaculture ponds the most harvested species are Rohu (61%) and Catla (57%), indicating that these two varieties are the most popular choices among farmers for pond-based aquaculture. Common carp also stands out, with 51% of farmers reporting its inclusion in their harvests. Similarly, Narain fish, harvested by 53% of farmers, shows a strong presence. Other species harvested by smaller proportions of farmers include Bighead harvested by 31% of farmers, and Grass carp by 23%. Species like Karot (1%), Gohoriya (5%), Kheola (2%), Chital (0%), and Karchakari (2%) are harvested by relatively few farmers. Most of these harvests are not farmed and come into aquaculture systems from the wild (Figure 11).

On the other hand, a diverse range of fish species are caught by farmers from large dams like Bargi and Matiyari, under capture fisheries, showcasing a mix of both commonly and less frequently harvested varieties. Among the total sample, Rohu emerged as the most widely captured species, with 31% of farmers involved, followed closely by Katla at 29% and Padhan at 28%, indicating these varieties' prominence in the local capture environment. Narain was also significant, harvested by 26% of farmers, reflecting its importance as an abundant variety. Other notable variety include Talafiya at 20%, Baren at 25%, and Mixed Small River Varieties (MSRV), harvested by 13% of farmers, which suggests their role in supplementing the primary catch. Less commonly caught species include Khewla (3%), Bighead (3%), and Cheetal (4%), while fish like Bera, Sondh, and Jhinga are harvested by a marginal 2-4% of farmers. Some varieties, such as Kusua, Gegra, Sirni, Banji, Bami, and Crab, showed no reported catch from dams (Figure 12).

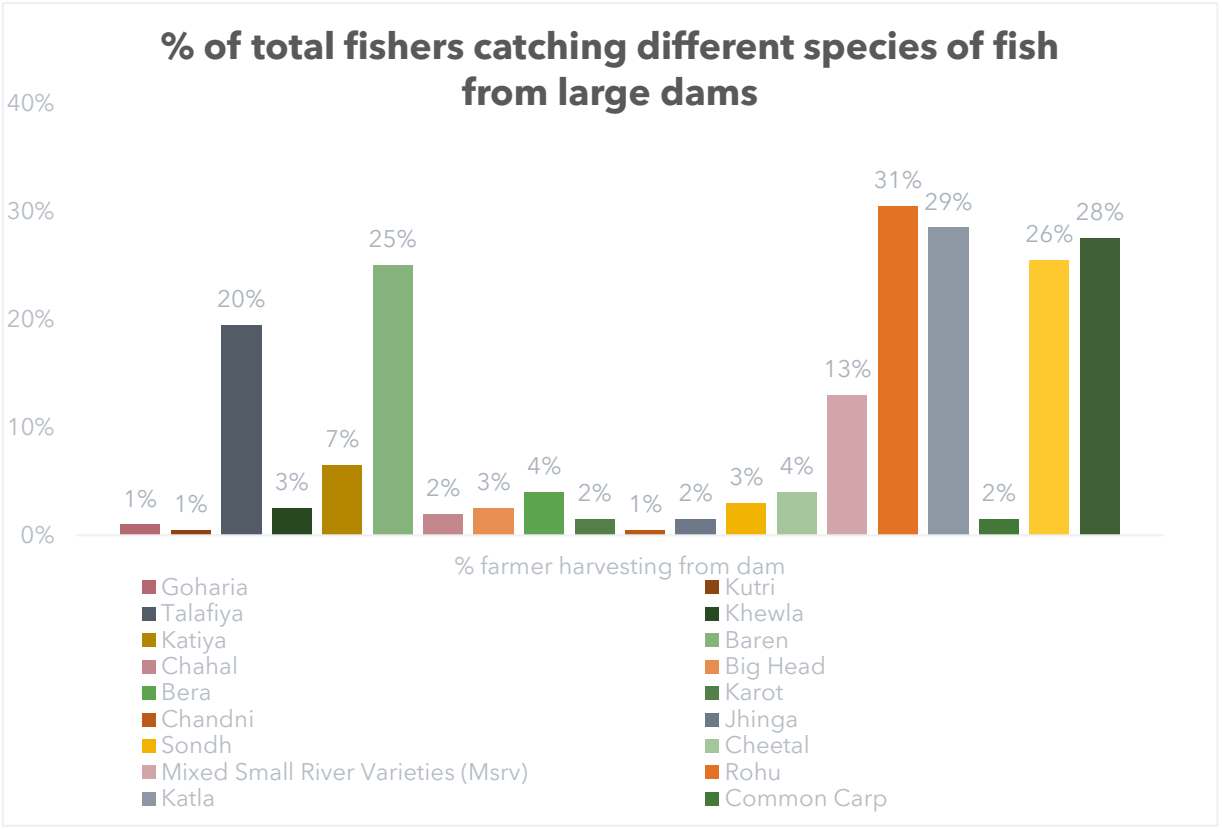


Figure 12 An overview of aquatic food resources from large dams

The data provides a detailed overview of the fish harvesting practices of fishers who depend on rivers as a primary source of aquatic resources. The most caught varieties from rivers include Catla (37%), Rohu (34%), and Narain (29%), showcasing the dominance of high-demand and commercially viable species. Kusua and Goharia, caught by 14% and 19% of fishers respectively, are also notable contributors to the aquatic economy. Several species, such as Common Carp (16%), Padhan (16%), and Kutri (24%), are also well-represented among riverine catch. Species like Khewla (16%) and Katiya (11%) demonstrate a similar trend, underlining the richness of riverine biodiversity. Fish types like Big Head (5%), Crab (6%), and Bami (7%) are harvested by fewer farmers, reflecting their lower availability. Rarely harvested species such as Gegra (1%), Chahal (1%), and Banji (1%) highlight the extensive biodiversity of the rivers. While their contributions to the overall yield are minimal. Freshwater prawns/ Jhinga and Mixed Small River Varieties (MSRV), each harvested by 13% of farmers, these species play a versatile role, serving as both local dietary staples and market commodities (Figure 13).

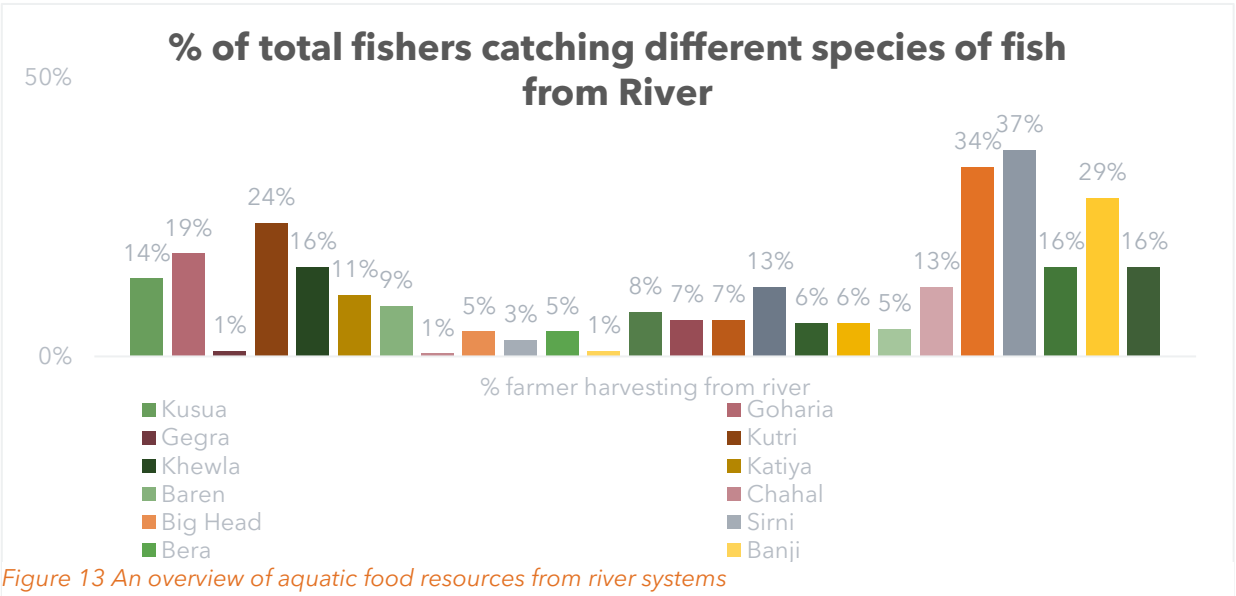


Figure 13 An overview of aquatic food resources from river systems

Figure 14 Aquatic food types in the local fish market of Mandla

9.2 Infrastructures:

Few infrastructure resources are available to support the expansion of scientific aquaculture or capture fisheries practices by rural farmers. Even while there are government hatcheries that mainly help with carp seed production, there are still not enough of them to satisfy local demand. Most commercial carp seed nurseries and raising facilities are privately owned, and there are very few of them. A satisfactory number of gear (net, handi etc.) stores were visible in each block's main marketplace. For fertilizer and insecticides, there are local agricultural fertilizer stores. Additionally, there is a privately held company in Bichiya Block that used to provide necessary medicines and supplemental feed to the entire district. The government has now promoted significant infrastructure development under 'Pradhan Mantri Matsya Sampada Yojana' (PMMSY), and two bioflock farms have been created in the Bichiya block. To inspire and encourage young people for scale and adoption, a local entrepreneur named Mr. Brajesh Thakur (Owner, Thakur Biofloc Fish Farm, Ramnagar, Mandla) also created a nominal payment based private training center and the necessary infrastructure (Figure 15).

Figure 15 Bioflock scheme promoted under PMMSY at Mandla

9.3 Techniques involved:

Capturing processes:

Both Indigenous traditional boats called "dugout Canoes/Dongi" (Figure 16) and modern boats (Figure 17) could be seen for riverine fishing operations, and the most popular tool for collecting fish in rivers, especially after the monsoon season, is a gill net/ Kisti net (Figure 18) while in case of aquaculture dragnet being used (Figure 19). The government makes sure that fishing in the Narmada River is prohibited during the monsoon season because it is thought to be the time when fish reproduce. Fish abundance is lower before the monsoon season and higher after. Fish catching was carried on by the fishing communities in Mandala who mainly belonged to Nanda and Barmaniya Samaj (OBC category). Most of them lived along riverbanks and had no other lands to use for alternative livelihood options, except their homes. Other than large river systems, the community used to catch small native fish species using their own equipment and techniques during the monsoon season when fish were available in other minor water resources including seasonal streams (Figure 20), paddy fields (Figure 21) and canals/small rivers (Figure 22). These fish were primarily used for domestic consumption. According to the community, between six to eight small native fish species typically begin migrating towards the highlands, primarily to breeding grounds in wet paddy fields, when they are most vulnerable to capture.

Figure 17 Dugout canoe / Dongi

Figure 16 Modern boats used to capture fish

Figure 19 Gill net/ Kisti net

Figure 18 Dragnet

Figure 21 Fish capturing technique in seasonal streams of Mandla

Figure 20 A farmer capturing fish from paddy field in Mandla

Figure 22 Indigenous technique for capturing fish from canals/small rivers.

The data on the fishing tools used by farmers provides insight into the types of fishing practices in place, as well as the preferences of farmers for different types of gear. A significant majority of farmers (55%) rely on Kisti nets, indicating their widespread use and preference among the farming community. A notable portion of farmers (27%) use rubber tubes. A smaller percentage (2%) of farmers use a combination of Kisti and Dongi, reflecting a specialized fishing approach that incorporates the benefits of both tools. Lastly, Dongi is used by 5% of farmers, which suggests that this craft is now less common but may still serve a specific purpose in certain fishing environments (Figure 23).

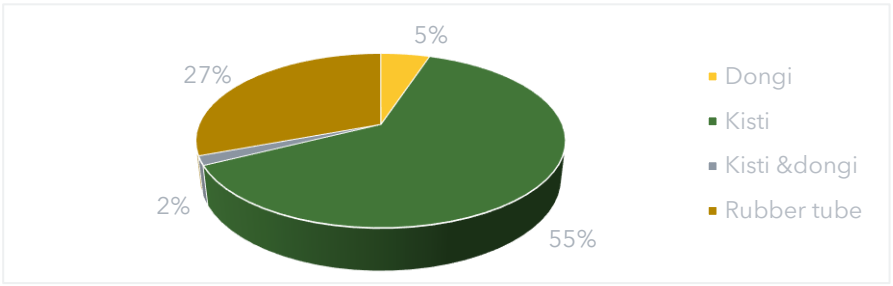


Figure 23 Percentage of fishers having different type of fishing gears

Aquaculture processes:

A very small portion of farmers (only 1%) use boats for aquaculture operations. These farmers have a consistent and higher annual expenditure of ₹15,000, with no variation in the spending, suggesting that the use of boats is a stable but expensive investment for those who own them. A larger group of farmers (about 16%) use Dongis, with an average annual expenditure of ₹13,484. The expenditure for Dongi users varies widely, from a minimum of ₹4,000 to a maximum of ₹90,000, indicating that some farmers invest heavily in Dongis, possibly due to differences in the size, quality, or customization of the gear (Figure 24).

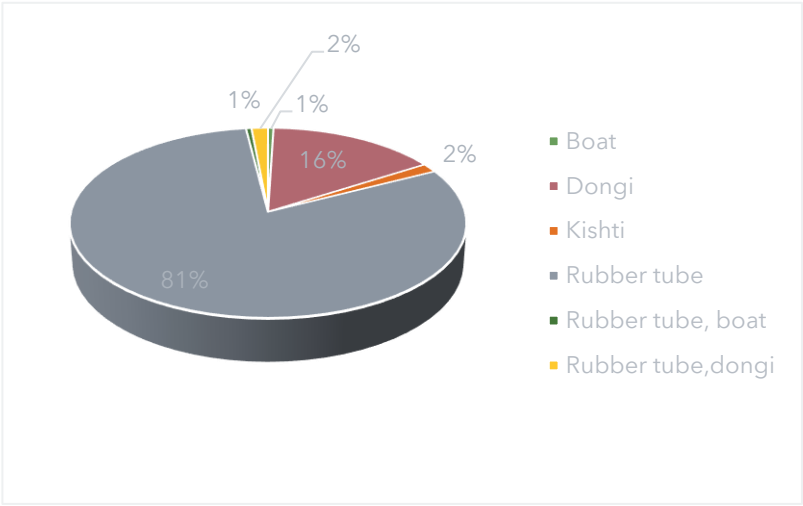


Figure 24 Percentage of farmer having different fishing gear

Farmers using Kishtis (approximately 2%) spend significantly more, with an average annual expenditure of ₹27,333. The minimum expenditure is ₹12,000, and the maximum is ₹50,000, reflecting the larger financial commitment required for purchasing or maintaining Kishtis. The vast majority of farmers (around 81%) rely on rubber tubes, with a much lower average annual expenditure of ₹1,243. The minimum expenditure for rubber tube users is ₹400, and the maximum is ₹5,600, indicating that rubber tubes are an affordable and widely accessible option for most farmers. This type of gear is economically viable and used by the majority of the farming community.

Due to the usage of fish seed, mostly fingerlings, aquaculture is still based on antiquated methods and may be seen as extensive. Even if some farmers have improved themselves through government or NOG (like FES) extension assistance, most of them are still not able to achieve a standard level of productivity. The average yearly productivity varies from 200 – 700 INR/ha, whereas the average annual expenditure is 25000 – 40000 INR/ha. Nonetheless, semi-intensive aquaculture frequently uses supplemental fish feed, vehicle tubes, lime, manure, dragnet, and inorganic fertilizers (SSP and urea) in addition to fish seed. Figure 26shows a typical sort of spending for a semi-intensive aquaculture operation. In order to maintain the appropriate stocking schedule and quality, there has been a noticeable reliance of Mandla's fish farming communities on West Bengal-based carp seed producers.

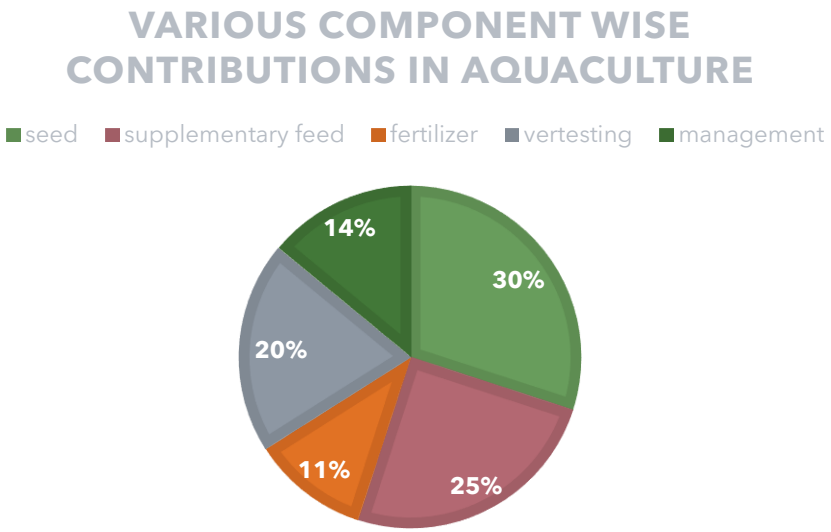


Figure 25 Mandla's semi-intensive aquaculture components

9.4 Aquatic food utilization processes:

The community uses aquatic animals in the local market in four primary ways: fresh or live, smoked, dried Figure 14), and frozen (Figure 26). When it comes to aquatic plants, two primary marketing strategies have been implemented: selling either freshly harvested or boiled products. Fish curry, smoked fish, and dry fish in vegetable curry were the three major ways that communities used to love to eat it after obtaining it via marketing or on their own (Figure 27). Mandla's capture fisheries and aquaculture resources account for 57 % of them, whereas 43% are imported from outside in the local market. It's interesting to note that large fish from the Narmada riverine systems are rarely found at the local market in Mandla. Instead, a sizable amount of them is transported by train from Jabalpur to the Howrah fish markets in West Bengal.

Figure 26 Mandla market offers frozen freshwater fish that is imported from nearby states

Figure 27 Three important ways of fish consumption in Mandla

9.5 Community structure and financial status:

The study indicates, community involvement has been significant, particularly when it comes to fish capture. Almost every member of the household appears to be involved in the process of capturing fish, particularly in Nanda and Barmaniya communities (Figure 28). However, these specific communities have increasingly begun migrating or opting to work as daily wage laborers as an alternative livelihood, driven by the gradual decline in natural fish stocks in the river over the years. Although this community uses fertile riverbank soil after the monsoon season to cultivate their own food (such as vegetables and paddy), they primarily lack agricultural land and sufficient capital to begin alternative farming. Apart from this, there are a few notable fishing villages in the Bichia block where a sizable portion of the tribal communities (Schedule Tribe/ST category) engage in capture fisheries from small irrigation dams (Figure 29). Nevertheless, in certain instances, they release fingerlings, which may be classified as aquaculture in a broad sense. Fish capture from rivers and other resources is often done on an individual basis; but, in the case of aquaculture, the community style of approach was evident in every village that was investigated.

Figure 29 Representatives of Nanda community, engaged in capture fisheries

Figure 28 In Saraitola village, a tribal group practiced community fish farming

Communities that traditionally engaged in fish harvesting in the Narmada River, are now prohibited from selling their catch directly to the public. They are bound to sell their harvest to the contractors (who have an agreement with the government regarding the utilization of riverine fish stock) for far less money as compared to the actual market price. However, these problems are no longer present for those who practice aquaculture or get fish from alternative sources. The FES has worked to advance scientific aquaculture in village ponds through institutional assistance, capacity building, and critical input support. In certain instances, communities have found it beneficial to scale up their pisciculture operations. Although women also participated in fish capture in a small number of communities, significant female participation in post-harvest management has been observed in fishing villages (Figure 30). However, the participation of women in aquaculture is still quite low.

Figure 30 Women's engagement in capture fisheries and post-harvest management

9.6 Nutritional security:

Many people who have engaged in production systems regularly consume aquatic foods during the main seasons (post-monsoon). For the lean period (summer), they used to preserve their excess harvested small indigenous fish or prawns using a sun-drying technique, which enables them to store the product for up to three months. Nonetheless, our data shows that annual per capita fish intake is significantly lower than the national average. The rate of fish consumption is significantly greater among people who work in capture fisheries. Other than fish, tribes often consume freshwater crabs and mollusks. Apart from consuming aquatic foods, people in Mandla also eat a variety of aquatic foods (e.g. freshwater shrimp/ Jhunga, Crabs, Small indigenous fish species) to improve their health status mainly to deal with issues like pneumonia, cold, joint/body pain, dietary iron deficiencies etc.

9.7 Women's Roles and Opportunities:

Women in Mandla play a significant role in the aquaculture sector starting from capture to sale, particularly in post-harvest management activities such as cleaning, drying, and smoking fish. Their involvement is especially prominent in the production and sale of smoked fish, which provides a vital source of income for many rural households. However, despite their contributions, women face challenges such as limited access to cooperatives, inadequate infrastructure, and minimal government support. Increasing women's participation in aquaculture practices and providing training on sustainable and hygienic methods could enhance their economic opportunities and livelihoods. To address these gaps, targeted interventions could include forming women's self-help groups (SHGs) for aquaculture-related activities, improving access to government schemes, and providing financial incentives for women-led initiatives. Furthermore, integrating women into upstream processes, such as fish farming and cooperative management, could strengthen their roles and improve overall productivity in the sector.

9.8 Economic security and income disparities:

The analysis of annual household income among surveyed households of aquaculture farmers provides a clear picture of the community's economic condition. The average income is ₹66,335, while the median is ₹55,000, indicating that half of the households earn below and half above this amount, with incomes clustered closer to the median. The highest income, ₹6,50,000, reveals significant disparity, with a small proportion of households earning substantially more. This moderate-income inequality highlights the need for targeted development efforts, such as skill enhancement, micro-enterprise promotion, and improved access to income opportunities, to uplift lower-income households and foster equitable economic growth.

The data provided offers valuable insights into the production cycle patterns within the sample group. A large majority, 67.5%, reported completing only one production cycle, indicating that for most participants, the production process is relatively singular or occurs on an occasional basis. This is because majority of the aquaculture farmers follow the traditional process of single stocking during rainy season and multiple harvesting, as long as the water lasts or till summers.

Table 4: Number of production cycles

Number of production cycles		
	Frequency	**Percent**
1 production cycle	135	67.5
2 production cycle	25	12.5
Multiple production cycle	40	20.0

In contrast, 12.5% of the sample engaged in two production cycles, pointing to a more deliberate or efficient approach in their operations. Additionally, 20% of the sample indicated involvement in multiple production cycles, suggesting a more dynamic and ongoing production process. These participants have the resources, infrastructure, and demand to support continuous or repeated production.

This distribution of production cycles highlights the varying degrees of production intensity within the group. While the majority focus on singular production efforts, a significant proportion engages in repeated or more complex production cycles, showcasing the diversity in production strategies and operational capacities within the sample. It suggests that different individuals or entities may be at different stages of operational maturity or may be responding to unique external factors such as market conditions, resource availability, or business models.

The analysis of annual household income among the surveyed group of Fishers in capture fisheries on the other hand highlights key insights into their economic conditions. The mean annual income is ₹47,140, indicating the average income level across all households. However, the median income, which is ₹40,000, suggests that half of the households earn below this threshold, and the other half earn above it. This figure points to a slight skew in income distribution, with a concentration of earnings around the lower end. The mode, also ₹40,000, represents the most frequently reported income level, reinforcing the observation that a significant number of households share this income bracket.

The alignment of the median and mode at ₹40,000 for Fishers emphasizes that most households have earnings clustered around this value, suggesting limited income variability for a significant proportion of the population. Meanwhile, the higher mean income suggests that a smaller subset of households earns considerably more, pulling the average upward. This income profile highlights the economic challenges faced by the community, with most households earning close to the lower end of the income spectrum, underlining the need for targeted interventions to enhance earning opportunities and reduce income disparities.

Regarding the unnaturally low annual income reported in some cases, it is to be noted that Mandla is a classic example of certain indigenous households following an agro-ecologically sensitive livelihood where they grow their food in a typical multi-agri-commodity farming model and some communities also collect food from nearby forest lands. This is complemented by household-level livestock and fisheries for consumption. While in most such cases the household cash income is very low still the families have a consistent source of cultivated or collected food which is not represented in monetary terms. Additionally, they are recipients of various government social protection schemes where they receive rations and even cash, but such contributions are not reported as 'income' here.

People having the poorest socioeconomic backgrounds depended on the fish of the Narmada River for their livelihood. Because, in addition to the fish's limited availability, their selling prices ranged from 20 to 25 Indian rupees per kilogram. In contrast, fishers and aqua culturists who are not dependent on the Narmada River easily earn 150 to 220 Indian rupees per kilogram. In the case of dams and ponds, the income per household from aquaculture stays Rs. 55,237.00 when they practice in groups and Rs. 59212.00 when they practice alone. Along with their fisheries and aquaculture techniques, the communities that practice dry fish or smoked fish have shown increased income status, which is Rs. 51,105.00. The income of a fish seed producer is around Rs. 38,000.00. The highest income rate from fish is obtained through government-sponsored biofloc programs, which also use integrated agriculture or horticultural products which is about Rs. 6,50,000.00. Producers of water chestnut used to have strong earnings prospects in addition to fish. Water chestnut is currently a promising business concept in 9 villages due to increased commercial demand. Approximately 30% of the water chestnut farming communities in 9 (Ahmedpur, Babaghat, Babatola, Dudka, Gangora, Hradaynagar, Kakaiya, Shiv Batika and Shivvatika tola) villages from Bichiya and Mandla block have converted their low-agricultural and seasonal wet areas into water chestnut growing grounds (Figure 31. Table 5 shows the various revenue statuses of the different water chestnut-based cultivation practices.

Figure 31 Water Chestnut Cultivation in Mandla

The results indicate significant income disparities in Mandla's aquatic food systems show. For instance, fishers and aquaculturists who participate in biofloc programs earn up to ₹6,50,000 annually, while those engaged in traditional riverine capture fisheries earn as little as ₹47,140 annually. Similarly, the average income for aquaculture practitioners using tanks or ponds is around ₹55,237 when working in groups, compared to slightly higher earnings (₹59,212) when working individually. These disparities highlight the need for targeted interventions to uplift low-income communities. Promoting access to sustainable technologies, enhancing market linkages for small-scale producers, and introducing skill development programs can help bridge the income gap. Additionally, government support through subsidies, infrastructure development, and equitable policy implementation could ensure more inclusive growth in the aquatic food systems of Mandla.

Table 5: Average annual household income of different type of aquatic food system

Row Labels	Average of Annual household income
Table fish and Water chestnut production	71545.00

Water Chestnut production	64944.00

9.9 Marketing strategies:

Freshly caught fish from rivers are typically marketed directly from landing points or farm gates in the surveyed area (Figure 32). In Bichiya and Narayanganj block, however, locals used to make sure that there was a good harvest, particularly during weekly markets. The majority of fish imports from other states, like as Andhra Pradesh and West Bengal, occur at the large and frequent fish market in Mandla, besides locally available aquatic food products. The most advanced market kinds among the three blocks are found in Mandla, which has storage chambers to preserve unsold goods, ice packing facilities, and a concrete seating arrangement. Apart from fresh fish, women's involvement in making smoked fish was evident, especially when they targeted the main market in Mandala and the rural areas. Nonetheless, there were a considerable number of female dry fish vendors in each market. Other than this, the market also offers various parts of lotus plants (flower, leaves, stem and roots) that used to bring in a healthy profit.

Figure 32 Direct selling of fish from Farmgate

Freshly caught fish from rivers are typically marketed directly from landing points or farm gates in the surveyed area. Fishing rights are often auctioned by the govt. to contractors who collects fish from fishers. In return an amount to the tune of Rs 20-30 per kg, depending upon the species as charges for the catch. This is coordinated through the different Fishers' cooperative society which also arranges for govt. schemes and other benefits for member fishers. Thus, the major high valued fish catch from Narmada River and Bargi dam is collected and sold to distant markets by the contractor only. Low valued small fish catch from these water resources are however sold by fishers directly to local retailers or consumers. This is mostly in low quantities and available in weekends only in Bichhiya and Narayanganj. Major varieties which are supplied to contractors include Catla (reported by 39% fishers), Rohu (reported by 36% fishers), and Narain (reported by 36% fishers). Supply of Padhan is reported by 35% of fishers while Talafiya is reported by 20% and Baren by 25% fishers respectively are often sold locally by the fishers and do not come under the purview of the agreement with contractors. Other varieties like Katiya (9%), Khewla (4%), and Mixed Small River Varieties (MSRV) (5%) are also sold in smaller quantities. The majority of fish available in larger markets of Mandla is imported from other states, like as Andhra Pradesh and West Bengal, besides locally available aquatic food products. The most advanced market among the three blocks is in Mandla, which has storage chambers to preserve unsold goods, ice packing facilities, and a concrete seating arrangement for retailers.

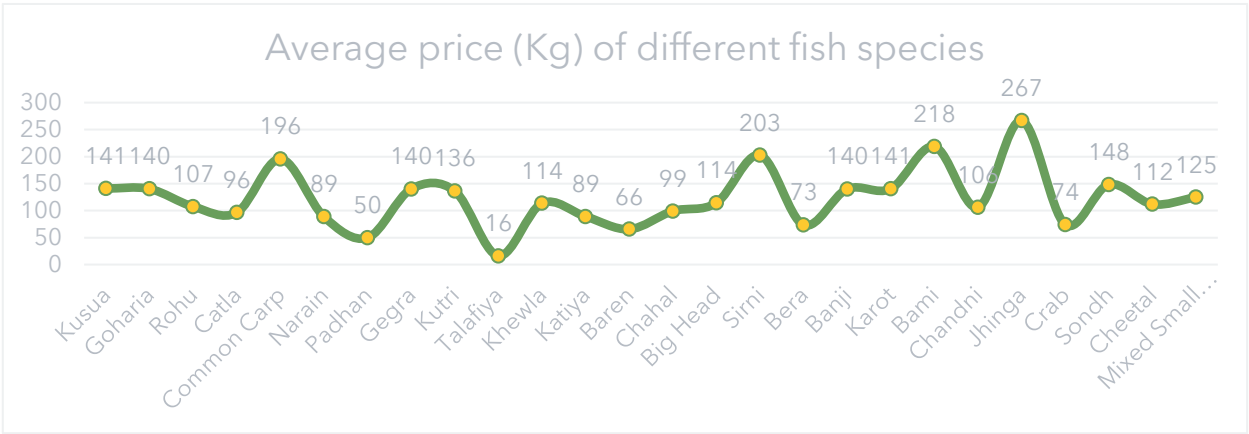


Figure 33 Average price (per Kg) of different fish verities

Some varieties command significantly higher prices, which may indicate strong demand, high market value, or premium quality. Jhinga (267) leads the market with the highest average price. Bami (218) and Sirni (203) also commands premium prices. Apart from fresh fish, women's involvement in making smoked fish is rampant across the district, especially around the main market in Mandla and the rural areas. Nonetheless, there are a considerable number of female dry fish vendors in each market. Other than this, the market also offers various parts of lotus plants (flower, leaves, stem and roots) that are used as offerings for worship as well as food (Figure 33).

9.10 Available government support:

There are 14 main government policies/ schemes that are supporting Mandla's aquatic food system producers either with additional revenue support or by providing financial security or by ensuring education. The specifics are as follows:

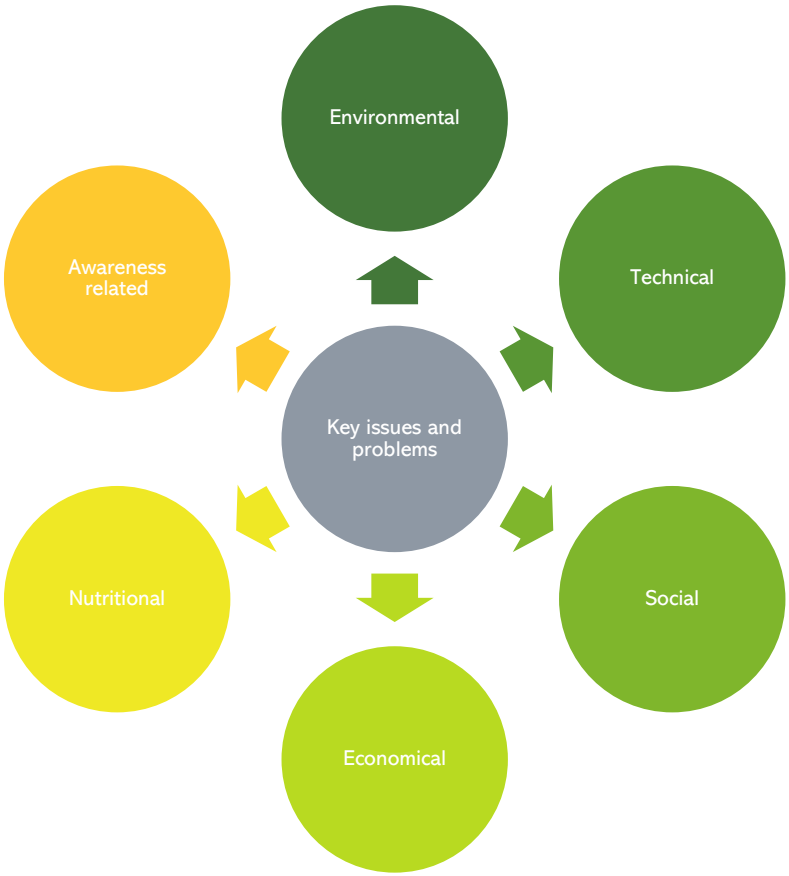
Table 6: Available government schemes and their facilities for Mandla's fishers' communities

Scheme Name	Overview
Livelihood Support Scheme (Deferred Wages Scheme)	This scheme is run by the Federation to support the livelihood of fishermen's families during the off-season. In this scheme, Rs. 5 per kg is deducted from the fishermen's earnings on the fish caught during the year. The Federation matches this amount, and during the off-season, fishermen receive Rs. 10 per kg based on their total production.
80:20 Boat and Net Subsidy Scheme	By the federation, an "80:20 Boat-Net Grant Scheme" has been launched for the fishermen to purchase boats and nets for fishing. Under which, an 80 percent subsidy amount is given to the fishermen for boat-net, the details are as follows. a.To the fishermen working for 150 days or more, a subsidy of Rs. 9600/- on an amount of Rs. 12000/- for purchasing 15 kg net. b. To the fishermen working from 100 to 150 days, a subsidy of Rs. 6400/- on an amount of Rs. 8000/- for purchasing 10 kg net. c. For the boat, a subsidy of Rs. 8000/-, Rs. 9600/- and Rs. 12800/- is given on the boat price of Rs. 10000/-, Rs. 12,000/- and Rs. 16,000/- between two fishermen in 5 years, respectively.
Janashree Bima Yojana	The Federation has implemented the "Janashree Bima Yojana" for the fishermen working in its water reservoirs. The premium of Rs. 200 per fisherman is split, with Rs. 100 paid by Indian Life Insurance, Rs. 50 by the Federation, and Rs. 50 by the fishermen. Benefits of the scheme: a. In case of death or total disability due to an accident, the dependent receives Rs. 75,000. b. For loss of one eye or one limb, the dependent receives Rs. 37,500. c. In case of natural death, the dependent receives Rs. 30,000. d. Two children of the fishermen studying in classes 9th to 12th receive a scholarship of Rs. 100 every month.
Grant Scheme for Diagnosis of Serious Illness	The Federation provides financial assistance in the form of grants to fishermen and their family members for the treatment of 22 serious diseases like cancer, heart diseases, kidney diseases. Benefits of the scheme: a. Rs. 40,000 for treatment of very serious conditions like heart, kidney, liver transplants, major surgery, and cancer. b. Up to Rs. 20,000 for serious diseases like heart-related issues, kidney disease, and minor surgeries.
Education Promotion Scheme	This scheme aims to make fishermen's children aware of education. Children who pass with first or second division in 8th, 10th, and 12th grades are awarded Rs. 2,000 and Rs. 1,000 respectively. Those who score more than 80% receive a special prize of Rs. 5,000.

Nishadraj Scholarship Scheme	This scheme encourages meritorious students from fishermen families to continue their higher education. **Benefits of the scheme** a. For technical education (medical, engineering, law), a scholarship of up to Rs. 20,000 or the actual expenditure. b. For non-technical education (BA, B.Sc, B.F.Sc, BCA, B.Com, B.Sc. Agriculture, etc.), a scholarship of up to Rs. 10,000 or the actual expenditure, whichever is less.
Chief Minister Meenakshi Marriage Scheme	Financial assistance of Rs. 20,000 is provided for the marriage of two marriageable daughters of working fishermen members of fisheries cooperative societies and for one remarriage of a widow/abandoned woman.
Incentive Award Scheme	To encourage the best committees and fishermen, the Federation has started the Incentive Award Scheme. Best committees receive awards ranging from Rs. 8,000 to Rs. 50,000, and best fishermen receive awards ranging from Rs. 5,000 to Rs. 30,000.
Grace Scheme	To provide immediate help to the family members of fishermen in case of accidental death, the Federation provides immediate assistance of Rs. 10,000 to the dependent member.
Bachat Se Rahat Yojana	To run the livelihood of fishermen in the closed season, the federation has implemented the "Bachat se Rahat" scheme, for the working poor fishermen of the registered fishery committees working in its subordinate reservoirs under the central and state governments. **Benefits of the scheme** Under the scheme, Rs 167 is deposited monthly for nine months from the fisherman members (up to Rs 1500 per year). In this, a total amount of Rs 4500 is paid to the fisherman members during the closed season for livelihood, by adding Rs 1500 from the state government and Rs 1500 from the central government.
Credit Card Scheme	The state government's "Fishermen Credit Card Scheme" has been implemented for the federation's fishermen to provide working capital for activities such as boat-net and fish seed production at "0" percent interest. Under the scheme, fishermen can take short-term loans for boat-net and fish seed production etc.
Jaldeep Scheme	Fishermen who reside temporarily on islands and remote inner banks for fishing are provided benefits of various government schemes at their place of work, including health check-ups, distribution of nutritious food, and vaccinations.
Pradhan Mantri Suraksha Beema Yojana	The Federation has implemented a central government accident insurance scheme for fishermen and their family members working in its subordinate reservoirs. Fishermen aged 18 to 70 years are insured under the scheme. The premium for the scheme is Rs. 12/- per person, which is borne by the concerned individual. **Benefits of the scheme** In case of death or permanent disability due to an accident during fishing or any other reason, the dependent family member will receive an amount of Rs. 2.00 lakhs. For partial disability, an amount of Rs. 1.00 lakh will be received by the dependent family member.

Pradhan Mantri Jeevan Jyoti Beema Yojana	This scheme has been implemented for fishermen aged 18 to 50 years working in reservoirs. The premium for the scheme is Rs. 330/- per fisherman. Out of which, Rs. 165/- is paid by the Life Insurance Corporation of India, while the remaining Rs. 165/- is shared equally by the Federation (Rs. 82.5) and the fishermen (Rs. 82.5). **Benefits of the scheme** In case of death of the insured member due to any reason, financial assistance of Rs. 2,00,000/- is provided to the dependents or nominated person.

6. Key problems



Environmental

- Flooding along the villages on the banks of the Narmada River has now become a common hazard for all communities that depend on capture fishing. After the construction of the Bargi Major Irrigation Dam, such circumstances became frequent.
- Loss of natural fish stocks in rivers and other resources used for capture fishing, as well as biodiversity.
- Exotic fish populations in natural water resources (rivers, dams, etc.) are growing rapidly.
- The environment is threatened by the use of dangerous chemicals when preparing smoked fish (Figure 34) and by the fast-rising use of pesticides in water chestnut production.

Figure 34 Use of nonedible chemicals during preparation of smoked fish

Technical

- Pisciculture is less productive because to unscientifically applied methods and the use of inadequate or lower quality inputs (seed, feed fertilizers).
- Rapid gill netting for capturing fish in river is endangering biodiversity and biomass of native fish populations.
- Locally produced, poor seed quality leads to reduced aquatic productivity and societal unrest.

Social

- Non-inclusion of fish in the diet due to religious reasons among some communities.
- Since not every group member is equally engaged, issues linked to community fishing can frequently be seen. The dominance of certain group members over others, their strategy of preventing others from participating, and their refusal to share the profits with others have been identified as the causes of this social conflict. Overall fish productivity in those community-managed water resources, however, was low and might not have been sufficient to meet the high demand from all community members.
- Negative problems, such as gears (especially fishing nets) theft, have been shown to demotivate certain fishing communities.
- Women have limited access to aquaculture because it is a male-dominated field.

Economical

- During lean periods, the communities of Nanda and Barmaniya are particularly affected by the economic turmoil. The worst were those who were entirely dependent on riverine capture fisheries because of the lack of personal land for alternative livelihood, their economically disadvantaged background, and their restricted access to forested areas. The average yearly income was found to be below the poverty line in many cases.

Nutritional

- Once more, the nutritional gain to families is lowest among communities that solely depend on riverine fisheries. Even respondents to the study noted that there were no proper two-course meals (lunch and dinner) available during the lean season. However, in the case of tribes, their territories are typically located close to the forest, and the available resources mitigate their nutritional demands to some extent.
- The use of inedible chemicals to prepare smoked fish poses a risk to human health and reduces the nutritional content of the product.
- High alcohol consumption (made using traditional ways) by males and occasionally women in fishing communities increases health hazards.

Awareness related

- In Mandla, there is obviously a dearth of knowledge and communication between the government and the farming and fishing communities. As a result, most of the schemes/ government policies still remain obscure to many. Communities that rely on the Narmada River, however, have the most access to KCC, Bachat Sah Rashi considered as some crucial schemes in fisheries sector. Evidence of extensive training or capacity building has also been lacking. Because of this, a significant portion of the population continues to lack access to government facilities related to fisheries/aquaculture.

7. Impacts on human behaviour

During the survey, the fishermen and aquaculture communities showed a substantial stress response to the aforementioned issues. The following primary stress-related problems have been noted in some of these communities, and Table 7 highlights their primary mitigation techniques (if any are being identified) to tackle them.

Figure 35 Utilizing the Narmada riverbanks creatively for agriculture and aquaculture

Problematic circumstances' effects on human behaviour

Human behaviour related to stress and motivational forces in Mandla's aquatic food system depicted in Table 7.

Table 7: Consequences of human activity for those involved in aquatic food systems

Dimension	Problem	Immediate Impact	Coping strategies by the community	Mitigation strategies by external agents	Level of satisfaction with the mitigation/coping Strategies
Environmental Challenges	Loss of natural fish stock.	Less income and badly affected household nutrition.	Search for alternative livelihoods along with the use of local resources for horticulture/aquaculture.	- Necessary steps taken to restrict fish catch in the Narmada River during fish breeding season (monsoon). - River ranching programme initiated.	Low
	Increasing exotic fish population in natural water resources. (Figure 36)	Not yet identified	Not yet identified		
	Heavy use of pesticides for water chestnut cultivation.	A substantial rise in operating expenses.	Not yet identified		

Livelihood and Economic Challenges	Flood situations in riverbank areas.		Not yet identified	Not yet identified	Low
	Nonavailability of quality fish seed.	Poor productivity and income opportunity.	Not yet identified	Export of fish seeds from other states.	Medium
	Inadequate family income.	Endangering the health and nutrition of the household.	Willingness to take a different approach.	Assistance and funding from the government.	Low
	Private land is unavailable to a sizable portion of the fishing population.	Significantly lower income and a food shortage that causes a health catastrophe.	Efforts to combine common lands and resources (e.g., riverbanks and wet areas) for land-based and aquatic crop production. (Figure 35)	Not yet identified	Medium
	Notably lower prices for the harvested fish sold to Narmada River's adjacent fishing villages.	Severely demotivated the fishing communities because their household nutrition security and income are at risk.	Temporarily relocated to different parts of Madhya Pradesh or other states in search of food and alternative income sources.		Low
	Theft of expensive equipment used to produce aquatic food.	The main cause of demotivation is a large financial loss.	Not yet identified		
Social and Behavioural Challenges	Social conflicts	Unwillingness to continue the existing practices.	Not yet identified		
	Alcohol consumption rate is high in some fishing communities.	Regarded as essential for providing protection from the cold when operating in an aquatic environment.	Not yet identified		

	Less involvement of women in aquaculture.	Significantly demotivated women's communities that participated in other aquatic food system activities.	Participation of a small number of women's SHGs in aquaculture, though unscientific methods continue to result in low effectiveness.	Assistance provided by governmental and non-governmental organizations.	Low
	Religious concerns	Non-inclusion of fish/aquatic animals in the diet.	Fish-based diets are becoming more and more popular among younger generations due to health concerns in many surveyed households.	recommendation from individuals with backgrounds in human nutrition/health.	High
Knowledge and Awareness Challenges	Lack of awareness and communications.	Unwillingness to continue using traditional and indigenous practices for fisheries and pisciculture.	Attempting to get necessary assistance and support.	Support from governmental and non-governmental organizations.	Medium
	Unscientific operation processes.	Low fish yield in aquaculture facilities.	Adoption of semi-intensive aquaculture practices.	Assistance from government/non-government agencies.	High
Food Safety and Quality Issues	Use of harmful chemicals in smoked fish preparation.	Strong consumer demand but a considerable test loss in the finished product.	Not yet identified		

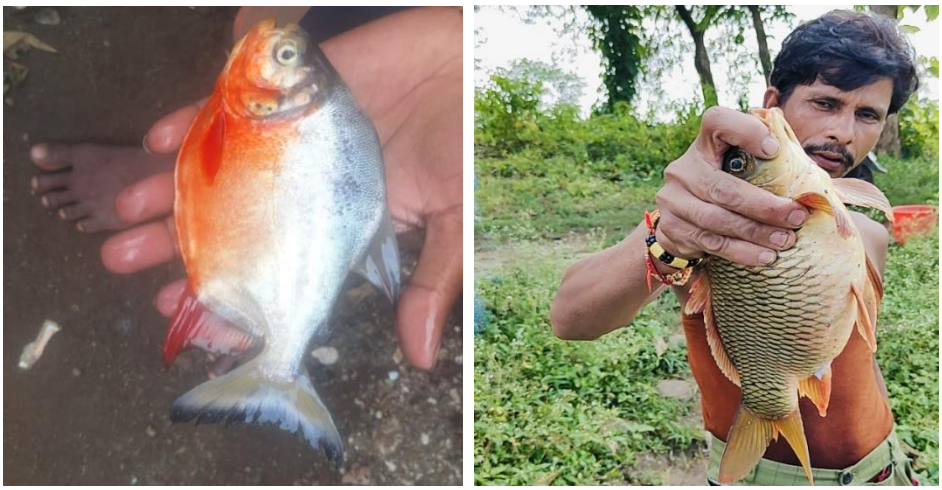


Figure 36 Two most abundant exotic fish types in river Narmada

8. Recommendations

Reassuring biodiversity in Narmada River

There is an urgent need to restore the Narmada River's native fish stock. In this context, determining the precise threshold would require taking ecological aspects into account and connecting them to the decline of biodiversity. Key steps include locating fish spawning areas, establishing fish sanctuaries, and defining operational zones, hours, and restrictions for fishing activities. Concurrently, alternative options for nutritional security and economic stability must be developed for communities dependent on the river for their livelihoods.

Easily operable scientific techniques and governance

To guarantee optimal productivity from the seasonal and perennial water resources currently available, scientific techniques for semi-intensive aquaculture should be implemented. Suitable resources include low-lying rice fields, tanks, ponds, and small irrigation dams. Small scale nutrient dense indigenous fish production in monoculture or polyculture can complement existing practices, as they have a high market demand. These techniques must be affordable, simple to implement, and replicable. Efforts should also focus on creating portable and small-scale fish seed production facilities to ensure accessibility for smallholder farmers.

Evaluation of Government policies

It is essential to assess the effectiveness of existing government policies and initiatives. This involves evaluating their impact and accessibility for underprivileged populations. Such assessments will guide the government in making informed decisions and ensuring that all programs effectively address the needs of the intended beneficiaries.

Nutritional and income security to the landless fishers' communities

Malnutrition is currently a major problem in Mandala, primarily affecting women and children in the fishing communities. Promoting tank, bioflock, and non-permanent structure-based aquaculture schemes can help address their nutritional and income need. Providing access to vested land on a lease basis for aquaculture should be considered by policymakers. Additionally, linking these communities with government health agencies can improve their overall well-being. Addressing income disparities through skill development, micro-enterprise promotion, and better access to economic opportunities is vital for fostering equitable growth.

Effective business model development

The primary goal of raising awareness among women who work in the smoked or dry fish processing sector is to ensure that they maintain proper hygiene. Producing clean dried fish cost-effectively can meet the strong market demand in several Indian states. Therefore, a new business model might be created by connecting these items with these markets. Business models should connect these products to broader markets while integrating women with aquaculture practices to ensure a steady supply of raw materials. Additionally, promoting the cultivation of water hyacinth, lotus, and makhana using natural farming methods can enhance nutritional value and open new revenue streams. Conducting an efficient value chain assessment will help identify product requirements and further opportunities for business expansion.

9. Concluding remarks

Our study on aquatic food systems in Mandla has recorded various challenges that need to be systematically addressed to transform it into a sustainable food system. Fisher Communities are in a precarious position contending with natural disasters like floods and fighting to maintain their basic household income and food. Those adopting aquaculture or related procedures are facing reduced output due to societal unrest, unscientific methods, and rising supplemental input costs. However, a high level of female participation indicates scopes for gender parity and economic empowerment. These findings highlight the need for strong developmental backing interventions. Mandla ecosystem demonstrates enormous potential for a productive aquatic food system. With scientific direction, targeted investments, and inclusive governance, the region can realize its full potential to enhance nutrition, livelihoods, and sustainable development.

This typology serves as a vital framework for researchers, decision-makers, and development organizations, providing evidence to leverage Mandla's abundant water resources for building a multifunctional landscape. Policymakers are encouraged to adopt Mandla as a pilot model for replicable aquatic food systems in other landlocked districts across India. By integrating this typology with localized context analysis and addressing specific bottlenecks, policymakers can develop strategic pathways to transform food systems into healthier, equitable, and sustainable networks. Mandla's success as a pilot model would pave the way for scaling these strategies to other regions, ensuring sustainable livelihoods, improved nutrition, and resilient communities nationwide. It is a call to action for all stakeholders to collaborate in addressing the challenges and harnessing the opportunities presented by Mandla's aquatic food systems.

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Contact

Ayan Samaddar, Post Doctoral Fellow, WorldFish India, **ayan.samaddar@cgiar.org**

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