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THE STUDY OF FISH BIOTIC COMMUNITIES AND SOCIO-ECONOMIC IMPACT OF THE INDIAN RESERVOIR FISHERIES

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Abstract
Reservoirs play a consequential role in the development of the nation and additionally have an integral role in fisheries and livelihood security of the local community. Therefore, present study is emphasized on synthesizing the available information on fish diversity and community structure of the potential Indian reservoirs and its effects on fisheries and other aquatic environment in reservoirs in India. In terms of fish diversity altogether 117 fish species were recorded from Indian reservoirs exhibiting rich fish diversity. Reservoirs have many uses from generation of electricity to irrigation purpose and also providing habitat to fishes and other aquatic life and in turn also help to provide feed and create revenue for fish communities. The reservoirs play an important role in the developmental process of a Nation and also have an integral role in fisheries and livelihood security of the local community. These reservoirs have both positive and negative impacts on fishes and other aquatic environment. In India, reservoirs are playing a crucial role in the fisheries. Some strategies have been suggested for sustaining river and reservoir fish biodiversity. Fish communities are often used as indicators of environmental quality. With the increase in population growth reservoirs are becoming important provider of animal protein and for generation of employment in particular to poorer sectors of the people.

Keywords: Reservoirs; Biodiversity; Fisheries; Aquatic environment; Potentials; Management issues.

Introduction

Freshwater is critical to human society and sustains all terrestrial and aquatic ecosystems. India has a large spread of freshwater resources that exist in the form of rivers, canals, reservoirs, lakes etc. More than 10.86 million people are depended on these different water systems in India and their fisheries. Fisheries play an important role in livelihood and nutritional security of the rural India. The climate of India has wide range of weather conditions from extreme cold to very hot. From past decade the weather in India has become less predictable due to climate change, so these situations make it important to store river water in the form of reservoirs. In India, reservoirs form an important source of fish production and presently, the area under reservoir fisheries has been estimated at about 3.0 million hectares and with the constant addition of new reservoirs and impoundments, this area is likely to further increase in the coming years[1].A reservoir is an impoundment obstructing the surface flow of a river, stream or any water course. The Indian reservoirs are distributed from Himalayas to Southern peninsula. Reservoirs are classified as small (1,000 ha), medium (1,000 to 5,000 ha) and large (5,000 ha) based on their hectare by National Consultation held in 1997 at Central Institute of Fisheries Research Institute, Barrack pore. The cumulative area of reservoirs in India are estimated to be 1,485,557 ha, 507,298 ha and 1,160,511 ha of small, medium and large reservoirs, respectively.With the constant evaluation of effect of dams on aquatic life and use of Environmental Impact Assessment (EIA) Indian Government has undertaken several initiatives like stocking dams with different fish species, rehabilitation of fishes getting extinct due to construction of dams, ranching programmes, environmental modelling, fish ways etc. The present paper highlights the potential of reservoirs in India with reference to fish community and biodiversity perspectives for conservation as well as stock enhancement and management challenges and advocates for planning innovative strategies for sustaining river and reservoir fish biodiversity[1]. Beside all these conservation programmes we also need to focus on the study of fish biodiversity of reservoirs. Stocking of dams with fishes are generally provided that can result in many benefits such as creating new fisheries and also to enhance existing fisheries. These impacts are generally evaluated in terms of additional output of agricultural commodities, hydropower, navigation, fishing, tourism, recreation, prevention of droughts and reduction in flood damages, and are referred to as direct impacts[2]. Study of fish yield from dams need to be focussed for the conservation purpose. Reservoirs can generate a vast array of economic impact on both in the region where they are located, and at inter-regional, national and even global levels for protection of aquatic biota.

Objective of the Study

1. About basics of reservoir and reservoir Fisheries.
2. The basics of post-harvest techniques of fisheries and fisheries.
3. Socio-Economic Effect of Reservoir Fisheries.

Role of Reservoirs in Fisheries:

The "artificial lakes" are built to generate electricity and water for irrigation. Given that these aquatic organisms have enormous potential for fisheries, which in turn have several economic and social benefits. But at the moment, tanks in India

are concerned that they do not contribute to fisheries. According to the Associated Chambers of Commerce and Industry of India, fish production in India may grow at an annual growth rate (CAGR) of about 7 percent by 2016. From over 3.5 percent in 2012, fisheries development in India it was implemented for the development of reservoirs in Andhra Pradesh, Orissa and Uttar Pradesh during the ninth period of the plan. In India, the natural flow of all major rivers was regulated to meet the demand for water in the agriculture and energy sector, without paying special attention to the fisheries sector. As a result, the rivers have lost their character and the fisheries have suffered significant losses. Severe and drastic changes in the whole hydrological cycle of the river through the dams and water intake are recruiting species, especially large carp, which as flowing water. Larger dams are the main cause of degradation of the aquatic environment and disturbance of fisheries dependent communities along the river[3]. Tanks are an inseparable part of our natural landscapes. Tanks offer enormous scope for increasing fish production and can be developed as tourist areas with the use of sport fishing. New technologies and innovations would be needed to fully exploit the optimal production of fish from tanks.

Socio-Economic Effect of Reservoir Fisheries

Compared to crops and forestry, fisheries production can generate relatively high incomes for rural households. As a result, the average income of fishermen is much higher than that of agriculture. On the other hand, fisheries and aquaculture in reservoirs are relatively difficult compared to other economic activities such as agriculture and, as such, are less attractive to younger generations. We need to explore possible links between dams and economic growth and to systematically measure the actual impact of the crushed tanks on local growth and development. The cost-benefit analysis suggests that dams are only marginally profitable on average, although there is a big difference between a dams to dam.

Policy restrictions

The report of the World Commission on Dams (WCD) and numerous other studies have discussed the importance and difficulty of assessing the indirect effects of dams. Many political analysts have considered the awareness of the indirect impact of dams on fisheries and felt the need for proper assessment and quantification. Using a fishing dam can be an effective means of reducing poverty. Collective fisheries are relatively small contributing factors to the national fisheries sector, and governments are very concerned about them. Fishermen and fishermen are more susceptible to natural disasters. In general, tanks are located in distant areas where it is relatively difficult to access support systems such as technical extension services and marketing infrastructure, is usually weak.

Fish Biodiversity and Reservoir

The world is currently facing a freshwater biodiversity crisis and the key to preventing further extinction lies in understanding all the threats facing aquatic habitats. Dams create calm bodies of water, changing overall temperature regimes and sediment transport, leading to conditions which tend to favour generalist species. Overall, damming river flow will lead to both a loss of native species, but also an increase in exotic species which are more likely to become established in degraded habitats[4]. Amongst the threats to freshwater species, including climate change and pollution, the most difficult to quantify are man-made obstructions to water flow. The competition between resident species for food and breeding sites will increase as damming isolates populations, and perhaps more importantly, damming completely restricts migratory fish species. A dam will withhold sediment in the reservoir, not just decreasing the amount of substrate available to local freshwater species, but even impacting diadromous, estuarine and marine species much further downstream. For this reason, dams are one of the greatest global threats to freshwater biodiversity. Dams can be found in every major biosphere, but very little is known about the effect of river obstruction on freshwater biodiversity, especially on a global scale. Isolation may lead to decreases in genetic diversity and therefore puts species at greater risk from disease. Loss of specialist species, particularly endemics, changes the community structure and leads to biotic homogenization.

Fish Biodiversity and Utilization of Some Important Reservoirs

The Doyang reservoir of Nagaland is usually stocked with fingerlings of Indian major carps and exotic corps. 25 fish species diversity was found in this reservoir. The stocking is done at the rate of catla (30%), rohu (25%), mrigal (20%), grass carp (10%), silver carp (5%) and common carp (10%). Aliyar reservoir of Bharathapuzha basin in Tamil Nadu harboured a total of 44 endemic species and 7 introduced species. Thirumoorthy reservoir of Bharathapuzha basin in Tamil Nadu has 28 numbers of faunal species and revealed poor species diversity. Markonahalli reservoir in Karnataka has only 28 species of fishes out of which 23 are indigenous, 4 stocked and one exotic species have been recorded. Umiam reservoir at Meghalaya having 27 fish species out of which 24 are indigenous and 3 are exotic fish species. Therefore, development of sport fishing in dams needs different strategies and plans for fish species richness as dams have different environment than river system. So, far sport fishing is concerned the number of fish species present in Indian reservoirs is very low approx 23. The ornamental fish sector is more vibrant and remunerative and Indian reservoirs are rich in ornamental fish species like Puntiussp, Rasbora sp. 28 fish species belonging to 7 families with 2 specimens of family Bagridae, 19 of Cyprinidae, 2 of Channidae, 1 of Siluridae, 1 of Belontidae, 1 of Mastacembelidae and 2 of Sisoridae were collected from Pong Dam Reservoir, Himachal Pradesh. Bacchra

reservoir in Allahabad, Uttar Pradesh consisted mainly of rheophilic species of low population density and after impoundment the lentic body harbours 51 species of fish. Yerrakalva reservoir in Andhra Pradesh is medium productive and 13 species of fish have been recorded from this reservoir along with freshwater prawn[5]. In terms of fish diversity approximately 117 fish species are present in consolidated form in Indian reservoirs. Thus we need to stock dams with more fishes having value as sport. Indian reservoirs are rich in food fishes 96. Kulgarhi reservoir, Madhya Pradesh is the first reservoir in India where Hypophthalmichthysmolitrix was first introduced on experimental basis. Bhatghar reservoir of Pune, Maharashtra is one of the important reservoir in India. In this reservoir 48 species of fish are available commonly.

Distribution of small, medium and large reservoirs in India

States	Small		Medium		Large		Total	
	Number	**Area(ha)**	**Number**	**Area(ha)**	**Number**	**Area(ha)**	**Number**	**Area(ha)**
Tamil Nadu	8895*	315 941*	9	19 577	2	23 222	8906	358 740
Karnataka	4 651*	228 657*	16	29 078	12	179 556	4 679	437 291
Madhya Pradesh	6	172 575	21	169 502	5	118 307	32	460 384
Andhra Pradesh	2 898*	201 927*	32	66 429	7	190 151	2 937	458 507
Maharashtra	-	119 515	-	39 181	-	115 054	-	273 750
Gujarat	676*	84 124*	28	57 748	7	144 358	711	286 230
Bihar	112	12 461	5	12 523	8	71 711	125	96 695
Orissa	1 433	66 047	6	12 748	3	119 403	1 442	198 198
Kerala	21	7 975	8	15 500	1	6 160	30	29 635
Uttar Pradesh	40**	218 651	22	44 993	4	71 196	66	334 840
Rajasthan	389	54 231	30	49 827	4	49 386	423	153 444
Himachal Pradesh	1	200	-	-	2	41 364	3	41 564
Northeast	4	2 239	2	5 835	-	-	6	8 074
West Bengal	4	732	1	4 600	1	10 400	6	15 732

Effect of reservoir on Fish Migration

In another study, occurrence of about 75% fish species in the nearby dam site of river Gerua (under protected area) was reported out of total diversity biodiversity (87 species) recorded from the different sites of river Gerua, a tributary of river Gharga were reported. Presence of 46 freshwater fishes from Rajghat dam representing 73% of total fish diversity recorded in river Betwa was reported. Increased upstream and downstream predation on migratory fish is also linked to dams, fish being delayed and concentrated due to the presence of the dam and the habitat becoming more favourable to certain predatory species. The dam and reduction in river flow due to water diversion for irrigation would made the spawning migration of these fish impossible in the extreme upper and in lower stretch of river Betwa. Changes in discharge regime or water quality can also have indirect effects upon fish species. The effect can become severe, leading to the extinction of species, where no spawning grounds are present in the river or its tributary downstream of the dam[6]. They concluded that freshwater protected areas commonly result in increased fish abundances for those threatened fishes which are extremely important for biodiversity conservation and management. One of the major effects of the construction of a dam on fish populations is the decline of anadromous species. The building of a dam generally has a major impact on fish populations: migrations and other fish movements can be stopped or delayed, the quality, quantity and accessibility of their habitat, which plays an important role in population sustainability, can be affected. Fish can suffer major damage during their transit through hydraulic turbines or over spillways. Construction of reservoirs affects fish species diversity by sudden environmental changes from lotic to lentic due to which many species either escape to new conducive environments, few species get adapted to changed environment. Mahseer the most prestigious fish of our country is very badly affected due to dam construction and now this fish is categorized under endangered status. Reservoirs are obstacles for longitudinal exchange along rivers and disrupt many natural environmental processes. Puntius species also disappeared in Cauvery post dam, which formed 28% of the landings prior to dam construction [5. Constructions of dams have badly affected migratory fishes like mahseer and hilsha. There is huge loss to our indigenous fish species due to construction of dams across the Nation. Several studies reported that dams have serious impacts on fish assemblage structure and fish species richness[7]. The number of fish species decreased from 107 to 83 because the migration was interrupted by the Xinanjiang dam (China. This fish was once in abundance in river

Narmada but now it has wiped out because of dams. Hilsa fisheries in Cauvery collapsed in the upstream after construction of Mettur dam.

Mitigation Programmes

Climate change, more particularly harsher weather conditions, will have impact on the quality, productivity, output and viability of fish and aquaculture enterprises, thereby affecting fishing community. The small-scale fishers may be faced with greater uncertainty as availability, access, stability and use of aquatic food and supplies would diminish and work opportunities would dwindle. Aquaculture development opportunities will increase in particular in tropical and sub-tropical regions[8]. The climate change in warmer regions offers new opportunities as production in warmer regions will increase because of better growth rates, a longer growing season and the availability of new fish farming areas where it was once too cold.Mitigation is the process to minimize the damages caused by dam construction to natural habitats. They may include restoration, enhancement, or creation. Mitigation can be as simple as changing the location of the planned activity on the site or as difficult as building new areas, such as wetlands, to compensate for the area being destroyed. Before construction of dams we need to plan programmes for the preservation and protection of these important gems of our Country from getting extinct. The Mahseer project started in 1970 at Lonavla can be described as the biggest Indian conservation effort after Project Tiger and is best example for the conservation and development of ecotourism. Tata electric farm Lonavla, devoted to conservation of mahseer species through breeding and other programmes are running with good result[9].

Generating Fish Ways

A team of researchers at Jadavpur University here has developed a biodegradable energy harvester from raw fish scales - which could be tapped as a sustainable green energy source for next generation self-powered implantable medical devices. It also has the potential for personal portable electronics with reduced e-waste elements said the researchers. Fish scales, a by-product that is usually thrown away, contain collagen fibres that possess a piezoelectric property, which means that an electric charge is generated in them in response to mechanical stress. The researchers have synthesised flexible bio-piezoelectric nanogenerator (BPNG) from this bio-waste. Assistant Professor at Organic Nano-Piezoelectric Device Laboratory, DipankarMandal explained: “We collected bio-waste in the form of hard, raw fish scales from a fish processing market, and then used a demineralization process to make them transparent and flexible.” “We were able to make a bio-piezoelectric nanogenerator (or energy harvester) with electrodes on both sides, and then laminated them,” said Mr.Mandal, from the Department of Physics, at Jadavpur University.

Recycling value

The recycling of the fish by-products into the BPNG via one step process is a promising solution for the development of value-added products and also to reduce the e-waste.The nanogenerator also scavenges several types of ambient mechanical energies such as body movements, machine and sound vibrations, and wind flow which are abundant in living environment, and even repeated tapping with a finger. Repeatedly touching the BPNG with a finger can turn on more than 50 blue LEDs. The team’s work is the first known demonstration of the direct piezoelectric effect of fish scales from electricity generated by a bio-piezoelectric nanogenerator under mechanical stimuli - without the need for any post-electrical poling treatments.

Potential uses

The group’s work could potentially be used in transparent electronics, biocompatible and biodegradable electronics, and edible electronics. It can also be used in self-powered implantable medical devices, surgeries, e-healthcare monitoring, as well as in vitro and in vivo diagnostics, apart from its myriad uses for portable electronics. “In the future, our goal is to implant a bio-piezoelectric nanogenerator into a heart for pacemaker devices, where it will continuously generate power from heartbeats for the device’s operation,” Mr.Mandal said. “It will then degrade when no longer needed. Since heart tissue is also composed of collagen, our bio-piezoelectric nanogenerator is expected to be very compatible with the heart.”

Indian scientists recycle fish bio-waste into green energy

A team of researchers at Jadavpur University here has developed a biodegradable energy harvester from raw fish scales that could in future replace pacemaker devices for the heart. The energy harvester thus could be tapped as a sustainable green power source for next generation self-powered implantable medical devices. It also has the potential for personal portable electronics with reduced e-waste elements said the researchers. The by-product of fish scales that is usually thrown away contain collagen fibres that possess a piezoelectric property, which means that an electric charge is generated in them in response to mechanical stress. The researchers have synthesised flexible bio-piezoelectric nanogenerator (BPNG) from this bio-waste. Assistant Professor at Organic Nano-Piezoelectric Device Laboratory, DipankarMandal explained: "We collected bio-waste in the form of hard, raw fish scales from a fish processing market, and then used a demineralization process to make them transparent and flexible." "We were able to make a bio-piezoelectric nanogenerator (or energy harvester) with electrodes on both sides, and then laminated them," said Mandal from the Department of Physics, at Jadavpur University. The recycling of the fish by-products into the BPNG via one step process is a promising solution for the development of

value-added products and also to reduce the e-waste[10]. The nanogenerator also scavenges several types of ambient mechanical energies such as body movements, machine and sound vibrations, and wind flow which are abundant in living environment, and even repeated tapping with a finger.

Potential of Reservoir Fisheries

India having 19,370 small reservoirs with total water surface area of 3 153 366 ha. At least 100 of them have been subjected to scientific studies. In reservoirs along with protection of natural fish biodiversity tourist recreation and boating can also be maintained that will also help to generate employment for people of the area. Different culture practices can be adopted in reservoir system to enhance production in fisheries. Fish production in reservoirs can be enhanced by using various cultural aspects for fish culture viz cage culture, pen culture etc. These culture systems not only will be helpful to increase fish production of the reservoirs but can also help fishermen's to increase their livelihood by adopting these simple method of fish culture. Thus, reservoirs offer immense scope for increasing fish production. Cage culture and pen culture in reservoirs are the two most adopted systems of fish culture in India. But this system is used mostly for experimental purpose till date not adopted for commercialization or in order to enrich population in reservoirs. Indian reservoirs with water spread of 3.15 m ha, and yield potential of 50, 20 and 8 kg/ha/year only from small, medium and large reservoirs respectively, leave enough scope of enhancing fish yield from such resources through culture based capture fisheries[11].

Present and potential production from reservoirs of India

Category	Yield (kg ha^{-1})	Area (ha)	Present Production	Potential Production
Small	49.90	1 485 557	74 129	148 556
Medium	12.30	527 541	6 488	39 565
Large	11.43	1 140 268	13 033	57 013
Total		3 153 366	93 650	245 134

Since fish production from reservoirs is essentially extractive in nature, the essence of management strategy lies in exploitation of natural stocks. Nevertheless, the ecosystem management provides different degrees of freedom for stock manipulation, depending on the size and class of the water body. One of the possible criteria that can be used to differentiate between capture and culture fisheries is the extent of human intervention in the ecosystem management. While aquaculture systems provide maximum avenues for the man to monitor and change the habitat variables and the biotic communities at will, this freedom attenuates as we proceed from aquaculture to the culture-based and capture fisheries. In a large water body, managed on capture fishery norms, there is little room for altering the habitat variables and the scope for effecting change in biotic communities is limited to stocking and ranching, which have uncertain chances of success.

Cage and Pen Culture

Amongst the known modern aquaculture systems for increased fish production, cage and pen culture are about the cheapest to operate. A cage is a system that confines the fish or shellfish in a mesh enclosure and Pen is an enclosure to grow fish or prawn in a large water body. Factors such as increasing consumption of fish, some declining wild fish stocks, and a poor farm economy have produced a strong interest in fish production in cages. Cage aquaculture technology is of recent introduction in India and has advantages in many respects to increase fish production levels. Cage culture is i) compatible and not competitive with other fish production system and complementary to some, ii) raising of fish in cages is an alternative means of fish production, iii) applicable to most aquaculture species, including predatory fishes, iv) ideally applicable in open waters where fish yields are low and other fishery development is difficult or impracticable, v) cage fish culture provides accelerating growth in fish production in comparison with traditional aquaculture, vi) as the technology is very simple it could be easily adapted by poor and landless farmers and vii) harvesting of fish is easy and provides scope for yearround supply of fish to the markets. Therefore, the practice of cage aquaculture to grow fish seed for in situ stocking or to grow them for marketing has definite advantages with respect to technical application and ecological, social and economic performance over conventional system. CIFRI has developed a low-cost and simple technology for fish culture in pens erected in reservoir margins[12]. Pen culture is useful in water bodies, where use of fishing gear is difficult. There are three types of rearing done in the pens: i) from fry to fingerlings ii) from fingerlings to table size fishes and iii) from fry larval stages to table size prawn. Except from IMC and Prawn, catfishes and exotic fishes can be grown in the pen. Pen makes fish growing, easier and bigger by feeding and managing. Advantages of pen and cage culture are already reflected by several workers.

Cove Culture

Other than cage and pen culture another system of fish culture called Cove culture, is adopted in some Asian countries like China, Vietnam. A cove has several advantages over cage and pen culture as the use of coves neither competes with agriculture for land nor affects the normal water storage and discharge of the reservoir and the use of coves neither competes

with agriculture for land nor affects the normal water storage and discharge of the reservoir[13]. Cove culture involves partitioning off the reservoir with a barrier net fixed across the cove mouth. To prevent fish escape, the top of barrier net can be extended above water surface and the net bottom can be embedded in bottom mud by heavy stone bags. Cove culture in India is not practiced till date but it can be used as an alternative method to increase fish production in dams. Coves can provide fishes with abundant natural foods and natural habitat, and can be an ideal alternative for biodiversity conservation.

Conclusion

Along with these cultural practices we need to increase priorities on many other things like environmental flows, installing reliable and effective fish passes or ladders, enhancement of economic fishery resources, application of effective fishing gear and methods, more strict rules for protection of fishes in dams, effective elimination of harmful organisms and development of integrated fish-farming systems (e. Dams can thus improve fisheries biota to a large extent particularly tail water fisheries as the area below dams are rich in nutrients from the upstream reservoir. Stocking of the reservoirs with indigenous and other commercially important fishes can also enhance the fish production of reservoirs. Construction of dams has resulted in mixing of several fish species that have generated new gene pool, introduction of many invasive species. Reservoirs have both positive and negative effects on fisheries. This step is followed by various government agencies across the country like Madhya Pradesh Fisheries Federation has stocked Kerwa dam in Bhopal with the seed of golden mahseer (Tor putitora) brought from Directorate of Cold Water Fisheries (DCWFR), Bhimtal. Fish-livestock-forestry or fish-agriculture-livestock. Dams have somewhat positive impact socially but all that is at the expense of our nature and other form of life. The concepts like water and aquatic resource conservation, best regulation of existing facilities, rainwater harvesting, watershed and river basin management, water reuse etc. It is obvious that water resources are essential for sustaining the life on the earth and all kinds of socio-economic developmental activities and therefore, appropriate planning and management of aquatic resources are important since India, already suffering from the increasing population and shortage of all kind of natural resources like water. Efforts should be made to stock dams with local fish as they are well adapted to the environmental conditions, likely to survive well and these fishes are frequently available and this will also help to conserve diversity of the reservoir. Effective and innovative strategies can be taken up by the conservation agencies for sustaining river and reservoir fish biodiversity. Through better understanding of ecological principles playing role in defining trophic status and reservoir biodiversity along with sound and sustainable methods, the fisheries could be enhanced manifold. However, there is need to visualize many relevant issues of the sustainable aquatic biodiversity conservation. Exotic fish can also be stocked in the dam using cage and pen culture but proper care should be taken as if they enter into the wild, they can become serious pests which compete with native species and cause environmental damage. Location, geographical features, fish diversity etc. Therefore, a more refined biotic assessment program is required for protection of fish resources. Most importantly at first priority we need to conserve biodiversity of our reservoirs by adopting various scientific technologies.

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