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Assessment of fish diversity, species composition and CPUE trends in Tulshi reservoir, Western ghats, Maharashtra: Implications for sustainable fisheries management

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ABSTRACT

The present study investigates species-wise catch composition, relative abundance and catch per unit effort (CPUE) in Tulshi Reservoir, Kolhapur, Maharashtra, to assess fish diversity and its implications for sustainable fisheries management. A total of 29 fish species were recorded, with *Oreochromis mossambicus* (30.38%) emerging as the most dominant, followed by Indian Major Carps such as *Labeo rohita, Catla catla* and *Cirrhunus mrigala*. Notably, exotic species like *O. mossambicus* contributed significantly to total biomass, indicating ecological imbalances and potential threats to native fish populations. Th CPUE values showed a positive correlation with fishing efforts, suggesting increased yield with effort but also highlighting the risk of overexploitation. The findings emphasize the urgent need for conservation measures to protect indigenous species and ensure ecosystem stability. Strategic management through regulated fishing practices and continuous biodiversity monitoring is crucial for sustaining fishery resources in the reservoir.

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1. Introduction

Inland fisheries are essential for promoting the livelihoods and nutritional security of countless rural households worldwide. Freshwater ecosystems, including rivers, lakes, wetlands and reservoirs play a crucial role in enhancing food security and providing employment, especially in developing nations such as India (Ghosh and Biswas, 2017). Inland capture fisheries, typically small-scale and artisanal, hold significant socio-economic value, yet they remain inadequately represented in national policy frameworks and development strategies (Pulapparambil et al., 2019). Reservoirs, constructed mainly for irrigation, hydroelectricity and drinking water supply, have become significant factors to improving inland fish production in India. Maharashtra provides more than 2,100 reservoirs covering around 3.43 lakh hectares, positioning it as a significant state in the growth of inland reservoir fisheries (Nizara et al., 2017). The water bodies provide significant employment opportunities and improve food security for local people by hosting several native and non-native fish species. Excessive harvesting, faulty stocking methods and gear conflicts place at risk the viability of these fisheries by means of a lack of reliable monitoring systems and baseline data. Often used to gauge fishing efficiency and fish population abundance is catch per unit effort (CPUE). Defined as the number of fish caught by weight or number per standard unit of effort, such as gear-hours or fisher-days, CPUE (Ghosh and Biswas, 2017). It consistently proxies for assessing changes in stock density, projecting the consequences of fishing pressure and determining the physical and economic viability of fishery (Han et al., 2023). Particularly in data-limited inland fisheries, CPUE is usually the primary tool for fishery assessment and management Han (Han et al., 2023). Understanding the health of fish populations in reservoirs like Tulshi, which are heavily fished by traditional people using a variety of gear types, depends on standardizing and analyzing CPUE data. The sustainability of these fisheries depends on the control of fishing methods and community involvement in management as well as on natural conditions (Ghosh and Biswas, 2017). Improper gear utilization, such as fine-meshed nets and overfishing during spawning seasons, has been shown to reduce CPUE and hamper recruitment in various Indian inland lakes Often used in fisheries science, catch per unit effort (CPUE) assesses relative fish abundance and supports the assessment of fishing operation sustainability. Defined as the number or weight of catch obtained per standard unit of fishing effort. Changes in CPUE over time can show trends in fish stock health declining values frequently imply the overfishing or ecosystem degradation, whereas steady or rising values may reflect balanced exploitation (Akongyuure and Alhassan, 2021). In India, reservoirs play a critical role in inland fisheries, contributing to rural livelihoods and regional food security. Despite the vast potential of Indian reservoirs, fish productivity remains suboptimal, often due to inadequate scientific management and poor stocking strategies. Recent advancements emphasize the adoption of culture-based fisheries and co-management practices to enhance yields and ensure ecological sustainability (Sugunan, 2023).

From a fisheries management point of view, the Tulshi Reservoir, situated in the environmentally vulnerable Western Ghats of Maharashtra has remained unexplored. Though no thorough research has recorded its fish diversity or CPUE measurements, local people rely on it for fishing resources. By evaluating the CPUE in Tulshi Reservoir, recording the composition and abundance of captures fish species and producing data to assist sustainable fishing methods suited to local conditions, this study aims to fill that gap.

2. Materials and Methods

The present study was carried out over a full annual cycle to capture seasonal variations in fish catch and effort in the Tulshi Reservoir, located in the Kolhapur district of Western Maharashtra. Field visits were conducted fortnightly a month from March 2023 to February 2024, ensuring systematic coverage of the three major seasons in the region: pre-monsoon (March to May), monsoon (June to September) and post-monsoon or winter (October to February). This schedule yielded a total of 24 sampling events across the year.

At each site, direct observations of active fishing were made during morning and evening hours, the peak fishing periods. Fishers total catch weights were measured using a portable digital balance, while the number of individuals per species was also counted on-site. The time from gear deployment to retrieval was recorded to determine the total fishing time (in hours). Passive gears like gill nets and traps were monitored for soak time (Ghosh and Biswas, 2017).

Catch Per Unit Effort (CPUE) was calculated using the formula:

CPUE= Total catch (kg or number)/ Total effort (fisher-hours or gear-hours)

Effort was standardized in fisher-hours, where one fisher working for one hour equals one unit of effort. For example, two fishers using a net for three hours would represent six fisher-hours of effort. This method is commonly employed in CPUE-based inland fisheries research (Mariappan et al., 2025). The type and number of fishing gear types included floating gill nets and baited hooks. For gill nets, the mesh size ranged between 60 mm and 90 mm, with net dimensions varying from 6 to 10 feet in depth and 500 meters to 1 kilometer in length. Detailed records were maintained to account for gear specifications and variations across sampling events.

Using a pre-tested questionnaire, 06 local fisherman were interviewed semi-structurally during rest hours. Among the questions were average daily fishing time, number of gears used, weekly fishing frequency and perceived variations in fish catch over time. Especially in regions with little forma catch records, this participatory approach has shown to be successful in collecting consistent fisheries data. Data acquired were triangulated with direct observations to estimate overall fishing effort accurately. Data were gathered in Microsoft Excel and examined with PAST version 4.13 tools. Each site and season had CPUE values computed; gear specific CPUE values were generated to evaluate efficiency and possible overexploitation (Mushtaq et al., 2024).

2.1. Study Area

Located near Dhamod village in Radhanagari Taluka of Kolhapur district, Maharashtra, the Tulshi Reservoir is located. Set in the rich biodiversity of the Western Ghats, the reservoir sits at roughly 700 meters above sea level. Though it also helps inland fisheries and local economies, it was mostly built for irrigation and drinking water supply. Surrounded by lush deciduous and semi-evergreen forests, the reservoir gets water from seasonal Sahyadri range streams. Near Dhamod village in Radhanagari Taluka in Kolhapur district, Maharashtra, the Tulshi Reservoir is located. Set in the rich biodiversity of the Western Ghats, the reservoirs sit at roughly 700 meters above sea level. Though it also helps inland fisheries and local economies, it was mostly built for irrigation and drinking water supply. Surrounded by lush deciduous and semi-evergreen woods, the reservoir draws seasonal stream inflow from the Sahyadri hills. With significant rain from June to September, the region has a tropical monsoon climate. The reservoir and its surrounding ecosystems sustain a rich diversity of aquatic and terrestrial animals, making it an important site for ecological and fisheries-based studies.

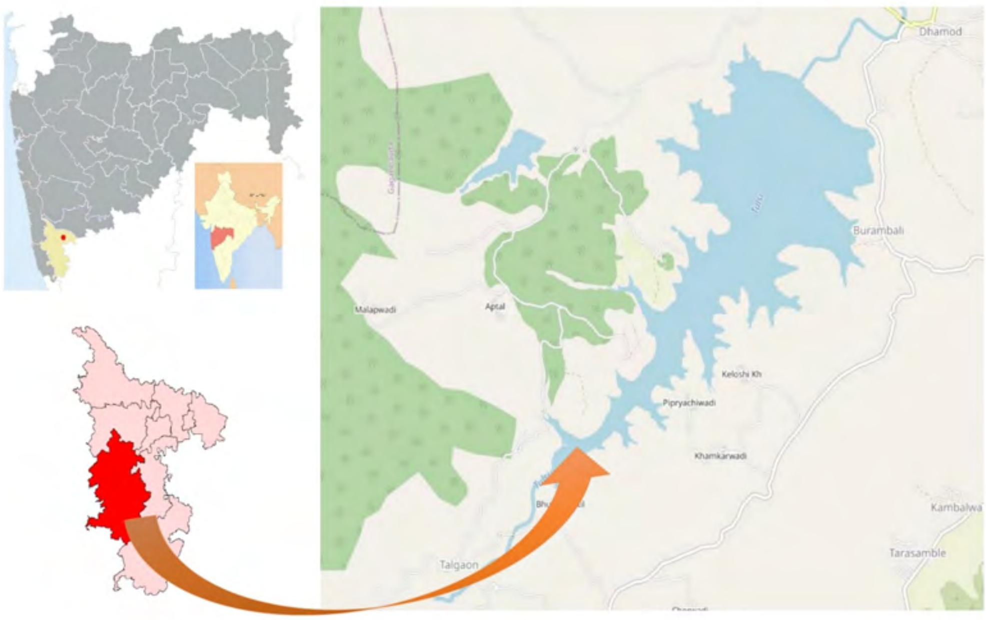

Fig. 1. The study area emphasizing Tulshi Reservoir near Dhamod village, Radhanagari Taluka, Kolhapur district, Maharashtra

3. Results

The studied reservoir ecosystem identified a total of 29 fish species from 17 families. The dominance and biomass contribution of individual taxa was determined by means of species-wise average percentage contribution to the overall fish catch. Of the observed species, *Oreochromis mossambicus* (Mozambique Tilapia) was the most prevalent, with a total catch contribution of 30.38% and the highest biomass proportion of 46.32%. This suggests a significant frequency of this foreign species, probably because of its fast reproductive capacity and great adaptability.

Contributing much to the capture with 11.31%, 11.07% and 10.42% respectively, the Indian big carps including *Labeo rohita* (Rohu), *Catla catla* (Catla) and *Cirrhunus mrigala* (Mrigal) together accounted for 32.80% of the overall catch. Reflecting their economic significance and good growth performance under the reservoir conditions, their individual biomass contributions were 8.62%, 10.13% and 9.21%.

With biomass shares of 3.81%, 4.48%, 2.48% and 1.62% respectively, secondary contributors included *Cyprinus carpio* (5.43%), *Ctenopharyngodon Idella* (3.77%), *Rita rita* (3.39%) and *Hypselobarbus kolashi* (3.32%). Though less common than the main group, these species biomass contributions imply they are larger-bodied and so significantly affect fishing output. Moderately represented were predatory and carnivorous species such as *Wallago attu* (2.98%), *Channa striata* (2.42%) and *Clarias batrachus* (1.49%), suggesting a balanced trophic structure within the

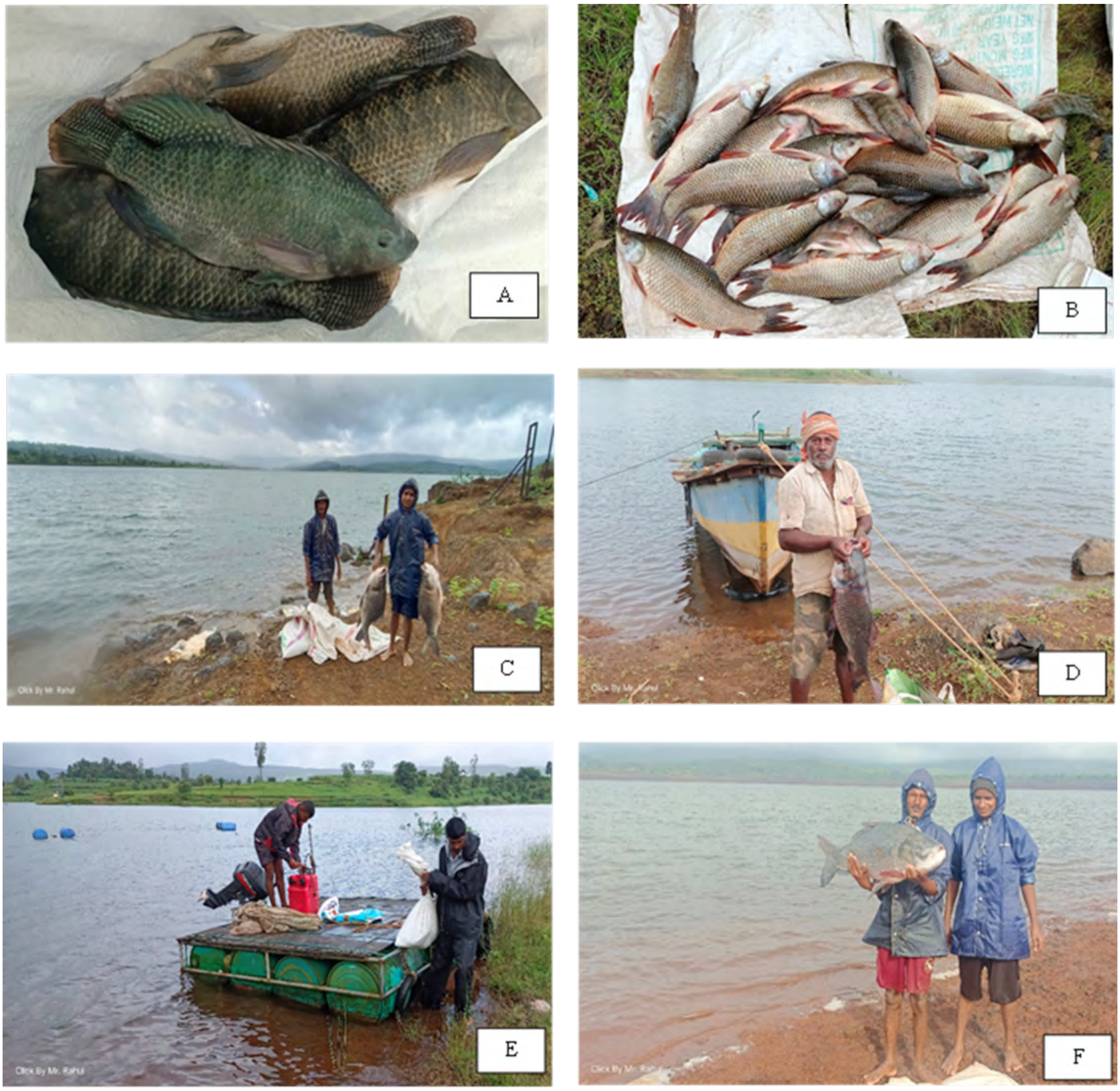

Fig. 2. Photographic representation of fishery activities and catch composition at Tulshi Reservoir: **A.** Abundant seasonal catch of *Oreochromis mossambicus* (Mozambique Tilapia); **B.** Mixed fish species harvested during routine fishing operations; **C.** Fisher displaying a 10 kg total catch obtained during the monsoon season; **D.** Large Tilapia catch (25 kg) with fishing vessels in the background; **E.** Mechanized diesel-powered boat employed for fishing activities; **F.** A local fisherman showcasing a 20 kg specimen of *Labeo rohita* (Rohu)

fish population. Small native species (SIS) such as Esomus danricus, Amblypharyngodon mola and Parabassis lala also contributed less than 1% each but are ecologically important as feed fish and biodiversity markers.

A notable observation was the presence of introduced species such as a *Hypophthalmichthys molitrix* (Silver Carp), although in minimal quantity (0.35%) indicating limited proliferation under current reservoir conditions.

The fig. 3 presents seasonal variations in CPUE (Catch Per Unit Effort) for Tulshi Reservoir, highlighting differences in fish catch efficiency throughout the year. The monsoon season recorded the highest CPUE at 27.63 kg/hour, with a total catch of 3978 kg over 144 fisher-hours, indicating peak fishing productivity during this period. This could be due to favorable ecological conditions, such as increased nutrient levels and fish movement associated with rainfall and water inflow. In contrast, the winter season exhibited the lowest CPUE, with only 2058 kg of fish caught, resulting in 7.35 kg/hour, likely reflecting reduced fish activity or dispersal patterns during colder months.

The summer and post-monsoon periods showed intermediate CPUE values of 17.11 kg/hour and 13.51 kg/hour, respectively, suggesting moderate fishing success. These seasonal differences underline the importance of timing and environmental conditions in fisheries planning and resource sustainability in the reservoir.

The study showed a clear relationship between fishing effort (gear-hours) and Catch Per Unit Effort (CPUE) in the Tulshi Reservoir. As fishing effort increased from 1 to 12 hours, CPUE also generally increased. At 1 hour, the CPUE was 3.89 and it steadily rose to 26.50 at 12 hours. The increase in CPUE was more noticeable between 3 to 6 hours, suggesting a short period of stability. However, a sharp increase resumed from 10 to 12 hours, indicating that longer fishing efforts captured more fish. Overall, the results suggest that extended fishing time leads to higher catches, but the rate if increase is not always constant. This highlights the importance of selecting the right fishing duration to maximize catch while avoiding overfishing. (Fig. 4)

The analysis of fish catch composition in the Tulshi Reservoir revealed that *Oreochromis mossambicus* made up the highest share, contributing 30.38% to the total catch. This was followed by native species such as *Labeo rohita* (11.31%), *Catla catla* (11.07%) and *Cirrhunus mrigala* (10.42%). Other important contributors included *Cyprinus carpio* (5.43%) and *Ctenopharyngodon idella* (3.77%). A collective group of other fish species accounted for 27.62% of the total catch. The predominance of *Oreochromis mossambicus,* an exotic species suggests it has established a strong presence in the reservoir. While its high density supports fishery yield, it may pose a threat

Table 1. The mean percentage contribution of each species to the total catch and their respective biomass percentages, reflecting species abundance and weight-based dominance

Sr. No.	Scientific Name	Common Name	% Abundance	Biomass Contribution (%)
1	*Oreochromis mossambicus*	Mozambique Tilapia	30.38	46.32
2	*Labeo rohita*	Rohu	11.31	8.62
3	*Catla catla*	Catla	11.07	10.13
4	*Cirrhinus mrigala*	Mrigal	10.42	9.21
5	*Wallago attu*	Freshwater Shark	2.98	1.45
6	*Channa striata*	Striped Snakehead	2.42	1.11
7	*Cyprinus carpio*	Common Carp	5.43	3.81
8	*Mystus vittatus*	Striped Dwarf Catfish	1.87	1.03
9	*Ompok bimaculatus*	Butter Catfish	0.90	0.58
10	*Glossogobius giuris*	Tank Goby	1.87	1.48
11	*Channa punctata*	Spotted Snakehead	0.80	0.58
12	*Clarias batrachus*	Walking Catfish	1.49	1.09
13	*Rita rita*	Rita Catfish	3.39	2.48
14	*Ctenopharyngodon idella*	Grass Carp	3.77	4.48
15	*Hypselobarbus kolashi*	Kolashi Barb	3.32	1.62
16	*Heteropneustes fossilis*	Stinging Catfish	1.21	0.89
17	*Esomus danricus*	Flying Barb	0.42	0.30
18	*Parambassis lala*	Elongate Glassy Perchlet	0.90	0.66
19	*Salmostoma boopis*	Boopis Razorbelly Minnow	1.04	0.76
20	*Puntius sophore*	Pool Barb	0.90	0.66
21	*Puntius ticto*	Ticto Barb	1.11	0.81
22	*Amblypharyngodon mola*	Mola Carplet	0.55	0.41
23	*Notopterus notopterus*	Bronze Featherback	0.45	0.33
24	*Garra mullya*	Mullya garra	0.42	0.30
25	*Mastacembelus armatus*	Tire Track Eel	0.21	0.08
26	*Tor khudree*	Khudree Mahseer	0.42	0.30
27	*Salmostoma boopis*	Boopis Razorbelly Minnow	0.31	0.14
28	*Osteobrama cotio*	Cotio	0.31	0.11
29	*Hypophthalmichthys molitrix*	Silver carp	0.35	0.25

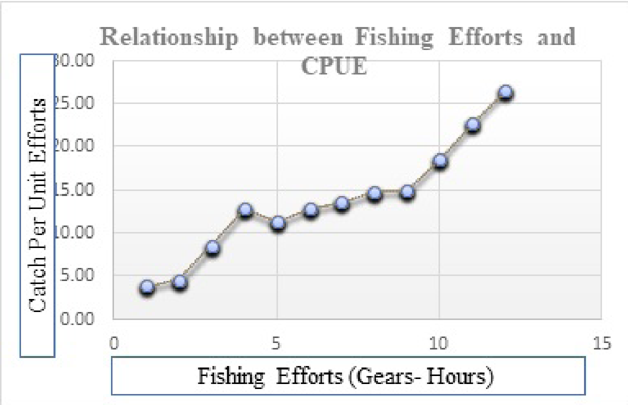

Fig. 3. Seasonal variation in Catch Per Unit Effort (CPUE) (kg/hour) in Tulshi Reservoir

to native biodiversity by outcompeting indigenous species for food and space. Therefore, it is essential to implement conservation strategies focused on protecting and restoring native fish populations to maintain ecological balance and long-term sustainability of the reservoir's aquatic ecosystem.

With biomass shares of 3.81%, 4.48%, 2.48% and 1.62% respectively, secondary contributors included *Cyprinus carpio* (5.43%), *Ctenopharyngodon idella* (3.77%), *Rita rita* (3.39%) and *Hypselobarbus kolashi*. Though less common than the dominating group, these species biomass contributions imply they are larger-bodied and hence significantly affect the yield of the fishery. Moderately represented were predatory and carnivorous species such as *Wallago attu* (2.98%), *Channa striata* (2.42%) and *Clarias batrachus* (1.49%), suggesting a balanced trophic structure in the fish community. Small indigenous species (SIS) such as *Esomus danricus, Amblypharyngodon mola and Parambassis lala* also contributed less than 1% each but are ecologically important as feed fish and biodiversity markers.

4. Discussion

This study on the Tulshi Reservoir shows a notable predominance of *Oreochromis mossambicus,* an alien species, which accounts for 30.38% of the whole capture. This trend reflects findings in other Indian reservoirs, where non-native tilapia species have spread. The addition of *O. niloticus* and *O. mossambicus* in the Guddemdodddi and Ramanpad Balancing Reservoirs of Telangana, for examplex has been connected to a fall in native Indian major carps (IMCs) including *Catla catla*, *Labeo rohita* and *Cirrhinus mrigala*, suggesting competitive displacement and environmental imbalance (Rao and Rao, 2023). Comparative studies with other reservoirs highlight the effect of foreign species on native fish diversity. *O. niloticus* founding in the Rihand Reservoir has been linked to lower native fish populations, which calls for ongoing monitoring to offset biodiversity decline (Alam et al., 2024). The Bargi Reservoir in Madhya Pradesh has similarly seen a drop in IMC catch from 83% in 2002-03 to 46% in 2019-20, together with a rise in local minor species, implying changes in community structure possibly affected by environmental changes and species introductions (Katre et al., 2023).

Data on Catch Per Unit Effort (CPUE) from Tulshi Reservoir shows a beneficial correlation between fishing effort and yield; CPUE rose from 3.89 to 26.50 as gear-hours grew from 1 to 12. This pattern corresponds to results from the Kaptai Reservoir, where CPUE for dominant clupeid species peaked in particular years, hence reflecting the impact of fishing pressure and stock dynamics on catch rates (Khatun et al., 2023). Exotic species like tilapia's spread creates major problems for reservoir fisheries management. Rapid reproduction and adaptation might cause native species to be suppressed by competition for resources and habitat modification. The occurrence of tilapia in the Mayar River of the Western Ghats has been noted as a danger to indigenous fish species, hence stressing the requirement of conservation actions to safeguard native

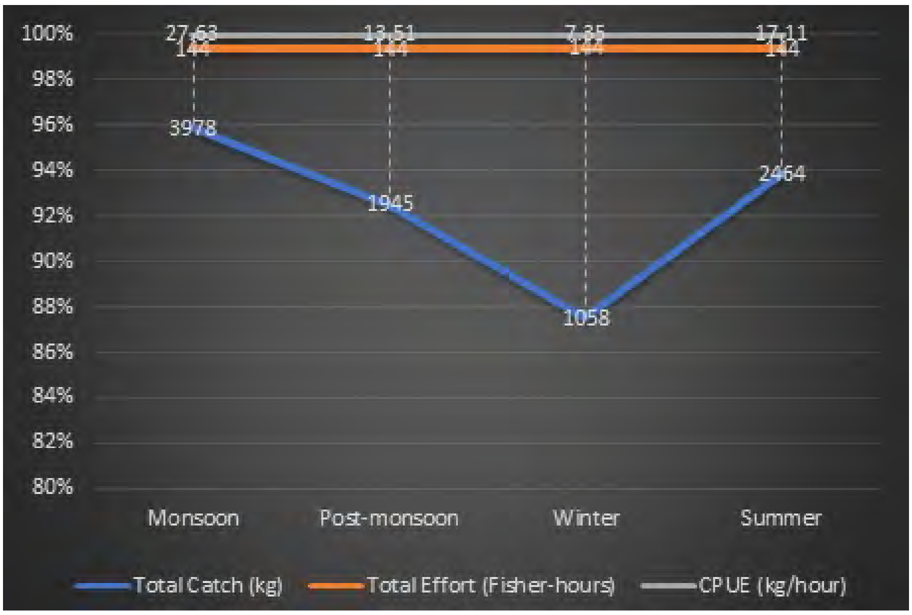

Fig. 4. Relationship between Fishing Efforts and CPUE of Tulshi Reservoir

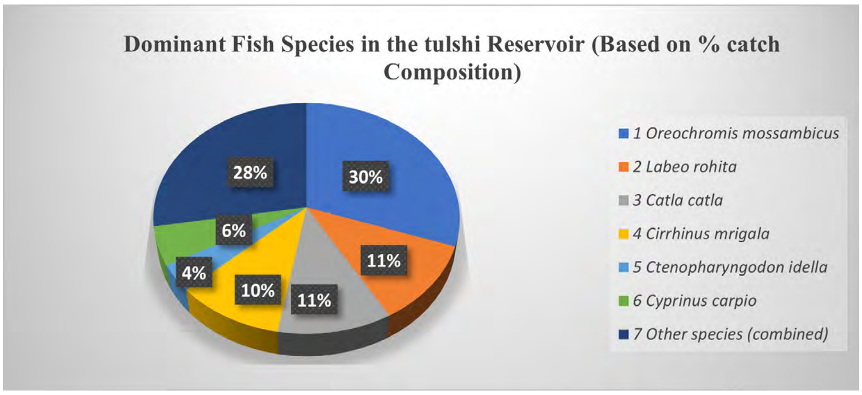

Fig. 5. Pie chart of dominant fish species in the Tulshi Reservoir

biodiversity (Atkore and Kavin, 2023).

Integrated management plans are absolutely necessary to meet these difficulties. These consist of fish population monitoring, habitat restoration and policy enforcement to limit invasive species expansion. Promoting the culture and protection of local species also helps to restore ecological balance and maintain the output of fisheries.

5. Conclusion

The results of the Tulshi Reservoir show a significant change in fish species composition, with the foreign *Oreochromis mossambicus* becoming the dominating species. This calls into question the long-term viability of native fish populations, especially commercially and ecologically important Indian Major Carps (IMCs). The high quantity and adaptability of tilapia could displace native species, hence lowering biodiversity and changing the natural balance of the ecosystem. The rise in CPUE with more fishing effort emphasizes the need of controlled fishing operations. Although unmonitored exploitation could lead to overfishing and stock depletion, especially of sensitive native species, improved short-term yields may result from increased effort. This calls for immediate application of management techniques emphasizing conservation. These should comprise monitoring of invasive species spread, restoration of native fish habitats and encouraging community awareness.

Sustainable fishing schedules and gear limits can also help to balance output with conservation by means of CPUE optimization. Such coordinated strategies will guarantee the long-term sustainability of the Tulshi Reservoir ecosystem and the livelihoods reliant on it.

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