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Status and development of reservoir fisheries under madhya pradesh fisheries federation: A case study on Indirasagar reservoir

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Abstract

Madhya Pradesh with its 0.46 million hectare water spread area has the maximum water spread under manmade lakes of all Indian states in terms of area and 1.695 lakh hectares tops the table in respect of medium reservoirs. The study concentrates on developing and managing Reservoir fisheries in Madhya Pradesh under the Madhya Pradesh fisheries federation. The reservoir area above 1000 hectares is under the control of the Madhya Pradesh Fisheries Federation (Matsya Mahasangh), an apex body of the fisheries cooperative society. Indirasagar reservoir, is the largest reservoir in India with a total area of 93000 hectares, with a total catchment area is 61,642 Km². The ownership of the reservoir is in the hand of the Narmada Valley Development Authority, an autonomous institution of the Madhya Pradesh government. Fishing in the reservoirs is allowed only to the member of the fishermen cooperative who was affected during the construction of the dam and reservoirs and whose house comes within a 10 km area of impoundment. The total fish production of Madhya Pradesh is about 2443 tonnes in 2018 and 1669 tonnes in 2019 which declined by 31.68% 2019. The reservoir has witnessed 60 kg/ha productivity in 2015, above the national average productivity of 46 kg/ha. The optimum yield has been studied by the Schaeffer model which is found to be 1728 tonnes with the optimum fishing effort of 240 fishers per day. The Species composition of the reservoir shows the catch of 15 fish species regularly reported in the Indirasagar reservoir and the relative proportional abundance rank is shown by the Whittaker plot which shows Catla species is the most abundant and Mahaseer is least abundant among the fish species from 2016 to 2018. The advance Fingerlings will be stocked annually in the Indirasagar (164.919 lakhs in 2019) reservoir by the Private Contractor under the supervision of the Madhya Pradesh Fisheries federation. The Pen culture was found to be the most suitable method to stock the fingerlings. In-time stocking can be done with the least mortality rate which will help in stock enhancement and optimum fish yield from the reservoir.

Keywords: Sustainability, productivity, optimum yield, species composition

1. Introduction

India has 19,370 reservoirs spread over 15 states with an estimated 3.15 million ha surface area at full capacity, and this is expected to increase due to execution of various water projects in the country (K.K Vass *et al*, 2009) ^[16]. The fishery is a state subject under the Constitution of India but only a few states have a policy specifically aimed at fish marketing, the only legislation for fish marketing is the West Bengal Fish Dealer's Licensing Order, 1975. The expansion of Inland fisheries has mainly been due to research and development breakthroughs, compliance with consumer demands and improvements in aquaculture policy, and moving from a traditional activity to a well-developed sector. The rapid growth of the sector has created huge employment opportunities for different skilled and unskilled workers for different support activities such as construction and the management of farms, hatcheries, feed mills, processing units, etc. The three Indian major carps, namely, Catla, Rohu, and Mrigala contribute as much as 87 percent of the total Indian aquaculture production. Ponds and tanks are the major resources for freshwater aquaculture in India. However, only less than 10 percent of India's natural potential is used for aquaculture (Ayyappan *et al*, 2013).

Research Objectives

1. To study the Catch, Stocking trend and to calculate the optimum fish Yield of the Indirasagar Reservoir.
2. To study the Species abundance and composition of Fish Species of the Indirasagar reservoir.

2. Materials and Methods

The secondary data was collected from the Madhya Pradesh state fisheries department, Madhya Pradesh Fisheries Federation, annual reports of the Narmada valley development authority, Food, and Agriculture Organization report, various Indian council of agricultural research institutes report, and published research articles.

2.1 Estimation of Maximum Sustainable yield (MSY)

The maximum sustainable yield (MSY) which is considered to be the biologically optimum yield, was estimated by means of the Schaefer (1954) ^[13] using data on catch and effort (average number of active fishers employed).

The model takes account of the fact that the yield per unit effort (Y/f) is a decreasing function of fishing effort (f), expressed by the equations,

$$\text{Eq.1} \Rightarrow Y/f = a - bf$$

$$\text{Eq.2} \Rightarrow Y = af - bf^2,$$

-the MSY and corresponding f_{msy} (optimum effort), are estimated by the following expressions.

$$\text{Schaefer MSY} = -a^2/4b$$

$$\text{Schaefer } f_{\text{msy}} = -a/2b$$

Where,

a and b are the intercept and regression coefficient, Y is yield, f is the fishing effort and f_{msy} is the optimum effort.

2.2 Rank abundance curve (Whittaker plot)

It is a chart used by ecologists to display relative species abundance where relative abundance of species against their rank in abundance is plot. Most abundant species is given rank1; second most abundant is 2 and so on. A shallow gradient indicates the high evenness as the abundances of different species are similar.

3. Study Area

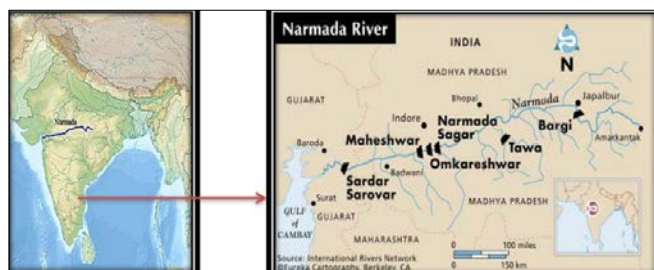


Fig 1: Map showing the Narmada River Projects along the streams

The Indira Sagar Dam is a multipurpose Dam project of the state of Madhya Pradesh on the Narmada River at the town of Narmada Nagar, Punasa in the Khandwa district of Madhya Pradesh. The foundation stone of the project was laid by the late Smt Indira Gandhi, former Prime Minister of India on 23 October 1984. The construction of the main dam started in 1992. The downstream projects of ISP are Omkareshwar, Maheshwar, and Sardar Sarovar Projects. To build it, a town of 22,000 people and 100 villages were displaced. The total catchment area at the dam site is 61,642 km². Indira Sagar Project is the mother project for the downstream projects in Narmada Basin with the largest reservoir in India. The total area of the reservoir at its full reservoir level (262.13 FRL) is around 91348 ha and for fisheries purposes, the total catchment area is around 59029 ha. The management of the Indirasagar dam is looked after by the National Narmada valley development authority (NVDA) and for the fisheries management it is transferred to the Madhya Pradesh fisheries federation in 2003-04.

4. Results and Discussion

At present, the Madhya Pradesh Fisheries federation has 6 large, 19 medium, and 1 small reservoir having an area of 2.28

lakh ha under fisheries management. In 2018, total fish production from various reservoirs under Madhya Pradesh Fisheries Federation was around 9128.131 tonnes and had average productivity of 40 kg/ha/year which was the highest in India. Gandhisagar reservoir which is the second largest reservoir in terms of area covered, having an area of about 41318 ha recorded 90kg/ha/yr productivity which was quite remarkable as compared to the national yield of 46 kg/ha/year in 2018-19.

Table 1: Morphometric features of Indirasagar Reservoir:

Particulars	Indirasagar Reservoir
Location of dam	Narmada Nagar Dist. Khandwa in Madhya Pradesh.
River	Narmada
Year of construction	2003-04
Reservoir level at FRL(mt)	262.13
Water spread area at FRL (Sq. Kms.)	913.48
Area available for fisheries purpose(ha)	59029
Total catchment area(km ²)	61,642
Gross storage capacity[(Bm ³ / (MAF)]	9.975
Purpose of construction	Irrigation, power generation (1000 MW), flood control, fishery and wild life conservation.

Source: Narmada valley development authority

People Public Private Model in Indirasagar reservoir

Fishing in the reservoirs is allowed only to the member of the fishermen cooperative who were affected during the construction of the dam and reservoirs and whose house comes within a 10 km area of impoundment (People). Madhya Pradesh Fisherman Cooperative federation is the nodal agency for fisheries in the reservoir (Public). For selling harvested produce lease is given to the highest bidder based on an open tender system. Fishermen cooperative society/ Registered commercial firm/ individual can participate in the bidding process (Private). The lessee will collect the fish catch from the members of the fishermen's cooperative society and sell it with the restriction that 10% of the catch must be sold in the local market. The closed season for fishing is from 16 June to 15 August every year.

The lease of the Indirasagar reservoir will be given by the open tender system to the private body and currently, it is given from the year 2018 to 2023 (5 Years) for the lease amount of Rs. 58.84 Crores. The rights for fishing in the reservoir are given to the local primary fisheries cooperative societies and at present 56 Cooperative societies have been registered on the reservoir having 3218 members. Out of these 49 cooperative societies were found to be actively involved in the fisheries and related activities. Thirty-three percent of the members of the cooperative must be fisherwomen. The reservoir area covers a total of 3 districts ie. Khandwa, Harda and Dewas. The Madhya Pradesh Fisheries Federation along with Narmada Valley Development Authority developed one Mahaseer hatchery in a 3 ha area to produce and rear Mahaseer fishes along the reservoir, though the Breeding trials have not been successful over the years. The Madhya Pradesh Fisheries Federation started collecting wild brooders from the Narmada River in 2019 and trying to breed in Indirasagar hatchery.

4.1 Madhya Pradesh Fisheries Federation Reservoirs fish production trend

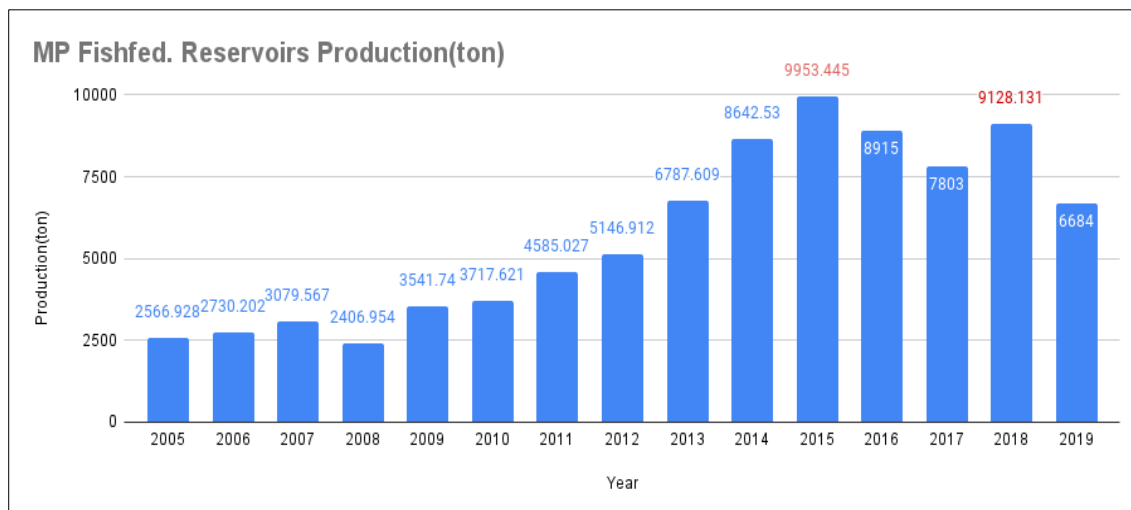


Fig 2: Madhya Pradesh Fisheries federation production.

Fisheries Federation production from the year 2005 to 2019, which shows the increasing trend of Fish production. This is

majorly due to the efficient seed stocking policy adopted by the federation over the years.

4.2 Fish Seed Stocking by Madhya Pradesh Fisheries Federation over the years in various reservoirs

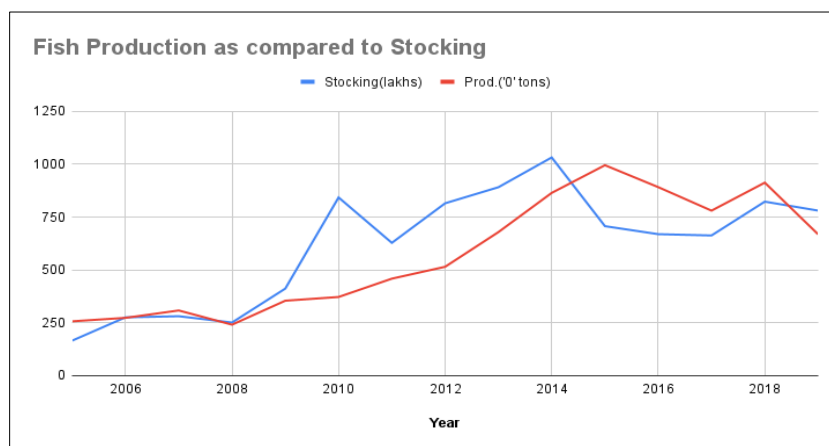


Fig 3: Fish Seed Stocking as compared to production in Madhya Pradesh reservoirs.

4.3 Fish Production in Indirasagar Reservoir(tonnes)

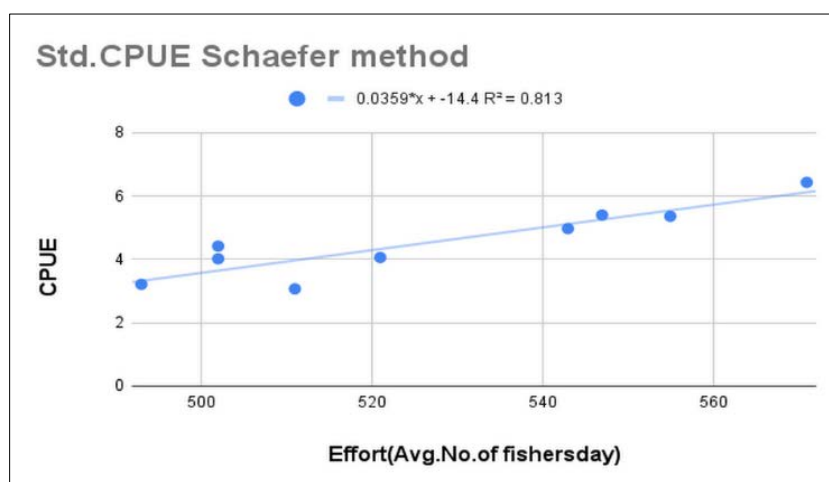


Fig 4: Fish Production in Indirasagar Reservoir (tonnes)

4.4 Status of Fingerling stocking in In Indirasagar reservoir (lakhs)

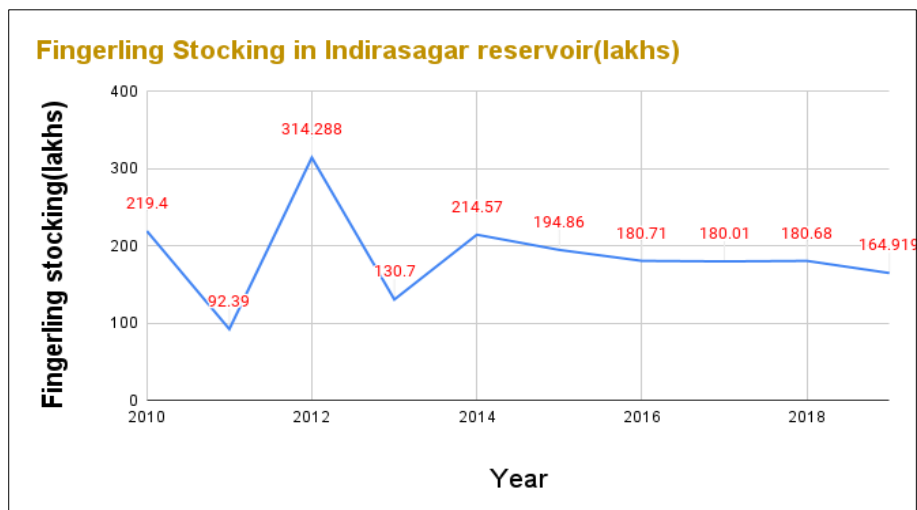


Fig 5: Fingerling stocking in In Indirasagar reservoir (lakhs)

4.5 Schaefer model for MSY calculation

The concept of Maximum sustainable yield (MSY) has been used in fisheries science for about a century and is defined as the highest average catch that can be continuously taken from an exploited population (stock) under average environmental conditions. (Handbook of fisheries, 2011) [9]. The concept of maximum sustainable yield (MSY) is intended on a biological approach of gathering maximum production and excepting the fish production of a certain reservoir or fish Fig.6. Average number of fishers/day over the catch per unit effort.

years to years. The relationship between these variables referred to the surplus production method of the Schaefer model.

Based on the calculation, the Maximum Sustainable yield of Fish in the Indirasagar reservoirs is about 1728 tonnes

i.e., Maximum Sustainable yield (MSY) = $-(14.40^2)/(4 \times -0.035)$,

Optimum fishing effort $F_{MSY} = -a/2b$
 $= -(-14.40/2 \times 0.035)$

Optimum Fishing Effort (FMSY)= 240 fishers per day (generally wooden canoes being operated by fishers). Steps of this method were taken by plotting the effort(f) value towards the Catch per unit effort(c/f,) and estimating the intercept (a) and slope (b) using linear regression and further, the catch MSY and optimal fishing effort calculated by the Schaefer equation. The equilibrium annual fish yield or MSY is found to be 1728 tonnes with the optimum fishing effort of 240 fishers per day. At this level catch per unit effort is high i.e. 7.2 tonnes per fisher. The large reservoirs like Indirasagar which is the income and livelihood source for the displaced tribal community of the Khandwa region in Madhya Pradesh which does not have any other source of income. The

sustainable exploitation of fish stock from the reservoir is very important to sustain the income of these fishers in long run. There should be close monitoring of private stakeholders not to exploit the fish in an unregulated way which can affect the sustainability of the reservoir which and ultimately affect the income of Fishers in long run. The regular and optimum number of fish Fingerlings should be stocked in the reservoir. The conservation measures that are being followed in Indirasagar reservoir are closed season from 16 June to 15 August, Mesh regulation (min. 40 mm bars), Ban on the use of monofilament webbings, and ban on catching of catla below 4 kg and Rohu/ Mrigal below 1 kg. Similarly, Karthikeyan *et al*, (ICAR-CIFRI), 2020 [8] studied the sustainability of the Bargi reservoir (23000 ha) in Madhya Pradesh and calculated the Maximum sustainable yield of the reservoir through Verhulst-Schaefer model and the total MSY found to be 787 ton.

The understanding of fish faunal diversity is a major gateway for the exploitation of freshwater reservoirs for food. (Battul *et al.*, 2007) [2]. During the last few decades, the fish biodiversity of the country has been declining rapidly due to anthropogenic environmental degradation like urbanization, damming, abstraction of water for irrigation and power generation, and pollution, which have devastating effects on freshwater fish diversity. (Lakra *et al*, 2009). The fish diversity in reservoirs is formed by the biodiversity of the original rivers, particularly the principal river system. There may be significant changes in the fish fauna after the impoundment due to changes in the hydrological regime and biological conditions (Sarkar *et al*, 2017) [11]. Chryspin *et al*, 2016 [3], studied ecological aspects of the fisheries and management in the Pechiparai reservoir of Kanyakumari district, Tamil Nadu which covers the institutional framework, fishing effort, and effect of stocking on fish production over the years.

4.6 Species wise distribution in Indirasagar from 2016-2019

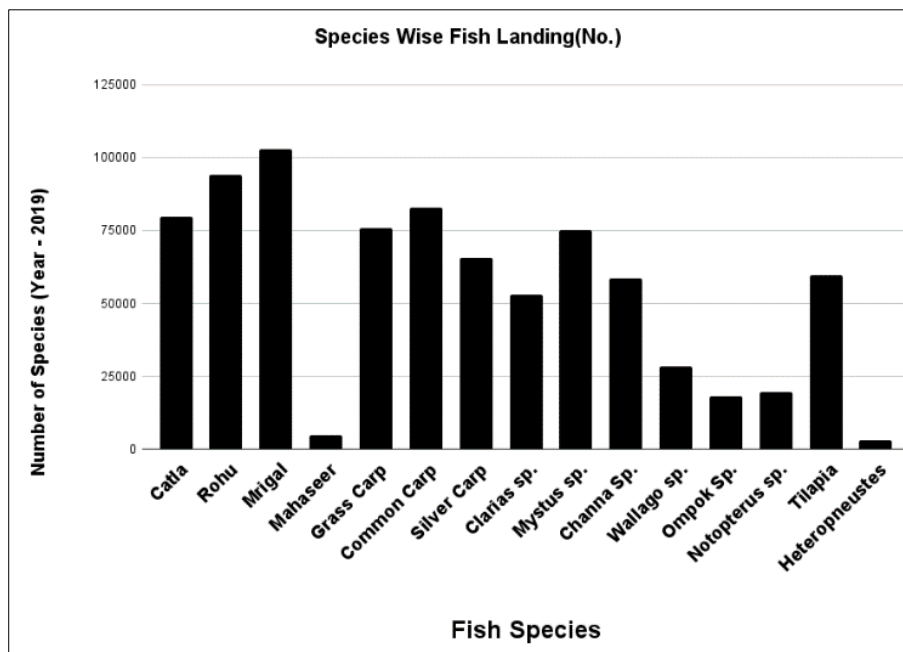


Fig 8: Species wise distribution in Indirasagar reservoir.

4.7 Proportional abundance of the Species in Indirasagar Reservoir (Whittaker plot)

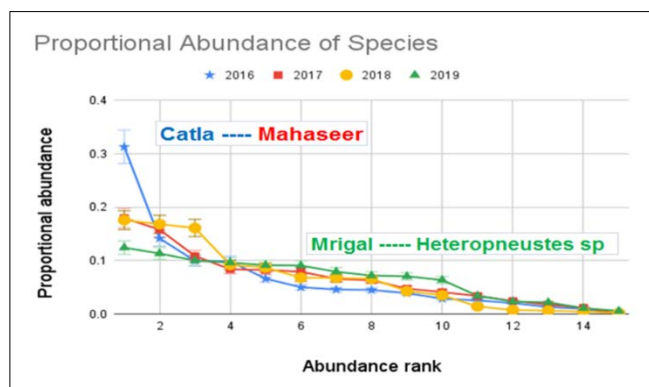


Fig 9: Whittaker plot for species distribution.

A rank abundance curve or Whittaker plot is a chart used by ecologists to display relative species abundance, a component of biodiversity. It overcomes the shortcomings of biodiversity indices that cannot display the relative role different variables played in their calculation. The rank abundance curve visually depicts both species richness and species evenness. Species richness can be viewed as the number of different species on the chart i.e., how many species were ranked. Species evenness is reflected in the slope of the line that fits the graph (assuming a linear, i.e. logarithmic series, relationship). A steep gradient indicates low evenness as the high-ranking species have much higher abundances than the low-ranking species. A shallow gradient indicates high evenness as the abundances of different species are similar. Here the analysis observed that the year 2017 and 2019 shows a shallow gradient which means high species evenness. Similarly, the 2016 and 2018 plot shows a steep gradient as compared to other, which shows the low

species evenness. The high species evenness shows the equal distribution of the species and the presence of stability in the ecosystem.

5. Conclusion of the study

In Madhya Pradesh, large Reservoirs are under Cooperative management, with fishing rights given to fishers which are welfare-based revenue models in operation. The fish yield of the reservoir increased from 1.1 kg/ha/yr. (Stocking Density: 86 fingerlings/ha/yr.) in 2004-05 to 43.46 kg/ha/yr. (Stocking Density: 304 fingerlings/ha/yr.) in 2017-18 due to the adoption of a fish stock enhancement strategy. The equilibrium annual fish yield or MSY is found to be 1728 tonnes with the optimum fishing effort of 240 fishers per day. At this level catch per unit effort is high i.e. 7.2 tonnes per fisher. The analysis observed that the year 2017 and 2019 shows a shallow gradient which means high species evenness. Similarly, the 2016 and 2018 plot shows a steep gradient as compared to other, which shows the low species evenness. The high species evenness shows the equal distribution of the species and the presence of stability in the ecosystem. Catla shows an increasing trend in Indirasagar reservoir from 15% in 2010-11 to 52% in 2017-18, it may be due to the strict policy of stocking regimes in the reservoir. The Indirasagar reservoir supports the income and livelihood of the displaced Fishers during the dam construction. They hardly have any other source of income rather than fisheries, so the management of available limited resources should be handled carefully by the government and also by the private stakeholders of the dam to sustain the socio-economic condition of the Fishers.

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