

Master copy



A REPORT ON THE SURVEY OF NORTH BIHAR IN RELATION TO EFFECTS OF GANDAK & KOSI RIVER VALLEY PROJECTS ON THE FISHERIES OF THE AREA

JAN. 1983

SURVEY REPORT
NO.-7

CENTRAL INLAND FISHERIES RESEARCH INSTITUTE

(INDIAN COUNCIL OF AGRICULTURAL RESEARCH)

BARRACKPORE • WEST BENGAL • INDIA

Not to be imd out

A REPORT ON THE SURVEY OF NORTH BIHAR IN RELATION TO
EFFECTS OF GANDAK AND KOSI RIVER VALLEY PROJECTS
ON THE FISHERIES OF THE AREA

by

H.P.C. Shetty & J.C. Malhotra

CENTRAL INLAND FISHERIES RESEARCH SUBSTATION
ALLAHABAD

CONTENTS

	Page
1. INTRODUCTION	1
2. FIELD SURVEY	2
2.1 Man Fisheries	2
2.1.1 Champaran district	2
2.1.2 Muzaffarpur district	10
2.1.3 Other districts	10
2.2 Riverine fisheries	11
2.3 Tank and pond fisheries	14
3 DISCUSSION	16
3.1 Effect of river valley projects	16
3.2 Destruction of fry and fingerlings	18
3.3 Erection of barriers ('bundhs') across inflow and outflow nalas	18
3.4 Effect of stagnant conditions due to lack of flushing	18
4 RECOMMENDATIONS	18
5 ACKNOWLEDGEMENTS	23
6 REFERENCES	23

The Gandak and Kosi river systems form an extensive network in North Bihar, in the districts of Saran, Champaran, Muzaffarpur, Saharsa, Darbhanga, Monghyr and Purnea. North Bihar as a whole may be treated as a vast inland delta, as all the principal rivers emerging from the Himalayas debouch in the plains and ultimately flow into the Ganga on the south. The process of this delta formation has been in progress for thousands of years by principal rivers like the Ghaghara, the Gandak, the Kamla and the Kosi by their heavy silt and detritus load from the Himalayas. In this process, the aforesaid rivers oscillated from east to west. Both the Gandak and Kosi rivers have changed their course ever so often, specially the latter, leaving behind varying stretches of water, the oxbow lakes. Some of these continue to retain their continuity with the original river through some narrow channels, at least during the rainy season, while some others are completely cut off and remain as isolated bodies of water. These are generally termed locally, as 'mans'. This is characteristic of the Gandak basin, specially in the districts of Champaran and Muzaffarpur. In addition to these, there are certain low lying extensive areas, termed locally as 'Churs', which get inundated from the flood waters of the adjoining rivers and retain the water for several months. In the Kosi basin, one encounters long stretches of old river beds and overflow channels ('dhars'), which remain dry during the greater part of the year. All these water bodies were reportedly yielding a good quantity of fish till recently. It is further reported of late that with the commissioning of the Gandak and Kosi Valley Projects, involving the raising or extension of existing bundhs and the construction of new ones, the continuity of some of the 'mans' and 'chaurs' with the river was lost, resulting in appreciable fall in their fish production. The need for a proper survey in this regard to assess the extent to which the river valley projects have affected the fisheries of 'Mans', 'Chours' and 'dhars' and to find out ways and means of rehabilitating the dwindled fisheries in these waters was voiced in 1968 by Shri H.N. Thakur, the then Development Commissioner, Government of Bihar, in his letter to the Director-General, Indian Council of Agricultural Research. Accordingly, a preliminary survey was carried out in two stages, from 24.2.69 to 4.3.69 and 12.5.69 to 25.5.69. While the first part of the survey, during which the Champaran and Muzaffarpur districts were covered, was conducted jointly by S/Shri H.P.C. Shetty and J.C. Malhotra, Fishery Scientists, the second part was carried out by Shri J.C. Malhotra alone and it covered the districts of Saharsa, Purnea, Monghyr and Darbhanga. During both the trips, Dr. P.S. Prasad, Research Officer (Fisheries), Government of Bihar, accompanied the

CIFRI officers. Further, the regional and district fisheries officers also accompanied the survey party in their respective region. A good number of the affected water bodies in the Gandak basin in Champaran and Mozaffarpur districts was visited and details regarding their fisheries during the last few years gathered. Similarly, the more important areas in the Kosi basin were also visited and details gathered regarding the magnitude of their previous and present fisheries.

The findings of the above survey and suggestions for fisheries development of the area are delineated in the succeeding pages.

Before undertaking the survey, the reported problems were discussed in depth at Patna with Shri H.N. Thakur, Chairman, Bihar State Electricity Board, Shri S.S. Mahdi, Director of Fisheries and Shri S. Sharma, F.D.O. All of them opined that the problem did exist in actual form in the basins of both the rivers. The cost of fish had shot up, and fingerlings, which used to be available in plenty in earlier years in several of the mans, had become scarce. This could be due to the cessation of inflow of waters from the main river because of river embankments, or due to the fishing out of breeders from mans adversely affecting the breeding in mans, if any. They also stated that most of the chaurs and mans were vested with the Revenue Department and that the Fisheries Department had no control over them, nor were they asked for their advice regarding fishery development in such waters. Based on a study recently conducted by him on the water and soil qualities of mans in the Gandak basin, Shri Saxena, Asstt. Research Officer, Directorate of Fisheries, Bihar opined that these waters were very fertile.

2

FIELD SURVEY

2.1 MAN FISHERIES

2.1.1 CHAMPARAN DISTRICT

A large number of mans of varying sizes and a few chaurs exist in this district. According to a list furnished by the State Government there are as many as 48 mans in this district, with their waterspread area ranging from 4-405 ha. However, according to the District Gazetteer, there are 43 mans extending over an area of 360 sq. km. According to the District Magistrate of the area (Shri Sriballabh Saran), the problem, which is very acute in the district, has been brought about by further raising of height in recent years of the Gankak embankments and the construction of new embankments, which have evidently cut down the amount of water flooding over to the chaurs

and mans. The embankments have been raised as flood control measures, and with the increased accent on agriculture, the embankments are likely to be strengthened and raised further to conserve water; but this is bound to have further adverse effects on the fisheries of mans by cutting them off completely from the river.

So far, only 5 of the mans have been transferred to the Fisheries Department, out of which two are departmentally managed, while the remaining three are auctioned out.

The available figures (furnished by D.F.O., Champaran) relating to estimated total fish catch in Champaran district, based on weekly coverage of two markets, at Motihari and Bettiah, indicate that the catches had progressively declined, though not, markedly, from 1965-1966 to 1967-1968. The relevant figures are given below :

Year	Marketed surplus in metric tonnes	Average price per m. tonne	Total value
1965-1966	2883.30	Rs. 2754.00	Rs. 77,64,193.80
1966-1967	2672.30	Rs. 2754.00	Rs. 71,99,193.80
1967-1968	2537.40	Rs. 3306.00	Rs. 83,88,934.60

A detailed account is given below of the various mans and one chaur visited during the survey in this district.

(i) Motijheel Man :

This is nearly U-shaped man, which divides the Motihari town into two halves. It is connected by a seasonal nala to R. Burhi Gandak on its north-western side, while on its eastern side it is connected by a canal to a bigger man, the Karariya Man. The latter connection was provided to divert excess flood waters entering the Motijheel. According to the District Magistrate of the area, this man will be connected with one of the irrigation canals, so that a continuous water supply is assured. A north-south road almost completely divides the man into 2 sections, except for a 10-12 m wide continuity in the middle.

It was reported that because of the Gandak Project very little water enters this man from Burhi Gandak. On either side of the road there was heavy infestation of water hyacinth. It was reported that earlier than there used to be good flushing of man with flood waters, the weeds used to flow down out of the man; but at the time of the survey they were found to choke large sections of the man. Carps have practically disappeared from this man due to lack of recruitment from the river, and the present fish fauna consists essentially of mud-fishes, specially Clarias magur.

At present, the water appears to be unsuitable for carp culture, being heavily polluted with untreated town sewage and sugar factory effluents. Most of the effluents from the only sugar factory in the area are reportedly discharged directly into R. Dhanauti, while the hot water is discharged into the Motijheel Man. Even this naturally upsets the ecology of the man.

(ii) Karariya Man

The Karariya Man situated east of Motijheel Man, is larger in extent (41 ha) and is comparatively less infested with water hyacinth. It is deeper too, with depths upto 4.5-6.0 m at some places. This man has been handed over to the Fisheries Department for development. About 10,000 fingerlings of major carps had been stocked by the Department in 1967 and again another lakh in 1968. Catla and rohu were reported to be showing very good growth in this man, while mrigal's growth was not satisfactory. According to the fisherman fishing in the reservoir at the time of survey, catla had grown to a size of as much as 3 kg in just 1 1/2 years. Fingerlings of catla stocked in September 1968 were found to have attained about a kilogram in weight at the time of the survey, i.e. in about 6 months. This man has an outlet to R. Dhanauti for the discharge of excess flood water. There is normally no incursion of river water into this man through this connection. In the absence of recruitment from the river, stocking of fingerlings has paid dividends in appreciably increasing the man's fish production.

(iii) Kharwa chur

This is situated about 8 km north of Motihari. It is a vast low-lying area about 26 sq.km in extent and situated about 16 km south-west of Burhi Gandak. This chaur continues to get flooded as before and the water remains there for about 4 months, i.e. July-October. It is fairly deep, with about 2-3 m of water. No fishing is done when the water is standing, but large numbers of fingerlings are collected by the Fisheries Department near the main road. Further,

when the water first flows in and finally recedes, fishes that come in and those that are trapped in shallow waters respectively are fished out by local people at certain vantage points. This chaur appears to be a suitable place for major carp breeding. However, no observations are available in this regard. It is necessary to ascertain this fact, and, if breeding does take place there, to retrieve the eggs or spawn for hatching and/or rearing for ensuring better survival.

Beyond the road, towards the west, the water from this chaur flows under the road bridge, gets channelised and flows into the Majharia Man about 2.5 km away. It is reported that the magnitude of the quantity of fingerlings in the chaur and of the fishery in Majharia Man have not declined, since flooding of these two continues to occur as before.

(iv) Majharia Man

This is about 100 ha in extent and is almost weedless. During monsoons, it gets connected to the Kharwa chaur at one end and to R. Dhanauti at the other. The first onrush of water is from Kharwa chaur and when it reaches a high level in the man it flows over to R. Dhanauti. Water from Dhanauti also flows in when its water level is higher than that in the man. The man is fairly deep, upto about 4.5-7.5 m. Since it opens out on either side during the monsoon, the fishermen fish out all the fish before the onset of monsoon for fear of otherwise losing them to the Kharwa chaur or to R. Dhanauti. As such the fishes are allowed to grow only for a year.

The annual catch from this man is reported to be well over 14 t. Medium sized Wallage attu, Mystus spp., rohu, catla and mrigal reportedly dominate the catches. A few murrels and singhi are also encountered, but magur is absent.

The recruitment of carp fry is mainly from the Kharwa chaur, but they may also come in from the Dhanauti. The magnitude of fry inflow from the chaur decreases considerably in lower floods. This is further affected adversely by the fixed engines operating these days at the chaur.

(v) Sugaon Man

About 26 ha in extent, this man is situated to the west of Burhi Gandak. It has been transferred to the Fisheries Department for development, but has been auctioned out by the Department to commercial parties for exploitation. However, it has been stocked by the Department for 2 years with about 20,000 major carp fingerlings each time. The man is quite deep at places (upto 6-9 m). It is comparatively free from weeds. It has practically no connection now with the river. In normal years, the only water inflow into this man is that from the adjoining catchment area, brought in by a few nalas. According to the local fishery operatives, major carps are practically non-existent now, while earlier there used to be a good major carp fishery when flood waters used to rush in from the Dhanauti. The construction of a bundh by local farmers on the path of onrush of flood waters, about 4-5 years earlier, has cut off the man from the Dhanauti, with the consequent decline in its fishery. The absence of fry of major carps in the man indicates that no major carp breeding takes place in the man. While catches prior to the erection of the bundh used to be of the order of 5.6 - 7.5 t/year they have dwindled down to only 1.5 - 2.0 t/year in recent years. Departmental stocking has partly revived the fishery. This man appears suitable for stocking, without involving much of capital investment for habitat improvement.

(vi) Amwa Man

This is located at about 26 km north-west of Motihari. Its total area, including land, is 60 ha, while the waterspread area is about 40 ha only, which shrinks to about 32 ha in summer. In the deeper portions, the depth varies from 4.5 - 9.0 m. The man is almost completely free from weeds. In recent years, there is neither inflow into nor outflow from this man. Earlier, Burhi Gandak waters used to reach this man, after flowing successively through Kohnra Nala, Chatia chaur, Lalsaraiya Man, Karamwa Man, Katahia Nadi and Kabulahia Nadi. From the opposite side of the man, the excess water used to flow out into the Dhanauti, from where fish used to enter the man. Occasionally water from Dhanauti also

used the enter the man under conditions of heavy flood in the river. The cessation of inflow from R. Gandak side now is reportedly due to construction of canals en route. The carp fishery has considerably declined now, while earlier daily catches of upto 3.7 t used to be recorded.

This is now managed by the Department of Fisheries. It was stocked in 1966 with about 40,000 fry of major carps by the local Co-operative Society and later in 1968 with 1 lakh major carp fingerlings by the Department of Fisheries. The man appears to be quite fertile in that catla, rohu and mrigal have recorded a growth of 6.5, 4.5-5.5 and 2.8 Kg respectively in a little over 2 years. In the absence of recruitment from outside, it is necessary to continue stocking this man.

(vii) Saraiya Man

This is almost a ring-shaped Oxbow lake, about 10 km long, with its width ranging from 270 m (at A) to 550 m (at B). Its area is about 240 ha. The rights of this man vest with the Forest Department, even though the proceeds from fishing are given to the Revenue Department. The man it leased out for fishing for a year at a time. During the year of survey, the lease had brought an amount of Rs. 13,000.

This man is connected to R. Gandak through a man-made canal which is having a sluice gate at the man end. The sluice is opened only when there is excess of flood water in the river. At point C, a natural nala connects the man to R. Nakhi, which in turn flows into the Gandak.

Fry and fingerlings of major carps are collected in the nala near point C and in part of R. Nakhi during September and October. At present the fisheries seem to have dwindled considerably. Carps are very scanty, while murrels, Mystus spp. and Wallago attu are the dominant species. The local fishermen attribute the decline to scanty rainfall. Further, there is reported to be large scale fishing of fingerlings by fixed engines all along the Nakhi, with the result the normal flow of fish seed to the man is hindered. In order to ensure proper recruitment to the man, it is necessary either stop leasing out R. Nakhi, or it be leased along with the man to one party only. The Forest Department had stocked the man in 1967 with 80,000 fingerlings.

(viii) Hardia Mān

This man is about 26 ha in extent, with its depth varying from 3-6 m. It is infested with aquatic grass (phragmites) in the marginal waters and floating and submerged weeds towards the middle.

This has been transferred to the Fisheries Department for development and some stocking has been done with major carp fingerlings. The stocked catla had grown to 4.5 Kg size in about 2 years' time. Large number of fingerlings moving from the Dhanauti to the man through the nala are sieved off there by fixed engines. Earlier a channel used to connect this man with R. Nakhi. It is now completely closed, having been silted up. This has cut off the incursion of major carps from R. Nakhi. The present fish fauna consists mainly of murrels, singhi and other catfishes.

(ix) Lalsaraiya Mān

This is a horse-shoe shaped man, about 20 ha in extent and infested with aquatic grass and water hyacinth at the fringes on both the banks. It used to receive water from Chatia chaur, but since about the last 14 years this incursion has stopped. Carps and

catfishes are scanty, and the fish fauna is dominated by live fishes. This man now vests with the Rehabilitation Department, which stocked it with about 1 1/2 lakhs of major carp fingerlings in or about 1960. All the same, the carp population is poor at the moment. This indicates that it is unsuitable for major carp stocking at the moment.

(x) Chilaraon Mān

This is about 1.6 km long and 48 ha in extent. The depth varies during the year from 6-9 m. It is connected to R. Dhanauti through 2 nalas, one at its southern end and another at its north-eastern end. The southern nala has been blocked by local farmers, thereby effectively preventing the ingress of water and fish seed from that nala throughout the year. The other nala, even through open, remains dry for the greater part of the year due to its high bed level. There was reportedly no flow through this nala also during the two previous years. This has deprived the recruitment of fingerlings into the man, since this nala comes through chaurs, which abound in fingerlings. The fishery has been fast declining and live fishes are presently dominating. Removal of the obstruction in the southern nala appears to be a necessity for improving the carp fishery of this man.

(xi) Turkaulia Mān

With a maximum waterspread area of about 120 ha, this man has depth up to about 15 m. The inlet nala from R. Dhanauti has a sluice at its western end, thereby restricting the inflow of water and major carp seed. This has resulted in the decline of the fishery. Further, major carp seed are screened off by numerous fixed engines in the nala, which is also fast getting silted up. All these have contributed to the decline of the fishery in the man.

(xii) Rulhi Man

This lake of about 60 ha extent receives river water every year, but in decreasing quantities since the last 8-10 years, from a nala, which is eventually connected to R. Burhi Gandak through two other mans, the Sirsa Man and the Bhorahan Man. The decreasing inflow is reportedly due to gradual filtering up of the canals and the construction of bundhs by farmers for irrigation purposes on the incoming nales. This has adversely affected the ingress of major carp seed. It is also reported that there is very heavy fishing of fingerlings in the nalas, for consumption.

The major carps still dominate the catches, but they are bound to dwindle unless action is taken to remove the barriers and prohibit destruction of fingerlings.

The northern bank is extensively cultivated, while the north-eastern sector is heavily infested with Phragmites. It is also infested with floating and submerged weeds.

(xiii) Sajahi Man

A narrow oxbow lake, it has a maximum width of only about 30 m and is about 13 km long. During the monsoon, however, the width increases to about 60 m. It is fairly deep (4.5-7.0 m). At one end, it is connected to R. Dhanauti through a nala, which has

a sluice in it. In order to protect their rice fields on the mān-bed fringes, the farmers keep the sluice closed, preventing the water from entering the mān. This has reduced the ingress of major carp seed into the mān. It is necessary to keep the sluice open at least for a few days every season when fish seed abound in the nala.

Aquatic grass infests a good section of the mān's fringes. Floating weeds such as Lemna and lily are also encountered.

(xiv) Bhorahan Mān

This is about 6.5 km long and 150-180 m wide. It gets flooded every year by flood waters from R. Sikrana. The excess water from this mān flows over into the Sirsa Mān. Because of the continued inflow of river water, the fishery is still in good condition, with major carps dominating.

(xv) Sirsa Mān

It is about 200 ha in extent. It receives the excess flood waters from Bhorahan Mān, and as such its fishery has not declined much.

(xvi) Majharia-Matwali Mān or Chand Saraiya Mān

Located near Piprakoti Agricultural Farm, this mān is about 200 ha in extent, with a width of about 90 m. It is connected to R. Dhanauti through a nala at its north-eastern end, about 2.5 km long and 6 m wide. At the mān end of the nala there is a sluice, which is opened as soon as the farmers have drawn sufficient

water for irrigation. Fingerlings enter the mān at this time. There is no destruction of fingerlings in the nala through the operation of fixed engines, since they cannot be operated in the prevailing fast current in the nala. The fishery in the mān is as yet maintaining itself, with rohu dominating the catches.

2.1.2 MUZAFFARPUR DISTRICT

The problem of decline in man fisheries is reportedly not acute in this district. The decline is noticed only in a few mans. This is possibly due to lesser extent of construction of new embankments in the district. A few of the mans have been passed on to the Fisheries Department for development, of which only one had been stocked in 1968. Only two mans were examined in this district.

(i) Sikanderpur Man

A nala at its northwestern end connects this man to R. Burhi Gandak, but it is having sluice at its river-end. All the same, there is inflow of water along with fish every year. However, the fishery seems to be sustained more on the intensive stocking of about a lakh of fingerlings every year over several years.

The road passing across the man gets covered during the monsoon. To the east of the road the man is heavily infested with floating weeds, including water hyacinth.

(ii) Japaha Man

This man was reportedly yielding a good crop of major carps in earlier years. Now it is heavily infested with weeds. Since about the last 5 years there is no inflow of water into this man, because of construction of an embankment on the nearby Burhi Gandak. At times during floods, water flows in from R. Baghmati. 'Live' fishes dominate the fish fauna, even though major carps are also present in appreciable numbers. This had been reported to be an important major carp breeding centre in earlier years (David, 1959).

2.1.3 OTHER DISTRICTS

Of the remaining districts surveyed, it was gathered that there were only a few mans in the northern part of Monghyr district and 38 mans, covering an area of only 60 ha, in Saharsa district. The fishery was reported to have sharply declined in all these mans.

2.2 Riverine fisheries : The river system of North Bihar may be grouped under three different heads, viz.,

- (i) Perennial rivers, i.e. those that are snow fed and bring water from the snow clad Himalayas throughout the year, like the Ghaghara, the Burhi Gandak, the Gandak or Narayani, the Baghmata, the Kamla, the Kosi and the Mahananda.
- (ii) Rain fed torrential rivers which bring a large volume of water during monsoon but which dwindle down to small streams during summer and winter months, such as, Masan, Pandai, Tilawa, Sikrana, Lal Bakeya, Lahhandi, Balan etc.
- (iii) Old river beds which do not run throughout the year but serve as unstable drainage channels during the rainy season, such as Furde, Dando, Dhanauti, Baya, Bainty, Kalikosi, Soura, etc. Amongst the different types only the perennial rivers afford fishery of any magnitude, the important ones being the Gandak, Burhi Gandak, Kosi and Mahanada.

2.2.1 River Gandak : The Gandak takes its origin in the Central Himalayas range and after passing through Nepal territory, where it is called 'Spat Gandak' or 'Country of seven Gandaks', debouches from a narrow gorge near India-Nepal border and meets the plains at Tribeni in the district of Champaran. At Tribeni, the rivers Panchanad and Sonaha join the Gandak. It then flows through the districts of Champaran, Saran and Muzaffarpur and falls into the Garga opposite Patra. The catchment area of the Gandak at Tribeni is about 37,814 sq.km.

Existing fishery : The 'trout' and 'grayling' zones of the river area in the territory of Nepal while the 'Barbel' and the 'bream' zones fall in the Indian territory. Mahaseer (Barbus tor) is the

obly economically important food fish available in the barbel zone, whereas carps like Catla catla, Labeo rohita, L. calbasu, Cirrhina mrigala, C. reba, L. bata, catfishes like Wallago attu, Mystus aor, M. seenghala, Silonia silondia, Bagarius bagarius and the feather-backs Notopterus notopterus and N. chitala are the commercially important food fishes available in the bream zone of the river. In the absence of adequate data on fish catch as well as on fishing effort it is difficult to comment on the present status of the fishery of the river, although the enquiries made with the local fishermen and the fishery officers revealed that the magnitude of the fish catch has been progressively declining in recent years.

Effects of Gandak Barrage on the fishery of the river :

A 838 m long barrage is under construction across the Gandak at Valmikinagar about 300 m downstream of the old Tribeni Canal Head Regulator. This shall be provided with 30 weir bays and 10 under-sluice bays, each 18 m wide. Pond level at R.L. is 110 m and H.F.L. at R.L. will be 112 m.

It has been computed, as per the Gandak Project Report, that the maximum discharge in the Gandak upstream of the barrage at H.F. level of 118.8 m shall be 7,00,000 cusecs and at the super flood level of 112.4 m it shall be of the order of 8,50,000 cusecs. However, according to the Superintending Engineer of the Project at Valmikinagar, the maximum inflow into the barrage area during the monsoon months is about 2 lakh cusecs. The absolute minimum discharge of the river at the lowest gauge of 105 m has been estimated to be about 8,000 cusecs. The 250 km long Eastern Canal takes off from the left bank and shall pass through the districts of Champaran, Muzaffarpur and end in the district of Darbhanga. It will have a head discharge of 14,110 cusecs and shall feed the following canals:

1. Don Branch Canal
2. Nepal Eastern Canal
3. Tribeni Canal
4. Tirhut Canal

The 193 km long Western Canal takes off from the right bank and shall pass through the districts of Gorakhpur and Deoria in U.P. and end in Saran district of Bihar. It shall have a head discharge of 15,800 cusecs during the irrigation season and shall comprise the following canals.

1. Nepal Western Canal
2. Main Western Canal
3. Saran Canal

It is, therefore, evident that during the monsoon season discharge from the barrage into the river downstream shall be of very high magnitude, while there shall be no discharge of water from the barrage into the river downstream during the summer months. As a result of this very little water shall flow through the river and more so during the hot season. As a consequence, for want of sufficient water, most of the river shall become an unsuitable environment for the commercially important food fishes to live, except the deep pools scattered here and there in the bed of the river. Further, it is apprehended that these congregations of food fishes in deep pools shall become vulnerable to catch by the fishermen and may cause further reduction in the population of the food fishes. It is also apprehended that the barrage and other flood control measures may bring about tremendous change in the pattern of silting and thereby annihilate the deep pools in the course of years, as has happened in the Sutlej after the construction of the Bhakra Dam and in the Cauvery after the construction of the Mettur Dam. This would adversely affect the breeding potential of the river and consequently recruitment to the fishery.

Further, the earlier 160 km long embankments constructed from the outfall of the river along the two banks have deprived the river of all the spill area in that region. Now, to intensify the flood control measures, new marginal embankments are being constructed as an extension of the old ones and the existing ones are being strengthened, repaired and their heights increased. This would further reduce the spill area and that too in the lower reaches of the river. This shall deprive the major carps of their breeding grounds in the spill areas of the rivers during the floods. This loss of breeding grounds shall adversely affected recruitment to the riverine fishery, as well as the availability of quality fish seed in the river. Enquiries with the local fishery officer revealed that the quantity of spawn from the Gandak has been going down year after year and so is the major carp content in it.

2.2.2 River Kosi : River Kosi is the other major perennial river of North Bihar and is the third biggest of the Himalayan rivers, being next only to the Indus and the Brahmaputra. It rises in Tibet

and joins the Ganga near Kureela after traversing about 724 km. On its way to the plains it is joined by a number of tributaries on its western side. The catchment area comprises eastern parts of Nepal and Tibet. Below Chatra, the river runs in a sandy alluvial plain, and winds its way southwards into the Ganga through a number of inter-lacing channels. The beds of these channels keep on rising gradually on account of masses of silt and sand which the river brings down in its steep course, so that when the river is swollen by floods, it cuts through the vulnerable banks and seeks new channels in the low-lying fan shaped inland delta. During the last 200 years the river has been changing its course in this manner and has moved westwards by about 129 km, bringing about devastation in its course.

To tame this river in the back ground of human suffering it was decided to construct a barrage at Hanuman Nagar and have flood embankments on either side of the river for a length of 240 km. With the completion of the 1149 m long barrage, provided with 6 left under sluices, 4 right under sluices and 46 spill ways, each 18 m wide, and the embankments in 1963, the Kosi has been robbed of its capacity to inflict damage, either by changing its course or by spilling during the floods. But these flood-control-cum-irrigation measures have affected the fishery of the river disastrously. Firstly, because of no discharge into the river outside of the monsoon season, very little suitable water area is available for the commercially important food fishes to live and grow. Secondly, prior to the construction of the two flood control embankment, the Kosi during floods used to inundate low lying areas, and the mature major carps used to migrate to those areas for breeding and spawn used to flow back into the river during the receding flood. The construction of the two embankments has deprived the Kosi its spill areas, as also the breeding grounds of the carps. As per the enquiries made with the fishermen of the area and the local fishery officers, this has already affected adversely recruitment to the river's fishery, as well as the qualitative and quantitative spawn potentials of the river.

2.2.3 River Kamla : The Kamla rises in Nepal and enters North Bihar just east of Jayanagar in the north and ultimately joins Kosi by various tortuous routes. The river changes its course from year to year and its old beds are found all over the northern parts of Madhubani sub-divisions. The main channels used to flow 16 km east of Madhubani, then 16 km west of it and now it flow

3.2 km east of Madhubani town. To feed the existing Kamla canal a weir was constructed across the river at Jayanagar and for controlling the monsoon flood marginal embankments have been constructed along the two banks. These measures have prevented the discharge of water into the river downstream of the weirs and also the spilling of the river during floods. Though major carps such as L. rohita, C. catla and C. mrigala and minor carps like L. bata and C. reba are available in the fish catches of the river, the fishery officers of the region informed that carp spawn was not available at any spot in the river. This non-availability of carp spawn could be attributed to the loss of breeding grounds consequent to the construction of the protective marginal embankments.

Similar irrigation-cum-flood control measures have been adopted for most of the other rivers of North Bihar and these have not only adversely affected the riverine fisheries, but have also affected the availability of spawn in all the rivers that have thus been harnessed.

Enquiries with the fishermen revealed that prior to the development of irrigation and flood control measures fish catches from the rivers of North Bihar were of higher magnitude as compared to the present annual landings. In earlier years rohu weighing 9-14 Kg., catla ranging from 14-18.5 Kg., and mrigal 9-11 Kg. were common in the landings from these rivers. But, after the development of the river valley projects the riverine fish catches have gone down by about 75%, and amongst the different fishes carps have been affected the most.

Tank and pond fisheries : Tanks and ponds scattered all over North Bihar are another important source of fish. In the district of Darbhanga, there are 7406 tanks with a total water area of about 5,000 ha, while there are 2,391 tanks/ponds with a total water area of about 1,148 ha in the district of Saharsa. But most of them need reclamation to make them suitable for fish culture.

The fish culture practices in vogue in the area are very unscientific, especially in impoundments situated in low lying areas. The ponds are neither manured nor stocked with selective, fast growing herbivorous species of fish having different feeding habits to ensure full utilisation of all the resources of the impoundment. Prior to the construction of protective embankments along the river banks, the ponds located in low lying areas used

to get stocked with fish seed of major carps, minor carps, minnows, catfishes, murrels, etc. during the floods, when the spawn-laden river water used to spill the banks and inundate vast low-lying areas and the fish seed which got stranded in the ponds after the flood waters had receded were allowed to grow in such impoundments for about a year and harvested before the next monsoon season. It is also possible that these spill areas were the breeding grounds of the fishes during floods and a part of the spawn thus produced was left behind in these impoundments. These inundations used to flush the pond and did not permit accumulation of detritus, silt, etc. at the pond bottom. Further, the highly turbid river water helped in controlling the population of all submerged weeds that might have grown in the pond during the preceding year. Production from these ponds, as told by the local fishery officers, ranged between 900 and 2,300 Kg/ha/yr.

After the execution of flood control measures, the rivers have been deprived of their spilling area, with the result that there is no annual flushing of the tanks and ponds. With this, the automatic removal of weeds and the auto-stocking of ponds have also ceased. Further, the tanks are getting silted up, because of the silt that flows in along with the run off from the adjoining catchment area and the accumulation of dead weeds at the bottom. This has not only reduced the water depth in the ponds, but due to heavy accumulation of organic matter at the bottom most of the pond environment has become very unhealthy for the fishes to live and grow. Mass mortality due to summer kill in the hot season is reported to be a common feature.

In the district of Darbhanga, ponds which have become shallow as a result of silting are used for culturing 'Makhna' (Eurghala ferox) and the farmer gets an annual income ranging from Rs. 2500/- to 5000/- per ha with a yield of 'Makhan' ranging between 186-260 Kg.

The ownership of the tanks still vests with landlords and only a few belong to the Government. The Government tanks are leased to fishermen co-operative societies for a maximum period of 3 years for fish culture. The societies in turn sub-lease the tanks/ponds for one year. The sub-leasees, because of the short lease period, do not invest much to improve the ponds, nor do they evince any active interest in enhancing the yield.

3 DISCUSSION

3.1 Effects of river valley projects

From the foregoing account, it is patently clear that the Gandak and Kosi Valley Projects have adversely affected the fisheries of North Bihar to a very significant degree. They have affected not only the fisheries of rivers, mans and chaurs, but indirectly culture fisheries as well, in that spawn production, on which culture fisheries lean heavily, has been drastically reduced due to loss of breeding grounds or inaccessibility to breeding grounds. It has been reported by David (1959) that the minor dhars of the Kosi, spread out in a network over an area of 647 sq. km., "become 'alive' by spilling flood waters of the main Kosi over its banks and serve as the foremost areas where these carps are now found to spawn". He also stated that the Jheels or mans connected with the Burhi Gandak attract fish for spawning and cited the case of Japaha Man in Muzaffarpur district where heavy spawning was reportedly taking place over an area of 10 sq. km. and huge quantities of breeders were being fished. The breeders were continually being replenished from the main river every year. All these depended on the main rivers overflowing their banks on to the connected 'dhars or mana'. But with the commissioning of the river valley projects, the picture changed substantially to harnessing of the water discharge for irrigation purpose and the construction, extension of raising of embankments as flood control measures. During the off-season, there is very little or no discharge at all from the barrages, while even during the rainy season, when the discharge downstream of the barrage along the main river is hardly affected, the river cannot overflow its banks and flood and adjoining breeding grounds in dhars, chaurs and mans due to the high embankments. The excess waters are diverted into irrigation canals, which are also bounded by high embankments. Thus, valuable breeding grounds of major carps have been lost, affecting adversely the fishery as well as the seed resources of these water bodies, as also these of the main rivers themselves.

The reduced or total lack of water discharge into the main rivers below the barrages has also served to eliminate a good number of deep pools which normally harbour the breeders. In the absence of deep pools, the breeder population will be quickly dissipated.

This will further reduce the seed producing potentiality of the rivers. According to the Superintending Engineer, Gandak Project, Valmikinagar, the maximum inflow into the barrage area in Gandak during the monsoon months is about 2 lakh cusecs, while the outflow along the 2 main canals during that period will be about 30,000 cusecs. Therefore, during this period, the flow of the river downstream of the barrage is hardly affected. But during the off-season (15th January to 15th March) when both inflow and outflow amount to about 10,000 cusecs, the barrage shutters would remain closed and the river downstream would be dry over a stretch of about 2 miles. However, sub-soil water and water received earlier during the monsoon months would ensure the presence of water in the deeper lower stretches.

Spawn prospecting investigations carried out by the Central Inland Fisheries Research Institute in collaboration with the Government of Bihar at Khagaria in the lower stretches of R. Burhi Gandak revealed almost the total lack of major carp spawn (Shetty, 1967). This could again be attributed to the high embankments on either side preventing the breeders from reaching their breeding grounds. Subsequent investigation carried out by the Bihar Directorate of Fisheries in the same river has served to confirm the above findings (Banerji, 1970).

3.2 Destruction of fry and fingerlings

Intensive fishing of fry and fingerlings of major carps for consumption, and not for stocking is carried out in the tributaries, the chaurs and the nalas flowing into or out of the mans. This reduces drastically the recruitment of major carps into the mans, the main rivers and their tributaries. Fishing for fry and fingerlings is usually carried out with the aid of fixed engines.

3.3 Erection of barriers ('bundhs') across inflow and outflow nalas

As reported above under section 2.1, at a number of places, local farmers have put up barricades in the form of bundhs of sluice gates across several nalas flowing into or out of the nalas, to meet their irrigational needs. Where otherwise there might have been free access of River water, along with breeders or seed, into the mans, these obstructions have served to cut off the connection with the result the fisheries in the concerned mans have progressively declined.

3.4 Effect of stagnant conditions due to lack of flushing

In earlier years when there used to be regular inflow into and outflow out of the mans, the condition of the water could never become stagnant and whatever floating weeds developed used to be pushed out of the mans. But with the almost complete cessation to inflow and outflow in the case of several mans, their waters have become stagnant and unsuitable for major carps, and large portions are choked with weeds like water hyacinth. In such waters, only 'live' fishes were found to thrive.

4 RECOMMENDATIONS

Considering the diverse facts stated above, the following recommendations have been formulated towards developing the fisheries and fish seed resources of North Bihar.

4.1 Conservation of riverine fisheries

4.1.1 Declaration of deep pools as sanctuaries

In view of the reduced discharge during the off-season from the barrage exposing vast areas of river-bed and restricting the number of deep pools where breeders could take shelter, it is necessary to declare the deep pools in such areas as sanctuaries, where fishing should be strictly forbidden for at least a couple of months before the onset of the breeding season.

4.1.2 Stocking of depleted river stretches

Where the damage has already been done, it is desirable to stock such depleted river stretches with requisite number of major carp fingerlings collected from elsewhere or raised in fish farms. Apart from adding to the fishery of the river, this will also serve to build up the breeder population, which will be useful in river stretches where access to breeding grounds is not yet lost.

4.1.3 Conversion of old river beds and shallow mans into fish farms

The large number of shallow old river beds in the Kosi basin and some of the shallow silted up mana can be usefully converted into fish farms, which should cost less than the construction of farms on plain land. Such conversion of extensive water areas for fish culture should go a long way in utilising the enormous seed resources of the State.

4.1.4 Induction of bundh-breeding

It is difficult to retrieve most of the lost major carp breeding grounds. With the increasing accent on agriculture, the embankments are likely to be strengthened and extended further. In order to make up for this heavy loss, it is recommended that the State take up on a priority basis the introduction of bundh breeding of major carps in suitable areas. As it is, bundh-breeding is reported in some parts of Bihar, even though no detailed observations appear to have been made so far in this regard. Low-lying gently sloping areas near chaurs, where there is normally an onrush of flood waters every season, may be chosen for this purpose. Another alternative is to divert irrigation canal or river water or catchment run-off to suitable areas where dry bundhs can be constructed on the pattern of those in Madhya Pradesh. The rich experience of Government of Madhya Pradesh in the construction and operation of dry bundhs can be drawn upon in this connection.

4.1.5 Location of spawning grounds and retrieval of eggs and spawn

A systematic examination of all chaurs and māns must be undertaken during the monsoon months to ascertain the occurrence of major carp breeding in them. Where breeding does take place - it is already known to be taking place in some - it is highly necessary to retrieve the eggs and spawn and rear them up to fingerling stage in fish farms, in order to ensure better survival. Seed thus obtained can be used for stocking the same and other waters. Necessary steps should also be taken to conserve the breeders in māns where breeding is taking place.

4.1.5 Removal of obstructions across inflow and outflow nalas

The erection of obstructions in the form of bundhs or sluices across the inflow and outflow nalas of several māns has seriously restricted the ingress of breeders or seed into the māns, resulting in the gradual but certain decline of their fisheries. This can be overcome by the removal of such bundhs, and the opening of sluices at least for a few days when fish seed abound in the inflow channel. In Kharwa chaur and Mjharia Man where floosing continues as before, the fishery has not in anyway declined. Therefore, wherever possible, connections with rivers should be maintained by the removal or regulation of obstructions. The connection could also be provided through the irrigation canals at least during the monsoon months, when the canal water is not required for

irrigation purposes. The maintenance of a regular inflow will, apart from bringing in fish seed, also serve to flush the mans, which would help in avoiding stagnant conditions and accumulation of weeds, as has happened in Motijheel Man. The proposed connection of Motijheel Man to an irrigation canal should go a long way in rehabilitating that man.

4.1.7 Prevention of destruction of fish seed

The large scale wanton destruction of fry and fingerlings of major carps, referred to under Section 2.1, should be prohibited by legislation in order to conserve the valuable seed. Such fishing should be allowed only for stocking purposes. The present destruction has been possible to a large extent for the decline in the fisheries of several mana.

4.1.8 Stocking of suitable mana

It has been found that most of the mana are fertile and can, therefore, support a good population of fish. Most of the mans which have been stocked by Fisheries Department have yielded good results in that the major carps have shown excellent growth. Specially in the context of little or complete lack of auto-stocking in most of the mana, it becomes impetive to stock rationally all the suitable mana with major carp fingerlings. To start with, it is necessary to make at least a rough appraisal of food resources of the water body for deciding on the species to be stocked and their relative numbers. In cases where heavy capital investment is involved in improving the habitat or in reclaiming the man, 'live' fish culture may be restored to instead of major carp stocking.

4.1.9 Weed control

In order to improve the habitat for fish growth and to facilitate fishing operations, it is necessary to eradicate obnoxious weeds wherever they occur in otherwise fertile mans, ponds and tanks. Grass carp can be introduced to control submerged weeds, while manual or mechanical-cum-chemical methods be adopted to eradicate marginal and floating weeds. Regular inflow and out-flow of water will also serve to push out some of the floating weeds.

4.1.10 Prevention of water pollution

The pollution of Motijheel by untreated town sewage and sugar mill effluents should be prevented forthwith, lest the

entire man should become uninhabitable to fishes.

4.1.11 Provision arrangement for flood waters to reach mans and chauras bypassing irrigation canals.

According to the Superintending Engineer, Gandak Project, the irrigation canals of Gandak Project will not come in the way of natural flood waters flowing towards chauras and mana, since provision would be made for such waters to bypass the obstruction of the canal embankments by constructing a channel across the irrigation canal below its bed level. One such construction was seen during the survey in Champaran District. It is recommended that such arrangements be provided at all important points.

4.1.12 Reclamation of derelict ponds and tanks

Efforts must be made to reclaim as many as possible of the derelict ponds and tanks in the eastern districts of North Bihar for bringing them under major carp culture. Where the capital investment involved is too high, such waters may be profitably used for 'live' fish culture.

4.1.13 Procurement of fish seed

The seed of major carps required for stocking the various waters may be collected from the rivers, mans and chauras of the area, or brought from the Ganga centres. This can be further supplemented by producing quality seed by induced breeding through hypophysation. A few induced breeding centres may be set up in each district.

4.1.14 Utilisation of the abandoned stretch of Triveni canal for fish culture

The State Government had desired the preparation of an immediate interim report on the possible utilisation of the 3.6 km long abandoned stretch of Triveni canal for fish culture. The report given thereon is appended to this report (Appendix-I).

4.1.15 Utilisation of irrigation canals for fish production

Apart from drawing water for mans, chauras or bundhs, the vast network of irrigation canals can also be made use of for stocking fish fingerlings in them towards increasing fish production in the area. In some countries of the Far East, fantastic fish productions have been obtained in running water fish culture and cage culture. While most of the canals are not deep enough for cage culture, it is worthwhile exploring the possibility of establishing

running water culture in the area, making use of the constant supply of running water from the canals.

4.1.16 Transfer of waters to Fisheries Department for development

As yet only a few of the water bodies have been transferred to the Fisheries Department for development. Most of the waters still vest with the Revenue Department. It is needless to state that practically nothing is done towards developing the fisheries of such waters. It is, therefore, urgently necessary to transfer all water bodies to the Department of Fisheries for their fisheries development and management. After taking over the waters, even if they are leased out to private parties for exploitation, the Department should itself evolve the stocking policy and effect stocking. While leasing out, it may also be advantageous to lease out the man and the connected inflow and outflow channels to the same party, so that the incoming seed are not want only destroyed and auto-stocking of the man is assured.

5. ACKNOWLEDGEMENTS

A large number of officers of the Directorate of Fisheries helped in various ways in the conduct of the field survey. The authors are thankful for all their help. The authors are highly grateful to Shri H.N. Thakur, Chairman, Bihar State Electricity Board and former Development Commissioner of Bihar, at whose instance this survey was undertaken, for his stimulating discussions, useful advice and kind help. They are also indebted to Shri S.S. Madhi, I.A.S. the then Director of Fisheries for providing all the facilities and for his very keen and inspiring interest in these investigations. Dr. P.S. Prasad, Dy. Director of Fisheries (Research) accompanied the central party through----- out the survey and was a steady source of help with his keen interest in the work. The authors are thankful to him and also to Sarvashri S. Sharma, Dy. Director of Fisheries, B.N. Prasad, A.F.D.O., R.B. Singh, A.F.D.O., R.C. Srivastava, F.D.O. and Saxena, A.R.O. for useful discussions and help. The stimulating discussions the authors had with Shri Ganguli, Regl. Devt. Officer, Muzaffarpur, Shri Sriballabh Saran, D.M. Champaran and Shri Jaishankar Thakur, S.E. Gandak Project, Valmikinagar are also thankfully acknowledged here. Lastly, the authors owe a great deal to the guidance and inspiration of Dr. V.G. Jhingran, Director, Central Inland Fisheries Research Institute, Barrackpore.

6. REFERENCES

- (1) Banerji, S.R. (1970) - "A note on the quality of fish spawn collected from the river Burhi Gandak in North Bihar". Sci. & Cult., 36 (6) : 337 - 339.
- (2) David, A. (1959) - "Observations on some spawning grounds of the Gangetic major carps with a note on carp seed resources in India". Indian J. Fish., 6 (2) : 327 - 341
- (3) Shetty, H.P.C. (1967) - "Report on fish spawn investigations, 1966. 3. Bihar, Uttar Pradesh and Punjab". Bull. cent. Int. Fish. Res. Inst., Barrackpore 11 : 80 p.

APPENDIX-IA REPORT ON THE UTILISATION OF THE ABANDONED STRETCH OF TRIVENI CANAL IN CHAMPARAN DISTRICT, BIHAR, FOR FISH CULTURE

During a recent survey of māns and chāurs in the districts of Muzaffarpur and Champaran, undertaken on the request of the Government of Bihar from 24.2.69 to 4.3.69, the necessity for examination the possibility of utilising the abandoned stretch of the old Triveni Canal was pointed out by several State Government Officers, Viz. Shri H.N. Thakur, Chairman, Bihar State Electricity Board; Shri S.S. Madhi, Director of Fisheries; Shri S. Sharma, F.D.O.; Shri Sriballabh Saran, Dist. Magistrate, Champaran and Shri R.C. Srivastava, D.F.O., Champaran. The concerned area was, therefore, surveyed by the undersigned and his colleague Shri J.C. Malhotra, F.S., accompanied by Dr. P.S. Prasad, Fisheries Research Officer and Shri R.C. Srivastava, D.F.O., Champaran.

The old Triveni Canal takes its origin about 500 meters upstream of the Gandak barrage under construction of Valmikinagar. This canal had no headworks, and water used to be drawn into it through gravity only, the canal bed being at a lower elevation than the water level in the river. This was the main irrigation canal from R. Gandak. With the construction of the barrage about 500 m downstream of the starting point of this canal, the latter has now become obsolete, and a new link canal has been constructed just above the barrage. This link canal joins the old Triveni canal at a point about 3.6 km from the point of origin of the latter. After this confluence, the old canal continues as before. Because of this link canal, the 3.6 km stretch of the old canal has become superfluous to the irrigation authorities, who, however, are readily agreeable to pass it on to the Fisheries Deptt., for purpose of fisheries development work.

The concerned stretch of the canal has an average width of about 30 m. The water is clear and weed free, while the canal bottom is gravelly. Two torrential seasonal nalas flow into the canal from the catchment area east of the canal. The first nala, the Bisha Hala, joins the canal at a point about 2 km from the point of origin of the canal. The discharge from this nala is reported to be about 600 cusecs during the monsoon months.

The second nala, the Rohuva Nala, joins the canal a little before the confluence of the old canal with the link canal. The discharge of this nala is reported to be about 200 cusecs during the monsoon. The Done Canal, a branch from the link canal going to Nepal overflies the abandoned stretch of the old canal in between the two nalas.

The problem posed by the State Government officials consisted of the following:

- 1 Can this stretch of the canal be utilised to advantages for fish culture ?
- 2 Both the inflowing nalas are highly torrential, bringing in lot of tree stumps and even boulders; as such it is not possible to put any barrier at the points of their entry into the canal. On the other hands if barriers are not erected, the stocked fishes are likely to escape out of the canal into the nalas. What measures could be taken for solving these difficulties ?

It is to be stated that the concerned stretch of the canal offers an excellent source of water for fish culture, since the irrigation authorities have reportedly offered to maintain the desired level of water in this stretch and are prepared to construct at the point of confluence of the link canal the necessary bund with suitable provision for ingress of water for maintaining the desired level.

The water body being not very extensive, its productivity can easily be raised through manuring of the water and artificial feeding of the fishes, if necessary. For efficient management, however, it is always advantageous to have small bodies of water. It may, therefore, naturally suggest itself that the canal should be sub-divided into a series of ponds. This is not easily practicable in the present case, partly because of the influowing of two torrential streams and partly due to the difficulty in maintaining the water level inside individual ponds after they are bounded off from each other. Further, this involves additional expensiture on the construction of bunds. Ordinary earthen bunds if constructed anywhere below the Bisha Nala (the 1st nala) are unlikely to withstand the torrential flow from one or both the nalas. However above the Bisha Nala, bunds, if constructed, will not besubjected to any severe stress, and as such can easily hold. The only problem will be to get sufficient water from the lower part of the canal. Since, however, the supply of sufficient quantity of water from the point of confluence of the link canal is reportedly assured

from the irrigation authorities, the above difficulty can be overcome by either installing sluice gates or hume pipes in the partition bunds. The partitioning off of at least a portion of the canal will facilitate differential culture of different combinations of species, whenever necessary, and for effective manuring and artificial feedings, specially when sufficient funds may not be available for treating the entire stretch of the canal. The partitioning of the canal will also make netting operations much easier.

It is, therefore, suggested that the stretch of the canal above the Bisha Nala may be partitioned into five sections. This stretch is not subjected to the torrential inflow from the nalas, and ordinary earthen bunds should suffice. If there are not nursery facilities nearby, as appears to be the case, one of the sections, preferably the uppermost section, may be further subdivided into a number of nurseries, wherein the spawn can be reared up to fingerlings or at least fry stage, before they are stocked in the remaining portion of the canal. Even though there appears to be no indigenous predator population in the canal at present, the waters that will be taken in from the link canal are likely to bring in some predatory fishes. As such, it is not advisable to straightway stock spawn in the entire canal.

In case partitioning of this stretch of the canal is not found feasible due to some reason or the other, at least one wire screen partition may be installed across the canal just above the point of inflow of the Bisha Nala. That will serve to keep the fishes in this major stretch from ascending up the nalas or even going out of the canal along with flood waters brought in by the nalas. A number of such wire screens can also be utilised to partition this stretch. However, this will not facilitate differential culture operations, if desired since the water will still be one continuous body. The stretch of the canal below the Bisha Nala cannot be partitioned effectively. However, it can still be used for fish culture, since the nalas are only seasonal and the torrential flow and flooding cease with the closure of the monsoon. The chances of escape of the fishes up the nalas, as feared by some of the departmental officers, are not really much, since the streams are only seasonal and pretty steep too. Even if the fishes ascend the nalas, they are bound to come back to the canal with the receding water, unless they are slaughtered by people in the shallower parts of the nalas, which, however is unlikely since the area appears to be unpopulated. Further, there is the possibility of mature fishes breeding in the nalas or their adjoining flooded areas. This will lead to auto-stocking of the canal.

If sufficient funds will be available for the project, this lower stretch of the nala also be partitioned; but the partition bunds will have to be of concrete. They should either be provided with sluices or kept sufficiently low for the flood water from the nalas to overflow easily, without damaging the side embankments. Similarly, the bund at the lowermost end of the canal will have to be strong structure, with suitable arrangement for allowing the escape of flood waters and the ingress of water from the link canal. It is presumed that the irrigation authorities will provide the necessary suitable structure at this end.

In case construction of concrete bunds is not feasible, three or four wire screens may be installed in this stretch during fair weather only to facilitate differential stocking and also fishing operations. In order to prevent the escape of fishes from this stretch along with flood waters during monsoon, it is desirable to transfer as many of the fishes as possible to the partitioned portion of the canal above the Bisha Nala. They can be retransferred to the lower stretch after the monsoon season.

The piers of the road bridge across the canal will partly serve to arrest the branches of trees, etc. floating down the canal during the rains. They can be made more effective by tying bamboo poles to them at right angles to the course of the canal. The branches, etc. accumulating at this point should be periodically removed in order to ensure smooth flow of water. A floating bamboo bridge, secured at its two ends on the embankments, can also be installed lower down for further arresting of floating branches, etc.

The water of the canal at the time of the survey did not appear to be rich in plankton. However, filamentous algae were observed in appreciable quantities at several spots. It is necessary to improve the quality of water through manuring, using both organic and inorganic fertilisers, with suitable dosages of time. While manuring of the upper stretch above the Bisha Nala may be undertaken before the outbreak of monsoon, in May or early June, that of the lower stretch should be taken up only after the rains, are over as otherwise the fish feeding with mustard oil cake and rice bran may be resorted to, if felt necessary. Rohu (Labeo rohita), mrigal (Cirrhina mrigala) and Kalbasu (Labeo calbasu) appear to be most suitable for stocking in this canal. After it has been possible to raise the level of plankton production in this water, catla (Catla catla) and silver carp (Hypophthalmichthys molitrix) may also be introduced. The possibility of culturing mirror carp (Cirrhinus carpio var. specularis) is also worth trying.