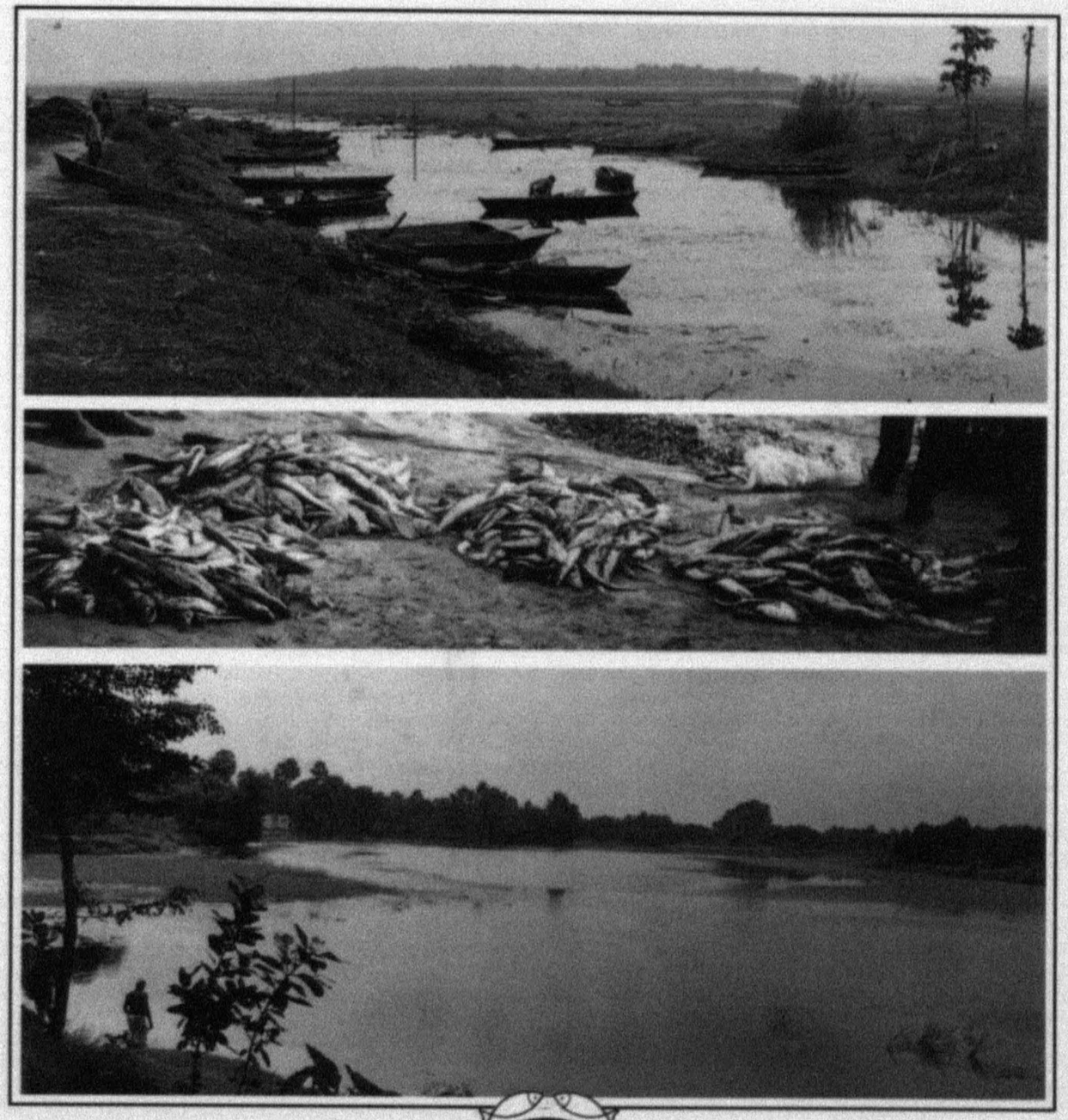
ECOLOGY AND FISHERIES OF OX-BOW LAKES *(MAUN)* OF NORTH BIHAR

-A threatened ecosystem



CENTRAL INLAND CAPTURE FISHERIES RESEARCH INSTITUTE

(Indian council of Agricultural Research)

BARRACKPORE - 743101 WEST BENGAL

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by
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Bull. No. 74 **August 1997**

(Issued on the occasion of Golden Jubilee Celebrations)

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ISSN 0970-616 X

Published by : **The Director, CIFRI Barrackpore**

Printed at : **Calcutta Laser Graphics Pvt. Ltd.**
71, Hari Ghosh Street
Calcutta-700 006

PREFACE

The Eastern and North-Eastern states of India in the Ganga and Brahamputra basins are endowed with vast resource of floodplain lakes. The floodplain lakes in general and the ox-bow lakes in particular (commonly known as *maun* in Bihar) have enormous importance in the socio-economics of the people of these states. The Gandak basin of North Bihar has a chain of ox-bow lakes, which support a large section of human population by providing potable water, water for irrigation, fish and shell protein, nutritious fruits (*Eyrale ferox*) and many kinds of edible leaves. The oxbow lake ecosystem by virtue of its riverine orgin had the distinction of being a rich depository of biodiversity, besides acting as renewable source of capture fishery till recently. However, the increasing anthropogenic activities in the catchment areas and subsequent modifications of the river basins, the lakes are subjected to over exploitation, indiscriminate land use pattern and ingress of pollutarits from various sources. The ox-bows of north Bihar are gradually becoming critical in terms of fish and fisheries and are facing the danger of extinction. The level of silt load and enrichment of nutrients have assumed serious proportions and in the process heavy infestation of thick macrophytic stands have developed, a typical case of high eutrophication. The ecosystem, in fact, is heading fast towards swampification owing to ever increasing organic deposition at the bottom through decaying vegetation. In order to conserve the rich biodiversity and to achieve the goal of sustainable fish yield from this ecosystem, scientific management is the order of the day.

A modest effort has been made in this document to highlight the present state of ecology and fishery of the ox-bow lakes of North Bihar together with its present of level biodiversity. Efforts have also been made to suggest measures for holistic and sustainable development of their fish and fisheries in harmony with the environmental conservation.

M. Sinha
B. C. Jha

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1. INTRODUCTION

The State of Bihar occupies an important place in the map of Indian union due to its vast resources, both in terms of mineral and agriculture The state is almost horizontally bisected, into the mountainous Southern Plateau with high mineral reserves and the northern fertile plain, by the river Ganges The North Bihar (23^{0} 12' to 27^{0} 22' N latitude and 83^{0} 22' to 88^{0} 20' E longitude) is bestowed with many perennial rivers, originating from the adjacent country, Nepal and among them Gandak, Kosi, Burhi Gandak, Ghagra, Kamala, Mahananda and Bagmati are significant The natural location of north Bihar is such that it passes through all the viscissitude of seasonal changes and experiences the worst of heat and the worst of cold and in the bargain plenty of rain and flood The North Bihar has two distinct river basins (i) the Gandak basin and (ii) the Kosi basin The Gandak basin is bestowed with vast resources of fisheries waters and among them naturally formed meanders, the ox-bow lakes, are highly significant biologicaly These water bodies came into existence due to the changing course of rivers, a characteristic phenomenon in the flood plains In India such lakes are therefore, confined mainly to the states of Bihar, West Bengal, Assam, Manipur and Eastern Uttar Pradesh

The ox-bow lakes are the life line in respective states of their existence and are highly significant from fisheries point of view They have a definite bearing on the socio-economic conditions of the area, being one of the major sources of livelihood for thousands of fishermen living in their vicinity Unfortunately, these resources have suffered utter neglect in the past in spite of their varied usage in general and fish yielding potentialilties in particular Most of such lakes have become shallow and the process is still continued in absence of judicious planning and proper care The situation has further been aggravated as these water bodies have been asaulted brutally, through indiscriminate interferences by man, especially in relation to the dumping of factory and domestic wastes Many of such lakes are gradually changing linto swamps and are in the process of becoming grass lands In this regard mention may be made of Akhara Ghat maun in Muzaffarpur which has been converted in to a swamp due to the pilation and succession of weeds

Similarly Kanti ox-bow lake of Muzafarpur has already lost its original characteristics and is in the process of extinction due to the deposition of thermal ash from Kanti Super Thermal Power Plant Many more such examples can be cited but in general the ox-bow lakes are dying a silent but natural death and thus call for a concerted management approach to revitalise their potentialities or at least to slow down their process of extinction in order to conserve the rich biodiversity thriving therein

The present work is confined mainly to the oxbow lakes located in North Bihar Gandak basin in particular which are distributed in the districts of Muzaffarpur, East Champaran West Champaran and Samastipur and Begusarai A total water spread area of more than 7000 ha are available in this region where fisheries activities are done Out of this an area of 5000 ha can be utilised for fisheries management practices The rest of the area are flood prone due to the raising of embankment as they are completely inundated by the river waters during the monsoon months District-wise break-up of ox-bow lakes has indicated that maximum number fall under East and West Champaran (80%) followed by Muzaffarpur (15%), Samastipur (3%) and Begusarai (2%)

It has been estimated that a total of 150-300 active fishermen are actively engaged in each lake The fisheries is restricted mainly to small and predatory fishes Nets and gears are of very primitive type and grenerally of smaller mesh bars Traps are extensively used Shell fisheries is also very common in shallow lakes The average fish yield ranges between 40 and 200 kg per ha These lakes are also attracting good number of birds, both endemic and migratory Reptiles and crabs are common too

2. ORIGIN OF OX - BOW LAKES

The origin of ox-bow lake is a complex phenomenon and in this process many natural and human forces are involved Each group of lake is formed due to some specific reason and thus has specific characteristics and separate identity These diverse characterstics of lake groups or lake districts had always fascinated the limnologist and the fishery biologists The genesis of the formation of lake basins has been

A typical view of an ox-bow lake in North Bihar
with thick stand of submarged weeds

View of an ox-bow lake with extensive coverage of
water hycinth, *Echhornia crassipes*

A view of srinking water spread area in an ox-bow lake,
a common feature in North Bihar ox-bow lakes

identified as *constructive*, *destructive* or *obstructive* by geomarphologists and they have attributed seven main reasons for their origin, such as, (i) tectonic activities (ii) land slides (iii) glacial activity (iv) drifting activity (v) volcanic activity (vi) solution activity and (vii) fluviatile activity.

The clustur of natural lakes in the Gandak basin of the Ganga River System in North Bihar is an excellent example of fluviatile activity of the rivers. Sinuosity, produced by the accidental variations in the topography, exerts greater pressure on the concave side of the river and thus erosion sets in. The concavity is further been accentuated with the passage of time. The continuous deposition of silt, starts mounting pressure on the slower convex side of the river. A further increase in concavity and soil erosion causes the formation of meanders which ultimately cut-off and become isolated from the original source and as a result loop like impoundments are formed. The phenomenon is more pronounced in easily eroded flood plains as in North Bihar. The abandoned loop like channels, thus formed, are of varied depth, depending upon the depth of the parent river and the amount of silt load at the time of cutting of an impoundment.

The nomenclature of these abandoned impoundments is a moot point of discussion, however, they are generaly known as "ox-bow lakes". This nomenclature for such lakes, has originated from United States and is derived from resemblance in shape to the wooden U-shaped collar placed around the neck of a draft-ox and attached to the yoke (Hutchinson, 1957). The Ox-bow lakes are known by different names in defferent parts of India and abroad. In north Bihar they are known as *Maun*, in West Bengal and Assam *beels*, in Uttar Pradesh as *tal* or *Jheels*; in Australia they are known as *Bellabongs*, in France as *Lones* and in Germany as *Altwasser* (Hutchison, 1957).

3. HISTORY OF OX-BOW LAKES IN GANDAK BASIN

The formation of ox-bow lake is a long drawn process and is affected due to the fluviatile activites of rivers, specially in flood plains. It is obvious, therefore, that flooding of rivers has a definite bearing on the

creation of such lakes and the process is further been accelerated if the incidence and the intensity of flood are recurring and forceful.

The most significant rivers which are associated in the creation of ox-bow lakes in Gandak basin, are Burhi Gandak, Bagmati and their tributaries. Prior to the construction of embankment on either side of the rivers (Burhi Gandak in particular), as flood control measure, they invariably changed their courses and thus *meanders* were formed, which ultimately cut-off from the original rivers, either fully or partially and assumed the status of ox-bow lakes, 'Live' (open) or 'dead' (closed).

The history of certain ox - bow lakes viz. Brahmpura, Manika, Motijheel etc . in this lake district dates back to more than hundred years and it is believed that they have been originated after the great flood of 1867 A.D. in Burhi Gandak, which inundated the entire basin, leaving a few isolated islands. The authenticity of this report holds good according to the records available with the local revenue authorities at Muzaffarpur.

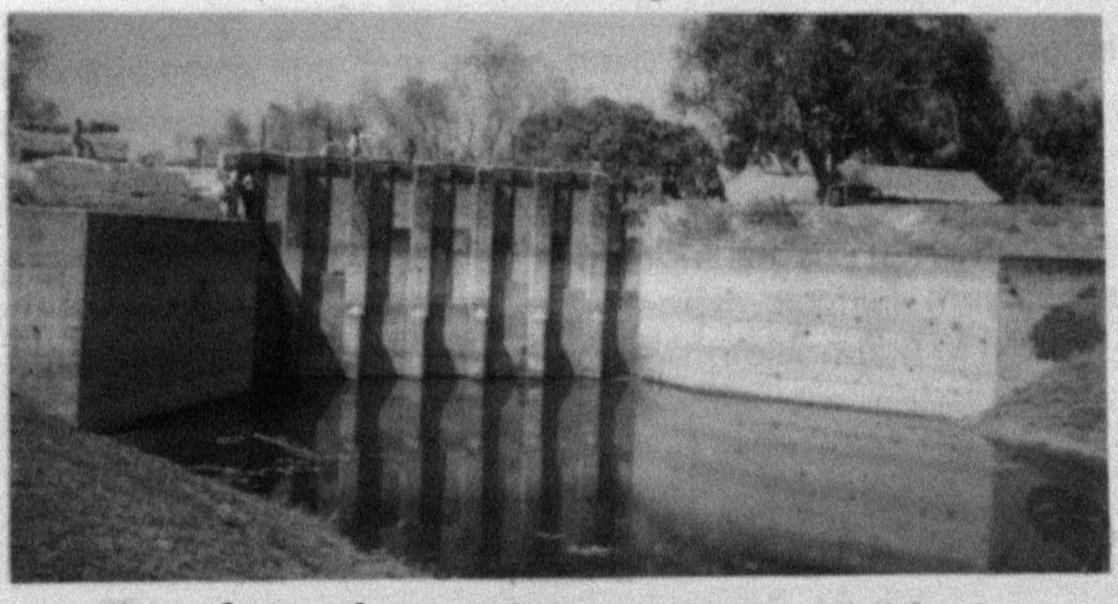
In this context, it is worth mentioning that the year 1987 also, experienced almost same fury of floods, wherein the flood protecting embankments were breached at several places causing the formation of sporadic meanders here and there. It is most likely that some such meanders may develop into ox-bow lakes in due course of time and with further provocation from the nature.

4. RESOURCE AND CLASSIFICTION OF OX- BOW LAKES IN GANDAK BASIN OF NORTH BIHAR

The lake district in Gandak basin comprises a number of 'U' shaped natural impoundments, originated due to the fluviatile activity of Burhi Gandak and its tributaries. A survey of this lake district revealed the existence of 63 well established lakes, besides there are many others which have either become extinct due to certain bio-geological phenomenon or are in the process of extinction. Many more lakes are also there whose process of formation has been halted due to the raising of earthen embankment, a measure of flood control, and as such these

Reclamation of lake areas for aerable land is rampart in North Bihar - a view of Manjhaul lake, Begusarai with *Azolla pinnata* and reclaimed marginal lands

Excessive draining of lake water through man made canals has also been attempted in North Bihar to generate additional land for agriculture



View of a non-functional sluice gates, installed for the regulation of water in an ox-bow lake

lakes remain in half-formed state but still have open connection with the parent river, resulting into complete inundation during the monsoon months. However, they serve as good resource for capture fisheries, being a collection sink of riverine stock during the flood.

The existing ox-bow lakes of the basin are generally 'U'-shaped in extension. Area- wise these lakes are of varied dimension from very small (4 ha) to very large (400 ha). A total water spread area of ox-bow lake of around 7,000 ha is presently available in North Bihar for fisheries activities and have shown immense potentialities to augment fish production in the area provided proper scientific managment norms are applied.

Physically the ox - bow lakes of the basin can be classified as under :

(1) Well established lakes with connecting channels ;
(2) well established lakes without connecting channels ;
(3) well established lakes falling in between the embankment and the river which are flooded during the monsoon and
(4) half-formed lakes between the embankment and the river which are engulfed by the river during monsoon.

An artificial classifiction of these lakes can also be made as:

(1) The 'Live' or 'open' lakes,
(2) the 'dead' or 'closed' lakes, and
(3) the partially fluviatile incomplete lakes.

Characteristically the 'live' lakes have shown greater potentialities for fisheries development due to the following apparent reasons .

(a) The influx of flood water during monsoon helps in uprooting the choked aquatic vegetation to a greater extent which makes the lake water more conducive for the better proliferation of biotic communities.

(b) The influx of allochthonous energy input through the flood water, helps in increasing the energy budget, which in turn provides better opportunities for the growth of primary producers, the basic for aquatic productivity.

(c) The influx of river water helps in natural recruitment of prized fishes, major carp in particular, thereby making the lakes more viable economically.

The 'live' lakes have disadvantages in their own way as they are silted considerably with the influx of silt load along with the flood waters and thereby becoming shallow to shallower every year. The benthic enviroment is worst affected in the process as the niche is drastically altered due to the sudden deposition of silt load. The phenomenon affects the benthic environment in two conspicuous ways as under:

(1) The existing flora and fauna are either killed or displaced from their native habitat.

(2) The "oxidative micro - zones" are covered under the silt, which in turn inhibit the release of nutrients in the media and thus the entire productivity equillibrium is disturbed.

Whatever, the eco-limnological adverse impect may be ,the 'live-lakes' have definite edge over the 'dead-lakes', especially in relation to the following apparent reasons:

(a) The absence of any connecting channel in dead lakes leads to vigrous growth of aquatic-weeds indirectly, as the influx of water is restricted to monsoon rain only, which is unable to exert any kind of pressure to uproot the vegetations.

(b) Greater proliferation of aquatic plants contributes very high semi-decomposed vegetative matter at the bottom and as a result the bulk of the oxygen budget is consumed to oxidize the same at that

strata. In such lakes occassionally the BOD value increases remarkably at the cost of dissolved oxygen. The phenomenon exerts great stress and strain to the biota thriving there in. The foul odour emitted from such lakes is a pointer towards this process.

(c) No natural recruitment of prized fishes takes place in such lakes and thus the water is gradually dominated by species of less economic value and market acceptability.

(d) Luxuriant growth of unwanted weeds makes the fishing activities all the more difficult, resulting in poor yield.

(e) The renewal of allochthonous energy budget is dependent on the monsoon run-off from catchment area only, which is generally, not sufficient to support luxuriant growth of primary producers and as a result the abundance of phytoplankton is invariably poor.

The third category of ox-bow lakes "the partially fluviatile" types are strategically unsuitable for taking up any management approach as they fall in between the artificially raised earthen embankment and the river and thus get lost during the monsoon months, when the river water spreads. Practically, they become a part of the swollen river course, leaving no approach to the lake site. However, they are quite significant from capture fisheries point of view after the river water recedes to its original courses during the post monsoon months. Incidence of natural recruitment is significantly high in these lakes as they act as a collection sink of river stock and are ideally suited for capture fisheries practices atleast for six months. This category of lakes are almost akin biologically to the "live-lakes" to some extent but are getting silted at a faster pace. In the face of such odds, the very existence of such lakes becomes doubtful.

5. DISTRIBUTION

Distribution of ox-bow lakes in different parts of Gandak basin has been presented in Table 1.

Table 1: Distribution and area of existing of ox-bow lakes in Gandak basin

Name of lakes	Area in ha.
MUZAFFARPUR DISTRICT	
Brahampura	45.50
Manika	105.50
Motipur	110.00
Jhapaha	140.00
Kanti	100.00
Murra	15.00
Rahuwa	30.00
Bhoosra	45.00
Bachaha	30.00
Semera	16.00
Matiha	20.00
Rajwara	12.00
Morsandi	60.00
Ghosod	50.00
EAST CHAMPARAN & WEST CHAMPARAN	
Motijheel	100.00
Kararia	120.00
Basmanpur	50.00
Sirsa	80.00
Sajhi	40.00
Rulhi	80.00
Majharia	60.00
Chilraon	80.00
Turkaulia	100.00

Contd.....

Name of lakes	Area in ha.
Sonbarsa	40.00
Phulwari	80.00
Sugaon	80.00
Paswaw	20.00
Chakin	20.00
Pipra	70.00
Matwalia	90.00
Barwalia Izamali	08.00
Narmaida	20.00
Sonwalia	40.00
Karekatti	40.00
Sirha Chorwa	70.00
Chaknaha	400.00
Rajpur	80.00
Bakya	160.00
Piprao	164.00
Rohna	20.00
Samanjia	40.00
Mati	40.00
Pipra pakri	400.00
Gobni	40.00
Lal Sariya	230.00
Jaganathpur	40.00
Amwa	60.00
Bhawanipur	20.00
Saraya	400.00
Gahri	70.00
Hardia	48.00
Bhakubar	04.00
Vaishali	40.00
Piprasi	08.00
Bishambharpur	45.00
Tateria	130.00

Muktapur	60 00
Dholi	08 00
Bamanpura	15 00
Poaram	30 00
Ilmasnagar	27 00
Manjhol	11 00

6. A BRIEF ACCOUNT OF SELECTED OX- BOW LAKES

1 Brahmpura

Brahampura maun (ox-bow lake) is located in the city of Muzaffarpur. It is almost, a L-shaped lake with an area of about 76 ha. The depth ranges between 2 to 4m. Characteristically it is a 'Live lake' as connected with river Burhi Gandak through a channel. The lake is highly infested with aquatic weeds and among them *Eichhornia crassipes* (floating) and *Hydrilla verticillata* (submerged) are predominant. The surface area of the lake is covered by *E. crassipes* to the tune of almost 100%.

It receives bulk of the city sewage, besides being subjected to other human interferences like washing of clothes, animals etc. It is, also used for the recreational purposes such as plying of boats etc.

2 Manika

Manika lake is located 13 km east of Muzaffarpur town. It is relatively larger and "closed" impoundment, having an area of 105 ha and is 'L' shaped in extension. It is a meander of Burhi Gandak but with the lapse of time and due to the raising of an earthen embankment the connecting channel has become defunct.It is fed by the monsoon run - off from a small catchment area. The depth profile indicates very little fluctuation in its level, ranging between 1 and 1.5 m only. The entire lake

is highly infested with aquatic weed to the tune of almost 100% of the surface area. The submerged weed like *Hydrilla verticillata* and *Najas minor* are predominant. A portion of the lake is used for 'Makhana' farming also. The fisheries is largely dominated by small forage and cat fishes. The share of major carp is meagre, 5-10% only.

3. Kanti

Kanti ox-bow lake is a typical 'U' shaped in expansion and is located about 16 km west of Muzaffarpur town on the Muzaffarpur-Raxaul highway. It is a live lake but in recent years has been converted in to a receiving pot of thermal ash from kanti power plant and for this purpose the lake has been segmented into three parts by raising earthen 'bunds'. It is a shallow water body with depth ranging between 1.5 and 3m. However, a maximum depth of 8m during the monsoon months has also been recorded in certain pockets after the ingress of flood water from Burhi Gandak.

Man induced alteration of natural impoundments is very common in recent years and the Kanti ox-bow lake is an glaring example of this. Almost 60% the lake has already been filled with ash. The man made interference in this lake has not only caused colossal loss of aquatic resource but of valuable biodiversity also.

The area of the lake is about 60 ha and is highly infested with submerged vegetation, besides the colonisation of marginal 'reeds'. Occurrence of fish mortality is a regular phenomenon in this lake during the last few years, specially during the summer months .

4. Motipur maun

Motipur ox-bow lake is the biggest lake in Muzaffarpur district and has a water spread area of about 110 ha. It is a closed lake with no connecting channel. The water depth ranges between 2.3-5 m. It is located in the west of Muzaffarpur town at a distance of 36 km on the Muzaffarpur-Raxaul highway.

The lake receives sugar factory wastes causing considerable damage to the biotic communities as roughly 10 ha. water area has almost become a biological desert. The lake is highly infested with aquatic weeds of varied kinds *viz.* submerged, emergent and floating and the coverage ranges between 50 and 80%.

Channa spp, *Nandus nandus* , *Notopterus chitala* etc. form the major fishery of the lake . The contribution of major carp in the total catch is a meagre 5% only.

5. Motijheel maun

This ox-bow lake is located in the middle of the Motihari town (East Champaran) and is almost 'U' shaped in extension. The area of the lake is about 100 ha with a depth ranging between1.0 and 2.5 m. It is a 'live lake' and connected with two tributries of Burhi Gandak , the Sikrahna and the Dhanauti. The bulk of sewage of the Motihari township is being discharged in this lake. In addition to this many other human activites like bathing , washing etc. are common in this lake. However, the disposal of sugar factory wastes is of serious nature, causing extensive damage to the biotic communities including fish.The entire water spread area of the lake is choked with different kind of weeds and among them the floating weed, *Eichhornia crassipes*, is highly conspicuous. The fishery of the lake is dominated by forage and cat fishes.

6. Kararia maun

Kararia lake is located about 2 Km west of Motihari town and having a water spread area of around 100 ha. The depth ranges between 2.5 and 5.0m. It is connected with Dhanauti river on one end and with the Motijheel on the other. The lake is almost 'U' shaped in extension. It receives sugar factory effluents.

The lake is heavily infested with aquatic weeds with an estimated surface coverage of about 75%. Submerged weed like *Hydrilla verticillata*, *Najas minor*, *Potomageton pectinalis* are predominant . Cat-fish and forage fishes form the dominant fishery of the lake.

7. Sirsa

Sirsa lake is located about 10 km East of Motihari town and having a water spread area of 88 ha. Physical extension of the lake is U-shaped and the water depth ranges between 3.2 and 8.5 m. It is a "live lake" as connected with Sikrahna river, a tributary of Burhi Gandak.

The lake is heavily choked with aquatic weeds of different types but the submerged weeds are predominant. The fishery is restricted to cat-fish and forage fishes.

8. Turkaulia

The lake is located at a distance of 6 km. West of Motihari town. The water spread area is about 80 ha. with U-shaped extension. The water depth ranges between 2-3 m only. It is a closed lake as having no connection with any river.

Almost 80% of the surface water area is infested with aquatic vegetation and among them submerged weeds are dominant. The cat fish and the forage fishes constitute the major fishery of the lake.

9. Matwali

This lake is located about 7 km East of Motihari town. The area of the lake is about 105 ha with a depth range of 2.5-6.5 m. It is a 'live lake' as having connection with Dhanauti river, a tributary of Burhi Gandak.

The lake is no doubt infested with aquatic vegetation but the coverage of hydrophytes is about 50% or even less. The fishery of the lake though dominated by cat fish and smaller fishes but there is sizeable abundance of major carp also.

10. Chilraon

This lake is located in the South-West of Motihari town, at a distance of around 10 km. It is a 'U' shaped lake with one arm wider than the other. It is relatively smaller lake of 40 ha only. The water depth ranges between 2.2-6.5 m. The lake is connected with Dhanauti river and thus a 'live-lake'.

Infestation of aquatic vegetation is estimated to be about 75% with the submerged weed being the dominant.

11. Majharia

This lake is located 6 km South of Motihari town and is typically 'U'-shaped in appearance. It has a area of 65 ha and the depth ranges between 2.2-4.1 m. The lake is 'live' in nature having connection with two rivers 'Dhanauti' and 'Sikarahna'. Infestation of weed is comparatively low, around 40%. Submerged weeds like *Najas minor* and *ceratophyllum demursum* are predominant. Cat fish and forage fish form the dominant fishery of the lake. Gastropods are the most dominant benthic fauna.

12. Basmanpur

Basmanpur ox-bow lake is located 12 km East of Motihari town. This is a relatively smaller lake with 40 ha water spread area.The depth ranges between 1.0-1.8 m only. It is connected with the river Sikarahna and thus 'live' in nature.

Aquatic hydrophytes are the most dominant flora and the extent of infestation is estimated to be about 50%. As usual the submerged weeds, *Hydrilla verticillata* in particular, is very dominant. The fishery of the lake is dominated by forage fishes followed by cat-fish and carps. Gastropods are available in plenty, thriving on the marginal areas of the lake.

13. Lal Saraiya

It is located 20 km. East of Bettiah town (West Champaran) and having a water spread area of 230 ha. Broadly, it is U-shaped in extension but somewhat peculiar in shape due to the presence of two prominant arms. It appears that these arms might have been small 'nallahas' earlier but later became the part of the system. The lake is 'live' in nature as having connection with Dhanauti river, a tributory of river Burhi Gandak.

The lake is almost choked with aquatic weeds, covering almost 70%of the surface area. Qualitatively submerged weeds remain the dominant hydrophytes. However, floating weeds like *Wolffia sp.* and emergent weeds like *Nelumbo nucifera* and *Euryle ferox* are also present.

The fishery of the lake is though dominated by cat-fish and forage fishes, the major carps are also sizeable in abundance. Gastropods are the dominant benthic fauna of the lake which at times contribute to shell fishery also.

14. Gahri

Gahri lake is located at a distance of 16 km South of Bettiah town (West Champaran) and having a total water spread area of about 70 ha. It is comparatively deeper as compared to other lakes of the area having a depth range of 5-8.2 m. The physical appearance of the lake was originally 'U'- shaped but with the gradual deposition of silt load one of its arms has been separated and as a result it has been converted into two distinct lakes and now they appear like fingers. The lakes have lost their connecting channels and thus transformed in to ' dead lakes'.

The extent of weed infestation has been estimated to be arround 75%. The lakes are though dominated by submerged weeds, though emergent weeds are also prominent during autumn and early winters. The fishery of the lake is mostly of uneconomical fishes.

15. Hardia

This is located 15 km South of Bettiah town and is 48 ha in extention . Water depth ranges to 4-6 m. Physically the lake is finger-shaped in appearance and is closed in nature as having no connection with any river.

Infestation of weed is around 75% over the surface area, with the dominance of submerged hydrophytes. The lake serves as a potential sanctuary for resident and migratory birds.

Fishery of the lake is as usual dependent on the abundance of forage and cat-fishes.

16. Dholi

It is located 26 km West of Samastipur town. This lake is a small one having a water spread area of 8 ha only. The water depth ranges between 1.5 and 3.0 m. The physical appearance of the lake is almost 'U' shaped and is of closed type. The lake is heavily choked with aquatic vegetation like *Hydrilla*, *Potomageton* etc. The fishery is almost negligible and is dominated by trash and forage fishes. The lake is under the control of Rajendra Agriculture University and is generally used for lift-irrigation purpose to irrigate their experimental farms.

17. Muktapur

It is located 6 km North of Samastipur town and is one of the largest ox-bow lakes of the district with a water spread area of 60 ha. It is a 'U' shaped impoundment and is heavily choked with macrophytes. The depth of the lake varies between 3 and 6 m. One of arms of the lake receives jute mill wastes occassionally. The fishery of the lake is largely dominated by murrels and and cat-fishes. The cotribution of major carp is poor in the range of 3.4 to 12.2%.

7. PHYSICO-CHEMICAL STATUS OF SOME SELECTED LAKES

7.1 Water

Physico-chemical properties of water are the most important factors responsible in shaping the biotic communities. A shift in the desired level of physico -chemical properties affects the productivity chain adversely and as a result the entire aquatic productivity equillibrium is disturbed. As mentioned in earlier chapters the Ox-bow lakes are very complex biotope due to so many geo-morphological factors. All the lakes in Gandak basin are highly infested with aquatic weeds and are subjected to many indiscriminate interferences of human being, resulting in substantial variations in their physico - chemical propeties.

Perusal of data collected from certain representative lakes showed close proximity in relation to their trend and fluctuations. The data discused here are based on Anon (1980, 81, 84, 86-87). However, the work of Srivastava (1984) has also been considered at times. Table -2 gives the physico-chemical status of water of four important lakes of the state.

Table - 2 : Physico-chemical status of certain ox - bow lakes of North Bihar

Factory	Brahampura	Manika	Kanti	Motijheel
W. temp ^{0}c	16.5 - 31	15.0 -33.0	17 -30	17.00 - 31
Turbidity (cm)	45 -160	-	-	60.00 - 153
pH	6.5 -8.2	7.3 -9.4	6.8 -9.0	7.00 - 8.4
Dissolved Oxygen (ppm)	1.6 -14.0	0 -12.0	0.05 -10.0	3.50 - 13.0
CO_2 (ppm)	nil -20	2.6 -8.2	0.0 -30.0	7.60 - 19.0
Alkalinity (ppm)	155-610	80 -130	110 -250	220.00- 510
Phosphate (ppm)	Tr.-0.008	-	-	0.02 - 0.5
Nitrate (ppm)	0.1-0.5	-	-	0.18 - 0.89
Siticate (ppm)	11-19	-	-	10.00 - 20
Pr.Productivity (mg c/m^3 / hv)	31.2 -125.0	16-125	Nil -35	40.3-131.0
Sp. conductivity (µmhos)	-	370 -584	250 -950	560-1136
Redox potential (mv)	+109	+ 72	+35 228	-

7.2 Soil

The benthic niche of ox-bow lakes signifies somewhat unique characteristics. It comprises both 'dynamic' and 'static' states of nutrient budgets. Replenishment of nutrients takes place in 'open type' lakes during the influx of monsoon flood, and thus the niche exhibits dynamic state whereas in case of 'closed type' the monsoon run-off is negligible and thus such niche is largely in static state. Recycling within the system is the only source of nutrienls available in closed type of lakes. Table - 3 shows the soil characteristics of few lakes of North Bihar.

Table - 3 : Soil characteristics of certain lakes of North Bihar

Factors	Manika	Brahampura	Kanti	Motijheel
pH	7.9-8.2	7.7-8.0	7.9-8.1	7.8-8.2
Total Nitrogen %	0.07-0.13	0.08-0.14	0.08-0.12	0.0-0.2
Total Phosphate %	0.5-1.0	0.4-0.7	1.1-1.2	0.5-0.9
Organic carbon %	0.32-2.2	0.4-2.6	2.5-2.8	0.5-2.8
Redox potential (mv)	-145	-306	- 322.5	-

8. BIOLOGICAL PROPERTIES OF OX-BOW LAKES

8.1. Plankton

The role of plankton in the trophic cycle is well recognised (Hutchinson, 1967; Bennentt,1971). The quantum and texture of plankton and their respective importance have widely been recognised throughout the globe and remained a matter of attraction for limnologists and fishery

biologists. The investigation pertaining to the diversity and dynamics of plankton in ox-bow lakes of Gandak basin remain neglected till date as very little has been done to unravel their characteristics .

It is an accepted fact that plankters are ubiquitous in distribution and are the most desirable organisms in the grazing chain in an aquatic ecosystem. The community structure and quantum of planktonoic biomass are largely governed by the prevailing environmental conditions. This singular characteristic of the group has contributed to a number of good biological indicators of water quality.

The ox-bow lakes in this basin have been subjected to utter negelect in the past and in absence of proper care the process of ecological succession is rapid and as such they are in the advance stage of eutrophication. Presently the biotic communities, including plankton, indicate a negative trend of productivity. The plankton population of the lakes, both in terms of abundance and texture, have been adversely affected with the greater infestation of macrophytes.

An attempt has been made here to throw some light on the pattern of plankton abundance, based on the data collected from some selected lakes. Quanitative abundance of plankton in three lakes of the state is depicted in table 4.

Table - 4 : Abundance of plankton in lakes of North Bihar

Lakes	Range of net plankton U/1	Range of nanno plankton U/1
Brahmapura	1000 - 3000	-
Manika	450 - 950	-
Kanti	230 - 1500	1800 - 35000

8.1.1 Net Plankton

i) Brahampura lake

The plankton population of this lake was found to range between 100-3000 u/1, with greater abundance in spring and the lowest in July. The lake has the tendency to produce sproradic blooms of *Ceratium*, and *Hirundinella* (178,000 u/1). Diatoms and Dionophyceae have been found to be the dominant plankters throughout the year. However, an upsurge of bluegreens in post-monsoon months has also been observed. The rotifers and the cyclops were the main zooplankters.

ii) Manika lake

The plankton population of this lake was found to range between 450 and 940 u/1. Members of Bacillariophyceae appeared regulating the communuty structure. Strickingly, the zooplankton was found to dominate over phytoplankton, at times.

iii) Kanti lake

The plankton of this lake was found to range between 230 and 1500 u/1 with a biomodal pattern of annual fluctuation. The primary pulse generally associated with spring while the secondary to post -monsoon. Bacillariophyceae was the most dominant group .

8.1.2. Nannoplankton

Very little work has been done on nannoplankton in India and only recently it has received some attention. It has been estimated that more than 70% of the primary productivity is being contributed by this group alone (Pathak and Natarajan,1983). It is obvious, therefore, that indepth studies are required for better understanding of the ecosystems. The study of nannoplankton assumes added significance in these lakes having high incidence of macrophytes and poor abundance of net plankton.

Only one lake has been studied in relation to nannoplankton in the entire state. The Kanti lake revealed very high incidence of nannoplankton population,18000-35000 u/1, as compared to the net plankton which fluctuated in hundreds only. The primary productivity of the lake (studied with C^{14} radio-isotopes) revealed that 71% of the organic matter was synthesised through the nannoplankton alone. It was indicative therefore, that studies on nannoplankton in ox-bow lakes require more attention, since they also, significantly, contribute in the grazing chain of the trophic cycle.

The qualitative texture of nannoplankton in Kanti lake showed the dominance of filamentous bacteria like *Leptothrix*, *Rhabdachromatin*, *Thiopedia*, *Chlorobium* etc. and the group was found contributing more than 90% in the total abundance. The community structure of nannoplankton in the lake and the magnitude of primary production by the group creating a state of confusion that either certain such bacteria are capable of synthesise carbon without the presence of chlorophyll or the chlorophyll bearing nannoplankters are activised with the association of certain bacteria. The matter needs immediate attention and probe to unfold the dynamics of productivity in ox-bow lakes.

In this context it is worth to mention here that in many aquatic environment a deviation in the normal "calvin photosynthetic-cycle" may take place (Venkataraman et al 1974). Fogg (1968) has established that many bacteria, *Chlorobium thiousulphaticum* in particular, can synthesise carbon by a reversal of Kreb Tca Cycle (Fig.19) in stressed environment. In the photosynthetic bacterium, *Chlorobium thiosulphaticum*, ferredoxin is directly used in the carboxylation without the involovment of $NADPH_2$ as a hydrogen donor . The ferredoxin is generated photosynthetically and this type of carbon fixation is known only in anaerobic bacteria.

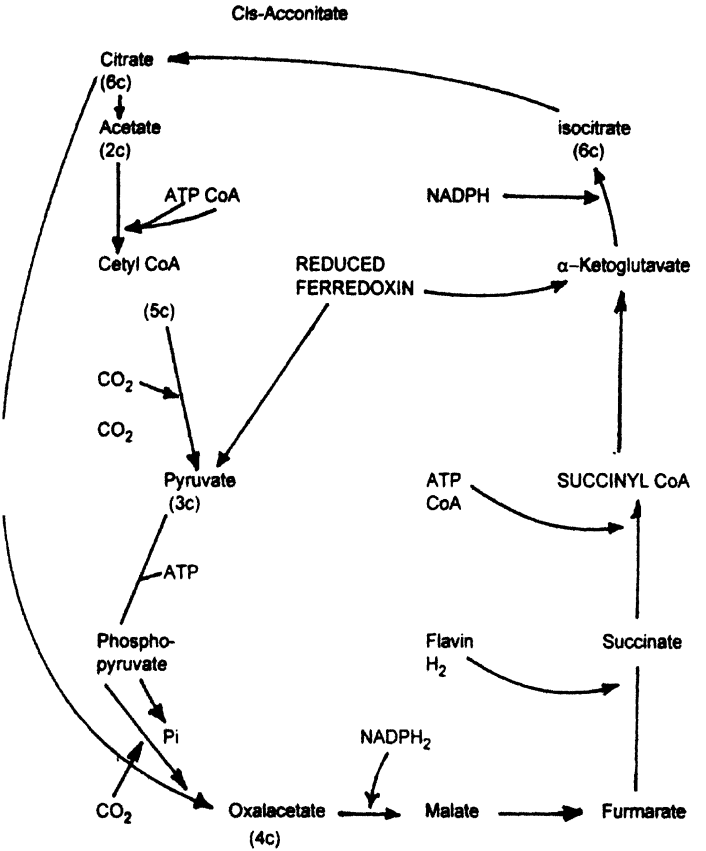


Fig - 1: The reductive carboxylic acid cycle of *Chlorobium thiosulphaticum* (after Fogg)

It may be that the higher photosynthesis through the nannoplankton in ox-bow lakes, where the filamentons bacteria including *Clorobium* are in dominance might be following the above pathways. however, the role of other filamentous bacteria like *Thiothrix*, *Thiopedia*, *Sarcina* etc. needs careful investigation by doing laboratory culture and exposing them to C^{14} isotope to establish their photosynthetic behaviour.

8. 2. Periphyton

Biota prevalent at the solid-liquid interface, constitute one of the vital ingredients in the community structure of lakes and stream ecosystems. Such organisms, are refered to as *the periphyton*, having the characteristics to withhold themselves over submerged or floating substratums with the help of an adherent secreted by them. The study of periphyton assumes greater significance in weed choked impoundments as they tend to grow there luxuriantly, contrary to phytoplankton which is generally poor. Ox-bow lakes are shollow impoundments with massive infestation of hydrophytes and these water plants act as sheet anchor for periphytic proliferation, either in terms of substrata or in terms of nutrient supplier, to support the auxenic behaviour of the periphytons. It has been observed earlier that many hydrophytic plants provide nutrients to periphytons in general and diatoms in particullar specially in adverse situation (Jha,1986, 1987). It is strange that while investigating such lakes plankton studies have been given more thrust as compared to periphyton in spite of the fact that the later is more significant. It is obvious, therefore, that periphytic studies should receive a better deal to unfold the niche in relation to productivity of these weed infested impoundments.

Practically, very little is known about the periphyton from ox-bow lakes. However, an attempt has been made here to throw some light on this aspect of one of the ox-bow lakes.

8.2.1 Kanti ox - bow Lake (a case study)

Assemblage of community structure, over the suspended microscopic slides at different depths, exhibited a bimodal pattern of annual fluctuation, with the primary maxima, generally, associated with the lower temperature of the winter while the secondary to higher temperature of summer. The monsoon months showed relatively poor abundance of periphyton, which may be attributed to the influx of flood water and highly turbid conditions. Quantitatively the population fluctuated between 972 u/cm^2 and 4897 u/cm^2 (Table - 5).

Vertical stratification of periphytic population was found to be always highest at 1 m depth, followed by the surface and lowest at the bottom slides. Qualitative texture of the stratified materials over the suspended slides revealed significant diversity in relation to the number of taxons. There was a gradual fall in taxon from surface to bottom. It appeared that periphytic organisms have specific preference of depth for their colonization. Periphytic organisms, belonging to Myxophyceae and Chlorophyceae, generally, preferred upper strata of the water for better stratification, may be that they are more phototrophic in nature and thus require more amount of light. Members of Bacillariophyceae though showed a preference for 1m depth for better proliferation quantitatively, but they remained ubiquitous in distribution and as such found to be the most dominant group throughout the column of the water. A perusal of data from the lake revealed that Bacillariophyceae contributed the maximum (72.83-87.56%) in the composition of the community structure followed by Chlorophyceae (11.56-20.13%), Myxophyceae (8.67-16.53%) and animalcules (3.29-5.67%). Amimalcules were represented mainly by protozoans followed by rotifers and they exhibited a tendency to stratify more towards the deeper column of the water.

Months	Total Periphyton U/cm^2	% of different groups				
		Baci.	Chlo.	Myxo.	Protozoans	Misce.
April	2305	83.53	4.18	4.12	0.50	7.67
May	2164	80.08	5.00	4.08	0.83	10.01
June	972	82.14	5.16	4.00	1.27	7.43
July	980	85.39	2.37	3.13	0.76	8.35
August	2450	87.56	2.85	4.87	1.21	3.51
September	3508	80.08	3.64	4.34	1.00	10.97
October	3883	75.68	4.95	3.95	0.95	14.57
November	4269	74.81	5.08	2.57	0.81	16.73
December	4897	78.34	5.12	3.07	1.00	13.47

8.3 Fungi

Fungi are limnologically very important group of organisms in an ecosystem because they play significant role as decomposers. Many aquatic fungi are known as the best decomposers of cellulosic materials and due to this ability they assume an important place in the limnological studies of ox-bow lakes, which are largely infested with aquatic weeds, resulting into huge pilation of cellulosic material at the bottom constantly.

Keeping this in view an attempt has been made here to unearth the types of aquatic fungi prevalent in the ox-bow lake ecosystem. Regular and extensive collection of floating or submerged semi-decomposed hydrophytes were made from different ox-bow lakes and the fungi growing over them were isolated through laboratory culture and identified. The fungal taxon thus isolated revealed that bulk of them were saprophytic in nature capable to grow over dead plant or animal remnants. Fungal taxon as parastic on fish ,their eggs and other animals were recodred too, but the incidence of occurrence was rare and low.

A total number of 18 taxan belonging to 6 orders could be isolated and identified and have been listed here under the heading "Biodiversity" (10.2)

8.4 Aquatic weeds

The ox-bow lakes in the Gandak basin are highly infested with aquatic weeds. Apparently all the three types of vegetation viz. 'submerged', 'floating and 'emergent' were conspicuous but the extent of proliferation was quite high in case of the former. Incidence of algal weed, the charophytes in particular, and the marginal weeds were also, common. The extent of surface coverage in different lakes was found varying between 50% and 100%, depending upon the physical structure and types of effluents it receives. The 'live' or the 'open' lakes are comparatively less infested in general than those lakes which have no connecting channels with any river. Seasonal nallahas were found contribiting towards the introduction of many weeds specially floating in nature, like *Eichhornia crassipes* .

Density of aquatic weeds was found ranging between 4.0-25.0 g/m^2 (Table-6) with corresponding dry weight in the range of 0.3 to3.80kg/m^2. Perusal of data revealed that in 'closed lakes' the growth of hydrophytes was more luxuriant as compared to 'open lakes'. Brahampura, Kanti, Motijheel and Muktapur were the lakes having connecting channels with rivers, whereas Manika is completely closed type. In the later case the density of hydrophytes was almost double than the other lakes. However, Brahampura is an exception in this regard may be due to the greater abundance of *Eichhornia crassipes* .

Qualitative texture of macrophytes in these lakes have been presented under biological spectrum column (10.2).

8.4.1 Role of Aquatic Weeds in ox-bow lakes

The role of weeds in fishery water is both direct and indirect (Jhingran,1975; Jhingran,1986; Jha,1987). The ox-bow lakes in Gandak basin are highly choked with weeds and the following apparent characters were conspicuous.

- The lakes were over populated with predatory and forage fishes .

- The prized fishes were low in abundance and their population appeared going down every year.

- The euplanktonic population was much lower than the desired level .

- A strong sucession of weeds was evident affecting the ecosystem adversely, such as:

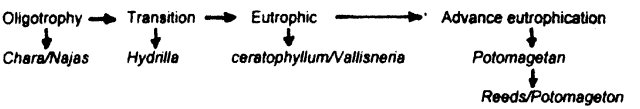
  Submerged→Emergent →Reeds→Reedy swamps→Floating island→Grass land.

- The excessive growth of weeds has reduced the nutrients, phosphate in particular, as most of the lakes were found having this nutrient in traces.

- The transperency of the lakes was generally high may be due to the poor abundance of plankton. This was becuse of the locking of nutrients in the hydrophytic chain and very little was available for the proliferation of primary producers, the phytoplankton.

- The alkalinity was on the increase in most of the lakes, leading to a stage of ultra oligotrophy with the lapse of time. A close look of the hydrophytic spectrum revealed the dominance of *Chara spp.*, *Vallisneria spiralis*, *Potamogeton pectinatus*, *Hydrilla verticillata*, *Najas minor* and *Ceratophyllum demersum*. It is known that *Chara* and *Najas* generally grow in calcium rich soil, *Vallisneria* in iron rich

soil, *Potomageton* in sterile soil. *Hydrilla* and *Cartophyllum* prefer to grow in nutrient deficients or transitory water. Based, on these facts the possible ecological succession of weeds can be drawn as under :



- That the mountain of algal weeds contributed mainly by *Spirogyra*, *Rhizochlonium* etc; created almost an under water desert by preventing the sun light to penetrate. They also cause disturbance in fishing and other activities.

The development of macrophytes imparts certain characteristics to a water body. They limit the growth of planktonic algae either by shading or by competing for nutrients. Macrophyte grazers are less efficient than algal grazers and as such they cannot control the higher plants leading to constant accumulation of detritus at the bottom. The ultimate impact of this phenomenon is reflected in lower efficiency of zooplankton production leading to low fish yield. In ox-bow lakes the detritus food chain appears to be more prominant, due to the massive growth and subsequent decay of macrophytes, than the pelagic planktonic food chain. The shallow depth and low turbidity allow the light to have access up to the bottom which promotes macrophytic growth further and thus enrich the detritus pool continuously.

The succession of weeds is an indicator of extreme eutrophication and a factor pointing towards unconducive ecological regime for fisheries development . The fisheries development in these lake has to be centred around the utilization or control of macrophytes to achieve the goal of sustainability .

Table - 6 : Abundance of weeds in ox-bow lakes

LAKES	BIOMASS	
	Wet weight (Average) Kg / m^2	Dry weight (Avarage) Kg/m^2
1. Brahmpura Maun Muzaffarpur	4.0 -22.00	0.50 -3.10
2. Manika Maun Muzaffarpur	8.0 -25.00	0.84 -3.80
3. Kanti Maun Muzaffarpur	4.0 -12.00	0.30 -1.58
4. Motijheel Maun Motihari	6.0 -11.50	0.58 -1.75
5. Muktapur Maun Samastipur	7.0 -13.80	0.80 -1.59

8.4.2 Index of similarity in the Aquatic weed in ox- bow lakes

The macrophytes dominate the biotic spectrum of the ox-bow lakes in terms of primary productivity and as a result this factor must be given utmost consideration before taking up any management approach. It is essential, therefore, to test the level of 'similarity' and 'dissimilarity' which exists among these lakes so that a workable management policy, common or uncommon, can be formulated.

Sorensen (1948) has given a simple formula to estiblish the index of similarity between two stands of vegetation :

$$S = \frac{2C}{A + B}$$

Where, 'S' is the similarity index. A and B are number of species not common to both the stands where as C is the number of common specise.

Index of dissimilarity can be calculated as:

$$D = 1 - S .$$

Applying these formula in certain ox-bow lakes, randomly selected from different location from each district, revealed as under:

The similarity index (SI) = 0.74 and the dissimilarity index (DI) = 0.26 (Table- 7).

It is evident that most of the lakes in this river basin are near similar to each other, as the SI is more than 0.5 and DI is less than 0.5, in terms of mcrophytic abundance and therefore, a common methodology, to tackle this menacing problem, in relation to fisheries management may prove effective.

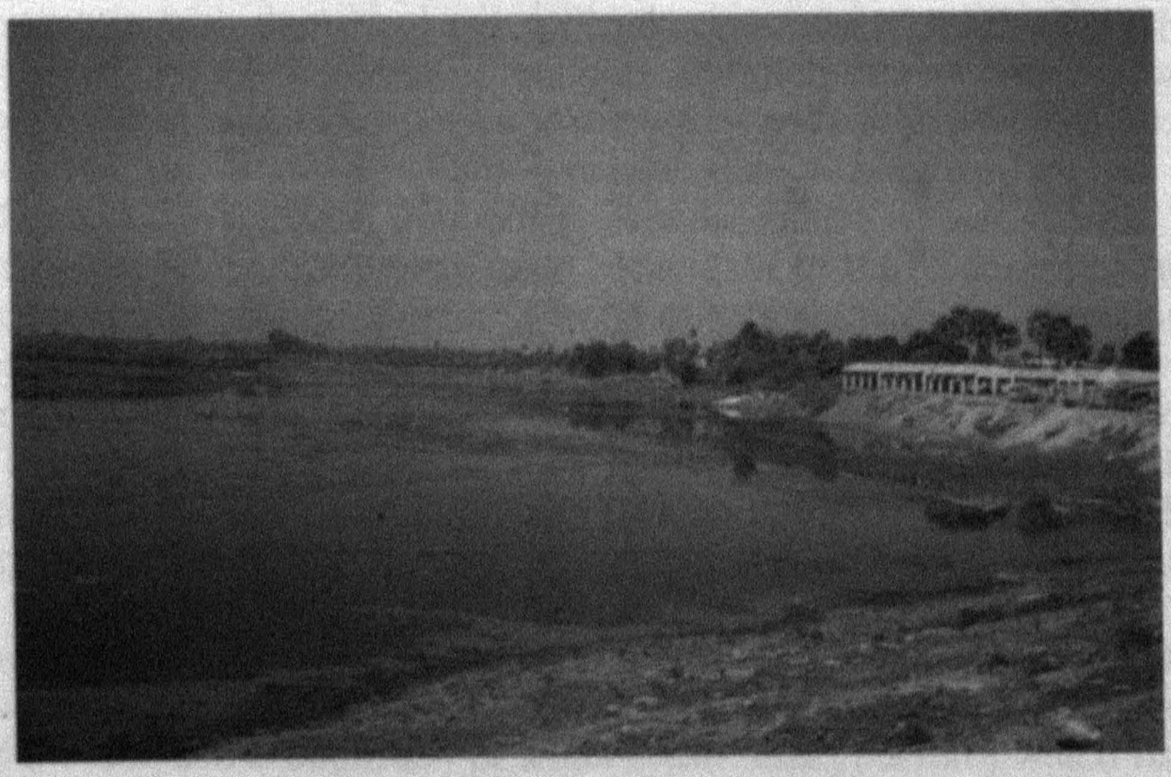
Table - 7 : Similarity and dissimilarity index in some lakes

Districts	No. of species	No. of common species	SI	DI
Muzaffarpur	41			
East Champaran	37	28	0.74	0.26
Samastipur	38			
West Champaran	35			

8.5 Bottom Biota

The incidence of benthic population, observed in different ox-bow lakes, revealed a population range of 220-5414 nos./m^2. The qualitative texture of the benthos was, in general, highly dominated by molluscans

Operation of *"Chatti jal"* (Mosquito net clothing) is rampant in North-Bihar lakes



Reclamation of ox-bow lakes for urban development is a common site in North Bihar - a view of Manjhaul lake, Begusarai

(94-96%). The greater dominance of molluscans was indicative of unproductive character of the ecosystem. It also suggests the possibility of the waters moving towards high alkalinity. For a good crop of mollusc the calcium content of the niche must be considerably high and when the preciptation of calcium is on the increase the alkalinity goes high leading to a state undesirable for a number of phytoplankton because the phenomenon of *Calcifobes* starts operating.

The community structure of macro-benthos comprised of organisms belonging to Trichoptera, Diptera, Hemiptera and Mollusca. The diversity of organisms has been presented under biological spectrum column.

9. FISH AND FISHERIES

Ox-bow lakes are one of the prime resources of fish protein in North Bihar. It is a paradox, however, that inspite of this fact the lakes have been neglected for such a considerable period. Parctically no work, worth the name, has been done to ascertain their biological behaviour and production proccesses.

The present investigation indicated that the lakes are in very poor health owing to high degree of eutrophication as reflectd by the massive infestation of aquatic weeds, besides other indiscriminate human interference. Most of the lakes are choked with weeds to the tune of 50 to 100 % and as a result they are in the advance stage of swampification.The prized economic fishes, Indian major carps in particular, have either completely been eliminated or their population has dwindled to an alarming proportion. Fishes of less economing value have occupied the niche on a larger scale along with the dominance of predators. The fishermen interviewed during the course of this study have opined that the catch of prized fishes is going down every year. The changed physical state of these lakes provide the least opportunity for breeding of carps and thus the natural recruitment which was taking place mainly through the connecting channel with Burhi Gandak or its tributaries, in case of open lakes, has lost the originality. Morever, the natural recruitment as such is not allowed to build the desired population due to the mass scale operation of small mesh nets (1-2 mm) which haul

them up at fingerling or juvenile stages. The fishermen are forced to operate such small bar nets owing to very poor availability of bigger fish. In the process of going for minor carps and smaller fishes the newly recruited major carps, specially during monsoon, are also fished out.

The fish fauna recorded from these lakes have been presented under the head Biodiversity (10). Altogether 71 species have been collected and documented here. The local names of each fish has also been given as far as possible.

Inspite of the fact that the ox-bow lakes of Gandak basin exhibited relatively high diversity of fish fauna, the medium sized fishes like *Notopterus notopterus*, *Mystus cavasius*, *Clarias batrachus*, *Chana gachua*, *Mastacembelus armatus*, *Mastacemblus pancalus* and big fishes like *Wallago attu*, *Channa marulius* and *Channa striatus* dominate the fishery to the tune of 35%. Fishermen community of the area have to depend on these less economic varieties for marketing. The prized carps like *Catla catla*, *Labeo rohita*. *Cirrihinus mrigala* and *Labeo calbasu*, though contribute to the fishery of these lakes but their availability is much low 3-22% only, The miscellaneous fishes are found to be the main stay for marketing and among them *Nandus nandus*, *Oxygester spp*, *Puntis spp*, *Mystus vittatus* are important. In fact these small fishes account for 50% or more of the daily catch, provide the basis for survival to the fisherman community.

Shrimp fishery has been found to be very common in these lakes as indicated by the extensive use of a large number of traps specially during the summer months. The period between March to June was found to be the best for shrimp fishery, which at times contribute up to 30% of the total catch.

To understand the mode and pattern of fishery in ox-bow lakes case studies made in certain lakes have been presented in Table 8.

View of fish harvest from an ox-bow lake with high dominance of forage and cat fishes

View of unorganised marketting of fish harvest from ox-bow lakes

View of fish harvest from an ox-bow lake with high dominance of forage and cat fishes

View of unorganised marketting of fish harvest from ox-bow lakes

Table - 8 : Fishery of certain ox-bow lakes (1980-1987)

Lakes	*% abundance of different group*			
	Major carp	Cat fishes	Miscellaneous	Shrimp
MANIKA				
1980	08.30	43.50	45.20	03.00
1981	03.09	41.30	50.00	05.88
1982	05.32	36.20	39.08	19.40
1984	14.67	23.24	45.68	16.41
BRAHMPURA				
1980	22.00	18.90	53.71	05.39
1981	03.38	29.60	58.45	08.57
1982	12.00	24.00	58.75	30.25
1984	-	-	-	-
KANTI				
1986	12.25	62.16	18.48	07.11
1987	12.85	53.81	22.99	10.35
MUKTAPUR				
1988	09.03	24.67	53.77	12.53
1989	11.45	18.11	58.34	12.10
1990	15.87	17.06	57.25	09.82
1991	21.00	14.99	60.08	03.93

9.1 Crafts and gear

The operation of gears vary in accordance with the depth of water, nature of fish to be caught, local availability of raw materials and above all

the physical condition of the water body to be fished. Nets made up of cotton or jute are more in practice as compared to nylon nets. Bamboo reeds and strips for forming barriers (bari) across the width of the lake are fairly common. The use of drag nets is not at all suitable in these systems owing to high infestation of hydrophytes. The details of the gears and nets have been presented in the table- 9. Small mesh size gill nets (Tiar nets) are extensively used largely due to the dominance of small forage, fishes in the system. The use of cast net was not very common because it was almost impossible to get weed free water in these lakes.

Table - 9 : Nets and gear operated in ox-bow lakes

Name	Mesh Size	Particulars	Fish commonly tapped
1	2	3	4
NET			
A. Drag Net			
1. Chattijal	2.0 cm	Rectangular either single or two pieces, length variable but usually 10 x 5 m each Madeup of cotton or plastic fibre.	Small size carps, trash fishes and prawns.
B. Gill Net			
1. Tiar net (with foot rope)	6.0 cm	50.0 x 4.0 mt, made up of Hemp or plastic	*Wallago attu, Mystus Seenghala, M. aor.* etc.
2. Tiar net (without foot rope)	2.4 cm	40.0 x 4.0 mt, made up of Hemp or plastic fibre.	Small fishes of all kinds.

1	2	3	4
C. Cast Net			
1. Bhirkha jal (rarely used)	1.0-3 cm	Circular , 6-7 m in diameter made up of nylon thread.	Small major carps, *Chela* spp. *Puntius* spp, *Mystus cavasius* etc.
D. *Scoop Net*			
1. Bisar jal	1-1.5 cm	8-10 m, V-shaped, made of bamboo poles	Minor carps, trash fishes and smaller cat fishes.
2. Bisari jal	0.8-1.0	Around 3m, V - shaped, made of bamboo poles.	All kinds of small fishes including juveniles and prawns.
E. Bag Net			
1. Kharail jal	Multime-shed	Conical 3-4 m long, diameter of the mouth 1/2 m.	Fishes of different size and types.
F. Misc. fishing gears and tackles			
1. Thapi net	-	Conical , basket like, made up of bamboo splits with a narrow circular opening at the top.	*Channa* spp.

1	2	3	4
2. Arsi	-	Cubical to rectangular with closod and narrower tail end, wider and front end 25 - 40 cm in diameter . Made up of fine bamboo splits.	*Puntius spp.* Trash fishes and other smaller fishes.
3. Bari fishing	-	Generally used in deeps water to barricade like screen Bamboo poles are used to fix the screen made up of fine bamboo splits .	All sizes of cat fishes carps and other small fishes.
4 Birti	-	Basket like , hemispherical to oval in shape. Made up of bamboo splits.	*Channa* spp, *Macroganthus aculeatum* etc.
5. Kanra	-	A bamboo fitted with a sharp narrow pear of iron, 1-2 in length.	Big sized fishes specially cat fishes and *Notoptorus*
6. Sahat	-	A bomboo fitted with 12 sharp narrow pears of iron at one end, appears like a broom stick with long handle. The length is variable depending upon the depth of the lake generally used with kharail fishing.	- do -

1	2	3	4
7. Boat	-	Wooden country made boats, 1-2 m x 4- 5 m , are generally used. The use of such small boats is necessitated due to massive infestation of weeds.	
8. Shaft			
(a) wooden	-	Wooden logs are tide together and a platform is formed generally, of 1-1.5 x 1.5 -2m dimension.	
(b) Banana	-	Banana stems are also used frequently for making platform .	

9.2 Fishing right of ox-bow lakes

The ox-bow lakes in Gandak basin are largely public properties barring a few having private ownership. The fishing right of these lakes is vested with the Goverment or Semi-Government agencies. The bulk of the waters are under the State Depertment of Fisheris. The State Department of Revenue has only limited lakes under its control. Some semi-Goverment bodies like State Electricity Board etc. have also control over certain lakes.

The Government of Bihar had notified these lakes under two catogories- (i) Lakes with "Makhana" and Lotus, and (ii) Lakes without Makhana and Lotus. Till recent past the fishing rights for the first category of lakes were vested with the Revenue Department, while the second category were under the Department of Fisheries. Recently, however, all the lakes have been brought under the Department of fisheries.

These lakes are auctioned annually to the local fishermen co-operative societies and the amount of auction varies from lake to lake,depending upon their area and pattern of fish catch. The revenue thus earned by the Goverment of Bihar through auction of these lakes ranges between Rs. 8,000.00 and Rs. 100000.00 per lake per annum.

During the course of the present survey of the lake district it has been found that many water bodies are lying unsettled due to the claims and counter claims by different co-operative societies for settelment in their favour and thus the Goverment is losing its revenue .

In recent years there has been an upsurge in the number of fake co-operative societies. This trend has led to the increase of group rivalary and has brought litigations. Many lakes remain unsettled for years together. There is an urgent need to enforce effective fishery legislation/co-operative societies act, so that timely settlement of lakes is done in effective maner and that the development of fishery as well as the conservation of resourses could be achieved.

10 BIODIVERSITY

10.1 Vertebrate fauna in ox-bow lakes of Gandak basin

The wellands in general and the ox-bow lakes in particular are known to be very rich in the abundance of 'Amphibia', 'Aves' and 'Turtles'.

Gandak basin is a good sanctuary for large number of birds, both endemic and migratory, due to the availability of many perennial water bodies and food materials. Many small to large and ugly to beautiful birds can be seen round the year but more during the winter months affected

by migration from other places. Among the birds located in this area, many are predatory in nature as well as carrier of many water born diseases specially to fishes and as such are significant limnologically. The area, close to Nepal, E.Champaran and W.Champaran are comparatively richer interms of the types of birds available (Table 10).

Table - 10 : Vertebrate biota in ox-bow lakes of Gandak basin

Class	Type	Local name	Location	Season/months
(A) AMPHIBIA	1 *Rana limnocharii* (weigm)	Medhak	Ubiquital	All seasons but more during June-September.
	2 *R. tigrana*	Medhak	"	"
(B) REPTILIA	1. *Lissemys punctali punctala* (Bona)	Agua Kachua	"	"
(C) AVES	***Herons***			
	(i) *Ardea punctali* manilensis (Mey)	Khyra. Usually solitary rarely in groups (fisheater)	Around Muzaffarpur and Samastipur lake areas.	Round the year
	Egrets			
	(ii) *Egretta alba modesta* (Gral)	Bara Bagula, White in colour of variable size -Fish predator	Throughout North Bihar	Round the year But more conspicuous during monsoon months.
	Stork			
	(iii) *Ciconia ciconia ciconia* (Linn)	Ujli (Fish eater)	In and around Muzaffarpur	June-October
	Goose			
	(iv) *Tadorna ferruginea* (Pallas)	Shah chakwa (Insects w/la)	Muktapur Man Samastipur, Motipur man Muzaffarpur	Winter months (migratory bird)

Table 10 contd..

Class	Type	Local name/ food habits	Location	Season/months
	(v) *Anser indiens* (Lathan)	Maogli	W.Champaran	Winter, Migratory bird.
	(vi) *Anser rubri rostris* (Swin.)	Kharhans (Insent)	W. Champaran	Winter, Migratory bird.
	(vii) *Dendrocygna javanica* (Hors.)	Seelhi (paddy grain and Dweels)	E.Champaran W.Champaran Muzaffarpur, Samastipur	"
	(viii) *Anas clypeata* (Linn.)	Ghirali (Gairdi) (Grhin & In sub.)	E.Champaran Muzaffarpur	"
	(ix) *Platalea leuco rodia major* (Tem. sehi.)	Chamche. in group of 20-25	Samastipur, Muzaffarpur	All seasons.
	Fulture			
	(x) *Gyps bengalensis*	Gidha. (dead anively)	All over	All seasons.
	Kite			
	(xi) *Milvuns migrans*	Cheel (fish. snaks. rats etc.)	All over	All seasons.
	Crane			
	(xii) *Authropoicea virgo* (Linl.)	Kurra	W.Champaran	Winter
	Snipe			
	(xiii) *Capella gallinago*	Chaha (weed grazer)	All over	Winter
	(xiv) *Capella Minima*	Chota Chaha (insects)	W.Champaran	Winter.

10.2 Biodiversity (Micro & Macro Organisms)

The biological spectrum or biodiversity presented here (table 11) is based on the studies carried by the authors, besides the work of Srivastava (1984) who studied the algae of Motijheel, (Motihari) and Brahampura (Muzaffarpur). The fish fauna of the ox-bow lakes of North Bihar is given in table 12.

Table 11: Inventory of biota from different lakes.

	LAKES				
ALAGE	*BP*	*ML*	*KL*	*MJ*	*MP*
A. Euglenophyceae					
Phacus agilis	p	p	-	p	-
P. cylindraceus	p	-	-	p	p
P. polytrophs	p	-	p	-	p
P. inflexus	-	p	-	p	-
P. curvicauda	p	p	p	-	p
Euglena gracilis	p	-	p	-	p
E. acus	p	-	-	p	-
E. spirogira					
E. elongata	-	p	-	-	-
E. proxima	p	p	p	-	p
E. polymorpha	-	p	p	p	-
Lepocinclis fusiforms	p	p	-	p	-
L. ovum	-	p	p	-	p
L. acute	p	-	p	p	p
Trachelomonas varians	p	p	-	p	-
T. robusta	p	-	-	-	-
T. volvocina	p	p	-	-	p
T. giardiana	-	-	p	-	-
B. Myxophyceae					
Aphanocapsa koordersi	p	p	-	p	p
A. grevillei	p	p	p	p	p
Aphanothece bullosa	p	-	p	p	p
A. pallida	p	p	-	p	p
Chroococcus macroeous	p	-	p	p	p
C. minor	p	p	-	p	p

contd.....

ALAGE	LAKES				
	BP	ML	KL	MJ	MP
C minutus	p	p	p	p	-
Gloeocapsa gelatinosa	p	p	p	p	-
Gloeothece fusco-lutea	p	-	p	p	-
G. rupestris	p	p	-	p	p
Merismopedia aeruginea	p	p	-	p	p
M glauca	p	p	p	p	p
M tetrapedia	p	p -	p	p	
Microcystis aeruginosa	p	p	p	p	-
Synechococcus aeruginosa	p	-	p	p	-
S cedrorum	p	-	p	p	p
Synechocystis aquatilis	p	p	p	p	p
Chamaesiphon sideriphilus	p	p	-	p	-
C. rostoffuskei	p	-	p	p	p
Gloeotrichia natans	p	-	p	-	-
G pilgeri	p	p	-	-	p
G rasiborskii	p	-	-	-	-
G. indica	p	-	p	-	-
Phormidium dimorphum	p	p	-	p	p
P. incrustatum	-	p	-	p	-
Microcoleus sp	p	-	p	p	-
Lyngbya birgei	-	p	p	p	-
L. ceylonica	-	p	p	p	p
L. hieromymusii	p	-	p	p	p
L. gracilis	p	p	-	p	-
L scotii	p	p	-	p	-
L. maganifica	p	-	-	p	-
Symploea muscorum	p	-	-	p	-
Schizothrix beccarii	p	p	-	p	p
Anabaena iyengarii	-	p	-	p	-
A. sphaerica	p	-	p	p	p
A torulosa	-	p	p	p	p
A. variabilis	p	p	p	p	p
A. orienthlii	p	p	p	p	-
A. voltzii	p	-	p	p	p
Aphanizomenon flosaquae	p	-	-	p	-
Alusira prolifica	-	p	-	p	p
A. fertilissima	p	p	-	p	p
Cylindrospermum indentatum	p	p	p	p	p

contd.....

ALAGE	LAKES				
	BP	ML	KL	MJ	MP
C. licheniformae	p	p	-	p	-
Nodularia sp.	p	p	-	p	-
Nostoc ellipsospermum	p	-	p	p	-
N. linnunis	p	p	p	p	p
N. hatei	-	-	-	-	p
N. muscorum	p	p	-	-	p
N. commune	p	-	p	p	p
Rhaphidiopsis indica	p	-	p	p	p
R. mediterranea	p	p	p	p	-
Scytonema fristchii	p	p	p	p	-
S. cincinnatum	p	-	p	p	p
Tolypothrix tenuis	p	p	-	p	p
Microchaete tenera	p	-	-	p	-
Calothrix fusca	-	p	-	p	p
Rivularia aquatica	p	p	p	p	-
R. beccariana	p	-	p	p	-
R. manginii	p	p	p	p	p
C. Chlorophyceae :					
Volvox globator	p	p	-	p	p
Volvox sp.	p	-	p	p	-
Chlorococcum infusionum	p	-	p	-	p
Chlorella vulgaris	p	p	p	p	p
Hydrodictyon reticulatum	p	p	-	p	-
Pediastrum simplex	-	p	p	p	-
P. duplex	p	p	p	p	p
P. ovatum	-	-	p	-	p
P. tetras	-	-	-	-	p
P. boryanum	p	p	p	-	-
P. angulosum	p	-	-	-	-
Coelastrum microsporum	p	p	p	p	-
Closteridium simensis	p	p	p	p	p

contd.....

ALAGE	LAKES				
	BP	ML	KL	MJ	MP
C. bengalicum	p	-	-	p	-
C. boesum	p	p	-	p	p
Schroederia indica	-	p	p	-	p
Characium ambiguam	p	-	p	p	p
C. angustum	p	p	p	p	p
C. braunii	-	p	-	-	p
C.nastum	p	-	p	p	-
C. orissicum	-	p	p	-	-
Palmella sp.	-	p	-	-	-
Sphacrocystis schrocteri	-	p	-	-	p
Torchisia reticularis	-	p	-	p	p
Golenkinia radiata	p	p	-	-	-
sorastrum bengalicum	p	-	-	-	p
Tetraedron minimum	-	p	p	-	-
T. trigonum	-	-	p	-	-
Oocystis crassa	p	p	-	-	p
O. lacustris	-	p	-	p	-
O. naegelli	p	-	-	-	-
Botryococcus brunii	-	-	p	-	-
Crucigenia fenastrata	-	p	-	-	-
C. quadrata	p	-	-	-	p
Scenedesmus accuminatus	p	p	-	-	-
S. armatus	-	p	-	-	-
S. bijugatus	p	p	p	p	p
S. dimorphus	p	p	p	p	p
S. obliquuas	p	-	p	p	-
S. prismaticus	-	p	-	-	p
S. quadricauda	p	p	p	p	p
S. longus	-	p	-	p	p
Ulothrix acqualis	p	-	p	p	-
U. moniliformis	p	-	-	p	p
U. subtilissima	p	-	p	p	-
U. variabilis	p	p	-	p	p
U. zonata	p	-	-	p	-

contd.....

ALAGE	LAKES				
	BP	ML	KL	MJ	MP
Cladophora crispata	p	-	-	p	-
C. golmorata	p	p	p	p	p
Rhizoclonium crassipellit	p	p	p	p	p
R. hierghyphicum	-	p	-	p	-
Pithophera rottben	p	p	-	p	p
P. clevach	p	p	p	p	p
P. variablis	p	-	p	p	-
Stigeoclonium attenuatum	p	-	-	p	-
S. nanum	p	p	-	p	p
S.tenue	-	-	p	-	-
Chaetophora elegans	p	p	-	p	-
C. pisiformis	p	p	p	-	p
Draponaldiopsis indica	p	-	p	p	-
Coleochaete irregularis	p	p	p	p	-
C. setata	p	-	-	p	p
Bulbochaete nana	p	p	p	p	p
Pseudoulvella americana	-	p	p	-	-
Aphanochaete renenus	-	-	p	-	-
Chaetonema irregularis	-	p	p	-	p
Oedoginum majar	p	-	-	p	-
O. monoliformis	p	-	-	p	-
O. multisporum	p	p	p	p	p
O. pusillum	-	p	p	-	p
Debrya madras-ensis	p	-	-	p	-
Spirogyra biformis	p	-	-	p	-
S. columbiana	p	p	-	p	-
S. setiformis	p	p	p	p	p
S. singularis	-	p	p	-	p
S. hollandiae	p	p	p	p	p
S. ellipsospora	p	p	-	p	-
S. hymarae	p	-	-	p	-
S. reticularia	-	-	p	-	-

contd.....

ALAGE	LAKES BP	ML	KL	MJ	MP
S. subsalsa	-	p	p	-	-
Mougeotia jeogensis	p	p	p	p	-
M. calcarea	p	p	p	p	-
Sirogonium fordanum	p	-	p	p	-
S. hui	p	p	p	p	p
S. sticticum	p	-	p	p	-
S. megasporum	p	p	p	p	-
Zygnema gorakporanse	p	p	-	p	p
Z . inconsipicum	p	p	p	p	p
Z. melanosporum	-	p	p	-	p
Z . normani	-	p	-	p	-
Z. sphaericum	-	-	-	p	p
Temnogametum tirupatiense	p	-	p	-	-
Zygnemopsis gracilis	p	p	p	p	-
Z. sphaerospora	-	p	-	p	p
Gonatozygon montaenium	p	p	-	p	p
Penium lanceolatum	p	p	p	-	-
P. margariteceum	p	-	p	-	p
Pleurotaenium trabecula	-	p	-	-	-
Clostrium acutum	p	-	p	-	p
C. lanceolatum	p	-	p	-	-
C.ehrenbergii	p	p	p	p	p
C. monliferum	p	-	p	-	p
C. venus	-	p	-	p	p
C. lunula	-	p	p	p	-
C. leiblenii	-	-	p	p	p
C. lineatum	-	p	p	p	-
Cosmarium javanicum	p	p	-	p	-
C. subpertumidium	p	-	p	p	p
C. subspeciosum	p	-	p	p	-
C. bengalense	-	p	p	-	-
C.contractum	p	-	p	-	-

contd.....

ALAGE	LAKES BP	ML	KL	MJ	MP
C.orientale	-	p	-	p	p
C. undulatum	p	p	-	-	p
Desmidium swartzii	p	-	p	p	-
Euastrum sphyroides	p	p	-	p	-
E. rostratum	p	p	p	p	p
Staurastrum gracile	p	p	-	p	-
S. truncatum	-	-	p	-	p
S. stellatum	-	p	-	-	p
S. hexacerum	p	-	-	p	-
Xanthidium cristalum	-	p	-	-	p
Xathidium acanthophorum	p	p	p	p	p
Staurodesmus megacanthus	-	p	-	p	-
Spondylosium planum	-	-	p	-	-
Sphaerozosma bengalense	-	p	p	-	-
Desmidium quadratum	-	-	p	-	-
Hyalotheca dissiliens	-	p	p	-	p
Docardium sp.	-	-	p	-	-
D. *Bacillariophyceae*					
Melosira moniliformae	p	-	-	-	-
M. varians	p	p	p	p	p
M. granulata	-	p	p	-	p
Cyclotella operculata	p	-	-	p	-
C. rotula	p	-	-	p	p
C. menighiani	-	p	p	-	p
C.stelligera	p	-	p	-	p
C. comta	-	p	p	-	-
Stephanodiscus stellata	p	p	p	p	p
Rhizosolenia sp.	-	p	p	p	-
Asterionella formosa	-	p	-	-	-
Fragilaria intermedia	p	p	-	p	p
F. capucina	-	p	p	-	p
F. construens var binodis	p	-	p	p	-

contd.....

ALAGE	LAKES				
	BP	ML	KL	MJ	MP
F. pinnata	p	p	p	p	p
Synedra acus	-	p	-	p	p
S. ulna	p	p	p	p	p
S. rumpens	p	-	p	-	p
S.vaucheriae	p	p	p	p	-
S. tabulata	-	-	p	-	p
Eunotia flexuosa	p	p	-	-	-
E. gracilis	p	p	p	p	p
Achnanthes axigua	-	p	p	-	-
A. minutissima	p	-	p	-	p
A. lanceolata	p	-	-	p	p
Coceoneis placentula	-	p	-	p	p
C.pediculus	p	-	p	p	-
Anomoeoneis lanceolata	-	p	p	-	-
Caloneis bacillum	p	-	p	-	-
Amphora coffeaformis	p	p	p	p	p
A. ovalis	p	-	-	p	-
cymbella affinis	p	-	p	-	p
C. microcephala	-	p	p	p	p
C. turgida	p	p	p	p	p
C. ventricosa	-	p	-	p	-
C. lanceolata	p	-	-	p	p
Diploneis subovalis	p	p	p	-	p
Frustulia vulgaris	-	p	-	p	-
Gophonema accuminatum	p	-	p	-	-
G. gracile	-	p	p	-	p
G. constrictum	p	p	p	p	p
G. angustum	p	p	p	p	p
G. oleveceum	-	p	-	-	p
G. parvulum	p	-	p	p	p
Gyrosigma attenuatum	-	p	-	p	-

contd.....

ALAGE	LAKES				
	BP	ML	KL	MJ	MP
G. accuminatum	p	-	p	-	p
Mastogloia smithii	p	p	p	-	p
Navicula cincta	-	p	-	p	-
N. cryptocephalla	p	p	p	-	-
N. cuspidata	-	-	p	-	-
N. diaphcephala	p	p	-	p	p
N. mutica	p	-	p	-	p
N. populа	p	p	p	p	p
N. rhyncocephala	p	-	-	-	-
N. lanceolata	-	p	-	-	p
Pinnularia major	p	-	-	p	-
P. oblonga	p	-	p	p	-
P. gibba	p	p	p	-	p
P. borealis	-	p	-	-	p
Stauroneis calcutensis	-	p	p	-	p
S. parvula	p	-	p	p	-
Epithemia argus	p	p	p	-	-
E. sorex	-	p	p	p	-
Hantzschia amphioxys	p	p	p	p	p
Nitzschia affinis	p	p	p	p	p
N. fonticola	-	p	p	-	p
N. sigmoidea	p	-	-	p	-
N. sinuta	-	-	p	-	p
N. palea	p	p	p	p	p
N. tenuis	p	-	p	-	-
Surirella ovata	p	p	p	p	p
S. robusta	-	p	-	-	p
Grammatophora serpentina	-	p	p	-	-
Diatoma vulgare	p	p	p	p	p
D. elongatum	-	p	p	-	-

contd.....

ALAGE	LAKES BP	ML	KL	MJ	MP
E. Dinophyceae					
Ceratium hirundiella	p	p	p	-	-
Peridinium weillii	p	-	p	p	p
P. inconspicuum	p	p	p	p	p
F. Xanthophyceae					
Tribonema minus	p	p	p	p	p
Botrydium gramulatum	p	-	-	p	-
Protosiphon botryodies	p	p	-	p	p
Ophicytium orbuscula	p	p	-	p	p
G. Rhodophyceae					
Composopogon aeruginosa	p	-	p	p	-
C. coerulena	p	-	-	-	-
Audoniella sp.	p	-	p	p	p
H. Crysophyceae					
Dinobryon Sertularis	-	p	p	-	-
Mallomonas mirabilis	p	p	p	p	p
Synura sp.	-	p	p	-	p

contd....

MACROPHYTES

Plants	*ML*	*KL*	*MJ*	*MP*
A. SUBMERGED WEEDS				
Cerotophyllum demursum	CC	C	C	C
Hydrilla varticillata	CC	CC	CC	CC
Naja gramine	R	C	C	C
Najes minor	C	C	C	C
Patamogeton pectinatus	CC	RC	R	RC
P persoleatus	C	R	R	R
Vallisneria spiralis	RC	C	C	R
Myriophyllum intermidium	RC	-	-	-
Aponogeton natans	R	CC	CC	-
Ottelia alismoides	-	C	C	-
Sagittaria sagittifolia	R	R	C	R
B. EMERGENT WEEDS				
Nymphea stellata	R	R	-	R
Euryale ferox	R	-	-	CC
Nelumbo nucifera	CC	C	C	CC
Nymphydes indica				
C. MARGINAL WEEDS				
Bagia capensis	C	RC	RC	R
Hydrocera triflora	RC	C	C	R
Aeschynemene asparaa	R	C	C	C
Nymphoides cristatum	-	R	R	C
Ipomea aquatica	CC	RC	RC	CC
Limnophila indica	C	C	C	C
Utricularis stelliris	RC	C	C	RC
Polygonum glabrum	CC	RC	RC	CC
P barbatum	R	CC	RC	RC
Hygrorhyza artista	C	C	C	C
Marsilea quadrifolia	C	C	C	C

D. FLOATING WEEDS

Jussiaea repens	RC	-	-	-
Trapa bispinosa	R	C	C	CC
T. maximowiczii	RC	R	R	CC
Lemna sp.	C	C	C	C
Pistia stroites	CC	R	R	C
Eichhornia crassipes	CC	CC	C	CC
Wolffia sp.	CC	R	R	CC
Salvania molesta	-	C	-	C
Azolla pinnata	R	CC	RC	C

Plants	*ML*	*KL*	*MJ*	*MP*
E. MARGINAL ALGAL WEEDS				
Chara braunii gum.	CC	R	R	CC
C. brachypus por.	-	C	C	R
C. benthamii Br.				
C. vulgaris linn.	C	C	-	R
C. contraria Kuz.	CC	-	-	C
C. corollina wild	-	-	-	RC
C. delicatula (ag .) Br	-	C	C	C
C. fragillis	C	-	-	-
C. gymnopitus	C	-	-	C
C. wallichii	R	C	R	-
C. Zylanica	R	C	-	-
Nitella staurtii	-	-	-	R
N. watti groves	C	-	-	C
N. pseudo flabella	CC	RC	RC	R
N. oligospira f indica	C	-	RC	-
N. accuminata	C	-	-	C
Tolypella prolifera	C	C	R	-

FUNGI

	BP	*ML*	*KL*	*MJ*	*MP*
A. Saprolegniales					
Achlya flagellata	p	x	-	x	x
A. bisexualis	p	x	p	x	x
A. prolifera					
Isoachlya anispora	-	x	p	x	x
Saprolegnia ferax	p	x	p	x	x

B. peronosporales

Pythium sp.

C. Mucorales

Mucomucedo	p	x	p	x	x
Absidia spinosa	-	x	p	x	x
Syncephalastrum recemosum	-	x	p	x	x

D.Sphacriales

Chaetomium sp.	p	x	-	x	x
Podospora sp.	p	x	p	x	x

E. Pleosporales

Leptospheria aquatica	p	x	p	x	x
Ophibolus spirosporus	p	x	p	x	x

F. Moniliales

Aspergillus phoenicis	-	x	p	x	x
A. fumigatus	p	x	p	x	x
Alternaria gomphrenae	p	x	p	x	x
Nigrospora oryzae	p	x	-	x	x
Penicillium citrinum	-	x	p	x	x

ANIMALS

ZOOPLANKTON

	BP	*ML*	*KL*	*MJ*	*MP*
A . Protozoa					
Arcella	P	P	P	P	P
Difflugia	P	P	P	P	P
Centropyxis	P	P	P	P	P
Actinophrys	-	P	P	P	P
Actinosphaerium	P	P	P	P	P
Heterophrulys	-	P	P	P	P

B. Rotifera					
Monostyla	P	P	P	P	-
Nothalca	-	P	P	P	P
Brachionus	P	P	P	P	P
Keratella	P	P	P	P	P
Lecane	P	-	P	P	P
Asplanchna	P	P	P	P	P
Filinia	P	P	P	P	P
C. Copepoda :					
Cyclops	p	p	p	p	p
Diphanosoma	p	p	p	p	p
D. Crustaceans					
Daphnia	p	p	p	p	p
Ceriodaphnia	p	p	p	p	p
Moina	p	p	p	p	p
BENTHOS					
A. Arthropoda :					
Platycentropus sp	p	-	-	-	-
B. Diptera					
Chironomus sp	p	p	p	p	p
C. Hemiptera					
Corixa sp	p	-	p	p	-

D. Mollusca

Melanoides linealus	-	p	p	-	-
Viviperous bengalensis	p	p	p	p	p
V Varialus	p	p	p	p	p
Indoplanorbis sp	-	p	p	-	-
pila globossa	p	p	p	p	p
Orbicula striatella	-	-	p	-	-
Lymnea columella	-	p	p	-	-
Gyraulus sp	-	p	p	-	-
Gobula sp	p	-	p	-	-

BP = Brahampura lake
ML = Manika lake
KL = Kanti lake
MJ = Motijeel lake
MP = Muktapur lake

P = Present.
X = Not sampled
- = absent

R = Rare
RC = Rare to commor
C = Common
CC = Abundant

Table 12: Fish fauna of ox-bow lakes in North Bihar

FISH FAUNA FROM OX - BOW LAKES OF NORTH BIHAR

Biological Name	Local name
Notopterus chitala (Ham)	*Chital*
N. notopterus (Pallas)	*Bhunni*
Gudusia chapra (Ham.)	*Chapri*
Gonialosa manminna (Ham.)	*Sohia*
Satipina phasa (Ham.)	*Phasa*
Chela laubuca (Ham.)	*Chelwa*
C. utrahi (Ham.)	"
Barilius bola (Ham.)	*Dhawai*
B. bendelisis (Ham.)	"
Danio rerio (Ham.)	
D. dangila (Ham.)	
Esomus danrica (Ham.)	
Amblypharyngodon mola (Ham.)	
Aspdoaria morar (Ham)	*Harda*

Catla catla (Ham.)	*Catla*
Cirrhinus mrigala (Ham.)	*Naini*
C. reba (Ham.)	*Reba*
Labeo bata (Ham.)	*Bata*
L. gonius (Ham.)	*kursa*
L. calbasu (Ham.)	*Kalbansh*
L. rohita (Ham.)	*Rohu*
Osteobrama cotio (Ham.)	*Gurda*
Puntius ticto (Ham.)	*Pothia*
P. sophore (Ham.)	"
P. sarana	"
P. chola (Ham.)	"
Botia dayi (Hora)	*Bhagwa*
B. dario (Ham.)	*Bhagwa*
Crossocheilus latius (Ham.)	
Noemacheilus botia (Ham.)	
Oxygaster bacaila (Ham.)	*Chelwa*
O. gora (Ham.)	"
Lepidocephalichthys guntea	*Guhma*
Mystus aor (Ham.)	*Aria or tengra*
M. seenghala (Syk.)	"
M. cavasius (Ham.)	*Tengra*
M. vittatus (Ham.)	"
Rita rita (Ham.)	*Rita*
Channa striatus	*Sori*
C. punctatus	"
C. gachua	"
Macroganlha aculeatus	*Gainchi*
Mastoceamblasus arwaters	*Bami*
Ompok bimaculatus (Bloch)	*Jalkapoor*
Wallago attu (Schul)	*Boari*
Alia colia (Ham.)	*Banspatta*
Clupisoma garua	*Garua*
Eutropiichthys vacha (Ham.)	*Bachwa*
Silonia silondia (Ham.)	*Silan*
Bagarius bargarius (Ham.)	*Bangari*
Erethistes hara (Ham.)	*Hadda*

Nangara nangara (Ham.)	*Panhi*
Heteropneustes fossilis (Bloch)	*Singhi*
Xenentodon cancila	*Kaua*
Chanda nama (Ham.)	*Chanda*
C. ranga (Ham.)	"
Scianea coitor (Ham.)	*Bhola*
Nandus nandus (Ham.)	*Dhalo*
Rhinomujil corsula (Ham.)	*Aruari*
Glossogobius giuris (Ham.)	*Bulla*
Sicamguil caseasia	*Kalksi*
Anabas testudineus	*Kabai*

II. SOCIO-ECONOMIC IMPACT OF OX - BOW LAKES IN GANDAK BASIN

The ox-bow lakes have substantial impact on the economics of the area in general and the fishermen community in particular. However, the situation is not very encouraging, at the present, as the lakes are poorly managed. Fishermen engaged in ox-bow lakes are sustaining themselves at below proverty level. Data presented in the Table 11 reveal that the annual income from fisheries activities of these lakes ranges between Rs. 875.00 and 4150.00 and thus the per capita income of the fisherman community, taking a family unit of 5 members, is very low in the range of Rs. 175.00 to 830.00. It is obvious, therefore, that the annual income earned by the fisherman families from the fishing activity being unreummerative, leads to their engagment as unskilled wage earners in other field as their own agricultural holdings are uneconomical. This picture of abject poverty is an indicator of dismal state of fisheries, which calls for urgent remedial measures. The ox-bow lakes are very potent biologically and thus are capable to generate better economic environment, provided cartain management practices are employed. The capture fishery from these lakes need be planned on the principal of culture fishery thereby a stocking based crop have to be given greater thrust, specially in the intial stages. However, this programme may receive a set-back in the face of high incidence of macrophytes and predators and as such proper plan on these aspects has to be thought upon before

hand. Giving allowance to the predation a high stocking density @ 3000 advanced fingerlings per hactare may increase the fish production to 1000 Kg/ha and in this way the annual income of the fishermen families may go up in the range of Rs. 3000.00 to Rs. 12353.00 . The present estimation is based on the periences gained by CIFRI in case of Kulia Beel, West Bengal (Annon, 1985).

Table - 13 : Existing and expected per capita income of fishermen from certain ox-bow lakes

Name of lakes	Produ-ctive area/ha	No of active fisher-men	Present annual income of one	Quantity of fish required @ 3000	Estimated seed pro-duction of (MT @	Cost of fish har-vested@Rs 15.00/Kg	Income after post stocking	Per capita income
Manika	106.00	225	1500	318000	106.0	15.90	7066.66	1413.33
Brahampura	45.5	100	3550	136500	45.5	6.82	6825.00	1365.00
Motipur	110.0	225	2025	330000	110.0	16.50	7333.33	1466.66
Kanti	100.0	125	1250	300000	100.0	15.00	12000.00	2400.00
Motijeel	100.0	175	2500	300000	100.0	15.0	8571.42	1714.28
Kavaria	100.0	170	3540	300000	100.0	15.0	8823.52	1764.70
Tukkauha	80.0	250	4150	240000	80.0	12.0	4800.00	960.00
Matwali	105.0	160	2000	315000	105.0	15.75	9843.75	1968.75
Gahri	70.0	85	1550	210000	60.0	10.50	12352.94	2470.58
Muktapr	60.0	165	1925	180000	15.0	9.00	5454.50	1090.90
Murra	15.0	75	875	45000	15.0	2.25	3000.00	600.00

12. FISHERIES MANAGEMENT OF OX-BOW LAKES

The objective of biological productivity management should ultimately be aimed for the welfare of human being. The production of biological materials in fresh waters terminates in the form of fish either harvested as human food or conserved for recreation. In recent years there has been great concern on the over production of primary producers like algae and many hydrophytes in our water wealths in general and lakes in particular. This, problem of "eutrophication" tends to cause imbalance in the system, resulting in to the loss of production required for human consuption.

The ox-bow lakes in Gandak basin are natural impoundments and are facing many problems. In recent years not only the bio-production but the very existence of these lakes are under threat. The lakes are becoming shallow to shallower every year and this is further been compounded with the massive infestation of hydrophytes. The lakes are generally over populatted with less economic fishes at the cost of prized ones and therefore, there is an urgent need for stringent regulatory measures and effective management norms for having economical fishery and to conserve the biodiversity.

i) Cluster approach of development

The Gandak basin revealed the presence of two distrinct categories of lakes (a) the closed types and (b) the open types. What is required to be done is to identify few lakes of each type on cluster basis so that two distinct sets of lakes are marked for applying specific management practices suitable to each type. To make it more lucid "open lakes" should be approached differently than the "closed lakes". The management methods or the technical know how thus perfected should be extended to other lakes of similar types. It is imperative, therefore to develop and conserve the lakes in phased manner. The task is daunting and as such all the agencies dealing or interested in the development of fisheries and in the eco-conservation of these aquatic environtments should play their role sincerely .

(ii) Upgradation of fishing gear.

The nets and gears, used in this basin, are primarily of very primitive type and thus need immediate upgradatation. The fact behind this technological stagnation of fishing kit is economic in nature. Firstly, the fishermen are not getting sufficient catch to even support their families properly, so they cannot affoard to buy expensive nets. Secondly, they are not sufficiently informed to make them aware of the scientific innovations. It is the responsibility of State Depertment of Fisheries and the Fish Farmers Development Agency to update their knowledge and to help them in obtaining financial assistance either as subsidies or soft loan.

iii) Management of weeds

The high incidence of macrophytes is a nagative development in the flood plain lakes which need to be tackled effectively for sustainable fisheries and for the conservation of these resources. The best stretegy would be to exploit these macrophytes in the conversion of fish flesh. Any developmental effort without the proper disposal of weeds can not be sustainable in view of their high incidence. The flood plain lakes in general and the ox-bow lakes in particular have shown the formation of "floating islands", due to the succession and pilation of weeds. The floating islands not only cause hinderence during the fishing activities but reduce the productive area of the lakes every year by converting a portion of the lake into swamp. There are three well established methods of weed control - (a) chemical, (b) mechanical and (c) biological. The quantum of macrophytes in ox-bow lakes has assumed such a proportion that no single method may be 100% effective and as such all the three methods have to be attemped in phased manner to restore the level of fish production which is cost effective.

iv) Stocking in ox - bow lakes

Regular stocking of major carp fingerlings has to be undertaken in close type lakes in absence of natural recruitment of these fishes. There are a number of arguments in favour or against the stocking in a system where many other species exist. Viosca (1945) has totally rejected the concept of stocking to build up population. Swingle et.al (1947), however, advocated stocking but suggested corrected stocking. In ox-bow lakes also, partial poisoning can be done prior to stocking so that the carrying capacity of the lake is not disturbed. Central Inland fisheries Research Institute, Barrackpore, has successfully demostrated in Kulia beel, West Bengal that fish production, in terms of yield can be increased through stocking. It has been observed that the production of the beel had gone up from 320 kg/ha/yr to 1077 kg/ha, when stocked with *Labeo rohita*, *Cirrhinus mrigala* fingerlings @ 8000/ha. The expriences gained by the institute in Kulia beel may be exteneded in the ox-bow lakes of Gandak-basin with suitable modifications.

The predator pressure is considerably high in ox-bow lakes as such planting of desirable species may be preferred. Procurement of stocking materials should be obtained from the riverine source or by hypophysation at the lake sites. The spawns can be reared either in earthen nursuries or small pen enclosures erracted in the lakes itself. Floating cages for the rearing of spwans to fingelings size, may also be tried in some selected lakes.

v) Proper utilization of benthic food chain

The benthic environment of ox-bow lakes in Gandak basin is largely dominated by the abundance of molluscans to the tune of more that 70.0% of the totat biamass. It was found that this niche of the system was under exploited, to a larger extent and thus substantial loss in total fish production . It has also been experienced while working in this system that in spite of the fact, that the 'mrigala' is a detritus feeder and the detritus load in ox-bow lakes is very high, its growth was comparatively poorer than 'rohu' and 'catla'. It may be that the fish is not getting desirable food materials, because of the poor growth of desired food material owing to the greater abundance of molluscans. Thus, in order to augment the fishery of this ecosystem proper exploitation of benthic niche is a must. Some fishes like *Pangasius pangasius* may be introduced in selective lakes, which feed upon molluscans extensively. The interaction should be watched carefully and if the results are positive further propogation should be advocated .

vi) Fish husbandery

Ox-bow lakes are ideal habitat for pen culture operations. Success achieved by CIFRI, in this regard has opened new vistas in the fishery development of problematic ox-bow lakes in Gandak basin. Total fishery development in these lakes is a long process and needs patience. Thus, the pen culture technology developed by CIFRI, Barrackpore may be propagated in the entire lake district and pen cullture operation should be started on a large scale, bringing the fishermen under some kind of co-operative fold. To start with and for the financial obligations involved in the operation the state Department of fisheries should take initiative.

CIFRI, Barrackpore has succesfully demonstrated in ManikaKanti and Muktapur ox-bow lakes of Muzaffarpur and Samastipur districts, Bihar that a 0.1 ha pen enclosure, errected towards the margin of the lakes and stocked with Indian major carps, (Catla, rohu and mrigal) could fetch 400 kg of fish flesh in a period of six months only.

The pen enclosures can be made of Bamboo spliting and for one 0.1 ha area a sum of Rs. 3000.00 (approx.) may be required. The cost of recurring expenditure like stocking materials, artificial feed and contigent labour has been worked out as Rs. 1500.00 and thus the total cost involved is Rs. 4500.00 with a return of Rs. 6000.00 in six months. Hence , a net gain of Rs. 1500.00 in six months is possible. It is evident that an estimated earning of Rs. 15000.00 /ha is of very high order ,specially when present level of earning is much low .

Ox-bow lakes are no doubt ideally suited for pen culture practices but all the ox-bow lakes are not suitable for the purpose. Gandak - basin is a flood prone area and the fluctuation of waters in open lakes are very high. It has been exprienced in Kanti lake that the maintainance of pen stock was difficult when the flood water suddenly entered the lakes though the connecting channel and the level water abrupts increased. It is advisable, therefore , that closed type lakes should be preferred for pen culture practices where the fluctuatuion of water level remains within manageable level. However, floating cages are worth trying in open type lakes .

RECOMMENDATIONS

The sustained development of ox-bow lakes, both in terms of fish production and the conservation of biodiversity, would need to have a holistic approach of resource management.

The wetlands in general and the ox-bow lalkes in particular, are one of the prime aquatic resources, supporting a rich biodiversity. In view of this, their exploitation must be rational. Using them for short terms gain or over exploitation for any purpose has to be avoided in order to strike a balance between sustainable yield and conservation.

There is an urgent need to identify the causes, opperating for the degradation of these resources so that necessary corrective measures can be adopted to halt the processes of negative impact on the biotopes.

The level of awareness among the local community regarding the value and utility of such lakes both for economic gains and social benefits, has to be increased.

Making the fisheries co-operatives viable in each lake or on a clustor of lakes to broad base their activities and to put a curb on the mushrooming of such societies for avoiding litigations and conflicts.

Development of ox-bow lake fisheries on sound scientific management norms to augment sustainable fishery and to avoid ad-hocism currently in operation.

The management approch should synthesise both conservation of the wild stock and cultivation of planted germ plasms.

In order to generate additional in come and to infuse entrepreneurship in fisheries activities pen and cage cultures are to be propagated where ever appropriate.

Strengthening of the credit and subsidy schemes to make the fisheries activities sustainable and economically viable.

Strengthening of the mechanism of technology transfer in order to achive the goal of holistic development of ox-bow lakes.

Enforcement of strict regulation to stop the disposal of unwanted effluents both domestic and industrial.

Extension of insurance scheme to fish farmers or at least to fish farmer's cooperative societies to receive compensation in case of crop failure due to calamities like flood or fish epidemics.

Rationalisation of priorities of various user groups in the resource for maximum sustainable economic gain.

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