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Assessment of Fisheries and Management- Insights from Dal Lake, Kashmir

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ABSTRACT

The present study was done during 2019-20 to assess the current fisheries status of Dal lake in terms of species diversity, trophic status, trends and patterns in fish catch, the lake's physicochemical properties and its management. Shannon-Wiener index used to calculate the species diversity was 2.08 with the species evenness value of 2.19. The water quality analysis revealed that the lake is highly polluted due to various anthropogenic activities like sewage influx, vegetable cultivation, tourism activities, etc. The lake is dominated by omnivorous fishes followed by herbivores and carnivores. The compound annual growth rate results from 1989 to 2019 for capture fisheries showed the positive growth rate of 0.23. A lack of coordination between the different governing bodies has led the Dal lake to its brim of death. It is recommended to restore by controlling the sewage influx and weed growth. Additionally, the existing pattern of governance and management needs to be modified.

INTRODUCTION

In India fisheries and aquaculture form an important sector of employment, livelihood, and food security. The total fisher population of the country is about 28.06 million and inland fisheries is increasingly contributing to the country's nutritional security, with a present yield of over 10.43 million tonnes (Handbook of fisheries statistics, 2020), contributing to nearly 75.25 per cent of the total fish production with an annual growth rate of 7.3 per cent.

Dal lake is an urban lake and is the second largest lake in the state, playing an essential role in the economy through its tourist attraction and as a source of food and water. Sir Walter Lawrence described the lake as Lake Par-Excellence and is considered as the "liquid heart" of Srinagar (Masoodi & Kundangar, 2018). The total area of the lake has reduced from ~32 km^2 in 1859 to 18 km^2 in 2018 (Mushtaq et al., 2018), mostly due to the expansion of settlement areas (Rashid et al., 2017). The lake is an essential source of livelihood for the people involved in fisheries, tourism and vegetable production and marketing. Nine fish species of commercial importance have been reported in Dal Lake, with *Cyprinus* and *Schizothorax* (Kashir gaad/ Snowtrouts) being the dominant genera (Imtiyaz et al., 2017). Besides a main source of fish, the lake also provides vegetables, *Nadroo* (*Nelumbo nucifera*), rhizomes, fodder, water, etc. Once potable, the water quality of the lake has deteriorated (Trisal, 1987; Jeelani & Shah, 2006), reflecting the aggregative impact of many anthropogenic activities such as sewage influx from houseboats, agricultural runoff, encroachment and population pressure (Yaqoob et al., 2008; Qadri & Yousuf, 2008; Khan et al., 2012; Salem & Jeelani, 2017). About 1200 houseboats present in the lake (Fazal & Amin, 2012; Qureshi et al., 2016) act as a considerable source of untreated sewage (Tanveer et al., 2017). The water quality of the lake has further deteriorated due to reduced inflow of streams to the lake (Mushtaq et al., 2020), a probable impact of climate change in the Himalayan region (Parvez et al., 2014). Besides increased organic load, known factors like human settlements, hotels, floating gardens, and even dhobi ghats on the periphery contribute to the lake's slow death (RS, 2008).

In addition to threats to aquatic life, the drastic changes in lake water quality over the last few decades (Kumar et al., 2022)

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have affected ecology of the lake (Ganie & Hashia, 2020). The population of the indigenous *Schizothorax* fish species of the lake has declined considerably due to high pollution and the introduction of common carp species (Kundangar, 2004; Qureshi et al., 2016; Shakir, 2019). Earlier, many scientific studies have been carried in Dal lake about limnology, ecology, fisheries, and socio-economics. To maintain the biological equilibrium and its robust management, it is necessary to assess the level of governance, management, and fisheries aspects of the lake. So, the present study was taken to understand the current status of fisheries and to describe the past dynamics of fish trophic status, species diversity, and catch trends concerning the governance policies in vogue.

METHODOLOGY

The status of fisheries management of Dal Lake was documented by analyzing the data collected from both primary and secondary sources during 2019-20. The primary data was collected from key informants, local leaders from fisher communities and Department of Fisheries (DoF) J&K, by semi-structured personal interview schedules and focussed group discussions. The data was also obtained from the Department of Tourism (DoT) J&K, and the Jammu and Kashmir Lake and Waterways Development Authority (JKLAWDA), the main players involved in the management and governance of the lake. Catch details in terms of quantity and composition were taken from lake fishers and the data repository of DoF, J&K. To understand the nature and future of snow trout fishery, a long-term trend analysis of catch was carried out to predict the production trend.

The published literature between 1975 and 2019 (Trisal, 1987; Wani et al., 2015; Bhat & Dar, 2015; Lone et al., 2017; Amin et al., 2018; Mushtaq et al., 2018) were reviewed to understand the status of water quality, including pollution status and certain ecological aspects of Dal lake. The main aim of this assessment was to quantify the changes in selected water quality parameters that have affected fish diversity and catch composition over the last three decades.

Shannon-Wiener index (1949) was used to estimate the extent of fish species richness and lake diversity for two different time periods (1989-90 and 2018-19). For each fish species in the composition, the trophic level value was obtained from the trophic analysis available online on the fishbase.org website. Based on the trophic level values, fishes were categorised into different types: Omnivores, Herbivores, Detritivores (2-2.9); Mid-level Carnivores (2-3.9); High-level Carnivores (4-4.9); & Top predators (5 & above).

To calculate the growth over multiple periods and its cumulative variations, Compound annual growth rate was calculated at ten years intervals from 1989 to 2019 by using the below formula

$$\text{Compound Annual Growth Rate (CAGR)} = \left(\frac{Ending\ Value}{Begining\ Value}\right)^{\frac{1}{n}} - 1$$

Where n = number of years

RESULTS AND DISCUSSION

Table 1 reveals fluctuations in various water quality parameters of Dal lake probably because of an increase in sewage influx, pollution loads, organic loads and subsequent degradation (Kumar et al., 2022). The major changes were reported around 2006-07 leading to the sharp decline in *Schizothorax* fish production. The dissolved oxygen levels had significantly declined since the 1990s due to excessive growth of weeds and macrophytes, a direct impact of lake pollution (Mushtaq et al., 2018).

At the physiographic level, it was observed that the encroachments of the water channels and consequent clogging have diminished the circulation and inflows into the lake. The water quality of Dal lake was polluted due to of the direct drainage of sewage influx from nearby residential areas, defunct sewage plants, and from inside human habitation, particularly houseboats and lake dwellers. The chloride content of the water had drastically increased since the last two decades from 2 to 2.7 mg/l in 2007, to 10.3 mg/l in 2017 (Mushtaq et al., 2018) which may be due to drainage coming from catchment areas, raw sewage coming from houseboats and nearby settlements and organic runoff from floating gardens of both allochthonous and autochthonous origin (Ahangar et al., 2012; Kumar at al., 2022).

On the other hand, no major change in average annual temperature was reported. The temperature values were found to be in the good range for the growth of plankton except for the winters when the freezing of the lake reduces the growth of aquatic organisms and therefore food availability. Dal lake revealed mesotrophic nature with a moderate primary production level. Qureshi et al., (2016) reported a major contribution of *Schizothorax* to the overall fish catch of the Dal lake before the introduction of common carp in Kashmir in 1957. However, after its introduction, the *Schizothorax* catch declined sharply. During personal interviews and group discussions, similar views were reflected by the key informants and local leaders of fisher communities. The carp fish species had maximum diversity (5 species) in the Dal lake, followed by *Schizothorax* (3 species).

Table 1. Changes in water quality parameters over the years in Dal Lake

Parameter	1974-76	1985	1996-1997	2006-07	2018
Water temperature (°C)	16.4	-	-	15	16.4
pH	7.4-9.5	8.7	8.7	7.8-8.3	7-10
Dissolved oxygen (mg L^{-1})	10.25	8.7	8.6	6.8	7.07
Total alkalinity (mg L^{-1})	69.5	85.6	104	115	101.75
Nitrate (µg L^{-1})	481	483	272	539	400
Ammonia (µg L^{-1})	23.6	37.0	362	438	40
Ortho phosphate (µg L^{-1})	65.5	80.5	135	93	40
Total phosphorus (µg L^{-1})	187.8	211.5	768	615	200
Total dissolved solids (mg L^{-1})	30.2	32.2	119.8	20	-

(*Source:* Abubakr & Kundangar, 2009; Khanday et al., 2018; Dar et al., 2020)

Nine commercial fish species in Dal lake were recorded. The exotic carps were found to be the dominating ones while the indigenous snow trout species showed less contribution to the overall fish catch. Figure 1 shows the contribution of different fish species to the fish catch of the lake with an index value (H-value) of 2.08, signifying the ecosystem diversity of the lake in terms of the available fish fauna. Shannon-Weiner Index estimated the species evenness value of 2.19, mainly due to the dominance of common carp with other fish species like *Schizothorax* being found in lesser numbers. The analysis of trophic metrics depicts that the lake was dominated by omnivore fish species (55.5%) followed by herbivores (33.3%) and carnivore fishes (11.2%), indicating significant gaps between various trophic levels. The trophic level score indicates the relative frequency of the fish among all the trophic levels available in that aquatic system (Dubey et al., 2012; Kumar et al., 2013).

The DoF, J&K stocks the Dal lake every year with fingerlings of common carp fish species at various locations with the help of local anglers. The present area of Dal lake is 18 km^2 (1800 ha), and on average 420,000 fry/year were stocked in the lake over the last few years with a stocking density of 250 fry/ha (DoF, 2022). This data indicates a low seed stocking level of the lake when compared to general recommendations of 300 to 500 fingerlings/ha (DoF, J&K). Moreover, the personal discussion with fishers also revealed similar concerns regarding the stocking of Dal lake. The annual catch from Dal lake, including all stocked and non-stocked fishes, was 450.5 tonnes. Historically, the total fish production of Dal lake ranged from as low as 262.03 tonnes in 2007-08 to a maximum of 475.65 tonnes in 2003-04 (Figure 2). Fish production in Dal lake has exhibited fluctuations in production across the time considered.

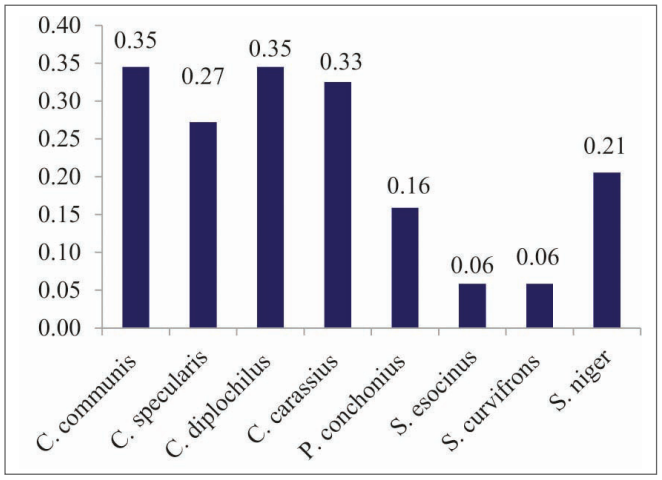

Figure 1. Species-wise contribution in the fish catch of Dal Lake

Based on data of total fish production (carp and *Schizothorax)* from 1989 to 2019, the estimated trend lines showed a severe decline in the catch of *Schizothorax* fish (Figure 2). The main reason for the reduction of snow trout production has been attributed to the water pollution owing to various anthropogenic activities (Qureshi et al., 2016). Pollution has badly affected *Schizothorax* fish production and has destructed the breeding grounds of the native fish. This impact has been very severe since 2007-08 and had a tremendous effect on the total fish production in Dal lake. Inspite of this, the total fish production of the lake has remained more or less constant due to the compensatory increase in performance of common carp fish production that is more resistant to the adverse environmental conditions of the lake.

CAGR was used to determine the growth in fish production in the lake over the time period considered (Table 2). The positive value of 0.23, depicts that in the given time period, there is an increase of 0.23 per cent in the fish catch from 1990-2019 which may be attributed to the considerable increase in the production of common carp. Decade-wise the growth rate was negative from 2000 to 2009, were a decline of 4.52 per cent occurred. The main reason for this reduced growth rate was the significant decline in *Schizothorax* fish production because of excessive pollution and the non-functioning of some sewage treatment plants (STP) at the lake periphery. The growth of *Schizothorax* from 1989 to 1999

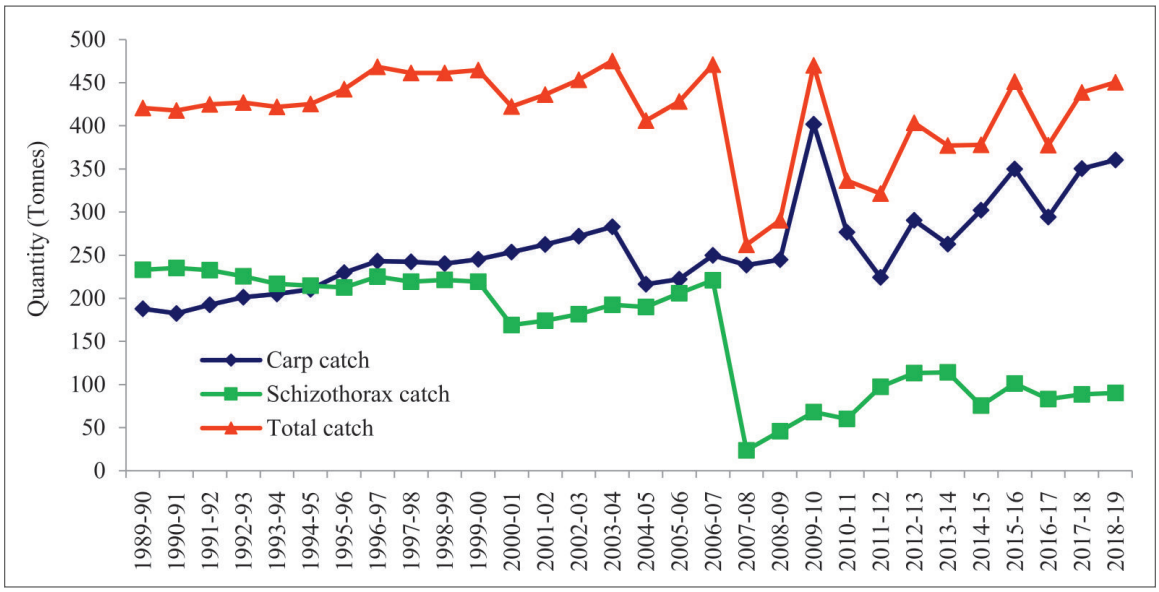

Figure 2. Carp and *Schizothorax* fish production in the lake

Table 2. Decadal CAGR of fish production in the lake

Time period	Total production	Carp production	*Schizothorax* production
1989-99	0.92	2.49	-0.53
2000-09	-4.52	0.19	-14.52
2010-19	4.49	4.22	2.83
1990-2019	0.23	2.20	-3.12

also showed a negative value, but the magnitude of the decline was very less. The fluctuations in the fish catch can be partly explained by poor management and more fishing effort.

The functioning and activities of DoF, J&K as understood during the present study are shown in Table 3. The fishing rights of Dal lake are fully vested in this department. It was observed that the fisheries aspect is being given less priority or at times neglected and remains a major issue regarding governance of the lake. It needs to be addressed in light of recent developments by following the various natural resource management strategies and the same has been reported by Tyagi et al., (2015) for reservoir fisheries management. More focus is given to the tourism sector because of more income from tourism activities in the lakes. Additionally, there is a lack of coordination between the mentioned departments involved in the management of the lake. However these things can be rectified by promoting the participation of all the key players and stakeholders in a single platform for the sustainable growth of the lake and similar findings have been reported by Priyanka & Devarani (2022).

Based on the nature of fishing and conservation status, four types of fishing licenses are issued by the DoF, J&K. These include fishing licenses in protected waters of the lake with a license fee of Rs. 600/annum, fishing licenses in reserved waters of the lake with a license fee of Rs. 500/annum, *Hakreeza* license with a license fee of Rs. 400/annum, *grass* license with a license fee of Rs. 500/annum and *Nadroo* (*Nelumbo nucifera*) licenses with a license fee of Rs. 1000/annum. All these licenses have a validity period of one year (April to March of the next year). The lessee has to follow specific rules and regulations as per the agreement regarding mesh size regulation, ban on fishing and fish marketing during the breeding season, prohibited fishing in sanctuaries, the proper size of fish to be harvested, stocking of seed and engaging only licensed fishers for fishing, etc. mentioned in the revised Fisheries Act 2018 (DoF, 2022).

It was observed that due to the unavailability of a proper fish market, the fishers themselves do fish marketing on the banks of Dal lake and in nearby villages, with fisherwomen selling the majority of the catch. The price of the fish varies as per the season, size of the fish, marketing channel, and market location. Fishers get more prices during winter and less during the summer season because of less availability and good condition of the fish in winter. The cost of fish (Carp and *Schizothorax*) in 2021 in distant markets during winter was Rs. 240 to 280/kg, and in the summer season, it varied between Rs. 180 to 210/kg. If the fishers sell their catch by themselves at the lake periphery, in the winter and summer seasons, they used to get a price was Rs. 220 to 250/ kg and Rs.170 to 190/kg, respectively.

Mainly two types of marketing channels were followed for fish marketing at Dal lake. The first and the shortest channel was from fishers to consumers directly. The second channel started from the fishermen to fisherwomen and then to the consumer. In the second channel, the female household member played a vital role. Almost 90 per cent of the catch from Dal lake was being sold through this channel only.

Most of the fishers were involved in fishing as their primary occupation. There was a lack of occupational diversification among fishers because of less involvement in activities other than fishing. So any fluctuations in the fisheries aspect of the lake will have a direct impact on fishers' livelihood. Iqbal et al., (2020) in their study found that joint ventures and participation of the stakeholders will help in improving the condition of the common resources and their development. In the case of winters, the temperature used to be very less and at times the whole lake may get freeze. From the livelihood perspective, the winter season was very crucial and fishers used to suffer many problems to meet their daily needs. This can be addressed by providing them some alternate livelihood options in the form of ornamental fishery, aqua-shops and aquaponics and can be enhanced by providing fishers hands-on training about the same activities, similar results were found by Sharma et al., (2011). As the lake is already a famous tourist destination, promoting aqua-tourism in line with agri-tourism will also be an emerging livelihood venture for the fishers (Slathia et al., 2015; Krishna et al., 2021). Also, for the better management of the lake, the fishers should be taken into consideration before formulating any scheme or policy.

CONCLUSION

Over the years the water quality of Dal lake has deteriorated causing adverse impacts on it fish fauna. The endemic *Schizothorax* fish populations have declined considerably owing to the pollution and introduction of exotics. At the same time, the total fish production of the lake has not much increased over the last few decades. The lack of proper governance, policy regulations and coordination between government agencies and fishers adds more negative impact to this. As observed, most of the policies have been formulated without considering fishers' perceptions. The DoF

Table 3. Functions performed by DoF, J&K

S.No.	Activities	Remarks
1.	Stocking	Done by DoF annually with an average stocking density of 250 fry/ ha/ year in Dal lake
2.	Monitoring and regulation	Insufficient management (no mesh size relation, fishing by non-license holders)
3.	Conservation	Ban on catching undersized fishes (less than 5 inches) but no ban on broodstock catch, ban season May 1st to June 30th
4.	Marketing	Sometimes the catch is sold at the lake by the fishers' and sometimes to the contractor directly
5.	Collection oflicense fees	Done by DoF

should initiate fish product development, ornamental fishery, aqua-shops, aquaponics, etc., to attract tourists to earn revenue for the fishers. Besides, tourism can also be an alternative livelihood for fishers, providing other means of economic source to the fishers.

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