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Reservoir Fishery Management and Development in Asia

Proceedings of a workshop held in Kathmandu, Nepal, 23–28 November 1987

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ABSTRACT

This publication presents the results of an IDRC-funded workshop held in Kathmandu, Nepal, 23-28 November 1987. Representatives from 15 countries reviewed the status of reservoir fishery research in Asia under the following topics: existing fisheries, limnological aspects, biological and resource aspects, management aspects, and culture. Papers were presented on these topics, but the discussion sessions were the main element of the workshop. Summaries of these discussions as well as a series of general recommendations that were generated during the final discussion are presented in this book. The potential for increased fish production in reservoirs and the need for early involvement of fisheries scientists in the planning and preimpoundment studies before dam construction are emphasized.

RÉSUMÉ

Cet ouvrage présente les résultats d'un atelier financé par le CRDI à Katmandou, au Nepal, du 23 au 28 novembre 1987. Des représentants de 15 pays ont examiné l'etat de la recherche sur l'élevage du poisson en étangs en Asie, en particulier les aspects suivants : les systèmes actuels, les aspects limnologiques et biologiques, les ressources, la gestion et l'élevage. Des exposés ont été présentés sur ces sujets, mais les discussions ont été l'élément le plus important de l'atelier. L'ouvrage présente également un résumé des discussions ainsi que les recommendations générales issues de ces discussions. On met l'accent sur la possibilité d'augmenter la production de poissons en étangs et la nécessité pour les ichtyologistes de participer trés tôt aux études de planification, notament de la mise en étangs du poisson, qui précèdent la construction d'un barrage.

RESUMEN

Esta publicación presenta los resultados de un taller auspiciado por el CIID en Kathmandu, Nepal, del 23 al 28 noviembre de 1987. Representantes de 15 países analizaron el estado de la investigación sobre pesquería asiática en embalses desde los siguientes ángulos: pesquería existente, aspectos lomnológicos, aspectos biológicos y de recurso, aspectos de manejo y cultivo. Las ponencias versaron sobre estos temas, pero las sesiones de discusión fueron el principal elemento del taller. Este libro ofrece los resúmenes de estas discusiones, así como una serie de recomendaciones generales emanadas de ls discusión final. Se subraya el potencial para incrementar la producción pesquera en embalses y la necesidad de una participación temprana de los científicos del área en la planificación y los estudios de apropiación que anteceden a la construcción de represas.

CONTENTS

AIMS AND STRATEGIES OF FISHERIES MANAGEMENT FOR THE TEHRI DAM RESERVOIR IN THE GARHWAL HIMALAYA, INDIA

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Abstract *A number of large man-made reservoirs have come into existence or are now being constructed in the Indian Himalaya, especially during the last 20 years. This is because of the initiation of various multipurpose river valley projects and has added considerably to the existing potential for the development of India's fishery resource. This paper discusses the aims and strategies of the fisheries management program for the Tehri Dam Reservoir. The basic aim of this program is to meet the ever-increasing demand for low-priced animal protein to feed the region's human population, which is suffering from malnutrition. Strategies for the management of the fish habitat, the fish stock, and the rehabilitation of the fishing community are suggested. To ensure a high, sustainable fish yield from the Tehri Dam Reservoir, some conservation measures are also recommended.*

India has a vast potential for reservoir fisheries development. Reservoir fisheries in India occupies 2 x 10^6 ha and is likely to reach 5 x 10^6 ha before the turn of the century. Many large man-made reservoirs have been constructed or are being constructed in the Himalayan region of India, especially in the last 20 years as a result of the initiation of many multipurpose river valley projects. In the Garhwal region of Uttar Pradesh, there are 23 constructed or proposed dams. The Tehri Dam, Asia's highest, is now under contruction. Its completion will result in the formation of a huge reservoir that will be available for fishery propagation and management.

The Tehri Dam Reservoir will be formed after damming the parent streams of the Ganges (Bhagirathi and Bhilangana) about 1.5 km downstream of Tehri (24.4° N, 78.5° E) (Fig. 1). The Bhagirathi and Bhilangana, like other Himalayan rivers, have steep banks and are in a narrow valley. The river bed is 594 m above mean sea level and the expected deepest foundation is 579 m above mean sea level. Morphometric data for the Tehri Dam Reservoir are listed in Table 1.

Geology of Reservoir Area

Geological factors can constrain reservoir development. Therefore, geological studies of the area are necessary when planning the infrastructure of the reservoir; production can be improved

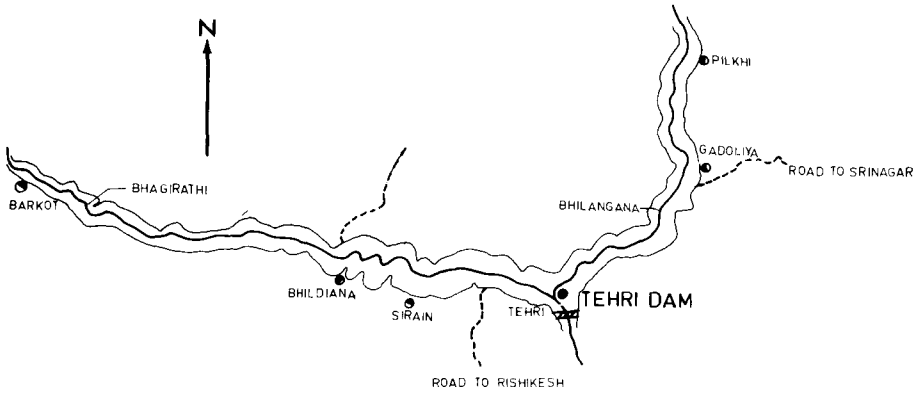

Fig. 1. Layout of Tehri Dam Reservoir.

without seriously disturbing the ecological system. The Tehri Dam Reservoir is located in the central Himalayas, which is of recent origin. The rock formation encompassing the reservoir area belongs to the phyllites of the Chandpur series (Tehri formation). In general, the rocks are alternately banded with argilaceous and arenaceous material. The foliation of phyllites generally strike in N 55° W - S 55° E to N 80° W - S 80° E with dips of 35-55° in the S 10° W to S 40° W direction (downstream).

Hydrology of Reservoir Area

Bharigathi and Bhilangana are snow-fed rivers originating in the Himalayan glaciers Gangotri (Gomukh) and Khatling. Hydrological data for the Tehri Dam Reservoir are listed in Table 1.

Preimpoundment Limnological Profile

To determine fisheries management strategies for the Tehri Dam Reservoir, a detailed limnological knowledge of the area is imperative. Preimpoundment limnological studies on Bhagirathi and Bhilangana have been made by Sharma (1984a) and Sharma and Konswal (1986). The results of these studies are presented in Tables 2 and 3, respectively.

Preimpoundment Fish Resource

Detailed surveys of the fish fauna of both Bhagirathi and Bhilangana have been made by Sharma (1983) and Konswal (1986). Bhagirathi contains 23 species belonging to 11 genera and 4 families, and Bhilangana contains 14 species belonging to 9 genera and 3 families. In addition to a survey ot the preimpoundment ichthyofauna, a survey of the main fisheries has been made (Sharma 1986). Indian Hill trout (snow trout) and mahseer (Tor tor Hamilton and Tor putitora Hamilton) were found to be the main fish of the preimpoundment area.

Table 1. Morphometric and hydrological data for the Tehri Dam Reservoir.

Morphometric data[a]		Hydrological data	
Parameter	**Value**	**Parameter**	**Value**
Max. dam height (m)	260.5	Annual precipitation (cm)	101.6-263.0
FSL (m)	830	Rivers' discharge (cumec)[b]	
		Winter	60
HFL (m)	835	Normal monsoon flood	900
		Max. flood	7800
Reservoir area at FSL (km^2)	42	At dam site	15540
Extent of reservoir (km)		Annual runoff (m^3)	
Up Bhilangana	25	Max.	11.2×10^9
Up Bhagirathi	44	Min.	5.5×10^9
		Mean	8.2×10^9
GSC at FSL (m^3)			
Live storage	2.62×10^9		
Dead storage	0.92×10^9		
Total	3.54×10^9		

[a]FSL, full supply level; HFL, highest flood level; GSC, gross storage capacity.
[b]Cubic metres per second past a given point.

Table 2. Preimpoundment (1979) characteristics of Bhagirathi.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Air temp. (°C)	16.6	19.0	26.3	27.8	34.6	36.3	32.6	31.3	27.8	26.4	21.3	16.0
Water temp. (°C)	13.0	13.6	16.9	19.8	18.8	18.8	15.4	17.8	19.0	17.8	15.3	12.0
Turbidity (%)	12.0	21.0	17.0	83.5	36.6	74.5	95.6	90.5	72.5	31.6	12.0	7.0
Water current (m/s)	0.438	0.340	0.355	0.756	1.057	1.970	3.331	3.602	2.056	1.314	0.938	0.841
pH	7.20	8.13	8.00	8.25	8.40	9.10	9.0	8.55	7.88	8.30	8.13	7.63
HMD[a] (m)	1.346	1.038	1.063	3.143	3.080	4.925	6.502	6.207	5.040	3.936	1.765	1.563
Dissolved O (ppm)	17.8	14.5	11.2	9.8	9.6	9.4	9.2	8.9	12.5	13.8	15.2	17.5
Free CO_2 (ppm)	4.00	4.63	5.38	6.38	4.20	3.13	3.90	4.75	5.63	5.10	4.50	4.30
Plankton (units/L)	1025	720	270	185	135	45	36	27	72	140	520	810
Benthos (units/m^2)	695	1012	837	866	290	60	33	33	107	278	346	554

Source: Sharma (1984a).
[a]HMD, hydro-median depth.

Table 3. Preimpoundment (1983) characteristics of Bhilangana.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Air temp. (°C)	13.2	14.7	21.3	19.2	27.1	29.7	30.2	34.0	33.6	28.0	22.2	14.2
Water temp. (°C)	10.1	12.7	14.1	16.2	21.4	19.2	19.4	19.1	19.0	18.2	14.1	13.2
Turbidity (%)	6.3	10.1	16.1	18.4	22.0	32.2	64.2	42.2	28.6	22.4	16.6	9.5
Water current (m/s)	0.212	0.229	0.325	0.252	0.516	0.845	1.480	1.398	1.132	0.391	0.212	0.188
pH	7.21	7.40	7.66	7.52	7.71	8.21	8.37	8.48	7.81	8.11	7.90	7.62
HMD[a] (m)	5.320	5.426	6.950	7.206	6.521	8.420	8.196	8.462	7.026	6.320	4.210	5.921
Dissolved O (ppm)	14.61	14.32	9.63	9.01	8.42	8.24	8.05	8.41	9.12	10.43	10.84	12.65
Free CO_2 (ppm)	0.32	0.41	0.92	1.21	3.56	2.12	1.82	1.21	1.57	2.02	1.42	0.53
Bicarbonates (ppm)	28.2	36.0	36.9	54.0	65.0	58.1	22.0	18.2	24.0	35.1	26.2	38.5
Carbonates (ppm)	-	-	-	-	-	-	-	-	-	-	-	-
Alkalinity (ppm)	28.2	36.0	36.9	54.0	65.0	58.1	22.0	18.2	24.0	35.1	26.2	38.5
Plankton (units/L)	27	21	16	20	12	7	3	4	10	8	13	18
Benthos (units/m^2)	609	787	696	409	263	95	59	59	87	212	371	549

Source: Sharma and Konswal (1986).
[a]HMD, hydro-median depth.

Fisheries Management Strategies

Fisheries management involves the manipulation of living aquatic resources, of the environment in which they live, and of the associated human communities (Welcomme 1985). Several management strategies for reservoir fisheries have been practiced with different degrees of success.

Management of Fish Environment

Fish production in the Tehri Dam Reservoir is secondary to hydroelectric power generation, irrigation, navigation, and tourism. Therefore, the existing environment is likely unsuitable for fish production. Problems that may arise are associated with unfavourable physicochemical conditions of the water, the feeding areas, migration, spawning grounds, excessive growth of aquatic weeds, and changes in fish species composition. Manipulation of the impounded area with respect to these factors is necessary to prevent population depletion and trophic depression.

Clearing and Leveling

In area to be affected by the dam, the town of Tehri will be submerged, 23 villages will be fully submerged, and 72 villages will be partially submerged. Therefore, the area must be leveled and cleared to make it suitable for the fish. The clearance of vegetation, which varies from dry subtropical to temperate shrubby, including a few exotics, should be selective and decided on the basis of feeding preferences, the proposed mode of fishing, and the fishing effort in the reservoir.

Fish Ladders

It has been well established that economically important species of the dam's area such as T. tor, T. putitora (Sharma 1984b), Labeo dero Hamilton (Sharma 1984c), and Glyptothorax pectinopterus McClelland (Sharma 1984d) are migratory, and any interruption in their movement would seriously affect the fisheries of the reservoir. Therefore, fish ladders will be established to facilitate upstream and downstream movement of the fish across the dam. For the successful operation of fish ladders (fish passes), fish locks should be included in the dam design. Fish locks are generally more effective than other fish passes and have been successful throughout the USSR (Jhingran 1965).

Improvement of Spawning Grounds

In most of the reservoirs of India, spawning-ground availability is the main limiting factor to the fish population. Parts of initially favourable spawning areas may become covered by sediments or made unsuitable by frequent water level fluctuations. Thus, in the Tehri Dam Reservoir, improvement of existing spawning grounds and the development of new ones is necessary for the successful propagation of indigenous and introduced species.

Downstream Management

The changes in water discharge and water quality below the dam will adversely affect the feeding and spawning grounds. This situation can be improved if the water released from the Tehri Dam Reservoir is adjusted by manipulating the downstream habitat to match the normal hydrological cycle.

Control of Eutrophication

There is strong evidence that, in time, reservoirs develop an excessive growth of aquatic weeds. This adversely affects fish development. To cope with this problem, herbivorous fish such as S. richardsonii, Garra gotyla gotyla (Gray), Crossocheilus latius (Hamilton), and a few exotic species such as grass carp (Ctenopharyngodon idella (Valenciennes)) and silver carp (Hypothalmichthys molitrix (Valenciennes)) can be introduced.

Management of Fish Stock

To ensure maximum production at the Tehri Dam Reservoir, the fish stock must be properly managed. The following eight points should be considered when devising management strategies for the fish stock.

- The species to be introduced should be fast growing, able to breed in confinement, and have a feeding habit suitable to the food available in the reservoir. Sharma and Bhatt (1986) have developed nine food chain models for the Tehri Dam Reservoir. Their models 7, 8, and 9 would be most appropriate for stocking because the species involved occupy all three niches of the reservoir: peripheral bottom, column, and surface.

- Some highly productive exotic species could be stocked to utilize any untapped niches in the reservoir.

- Production of the fish stock could be enhanced by enriching the food reserves at different trophic levels (Bhukaswan and Pholprasith 1977; Fernando 1977; Jhingran and Tripathi 1977). This could be achieved at the Tehri Dam Reservoir by acclimatizing and transferring choice feed organisms into the reservoir.

- For effective stocking, fish hatcheries should be established near the reservoir to facilitate easy transport of the raised fingerlings.

- Sport fish (Tor spp. and Schizothorax spp.) could be introduced to attract anglers and promote tourism.

- In the Tehri Dam Reservoir, the water level should be in accordance with the requirements of the fish population.

- Using selected species, trials with floating cage culture should be undertaken. Cage culture with supplementary feeding would be advantageous because the upper layer of the impoundment will be rich in plankton, will have an adequate supply of dissolved oxygen and a high pH, and will be slightly warmer than the rest of the water column.

- To prevent fish diseases, the reservoir should be stocked with parasite-free fish and strict disease control should be practiced.

Rehabilitation of Fishing Community

The submergence of Tehri and surrounding villages as a result of the Tehri Dam will necessitate the rehabilitation of about 20,000 people, including many fishermen. The government should relocate the

trained fishermen and other local inhabitants such that the collection and disposal of the catch is not a problem. The fishermen should be trained for deep-water fishing and a cooperative society of fishermen should be established to ensure proper marketing of the fish.

Conservation of Fisheries

To ensure a high and sustained yield of fish from the Tehri Dam Reservoir, strict conservation measures should be practiced. Overexploitation of the fish stock would adversely affect the growth rate and reproductive capacity of the fish population (Nikolskii 1969). The following three main conservation measures may be implemented.

Closed Season, Closed Area

In the Tehri Dam Reservoir, fishing should be prohibited from April to August, which is the spawning season of most of the stocked species (Sharma 1984b,c,d). If fishing is allowed at this time, spawning and the growth of fry and fingerlings are disrupted (Nikolskii 1979). Fishing should be prohibited in spawning areas and feeding grounds, where mature fish and fingerlings congregate.

Size Limitation of Mesh, Fish, and Catch

On the basis of preimpoundment studies on the spawning ecology and breeding biology of the fish (e.g., *T. tor*, *T. putitora*, *L. dero*, *G. pectinopterus*) of Bhagirathi and Bhilangana (Sharma 1984b,c,d), it is recommended that catching fish below 250 mm total length using a mesh size less than 30 mm be prohibited. A fixed catch limit should also be imposed.

Fishing Methods and Public Education

Destrucive fishing methods such as dynamiting, poisoning, and electric shock, which are freely practiced in the preimpoundment areas, must be strictly banned. A public education program should be initiated.

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