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ABSTRACT: *The paper examines various challenges facing development of fisheries resources in Kaptai reservoir, Bangladesh. The reservoir has undergone major changes in its catch composition since impoundment. Production records show a declining trend in the productivity of high valued fish. A host of managerial, socio-economic and environmental factors are responsible for the under utilization of the reservoirs' potential to provide high value freshwater fish. These include, deterioration of the natural breeding ground, environmental damage, poor implementation of regulations, inefficient fish farming technology, and poor management practices. These constraints are discussed and possibilities for future improvements are suggested.*

Key Words: Reservoir fishery, Management policy, Bangladesh

Introduction

The Kaptai reservoir in Bangladesh, one of the largest man-made freshwater reservoirs in South-east Asia (Fernando, 1980) was created in 1961 by damming the river Karnaphuli at Kaptai mainly to provide electricity with hydropower, while fisheries, flood control, drainage and irrigation, and navigation were considered as secondary options. The reservoir covers approximately an area of 58,300 ha (68,800 ha at Full Supply Level) and constitutes a significant component of inland water resources occupying 46.8% of total pond area of Bangladesh (Ahmed, 1999). Therefore, it offers a huge potential for fish production, a priority source of protein in Bangladeshi diet. Present contribution from this fishery is around 6000 mt per annum with high annual fluctuation (Ahmed et al., 2001). Performance of Kaptai reservoir suffers from a host of environmental, socio-economic and management constraints affecting its potential. A considerable number of people living in surrounding areas depend on this reservoir for their livelihood. Despite its great socio-economic values, past works on Kaptai reservoir focused on biological and limnological aspects of the fisheries (for example, Ahmed et al., 1994; Hye and Alamgir, 1992; Haldar et al., 1990; ARG, 1986; Azadi, 1985; Chowdhury and Mazumdar, 1981) with limited studies on its socio-economic aspects (for example, Haldar et al., 2003; Ahmed, 1999; Hye, 1988).

Given this backdrop, the present paper provides a critical analysis of the current status of Kaptai reservoir and highlights various constraints affecting its development as an important source of high value freshwater fishery and discusses potentials for improvement. The study is based on the analysis of information and data generated by Bangladesh Fisheries Research Institute, Riverine Sub-Station (BFRI, RSS) and review of works published by different authors as well as reports of Bangladesh Fisheries Development Corporation (BFDC), responsible for managing the reservoir since 1963.

Trends in fish production, productivity and composition

A total of 73 fish species belonging to 47 genera, 25 families, two species of prawn and one species of dolphin were identified so far (Ahmed, 1999). Of them, 31 species have commercial importance but their contribution to total landings is not significant due to change in the physical environment. Over the years eight species of fish totally disappeared, seven species are dwindling, seven new species were introduced and 11 species, mainly clupeids, became dominant in the reservoir (Ahmed, 1999).

The historical landing in BFDC managed pontoon shows that production of fish from this reservoir grew at an estimated annual rate of 3.5% since first harvest in 1966 to 2001 (Figure 1). The average annual landing was 3,530 mt with large variation between years. The maximum production of 6,586 mt was obtained in 1998 contributed mainly by explosive growth in clupeids. However, this production does not include fish caught for local consumption and pilferage to avoid royalty payments to BFDC. Estimate of such unrecorded fish ranges from 30% (ARG, 1986) to 40-50% (BFRI-RSS, 2000).

[Insert Figures 1 and 2 here]

The productivity record for the past 14 years (1987–2001) reveals that fish yield increased at an annual rate of 3.8% (Figure 2). The mean yield rate was estimated at 81.5 kg/ha with large variation over time. The yield rate increases to 105.9 kg/ha when an estimated 30% of unrecorded fish is added. The reservoir, is thus, can be classified as moderately productive when compared with its peers in Asia, for example, Thailand (Bhukaswan and Chookajorn, 1988), Indonesia (Baluyut, 1984) and India (Sharma, 1988).

Carps[1] used to be the predominant species in early years of post-impoundment which gave way to clupeids[2] (a marine derived fish) at present. Carps contributed 81.4% of total landing during first harvest in 1966 (Figure 1). The yield rate of carps steadily declined from 19 kg/ha during 1970s to only 5 kg/ha in the 1990s and now contributes only 5.1% of total landings. On the other hand, current yield rate of clupeids is 32 kg/ha. Among the clupeids, three pelagic species, *Corica soborna*, *Gudusia chapra* and *Gonialosa manminna* accounted for 63.4% of total catch in 2001, and is the highest contributing group growing at an annual rate of 8.7% over past 14 years (Figure 2). Dried fish[3] also contributes 28.3% of total landing, wherein clupeids constitute 80% of total weight. Similar explosive growth of clupeid (e.g., *Corica goniognatus*) was found in Thai reservoirs (e.g., Sirikit, Sirinthorn, and Lampao) with significant contribution (Pawaputanon, 1986). Fernando and Holcik (1991) and Fernando (1998) noted that in addition to lacustrine fish, marine-derived fish, e.g., clupeids, osmerids and some other families, colonized many reservoirs in recent years.

Environmental, management and socio-economic issues and constraints

World lakes suffer from one or more of these seven major threats: (i) accelerated eutrophication; (ii) invasive species; (iii) toxic contamination; (iv) overfishing; (v) water diversion; (vi) acidification; and (vii) climate change (Borre et al., 2001). Therefore, the main management challenge is to devise strategies that can effectively address most or all of these threats. Kaptai reservoir seems to suffer to a large extent from three of these seven major threats: (i) invasive species (e.g., the explosive growth of clupeids) – a key environmental constraint, (ii) overfishing of certain species – a common socio-economic constraint, and (iii) water diversion mainly to regulate electricity – a classic management constraint. The present section discusses some of the key environmental, management and socio-economic issues and constraints affecting Kaptai reservoir.

Environmental issues and constraints

Ecological changes: Great ecological changes were observed in reservoir ecosystem turning from acidic to neutral (Chowdhury and Mazumdar, 1981) and then to alkaline with pH level of 9.00 (BFRI-RSS, 2000). Based on the analysis of dissolved oxygen content, total hardness and pH level of water, Kaptai reservoir can be regarded as medium productive. The overall water quality seems suitable for enhanced fisheries. A key physical constraint of Kaptai reservoir is great fluctuation in water level due to the 'rule curve' set by Kaptai Hydro Power Station (KHPS) to regulate electricity supply. Further loss of water occurs due to irrigation and half of reservoir surface area dries out for at least three months a year. High water turbidity is also a remarkable feature of Kaptai reservoir caused mainly by soil erosion.

Primary production: Based on the analysis of primary production and fish yield in relation to gross synthesis and plankton biomass, the estimated production of Kaptai could reach between 19,000 – 26,000 mt whereas actual average production stands at only 6,000 mt per year with high annual fluctuation. Factors responsible for such variation include productivity of the reservoir, number of fishermen, fishing techniques and management policy. In general, shallow reservoirs with wide fluctuations do provide high fish production with high yield one year after high water level (Bhukaswan and Pholprasith, 1976).

Natural breeding: Natural breeding is the main source of auto stocking of a water body. Among the 73 species of fishes in Kaptai reservoir, most breed naturally. But major carps do not breed in confined water, although they can mature there. Several attempts were made to explore the breeding grounds of major carps of Kaptai reservoir and four suspected spawning sites were identified during mid-1980s (Azadi, 1985; ARG, 1986). BFRI-RSS (2000) suspects that natural spawning for major carps is not occurring successfully since 1990s. Among the assumed causes, siltation due to shifting cultivation, high water level fluctuation, lack of rainfall and thundershower at breeding time, low current velocity during breeding season and fishing pressure are suspected (Ahmed, 1999).

Exotic species: Since 1980s, BFDC used some exotic species in its stocking program but their subsequent landings have not been satisfactory. On the contrary, accidental introduction of the controversial exotic fish, Nile Tilapia (*Oreochromis niloticus*) in 1985 established itself successfully and currently contributes to 3% of total catch. Tilapia replaced all species including Gangetic carps in Vaigai Reservoir and seriously altered native species spectrum ultimately bringing down production in Amravati, Sathanur, and Powai reservoirs of India (Jhingran, 1992). Introduction of Nile perch (*Lates niloticus*) in Lake Victoria boosted fishing industries of Uganda, Kenya, and Tanzania at the cost of extinction of 200 fish species (Ntiba, et al., 2001). ARG (1986) cautioned that Tilapia might compete with native major carps for food and survival in Kaptai, which may be the case now.

Management issues and constraints

Management of Kaptai reservoir fisheries basically pertains to: (a) closing of fishing for certain period, (b) issuing license to the fisher, (c) implementation of fisheries act, and (d) the most advocated and widely practiced stocking and recapture technique. The fishery of Kaptai reservoir is leased to BFDC in 1963 for 99 years, who has landing station, ice plant and refrigeration facilities.

<u>Licensing and royalty payments:</u> Provision of licensing was initiated in 1972 by BFDC and gear licensing started in 1981. Only licensed fishers are allowed in the reservoir, but when compliance was checked through a survey, only 29% of fishers had fishing license (Ahmed, 1999). The government is losing approximately 420,000 BDT (7,200 USD) per year from license fee alone. Sometimes fish traders pay the license fee on behalf of fishers who are then obliged to sell their total catch to the traders at ex-vessel price which is 55% to 125% lower than the prices in local and city markets, respectively. BFDC collects royalty in cash ranging from 33-40% of total fish landing depending on species. High rates are imposed for high priced and big fish, thereby encouraging fish pilferage.

<u>Stocking and fishing pressure:</u> Fishing at Kaptai reservoir was banned for the first three years of its formation and 2.3 million pieces of major carp fries were stocked to build up a ready stock. Since then, BFDC liberates about 30 mt of fingerlings each year but with no evidence of any stocking success. During 1981-85, 1.6 million pieces of exotic carp fingerlings were stocked to colonize vacant/new ecological niches and to utilize aquatic weeds of the reservoir. Commercial landings from these three exotic species during 1983-1988 were only 3.17 mt, showing unsuccessful recruitment. Stocking of major carp fingerlings in the past did

not follow any number and species composition. From 1990 onward, stocking program of a predetermined number of self-sustainable sized (9-13 cm) fingerlings with a given species composition was implemented. Even then promising recruitment is not occurring at all, failure of recruitment is due to factors, such as, long journey of fingerlings during transportation (procured nearly 200km away from the reservoir) causing injury and infection, short time of acclimatization, lack of proper handling of fingerlings, lack of therapeutic measures, high water depth and possible inbreed-effect as fingerlings are procured from same origin every year. Evidence of inbreeding effect of stocked fish was found while cultured in pen installed creeks at Kaptai reservoir (Ahmed et al., 2002). Also, use of gears such as hooks and lines and brush shelters catch a significant portion of fingerlings during post-stocking period (Ahmed and Hambrey, 1999). Thus far funds spent on stocking for Kaptai Reservoir have been lower than the value of recaptured fish. The earnings grew at a rate of 16.8% while expense grew at a rate of 13.3% per year (Figure 3).

[Insert Figure 3 here]

Study on population dynamics and assessment of stock of any fishery is of great importance in management. Thus far, fishing pressure of only five commercially important species in Kaptai reservoir were analyzed. The results show that two species (*L. rohita* and *C. Mrigala*) are under high fishing pressure, *C. catla* is under optimum fishing pressure and *L. calbasu* and *O. niloticus* are under less fishing pressure. Therefore, any major change in the existing fishing exploitation of first three species will hamper maximum sustainable yield potential and calls for imposition of fishing regulation.

<u>Fishing prohibitions in closed period and fish harvesting target:</u> Fishing in Kaptai reservoir remains closed from mid-June to mid-September. Commercial exploitation usually stops (almost if not fully) during this period, but subsistence fishermen and tribal people continue

to catch fish for home consumption and illegal marketing. Also, in remote places of the reservoir, imposition of complete fishing ban is impossible. Artificial stocking is performed during the closing period to protect fingerlings from fishing but remains unsuccessful due to reasons cited above. Sometimes, start of the closure period is delayed to fulfill fish harvesting target set annually by BFDC which was not based on any factual data and scientific background (ARG, 1986). Jenkins (1985) concluded that the harvest of major carp might have exceeded the maximum sustainable level due to setting of such targets. Since 1980s, major carp fishery seems to be over-exploited and no larger sized mother stock is left for auto-stocking or subsequent breeding. Also, from the very beginning, fishing continued without following any particular regulation but mainly to fulfill harvesting target only.

<u>Minimum size of fish harvest and mesh size regulation</u>: In Kaptai reservoir, fishing is banned under the size of *C. catla* 2.0 kg, *L. rohita* 1.0 kg, *C. mrigala* 0.75 kg and *L. calbasu* 0.5 kg, respectively which is not strictly imposed. The minimum permissible mesh size for gill nets is 7.62 cm but is not followed by fishers because the clupeids are susceptible to this mesh size leading to poor catch and fishers resort to much smaller mesh sizes due to leniency in enforcement.

<u>Reservoir level and rule curve:</u> The mean water level fluctuation of Kaptai reservoir is 8.14 m (ARG, 1986). KHPS follows a rule curve to maintain this level but could not do so due to irregular rainfall. It is interesting to note that the water level of Kaptai reservoir was maintained at lower level during breeding seasons (June-August) since inception which is detrimental for natural breeding success. Fluctuation of water level and heavy shoreline siltation was identified as one of the major causes of gradual disappearance of fish species and destruction of natural breeding grounds in Lewis and Clarke lakes in USA (Walburg, 1976).

Administrative bottleneck: Four institutions are involved in administration of this reservoir with conflicting roles. BFDC is responsible for overall management and is concerned with commercial exploitation of fish, marketing, declaration of closed season, licensing, stocking, and guarding. BFRI provides research and technical support. However, Department of Fishery (DoF) coordinates all extension and conservation activities, except management, and is responsible for implementing the Fish Act, e.g., ban on undersized fish harvest, mesh size regulation, license checks, and monitoring of closed season. On the other hand, the Civil Administration (Deputy Commissioner) is actually responsible for final decision-making and enforcement of regulations concerning conservation and utilization of natural resources. In other words, institution responsible for management of the reservoir is not equipped with enforcement capabilities and vice-versa, thereby, resulting in a classic poor enforcement of regulations. Furthermore, the Rangamati field units of these institutions are poorly equipped, understaffed and underfunded coupled with inadequate logistic support and physical infrastructure.

Socio-economic issues and constraints of the stakeholders

In addition to BFDC, DoF, BFRI, and Civil Administration, two other major stakeholders are the fishers themselves and the fish traders whose socio-economic circumstances, customs and practices significantly affect performance of this fishery. For instance, the number and types of crafts and gears used in fishing as well as the method and timing of fishing has important implication on stocking success and fish yield. Some of the key issues are discussed below.

Fishing crafts and diversified fishing gears: In Kaptai reservoir, basically two types of fishing crafts, the large country boat (10-12m length; 1-2m breadth) and small country boat (6-8m length; 0.7-1.2m breadth) are found. The former is generally used for seine net and operated by 5-10 fishers while the later is used for other fishing gears and operated by 1-2 fishers. Occasionally, the tribal people use boat made by grooving a large timber log. All these crafts are made of indigenous timbers and are rowed manually. Only the carrier boats operated by fish-traders are mechanized.

Fishing operation in the Kaptai reservoir first started in January 1963 by small fishers with only three types of gears, namely, seine net, gill net, and hook and line (Mesbahuddin, 1966). However, currently a wider set of fishing gears is in use (Figure 4). In recent years, a shift in gear operation was observed. With the appearance of clupeids since 1980, a large number of very small meshed mosquito nets (beach seine) came into operation and is on the rise. Introduction of four-boat lift net is a new addition which consists of a net of four mesh sizes arranged vertically to catch different sizes of fish at one time. An unusual but a very destructive fishing method locally known as Brush Shelter (a Fish Attraction Device) has also been introduced in the reservoir since early 1990 and an estimated 1,000 brush shelters are in operation (Ahmed, 1999). BFRI-RSS (1993) estimated 679-gill nets, 305 seine nets, 93 lift nets, 18 push nets and 212 hooks and lines of different categories.

[Insert Figure 4 here]

<u>Role of fishers and fish traders:</u> Three categories of fishers are involved in fishing in Kaptai reservoir – (a) owner of boats, gears and are economically solvent; (b) owner of boats and gears but operate with a loan from fish traders; and (c) fishing-labor who are hired either on daily or monthly basis by (a) and (b). Both local resident and migrated fishers are found in Kaptai reservoir. About 38% of the owner fishers come from different districts of Bangladesh to the Kaptai reservoir during the fishing season accompanied with fishing-labor and play a vital role in commercial exploitation since local fishers are resource poor and are engaged in

subsistence fishing only. An estimated 5,560 fishers are engaged in fishing in Kaptai reservoir (Ahmed, 1999).

Fish traders and private entrepreneurs conduct all fishing and marketing activities, except fish harvest and provision of infrastructure. BFDC issues license to fish traders at a very low fee. Currently, 185 fish traders regulate fish trade in Kaptai reservoir, which increased from only 7 in early years. Of them, 30 traders (called master traders) handle the lion's share of commercial landing and control most fishers tied through loan disbursement (Ahmed, 1999). There are about 52 local markets along the reservoir, which are free from BFDC royalty where unrecorded fish were sold.

Potential for improvement

Since reservoirs are created artificially by flooding of a given habitat, some environmental changes over the maturation process are inevitable. For instance, changes in the species composition from riverine species (such as carps) to small pelagic species (such as clupeids) over time. The reservoir area was once part of the undulating valleys and lower reaches of the Karnaphuli River and its four streams and, therefore, now strewn with submerged wooden logs and hillocks, as the area was not cleared prior to impoundment. Therefore, decay of flooded vegetation and natural decline of the productivity of the changing water environment may also be responsible for poor productivity of this fishery. The loss of natural breeding ground of carps may be partly due to the fact that the natural floodplain habitat in which carps previously breed has been inundated or lost since impoundment. Nevertheless, apart from these natural and irreversible causes, other most likely causes of failure to improve production potential of Kaptai reservoir are ineffectiveness in implementing existing regulations, prioritizing needs, unplanned stocking program and setting unrealistic harvesting targets. Also, an essential element, the legislative policy framework for protection and conservation of aquatic resources of Kaptai reservoir is lacking which should be addressed urgently. To improve productivity of this reservoir, an integrated approach to reservoir management is essential. One of the key principles will be to ensure involvement of key stakeholders who are most affected by management decisions, particularly the resource poor fishers whose livelihood depend on this reservoir. Community Based Fisheries Management (CBFM) as a possible solution to promote fisheries in inland floodplains of Bangladesh were tested with support from WorldFish Centre, international donor agencies, local Non-governmental Organizations (NGOs), and local community organizations since 1996. Although results were mixed, important lessons emerged: (a) it is essential that communities obtain rights over the fisheries; (b) strong facilitation is necessary; (c) taking up visible resource management practices helps greatly; (d) success is more likely in homogenous communities; and (d) effective well-defined partnerships between NGOs and government (although difficult to establish) were sufficiently beneficial (Thompson et al., 2003). Similar CBFM as an overarching framework could be a viable option for managing Kaptai reservoir and should receive serious consideration. Also, sound management practice should be based on scientific evidence and factual data. To this end, surveys to generate information on number of crafts and gears, type, mode, intensity of fishers involved, catch per unit effort, fish composition and species diversity, can be conducted at least every five years. Furthermore, potential for future improvements in key areas are discussed below.

Stocking management

The usual solution to counter loss of natural breeding ground is artificial stocking which is followed in Kaptai but with caveats discussed in the previous section. A tripartite coordination between three main agencies, DoF, BFRI and BFDC can initiate production of self-sustained fingerlings within or along the reservoir area, thereby, avoiding transport of fingerlings from long distances that are characterized with various disadvantages. The on-going program of BFRI-RSS offers the potential. The management should also be aware of the inbreed-effect caused from artificial stocking. Stocking of hatchery-reared and other non-native fish can dilute the gene pool of the indigenous population if not managed properly. For example, hatchery reared steelhead trout (*Salma gairdneri*) were less successful in reproducing naturally than wild fish (Chilcote et al., 1986). Continuous monitoring and supervision of hatchery activities can ensure quality of fish seed. Two months of precautionary measures in the nursery grounds of supplemental stocking could substantially reduce natural and fishing mortality. At least 20% of fingerlings should ideally come from natural sources which points towards need to develop natural spawning grounds in upstream of the reservoir. Keeping water level at required optimum during spawning season would require strong inter-agency co-ordination between BFDC, BFRI, DoF and KHPS. In Cuba, a well-organized network of fish seed production centers caters stock requirements of all state-controlled reservoir fisheries (Sugunan 1997).

Effective implementation of fishing regulations

Effective implementation of existing fishing regulations, such as, licensing, mesh size, legal catch size, approved gear, fishing ban period, must be ensured. This can be achieved by major overhaul in defining roles and responsibilities of key agencies (BFDC, BFRI, DoF, and Civil administration) under a common policy framework avoiding existing contradictory management structure. Enforcement of actions should also be based on realistic fees and proper service provision from the authorities in return for these charges. Zoning of fishing areas with establishment of additional landing units and realistic fishing royalty can be an attempt towards reducing pilferage. To protect gravid brood at migration channel as well as enhance breeding performance, fishing ban period should start from early May and effectively implemented. In Thailand, use of high efficiency fishing gear in freshwater is prohibited from 16 May to 15 September, the spawning season of freshwater fishes. Fishing is also prohibited in rivers for a distance of 3 km downstream from the dam to protect migratory species (Bhukaswan and Chookajaon 1988). However, such compliance will only be feasible with active participation of all key stakeholders including fishers through active consultation, planning and consensus, a key feature of CBFM. Target oriented production plan of BFDC should be avoided. Also, gear approval is essential. On the basis of known stock, fishing licenses of different gears should be issued and fishers should be discouraged on the use of gill net, brush shelter and hooks and lines by raising awareness of the long term effect of such practices. For example, use of gill nets in rivers is categorically prohibited in Zimbabwe and a license is required for manufacturing, storing, buying or selling them (Sugunan 1997). Such an all-round policy instead of banning only use of a certain gear is likely to be more successful. Existing regulation on legal harvesting size of major carps needs effective implementation and should be penalized when breached.

Research and Development (R&D)

Need based research on management and production of Kaptai reservoir could be undertaken with a collaborative effort between BFRI and BFDC. New technologies to increase production could be another major research focus. For example, preliminary result from a 3-year collaborative study by BFRI-RSS and BFDC indicated that polyculture of Indian major carps and Chinese carps in pen installed creeks/coves constructed by fencing off constrict openings by small meshed nets might be a unique system to enhance fish production in the reservoir. Several creek sites along the reservoir water shed were identified where pen installation is possible. The average retrieval rate of stocked carps was 24.4% (range 6.5-38.5%). The average yield from the creeks was 966.0 kg/ha, 9 times higher than the natural catch (± 110 kg/ha) from the reservoir. The economic and ecological significance of creek aquaculture has not yet been completely assessed and deserves more experiments as well as assessment of risk involved with such techniques. However, if proven successful, this approach could create an avenue to improve productivity as well as generate income and employment. Adaptation of cage culture technique also exhibited promising results with respect to adaptability and survivability. Research is in progress for further technology development at BFRI. Also, it was found that nursing of spawn is possible in the creek environment during lean period. More experiments are required to identify a suitable technology package for this option. This technique might be an excellent option for raising fingerlings within the reservoir environment, which can reduce fingerling procurement cost of BFDC as well as mortality.

Building partnership, community participation and extension

Involvement of local fishers in raising stocking materials may create an avenue to establish a congenial environment for the success of supplemental stocking program. Periodical training for fishers on Fish Act and fishing regulation can be arranged during fishing ban period. Fish sanctuaries should be declared restricting year-round fishing around each known spawning and nursery grounds and this can be implemented effectively only with community participation and consensus. Awareness building program can be initiated with use of common extension techniques such as distribution of leaflet, booklet, poster, and using mass media for sustainable management of the reservoir.

Marketing and infrastructure support

In recent years, selected Indian states created public sector fisheries corporations, who follow a system of harvest sharing, whereby fishers give a share of their catch to the government as royalty of 25-50% depending on reservoir productivity. And in return, the government supplies boats, nets and all other fishing equipments (Sugunan, 1997). Kaptai reservoir management may consider worth of such practice. Direct market intervention to increase low ex-vessel price could prove difficult. In India, market intervention attempts made in the past by state governments did not show desired results (Sugunan 1997). However, facilitating institutional sources of loan could serve the purpose by freeing the fishers from ties of fish traders. Building fisheries cooperatives of local fishers could be a viable option that will enable them to compete with migrant commercial fishers who apparently do not have any commitment to conserve resources of Kaptai reservoir. Also, to ensure quality of fish harvested, ice for refrigeration should be made widely available in various locations of the reservoir by establishing more ice plants, currently a responsibility of BFDC.

Conclusion

The paper provided a detailed analysis of the various challenges affecting development of the Kaptai reservoir as a rich source of high value fishery. Apart from natural and environmental constraints, a host of managerial and socio-economic constraints are affecting performance of this reservoir. Nevertheless, there remain potential for improvement as discussed in the preceding section. Hope that result of this study will help in devising appropriate management strategies to develop full production potential of Kaptai reservoir fisheries.

Notes

1. These are the members of Cyprinidae (*Labeo rohita, Catla catla, Cirrhinus mrigala, and Labeo calbasu*)
2. These are the members of Clupeidae (*Corica soborna, Gudusia chapra, and Gonialosa manminna*).
3. Dried fish is a heterogeneous assemblage of short lived easily caught small or moderate sized low priced fish of all categories.

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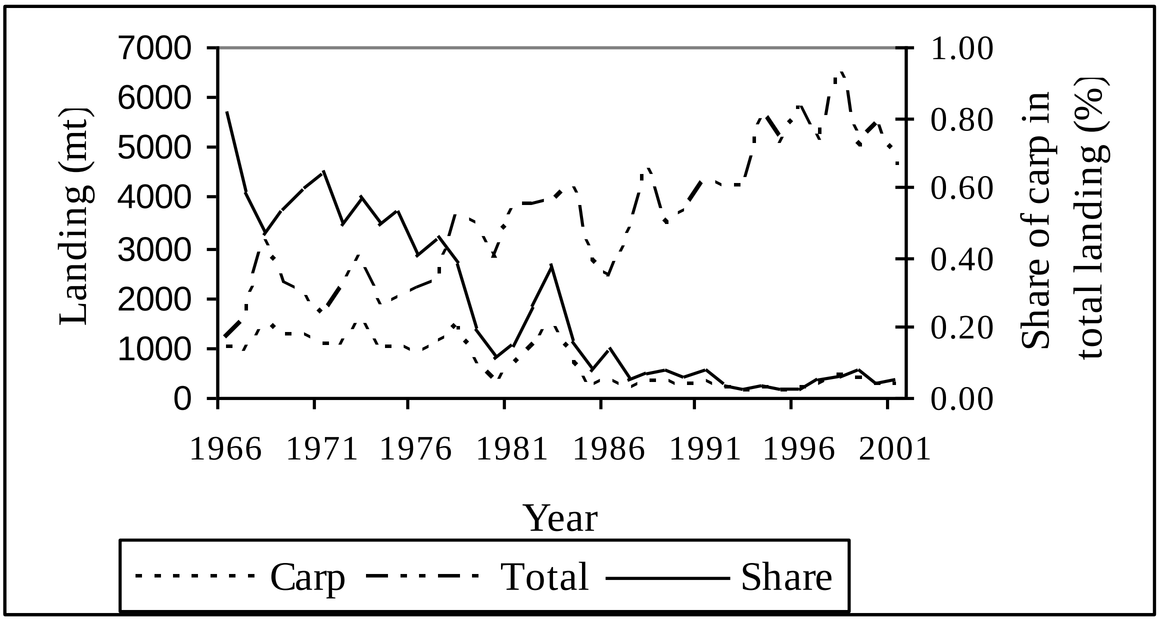
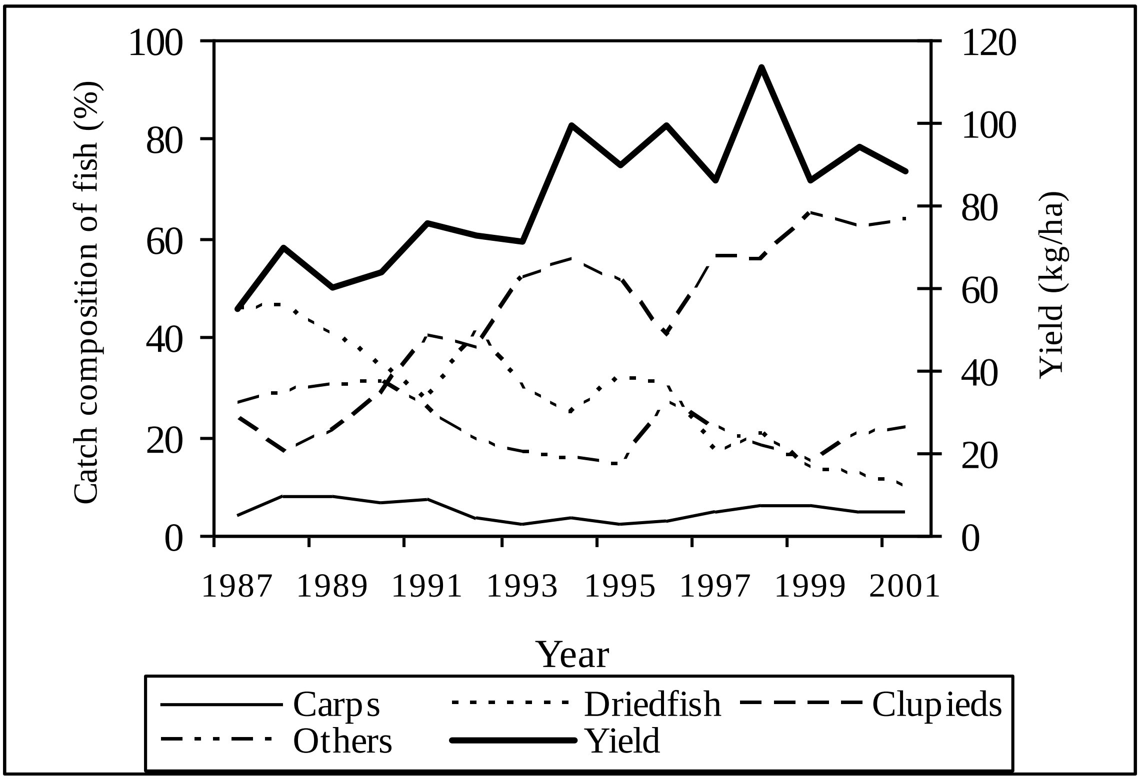


	Mean landing	**Std. Dev**	**Minimum**	**Maximum**	**Growth rate**
Carp	665.64	468.53	93.95	1635.12	-0.0773
Total fish	3530.44	1363.33	1206.63	6586.31	0.0347

Note: Growth rates are estimated using semi-log trend function: $\ln Y = \alpha + \beta T$, where T denotes time and β is the growth rate.

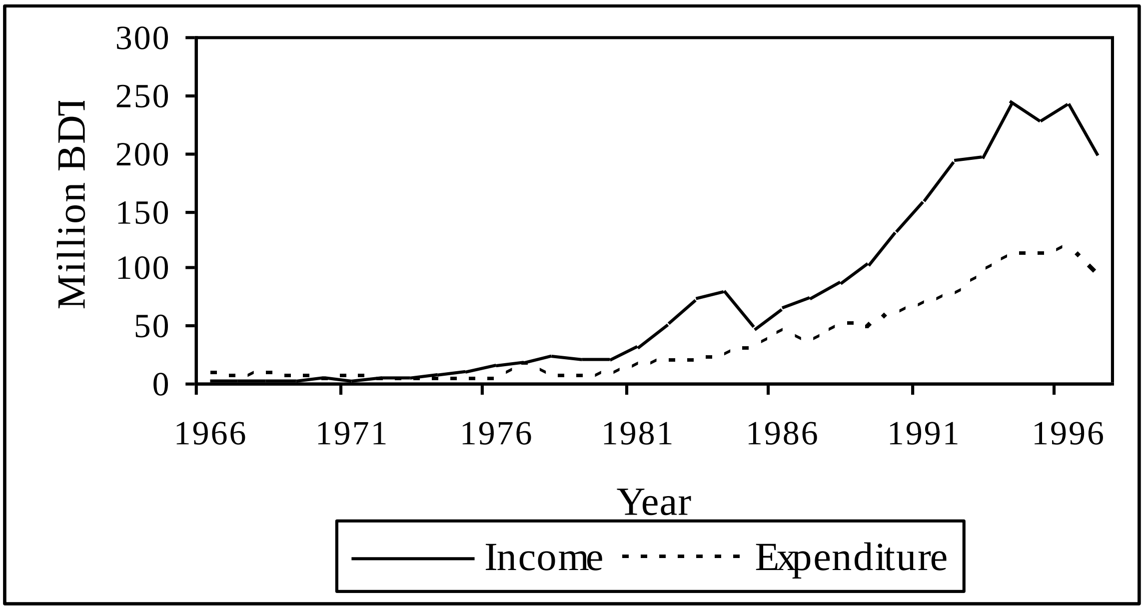
Figure 1. Trends in fish production in Kaptai reservoi3r (1966 – 2001).



	Mean	Std. dev	Minimum	Maximum	Growth rate
Yield (kg/ha)	81.49	16.51	54.56	112.98	0.0376
Catch composition					
Carps	5.11	1.99	2.20	8.27	-0.0203
Dried fish	28.33	11.97	9.95	46.12	-0.1001
Clupeids	44.54	16.27	16.60	64.92	0.0873
Others	22.10	5.73	14.38	30.71	-0.0330

Note: Growth rates are estimated using semi-log trend function: $\ln Y = \alpha + \beta T$, where T denotes time and β is the growth rate.

Figure 2. Trends in fish yield and catch composition in Kaptai reservoir (1987 – 2001).



	Mean	Std. Dev	Minimum	Maximum	Growth rate
Income	73.85	80.81	1.60	243.58	0.1682
Expenditure	34.56	37.81	1.73	117.62	0.1332

Note: Growth rates are estimated using semi-log trend function: $\ln Y = \alpha + \beta T$, where T denotes time and β is the growth rate.

Figure 3. Trends in expenditures and earnings from Kaptai reservoir by BFDC.

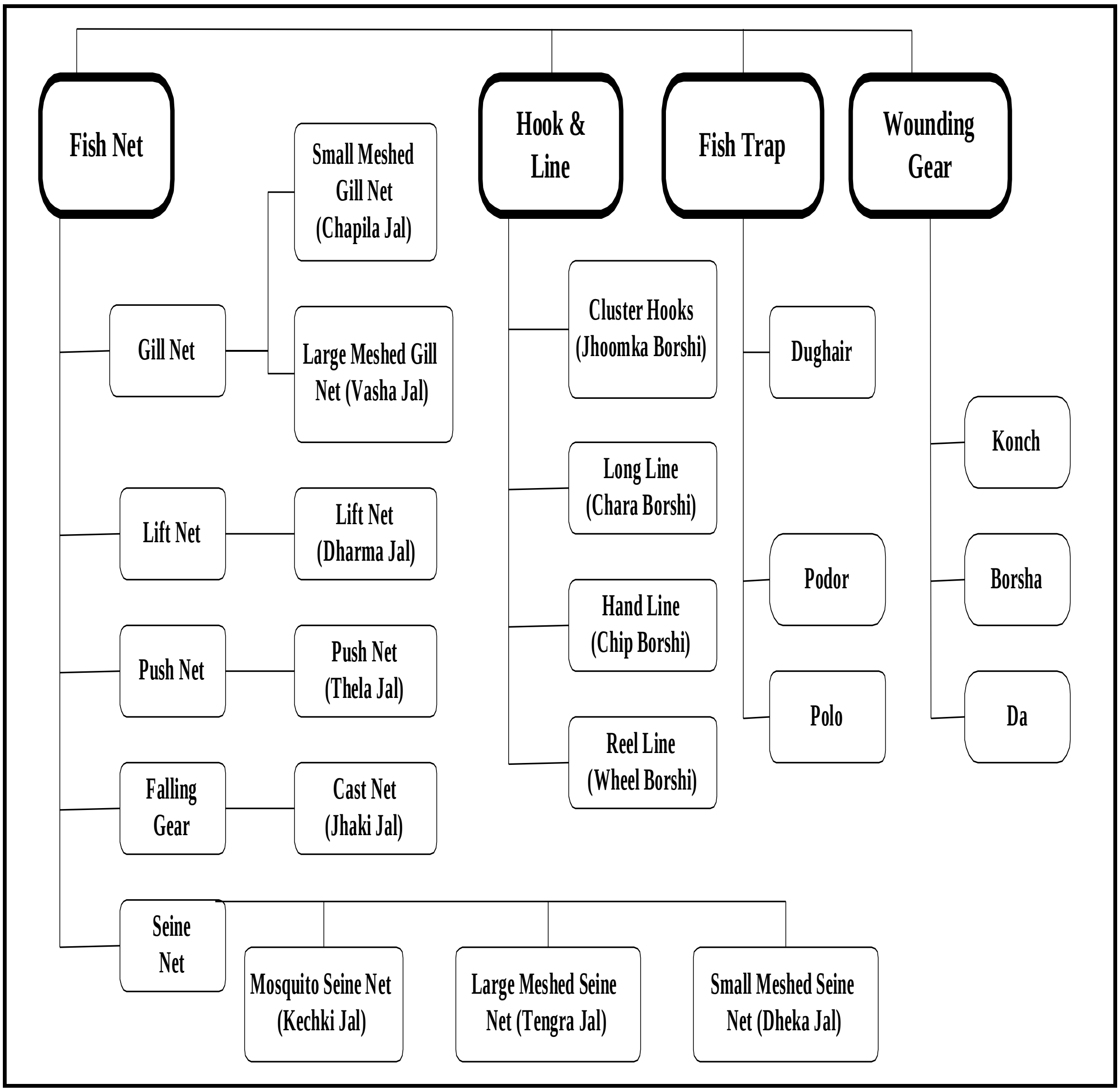


Figure 4. Classification of the fishing gears employed in the Kaptai reservoir.

Source: After Ahmed (1999)