Government of the People's Republic of Bangladesh

Ministry of Irrigation, Water Development and Flood Control
Flood Plan Coordination Organization

BANGLADESH ACTION PLAN FOR FLOOD CONTROL

COMPARTMENTALIZATION PILOT PROJECT (FAP 20)

SIRAJGANJ CPP INTERIM REPORT

ANNEX 5: FISHERIES AND AQUACULTURE

(FINAL DRAFT)

June 1993

Euroconsult/Lahmeyer International/Bangladesh Engineering & Technological Services/House of Consultants

under assignment to

DIRECTORAAT GENERAAL INTERNATIONALE SAMENWERKING
Government of the Netherlands

and

KREDITANSTALT FÜR WIEDERAUFBAU
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iii GLOSSARY

BBS	Bangladesh Bureau of Statistics
BFRSS	Bangladesh Fisheries Resources System
DOF	Department of Fisheries
CPP	Compartmentalization Pilot Project or FAP 20
FAP	Flood Action Plan
FCD/I	Flood Control Drainage and Irrigation
GOB	Government of Bangladesh
GPV	Gross Product Value
HA	Hectares
HH	Households
HYV	High Yielding Variety
Jalmahal	A leased water body or river stretch
KG	Kilogram
MDSC	Multi Disciplinary Sub-Compartment Survey
MPO	Master Plan Organisation
NGO	Non Governmental Organisation
SEM	Standard Error of the Mean
SPP	Species
T	Ton
TK	Thaka

iv SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

The fish species in Bangladesh can be divided in two major groups when their reproductive behaviour is taken into account:

River fish, such as the major carps, are spawning upstreams in the major rivers at the beginning of the rainy season. the eggs and hatchlings of this group of fish flow with the water current downstream, finally entering the floodplain where they find the nutrients for growth. This group of fish migrate back to the river as soon as the water recedes from the floodplain.

Beel fish, such as snakeheads, catfish etc are living in the beels. They reproduce in the pre-monsoon as the water level start rising. Nursing takes place in the inundated floodplain. With the receding waters this group migrates back or get trapped in the low lying beels

The difference in reproductive strategies is taken as a key point of attention once water management option are discussed.

The Bangladesh Fisheries Resources Survey System indicate that inland captured fisheries declined with approximately 44,000 ton/year during the period 1983-1989. Within the same period the inland aquaculture output of Bangladesh increased with 48,000 ton/year, mainly due to the "silver revolution" or the rearing of silver carps. The at present production of 1000 kg/ha/year obtained from managed ponds could be increased to 2000 kg/ha/year through the improvement of the culture methods used in the rural area's. It would give a maximum aquaculture output of 100,000 ton/year which indicates that mitigation of inland fish losses through aquaculture is limited.

The declining trend of inland captured fisheries is even more dramatic in the Sirajganj district where the production decreased with more as 50% from 31,000 ton/year in 1983 to 14,000 ton/year in 1990 and where 80 % of the production consists of miscellaneous species which is twice as the percentage for the whole of Bangladesh.

The main reasons for the decline in fisheries output of the Sirajganj district are:

* Blockage of migration routes of riverine fish species by the construction of the BRE.
* The complete disappearance of the floodplain which served as breeding and nursing area for both river and beel fish
* The increased fishing intensity
* The massive capture of fry for Aquaculture purposes
* The increased use of agro-chemicals
* Epizootic Ulcerative Syndrome a disease which attacks especially Beel fish and which has spread over South East Asia in the last decade.

Fishing activities in the project area can be divided in:

professional fishermen, their main occupation is fishing throughout the year and the number in the CPP area is estimated at 800.

Occasional or part time fishermen, these fishermen have next to fishing an alternative occupation. Their number has been estimated at 50 within the CPP area.

Subsistence Fishermen, subsistence fisheries is mainly done for home consumption and is almost absent within the CPP area. The Household Survey estimated their number at 2000 Households (3%-10%). The main reason for the almost non existence is the fact that "wetlands" were converted to "dry lands" due to the construction of the BRE and consequently the common property resources, needed for this activity, disappeared almost completely.

A survey indicated the existence of approximately 300 ponds covering on the average an area of 0.3 Ha. The estimate production level of 700 kg/ha/year is rather low and is caused by the used culture methods and the sandy texture of the soils. Total aquaculture output of the CPP area is estimated at 70 t/year.

The combined output of fisheries and aquaculture is estimated at 383 ton/year for the season 1992/93 and the distribution over the different habitats and fishermen is presented below.

HABITAT	PRODUCTION OF FISHERMEN (T/YEAR)			TOTAL
	PROF	OCCAS	SUBSIS	
RIVER	244	2	5	251
FLOODPLAIN & KHAL	27	3	1	31
BEEL	11	1	0	12
PITS	18	1	0	19
AQUACULTURE				70
TOTAL	300	7	6	383

The estimated production of 383 t/year means that the per capita availability of fish for the CPP area will be 1.3 kg/year, almost 6 times lower as the average availability of 7.6 kg/year for the whole of Bangladesh which indicates that probably substantial amounts of fish are obtained from outside the project area.

It is realized that agriculture and fisheries are in principle conflicting systems when water requirements are concerned. Serving agriculture as well as fisheries requirements can only be achieved when compromises are made. Two factors negatively effects the natural fish stocks:

* Drainage of rainwater congestion around the Beel in the pre and post monsoon in order to secure the crops of the low land farmers hampers the reproduction of "Beel" fish.

* Reduction of the inundated floodplain area by embankments, drainage in the monsoon and post monsoon and subcompartment water management reduces the total available nursing of grow out area for both "River" and "BeeL" fish.

Within the Sirajganj CPP area only the first effect is of major importance, the second effect took already place several years ago when the BRE was constructed.

Within the options as proposed for the CPP project the construction of several water inlet structures are included. The structures would be serve agriculture, fisheries and the urban area's. The last decades within the designing and operation of water structures the balance was almost always in favor of agriculture production systems. The following main design criteria must are formulated for more or less "fish friendly" structures:

* Free surface flow of water through the regulator
* Structures open during the first 4-5 weeks when the flood arrives, normally the period mid June - mid July.
* Water velocities not exceeding 1.5 m/sec.

In order to access the impact on fisheries of the different proposed options proposed by the FAP 20 team, a three step analyses which was developed for the Tangail CPP project was modified and used. The hydrographs from the hydrological model were linked with a fisheries production model. The season 1992/1993 is considered to be comparable with the without case, a stable BRE and no CPP, as within this season the flood was completely absent. Therefore calibration of the fisheries model was done on the without case with hydrological data (1 in 5 year) and the fisheries production of 1992/1993. The predicted total fish production under each option was subsequently subdivided species wide in order to create a differentiation in fish prices.

The "fisheries" model does not take into account the "new situation" of hatchling migration through the constructed regulators. However an attempt have been made to quantify this effect using production levels on a hectare bases and assuming several hydrological, technical and biological parameters and therefore the outcome is used as an indicator only

A summary of the impact assessment for the different options is presented below

OPTION	TOTAL FISH PRODUCTION T/YEAR	INCREMENTAL PRODUCTION T/YEAR	TOTAL VALUE (US$/YEAR)	DECREMENTAL VALUE (US$/YEAR)
Present situation, breaching of BRE	591	+209	616.000	+193.000
Without case, stable BRE & no CPP	382	-	423.000	
Option 1	401	+19	442.000	+19.000
Option 2A	379	-3	420.000	-3.000
Option 2B	364	-18	408.000	-34.000

Options 2A and 2B have a negative impact on fisheries as the total production decreases with respectively 3 and 18 t/year. The reduction of the production under option 2B is mainly caused by the embankment along the Ichamati floodplain which converts 1000 ha of floodplain into a sealed of area. The production under option 1 will increases with 19 t/year Incremental production, under option 1, takes place in the group of "beel' fish, mainly due to an increased inundation of the beel area in the pre monsoon and it discussed if this is not in conflict with the proposed drainage measures.

All options have a negative impact on fisheries production within the CPP-area when compared with the at present situation with breaches in the BRE but this should be considered an artificial situation.

Within the impact analyses the data are presented in tons/year or on a financial basis. It should however be realized that the major part of the losses consists of small and miscellaneous fish, the source of nutrition of poor households.

The impact of the BRE water inlet structures, as presented below indicates that there will be a positive effect on fisheries. It would lessen the negative impact for option 2A and 2B a little, it has however the same relative effect on option 1, which therefore remains the best of the proposed options from a fisheries point of view.

	WITH OUT CASE	OPTION 1	OPTION 2A	OPTION 2B	BRE WITH BREACH
AREA INUNDATED (ha)	2,100	2,297	2,233	2,233	8,670
VOLUME (million m^3)	31.5	34.5	33.5	33.5	130.1
MAX INCREMENTAL PRODUCTION (t/year)	21	23	22.3	22.3	86.7
% RIVER WATER	0	75	75	75	100
TOTAL INCREMENTAL PRODUCTION (t/year)	**0**	**17.3**	**17.3**	**17.3**	**86.7**

1. GENERAL INTRODUCTION

Bangladesh, situated in the delta of three large rivers and their tributaries, the Brahmaputra (Jamuna), the Ganges (Padma) and the Meghna, drains a huge catchment area outside the country, as well as the total surface of the country itself (142 000 km^2). The watersheds of these three river systems receive an average annual rainfall of 210 cm, 140 cm and 400 cm respectively. This rainfall combined with the snow-melt over the Himalayas generates a yearly runoff of approximately 1.5 million cubic meters. However the topography of the country does not allow an easy drainage of these quantities and consequently 30-40% of its area is flooded with nutrient rich water for almost six month a year.

Within the national context the annual fish production of approximately 840.000 mt plays an important role in the economy of Bangladesh. The sector accounts for 3% of GDP, 11 % of export earnings and 70% of the animal protein intake of its population. Inland fisheries and aquaculture are the major contributors of fish covering respectively 50% and 22% of the total production (BBS, 1989).

The scope of the fisheries component in the Compartmentalization Pilot Project (CPP-project) is to increase the availability of fish by securing fisheries production and by improving aquaculture. It is realised that this aim can only be attained with a thorough understanding of: the fish, the fishermen, their behaviour and habitats. The objective of the fisheries study for the Sirajganj CPP project area was to gather data on the existing fisheries situation, to analyses the impact of different proposed development option and to formulate mitigation measures for eventual negative impacts. The results of the study are presented in this report and a detailed mitigation plan will be finalized in the fourth quarter of 1993.

Traditionally, the term "**Fisheries**" is considered to encompass both aquaculture and captive fisheries. However, the technical natures of these two activities are completely different. Aquaculture has a "culture" pattern while captive fisheries has a "hunting" one. This difference must be taken into account when development options are formulated. For captive fisheries a management strategy should be developed in order to profit maximally from the existing fish stocks without destroying them (sustainable yielding). Aquaculture is more like farming and aims principally at optimum economic output. Within this context, the word **fisheries** will refer to captive fisheries only in this report.

2 FISHERIES RESOURCES IN BANGLADESH

Fish resources of Bangladesh can be divided in three categories each with its own subdivision:

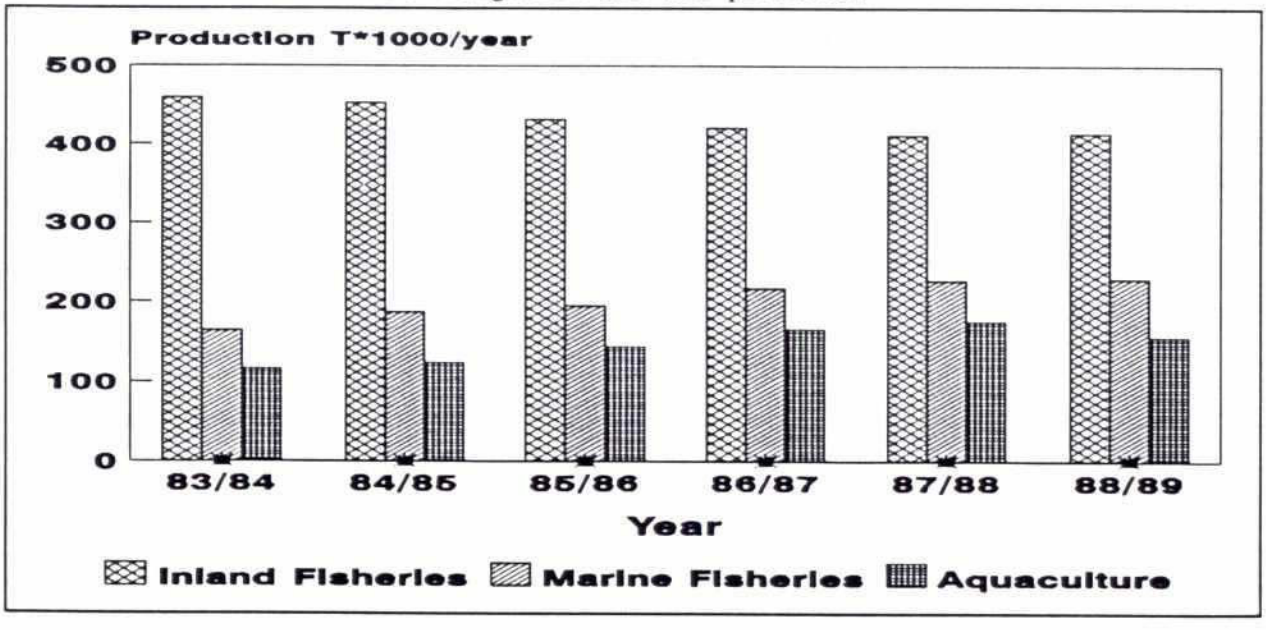
(a) Marine Fisheries
  1 Industrial trawling
  2 Artinisal fisheries

(b) Inland Fisheries
  1 River fisheries
  2 Floodplain fisheries
  3 Beel fisheries

(c) Aquaculture
  1 Fresh water pond culture
  2 Culture based fisheries in Boars
  3 Shrimp and Prawn culture

The production performance of the three categories is given in Figure 1. (BFRSS, 1983/90) The data show that the overall production of marine fisheries and aquaculture increased and that the overall production of inland fisheries decreased within the last decade.

FIGURE 1: Fish resources of Bangladesh and their production



3. BIOLOGICAL CHARACTERISTICS OF FISH COMMUNITIES IN BANGLADESH

A Hydrology and its impact on nutrients and water quality

The seasonal variations of flow in the rivers and the congestion of water in the depressions of the floodplain are the main factors influencing the behaviour of fish communities in Bangladesh.

The hydrology of the floodplain and rivers of Bangladesh can be divided in four periods each with its own characteristics:

(a) Pre-monsoon: The water level in the rivers and depression areas (beels) of the floodplain raises due to the early rains. The rising water invades the nearby plains and organic and inorganic matter lying on the plains enters solution, providing the nutrients needed for biological production.

(b) The monsoon: The continuous rainfall and the influx of water in the upper catchment areas saturates the main channels, the water continues to rise and eventually spills over through a system of channels inundating the floodplain and the low lying depression areas completely. Debris of animal and vegetal origin starts rotting and the availability of nutrients in the water increases rapidly.

(c) Receding waters: At the onset of the dry season the water in the floodplain start to flow back in the main channels. Gradually the floodplain dries up and the low lying "beels" and "pagars" are cut off again from the main river systems.

(d) The dry season: Within the dry season the evaporation and drainage of water exceeds the influx of water. As a result the water level in the rivers and permanent water bodies of the floodplain decreases.

B The behaviour of fish communities

Two main factors influence the behaviour of fish communities in Bangladesh.

(a) The nutrient influx during the pre-monsoon and monsoon provides favourable breeding, feeding and nursery areas for the most species of fish.

(b) The increasing harshness of the environment of the permanent water bodies of the floodplain during the dry season.

On the basis of their behaviour, mainly related to migration and reproduction, the fish species of Bangladesh can be divided into three groups:

(a) The so-called "**white fish**" migrate upstream and laterally to the inundated oxbow lakes and embankments adjacent to the river channel in the late dry season or early rainy season in order to spawn in the quiet sheltered and nutrient rich waters. The eggs and new born larvae of these species are transported passively by the flood into the floodplain area, where they feed on the developed plankton. At the end of the rainy season, the adults and young of the year escape to the main channel in order to avoid the harsh conditions of the floodplain during the dry season. "White" fish belong mainly to: Cyprinidae and Pangasidae, (Mrigal, Rui, Catla, Pangash, etc). Further in this report this group will be referred as "**river fish**".

(b) The so-called "**black fish**" are mainly omnivorous/carnivorous bottom dwellers, They reproduce at the onset of the pre-monsoon as the water level in the "beels" starts rising due to the congestion of rain water. They general have complex breeding pattern with multiple spawning, a great degree of parental care and migrate only laterally. At the end of the rainy season the young of the year and adults migrate back to, or get trapped in the low lying "beels" where they can survive the harsh conditions of these permanent water bodies during the dry season. They are adapted to resist low dissolved oxygen concentration and high water temperatures. The main adaptation is their auxiliary respiratory organ used for the uptake of atmospheric oxygen. The main species of the "black" fish are belonging to the Clariidea (Magur), Ophiocephalidea (Taki, Shol) and Anabantidae (Koi,Kholisha). Further in this report this group will be referred to as "**beel fish**".

4. FISH CONSUMPTION

A Bangladesh

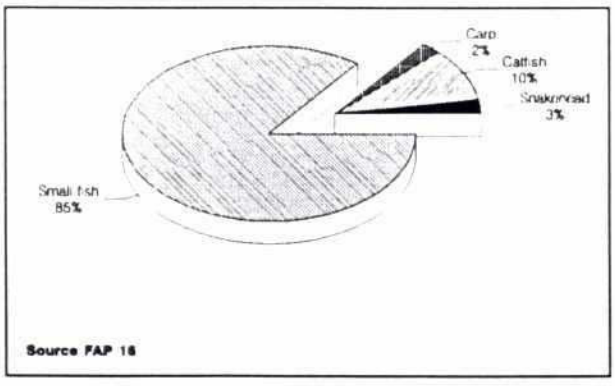
The data on availability of fish or consumption of fish for Bangladesh are not uniform. The annual per capita availability of fish decreases from 8.1 kg in 1975 to 7.6 kg in 1989 when only the total fish production and the population is taken into account. According to the results of the Household Expenditure Surveys the average annual per capita intake of protein increased from 9.8 kg in 1974 to 13 kg in 1986. This discrepancy could be explained by an underestimation of the fish catches, especially the subsistence catches, by DOF. It is expected that the importance of the subsistence catches within the rural areas would be reflected by a difference in per capita consumption between the rural and urban poorest groups. However as Table 1 indicates this is not the case.

TABLE 1: The relation between household income and per capita fish consumption in 1985/86

Monthly Household Income Group (Tk)	Annual per Capita Fish consumption Rural (kg)	Urban (kg)
< 500	4.36	4.82
1.000 - 1.250	8.51	10.31
2.000 - 2.499	12.88	14.00
4.000 - 4.999	15.46	18.02
>8000	21.70	22.06

Source: World Bank, Fisheries Sector Review, 1991.

FIGURE 2: Consumption of fish by groups in percentage of meals



The results of a preliminary household consumption survey of fish, rendered by FAP 16 in several districts of Bangladesh indicated the importance of the so called "small" fish (see Figure 2). The same study indicated that 62 % of the fish consumed was caught and 35% was bought.

B Sirajganj CPP project area

The total fish production of the Sirajganj project area has been estimated at 383 t/year (BRE & No CPP, see Chapter 8). With a population of 292,000 within the CPP project area, this production gives an annual per capita availability of **1.3 kg** only. This figure should be regarded within its perspectives (see Chapter 5). The Sirajganj district (old Pabna district) belongs to the group of "low" inland fish and produces approximately 2% of the total inland fish production. The major reason is the BRE which seals of the Jamuna river and consequently flood and the migration larvae and adult fish are sealed of also.

5 INLAND FISHERIES STATISTICS

A Bangladesh

The total inland fish production obtained through fisheries has remained stable within the last decade as can be seen in Figure 3. This overall figure could be soothing but unfortunately the "fisheries" reality, when looked upon in detail, gives a warning.
The annual fisheries production from rivers, floodplain and beels declined with 44.000 T during the period 1983-1989. Within the same period the aquaculture output of Bangladesh increased with 48.000 t.

FIGURE 3: Freshwater fish production of Bangladesh in tons/year

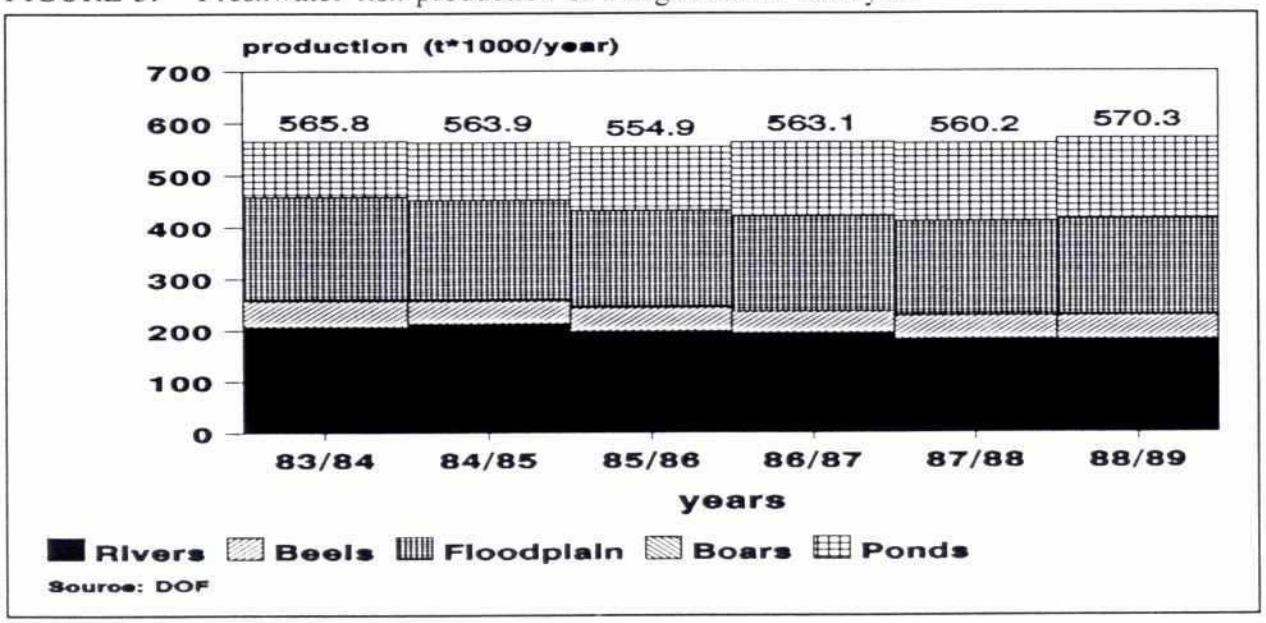
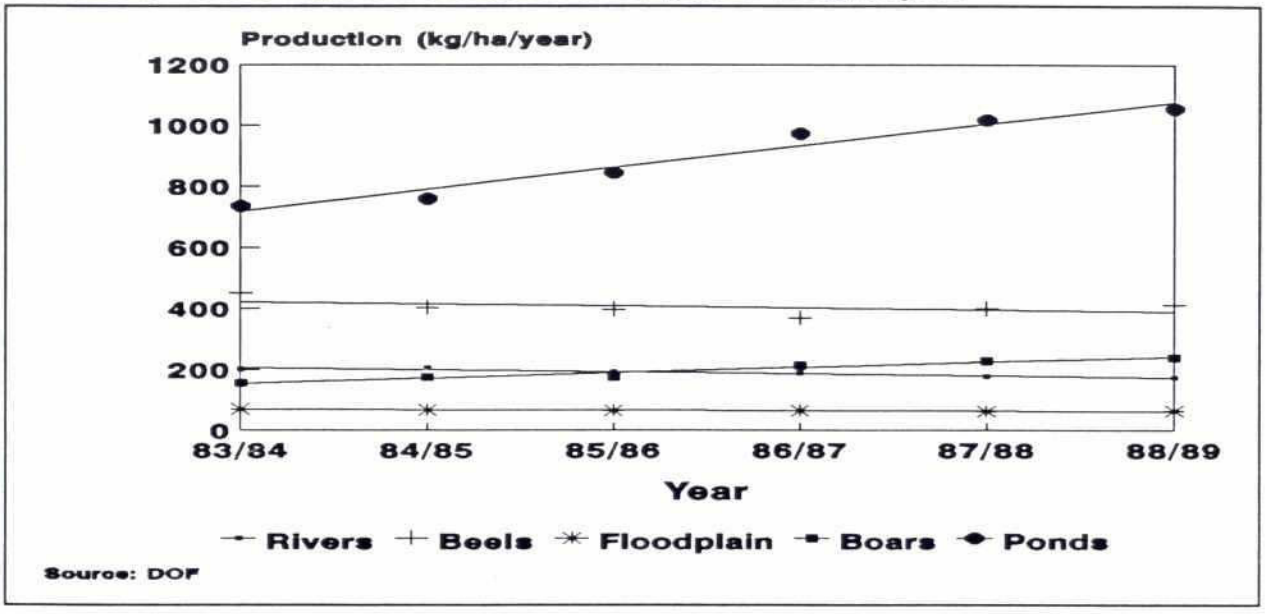


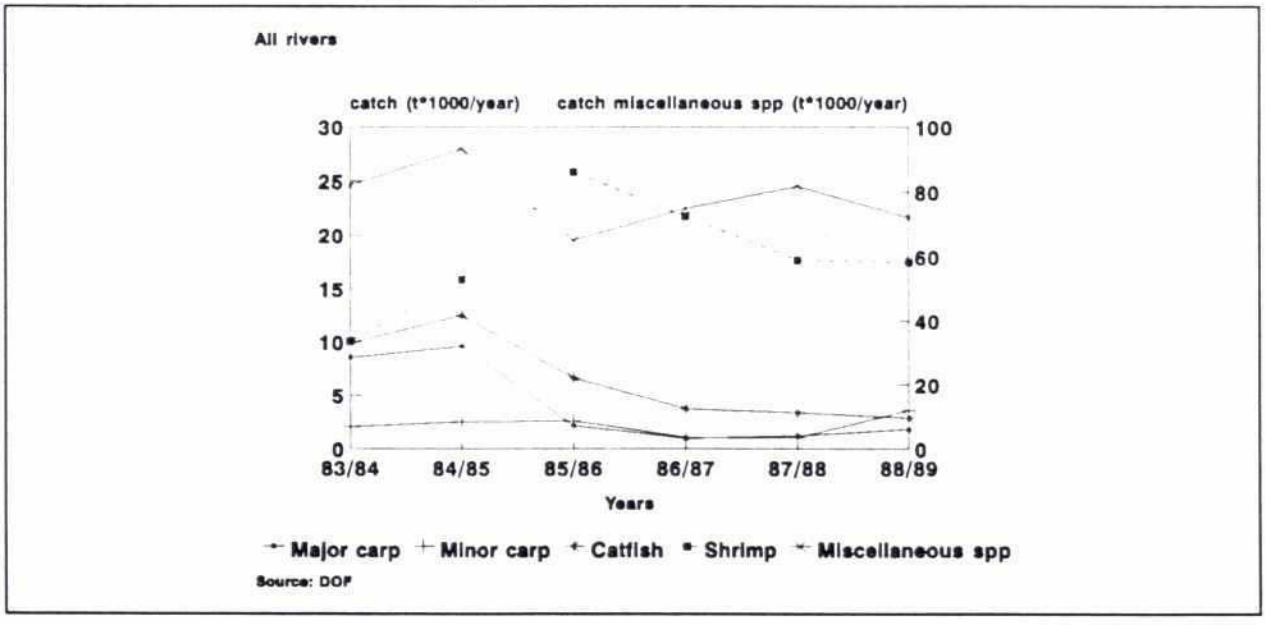
Figure 4 presents the production figure on a hectare basis for Bangladesh. On a hectare basis the decline of approximately 10 % of fisheries is not spectacular. The magnitude of the area in which this takes place makes it important.
Within the last decade the decline of fisheries output within 3.8 million hectare has been compensated by a increased aquaculture output obtained from 150.000 ha ponds.
The number of ponds remained more or less stable in the last decade, but their average annual production increased from 735 kg/ha/yr, in 1983, to 1055 kg/ha/yr in 1989.
An average production of approximately 2000 kg/ha/yr should be considered as the maximum level to be achieved and maintained in the field with the actual used methods, this production level is comparable with the levels obtained by the Myamensing Aquaculture Extension and development Project. It indicates that their is not much room left for a continuing cover-up by aquaculture.

FIGURE 4: Fresh water fish production of Bangladesh in Kg/ha/year.



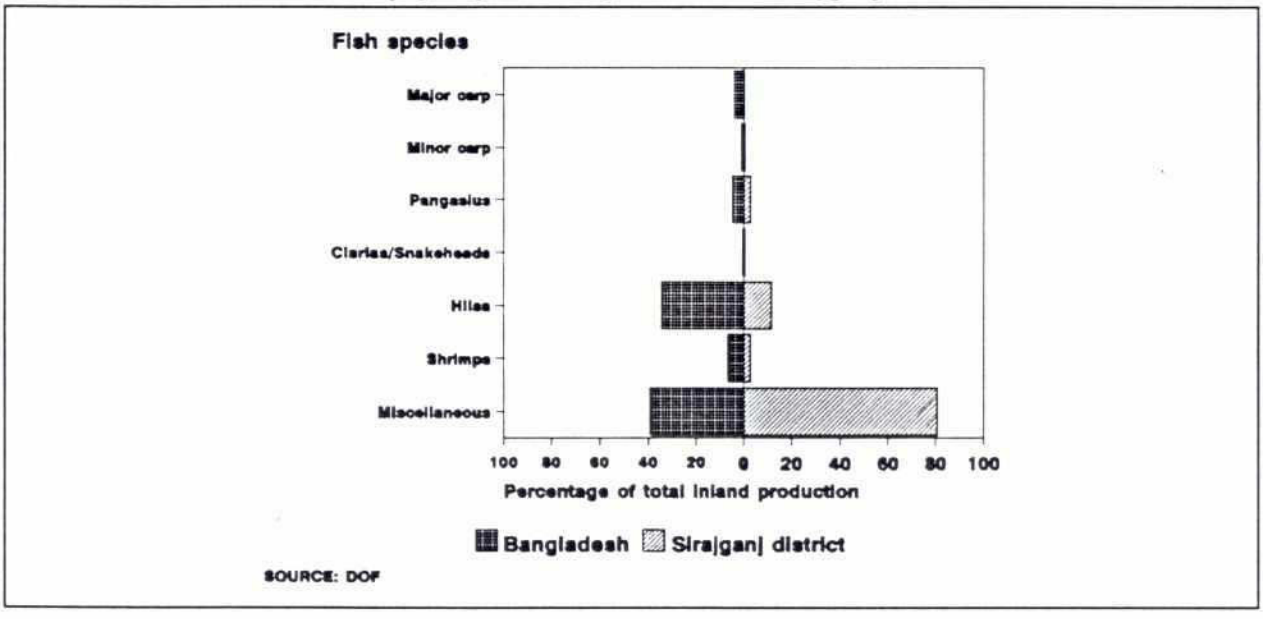
Ali and Zaman (1989), plotted in one graph the growth of flood control and drainage and the declined floodplain catches and it figured: more FCD means less fish (no quantifications are given). Such a relation does not give the "proof". However, when its is taken into account how carp depend on the floodplain in their early life and, and we look at the declined fisheries output of these species (Figure 5), it makes it a "reasonable" suspicion.

FIGURE 5: River catches of Bangladesh



Fisheries projects in Bangladesh, are upto now mainly focusing on the high valued carps, through the improvement of aquaculture techniques or through the introduction of culture-based fisheries (stocking programs). The importance of the miscellaneous or "small" fish for consumption has been indicated before in Figure 2. The importance of this group is also reflected in the catch statistics (Figure 6). Approximately 40% of the total inland fish production of Bangladesh is covered by the "small" fish, for the Sirajganj district the proportion of "small fish" is twice as high (80%) which is undoubtly caused by the construction of the BRE. This justifies the incorporation of this groups within all future development scenario's. In "economic terms" the 15 % of the major carps is probably of more importance, because of their higher "market" value. But validation on "market" value only can be questioned, and a paper on this matter has been presented by FAP 17, FAP 16 and FAP 2.

FIGURE 6: Fish catches by groups in Bangladesh and Sirajganj district.



B The Sirajganj district

Data on fisheries for the Sirajganj district alone are not available as the BFRSS still classifies data under the "old Pabma" district, which nowadays is divided in the Sirajganj and the Pabna. The old Pabna district (including Sirajganj) belongs to the group of "low" fish producers, as can be seen from the Table 2. The per capita availability of fish has been estimated at 3 kg/year in 1988/1989.

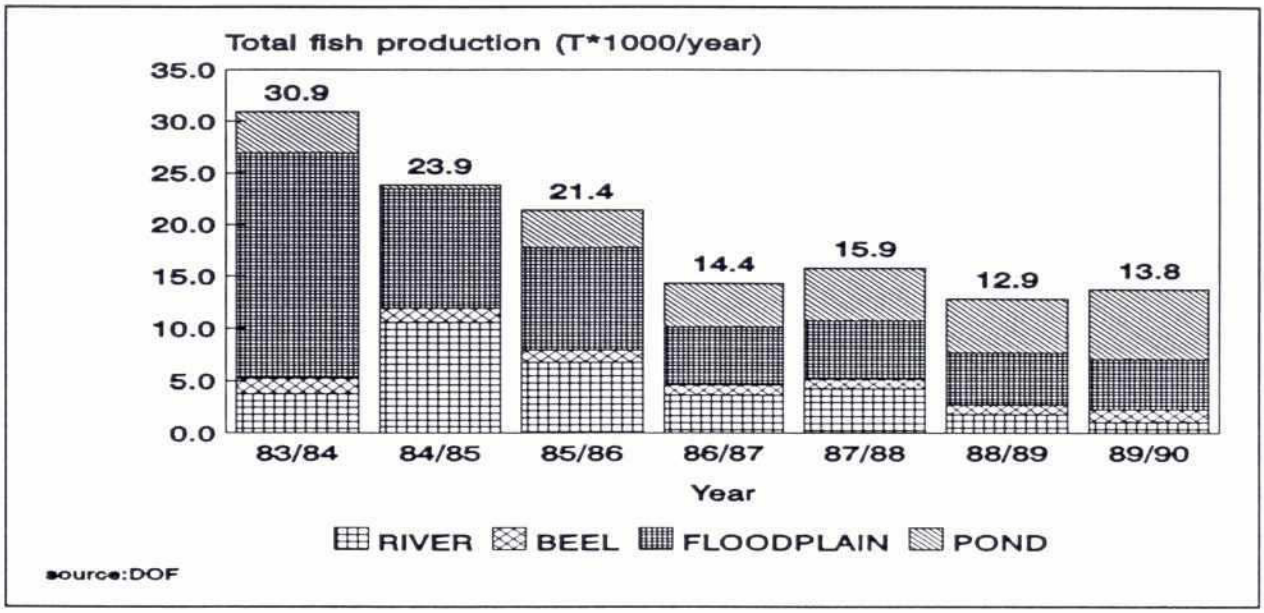
TABLE 2: Inland fish production and availability of fish per capita in the "old" districts of Bangladesh.

NAME OLD DISTRICT	AREA (KM^2)	POPULATION	NUMBER/KM^2	FISH PRODUCTION (T/YEAR)	KG/HA/YR	KG/PER-SON/YR
Kusthia	3440	2754049	801	5977	17	2
Tangail	3403	2943756	865	6965	20	2
Faridpur	6882	5428044	789	13884	20	3
Dinajpur	6567	3858084	587	10346	16	3
Rangpur	9256	7780907	841	22328	24	3
Dhaka	7470	13150908	1760	38533	52	3
Pabna	4732	4106488	868	12885	27	3
Mymenshingh	9668	13692042	1416	48745	50	4
Rajshahi	9456	6384068	675	24881	26	4
Bogra	3888	3302108	849	14370	37	4
Jamalpur	3349	1871772	559	8570	26	5
Jessore	6573	4812651	732	23167	35	5
Comilla	6602	8183688	1240	59807	91	7
Noakhali	5460	4621064	846	41737	76	9
Khulna	12168	5013746	412	47531	39	9
Sylhet	12927	5447681	421	54229	42	10
Chittagong	7457	7612695	1021	77728	104	10
Patuakhalia	4078	2014497	494	22530	55	11
Barisal	7299	5371647	736	73432	101	14

Source: Statistical Yearbook of Bangladesh 1990

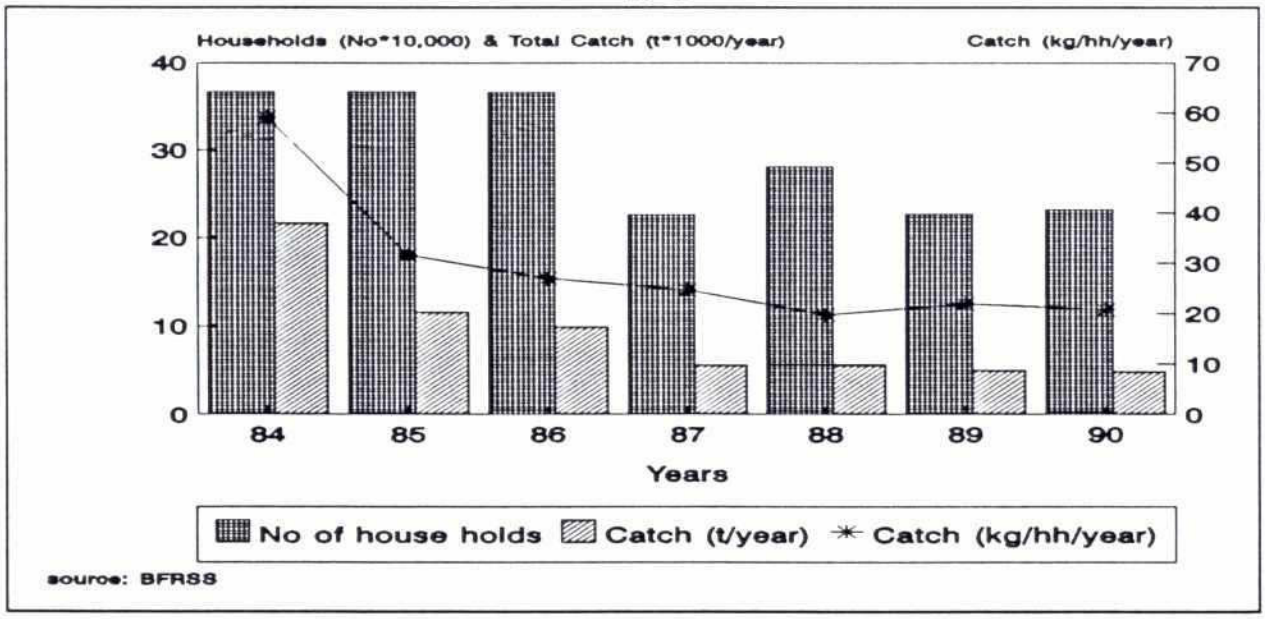
In old Pabna district, the main source of fish is: River fisheries, Beel fisheries, Floodplain fisheries and Aquaculture.
The total fish production of old Pabna district decreased from 30,936 t/yr in 1983 to 13,764 t/yr in 1990 (BFRSS,1983-1990). This sharp decline is observed in all fishing habitats ie; river, beel and floodplain as can be seen in Figure 7.

FIGURE 7: Fish catch from the different habitats in the old Pabna district



Subsistence catches from the floodplain covered 70% of the total inland fish production of the Sirajganj district in 1983/84 but declined sharply to approximately 34% in 1989/90 (see Figure 8). Within the same period the number of households engaged in subsistence fishing and their yearly catch decreased with respectively 38% and 66%.

FIGURE 8: Subsistence Fisheries in the Sirajganj district



6. FISHERIES RESOURCES IN THE CPP PROJECT AREA

The CPP project, with a total area of approximately 12,000 ha, is located on the right bank of the Jamuna river, north-west of Sirajganj Town. The boundaries are formed by: the Brahmaputra Right Embankment (BRE) on the eastern side, the Ichamati river on the western side, the New Bogra road in the south and the Ichamati branch in the north (See Figure 9).

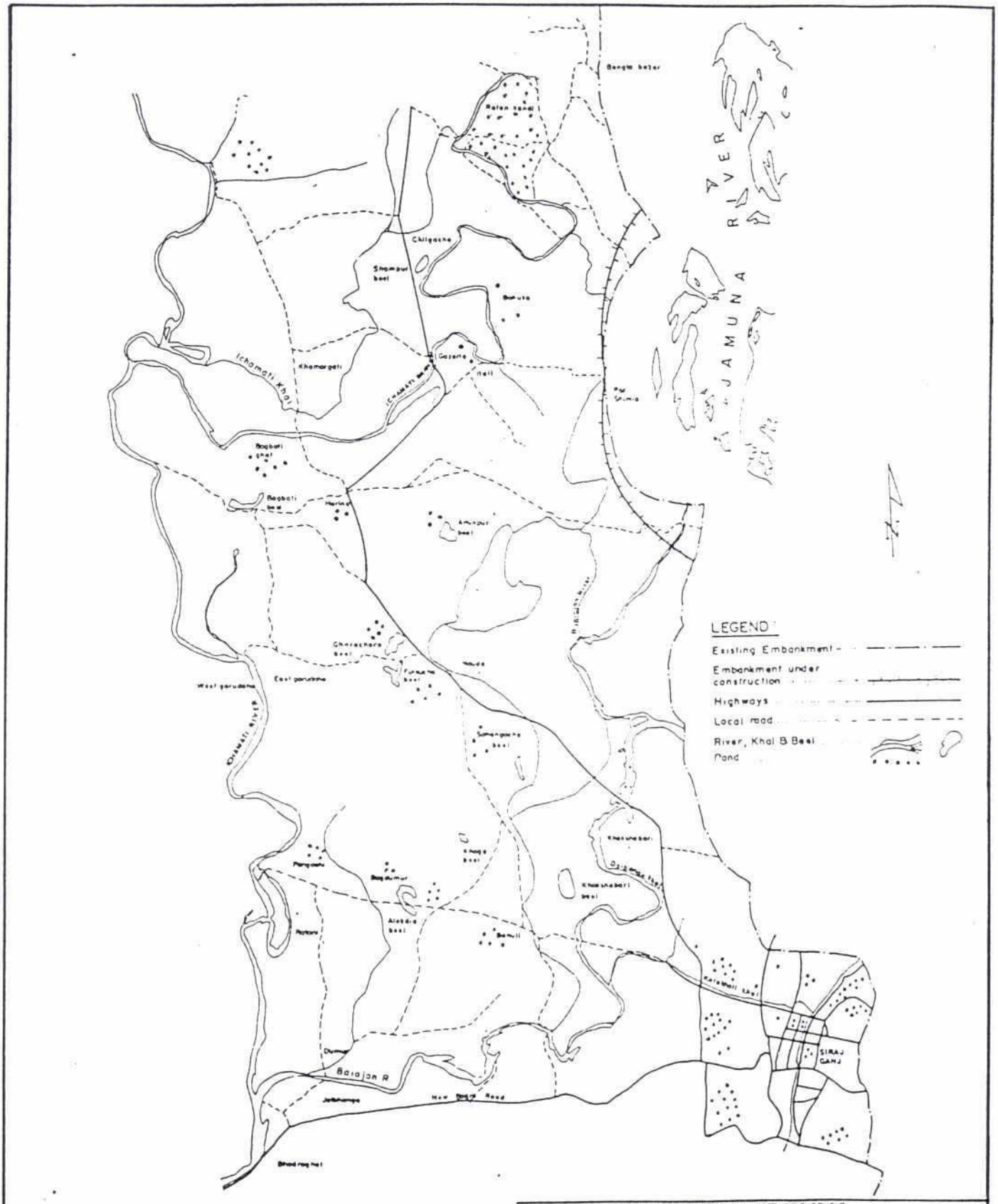
The BRE was constructed in the mid sixties in order to protect the area against flooding from the Jamuna river. Unfortunately the embankment started to erode in 1970 and breaches developed allowing the flood to enter several times within the period 1975 - 1992.

A Rivers

The *Kazipur* and the *Ichamati* rivers, At the extreme northern point, the Kazipur river flows south through Kazipur Thana and joins the Ichamati in Sirajganj. The Ichamati river enters Sirajganj thana from the north at Bagbari, a village near Dhunot in Bogra district. The combined waters of the Kazipur and the Ichamati river flow south by a winding course through Sirajganj until they fall into the larger river, the Karatoya, at Nalkassenganj.

The *Dhanbandi* river starts from the Jamuna near Sanchalia. It passes through town and falls into the Hurasagar near Maupur. A bridge, 120 feet wide was built over the river in 1892 and is called Elliot Bridge, named after Sir Charles Elliot. This river, very narrow at places, is now used as a dumping area of urban waste.

The rivers can be considered as "seasonal rivers" as they flow only during the rainy season. In the post monsoon they are cut of from the Koratia river and the water level decreases due to evaporation and seepage, creating isolated water bodies.



MINISTRY OF IRRIGATION, WATER DEVELOPMENT AND FLOOD CONTROL
BANGLADESH WATER DEVELOPMENT BOARD
FLOOD PLAN COORDINATION ORGANISATION

COMPARTMENTALIZATION PILOT PROJECT
SIRAJGANJ (FAP 20)

WATER BODIES OF SIRAJGANJ
CPP LOCATION MAP

Consultant: Euroconsult, Lahmeyer Int., Bets Ltd., HCL

Drawing no 9

C
FAP20
P

Km 0 1 2 3 4 Km
SCALE

B Khals

Four khals, used for the drainage of water, are located in the project area:

* ***The Ichamati Khal*:** this Khal connects the northern Ichamati river branch from Ratan Kandhi in Sub-Compartment #2 with the main Ichamati river near Harina in Sub-Compartment #4.

* ***The Bagdumur Khal:*** this khal connects the Fulkocha Beel in Sub-Compartment #6-8 with the southern Ichamati river branch near the village Dumur in subcompartment #8.

* ***The Katakhali Khal*:** connects Sirajganj town with the Daibhanga khal near Dithpur alla. This khal was constructed by an indigo planter in the colonial period and facilitated river transport to Sirajganj town.

* ***The Bhagdraghat Khal:*** this khal passes the new Bogra road and connects the old Daibangha river near Gobindapur in Sub-Compartment #8 with the Baniajan river South of the project area.

C Beels

Within the project area 9 beels are found (see Figure 9.) and the Characteristics are presented in Table 3.

TABLE 3: Characteristics of Beels located in the Sirajganj project area

NAME	COMPARTMENT NO	AVERAGE DRY SEASON AREA (ha)	OWNER STATUS	FISH STATUS
Khokshabari (perineal)	7	8.18	private	not stocked
Khaga (seasonal)	6	1.87	private	not stocked
Alokdia (seasonal	6	11.22	private	not stocked
Fulkocha (perineal)	6	7.85	leased	stocked
Bagbati (perineal)	4	6.73	private-/khas	stocked
Shampur (seasonal)	2	4.09	private	not stocked
Aminpur (seasonal)	5	5.24	private-/khas	not stocked
Sahancacha (Seasonal)	7	3.37	private	not stocked
Gharachchara (Seasonal)	4	7.11	private	not stocked
TOTAL		55.66		

The total dry season beel area of 55 ha as measured from aerial photo's (made in December 1990) is rather small but most beels are either privately owned, sometimes their is some controversion over the ownership status, or leased from DOF. Stocking of Beels and borrow pits by private owners is a phenomena regularly encountered within the project area.

D Floodplain

The situation of the floodplain is rather complex. Before the construction of the BRE approximately 8000 ha of floodplain got annually inundated by water from the Jamuna and Ichamati river. After construction of the BRE these floodplains were converted into agriculture land and only some flooding took place due to the congestion of rainwater and some flooding of the Ichamati river. From the mid 70's started to breach and within the last years this took place regularly. A breach of the BRE is comparable with the pre-BRE flooding as most of the water comes from the Jamuna and it will transport the hatchlings from the river. This "new" type of flooding however should be regarded as unwanted due its unpredictable occurrence.

E The present situation in the CPP project area

The fisheries situation in Sirajganj CPP Project area is rather complex. The negative impact of the sealing of the Jamuna river is clearly visible in all fisheries statistics from the Old Pabna which includes the Sirajganj district (see Figure 7). The breaches of the last years changed the situation a little, from a fisheries point of view, a breach early in the season is comparable with normal flooding of the area. All development options must be regarded in this context and it makes the establishment of a "real" baseline difficult.

Fishing activities in the project area can be divided in:

(a) **Professional fishermen**

The fishermen household survey indicated the existence of approximately 800 professional fishing households, with 1225 active fishermen in the CPP area. Their primary occupation is fishing. Their main fishing ground is found outside the CPP area; **the Jamuna** river, where their Jalmahals are located.During the dry season some fishing takes place in the pagards and beels, mostly on a sharing bases with the owners or lease holders. During the monsoon period fishing takes place in the floodplain, inundated by either rainwater congestion or river floodwater after breaching of the BRE.

(b) **Part time or Occasional fishermen**

These fishermen have next to fishing an alternative occupation and are mostly operating cast nets.Part time fishermen , as a separate group, are not existing in the fisheries statistics of Bangladesh. The number of occasional fishermen households operating in the CPP project area has been estimated at 50 and it is assumed that the on the average fish twice a week.

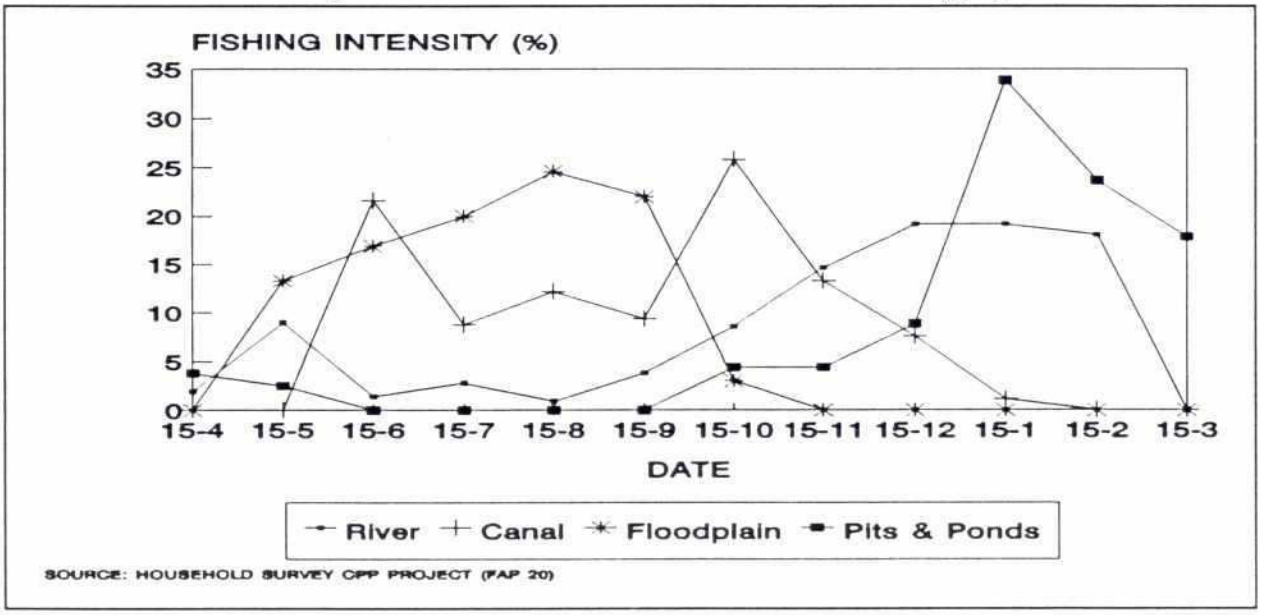
(c) **Subsistence fishermen**

The household survey of FAP 20 estimated that during the season 1992/1993, within 3 % of the rural households within the project area some form of fishing takes place for home consumption at some time during the year. The fishing calendar for subsistence fisheries, as presented in Figure 10, shows well that this kind of activity follows strictly the opportunities offered by the natural resources. Shifts from one resource to another is made when the new resource has an easier access or provides more fish. Subsistence fisheries can be carried out

freely in the channels and beels (if not stocked) using scoop nets, baskets, traps, lift nets, etc.

The percentage of subsistence fisheries within the Sirajganj project is almost absent if compared with 65 %, as estimated by a similar household survey executed in the Tangail CPP project area. The two household surveys estimated the number of subsistence fishing days at 60 and 183 for respectively Sirajganj and Tangail CPP area. It indicates clearly the limited availability for fishing grounds and fish for the rural households in the project area. It should be remarked however that 1992/1993 was an extremely dry year, the number of nets owned by the rural households (see Table 4) indicate that subsistence fisheries would be more in the range of 10 - 20 %.

FIGURE 10: The fishing calendar for subsistence fisheries in the Sirajganj CPP area



Used fishing gears

A variety of gears is used by in the Sirajganj CPP project area and the Jamuna river. Some gear are, as the seine net, are almost exclusively used by the professional fishermen and others, as the scoop net are exclusively used by the subsistence fishermen. A summary of the used gears is presented in Table 4.

TABLE 4: Gears used and their total number in the Sirajganj CPP-project area

GEARTYPE	FARMERS		NON FARMERS		FISHERMEN		TOTAL
	%	NO	%	NO	%	NO	
SEINE	1,5	142	0,0	0	34,5	294	437
GILL NET	2,3	218	3,1	614	1,8	15	848
DRAG NET	0,8	76	1,5	297	3,6	31	404
KOI NET	13,7	1301	3,0	594	58,2	496	2391
CAST NET	0,0	0	0,0	0	3,6	31	31
SCOOP NET	14,5	1377	8,3	1644	0,0	0	3020
LIFT NET	0,0	0	0,0	0	5,5	47	47
TRAPS	1,6	152	0,0	0	1,8	15	167
OTHERS	0	0	0	0	25,5	218	218
TOTAL		3266		3149		1147	7562

SOURCE: HOUSEHOLD SURVEY FAP 20

The total fisheries output of the CPP area was estimated by using the data on fishing intensity of the subsistence households with an average daily catch of 0.25 kg (383 gear samples, SEM = 0.014) and the average yearly catch of professional and occasional fishermen of the different habitats from the Household Survey, as given below in Table 5 and Table 6.

TABLE 5: Intensity of subsistence fishing and production of the different habitats of the CPP area estimated for 1992/1993.

HABITAT	FARMER AND NON FARMING FISHERMEN		
	% OF THE RURAL HH FISHING IN THE HABITAT	NO OF CATCH DAYS	PRODUCTION (T/YEAR)
RIVER	2	41	5
FLOODPLAIN & KHAL	1	13	1
BEEL	0	0	0
BORROW PITS	0	0	0
TOTAL			6

Source: Fisheries Household Survey and Special Fisheries Study, FAP 20

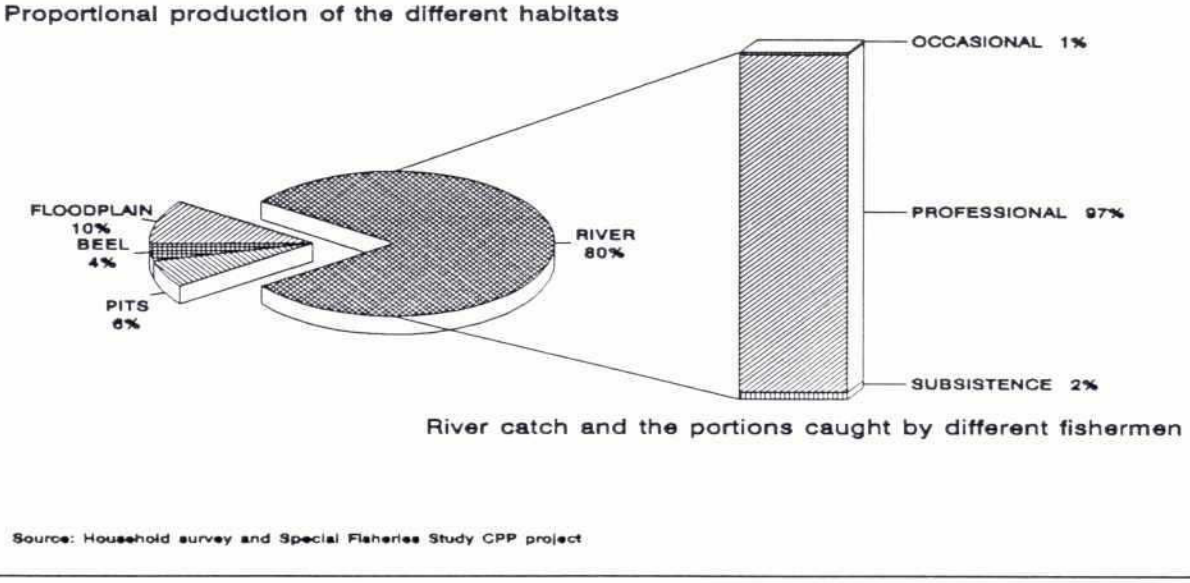
TABLE 6: Fish catches of professional and occasional fishermen in the different habitats of the CPP area.

HABITAT	PROFESSIONAL FISHERMEN (n=803)		OCCASIONAL FISHERMEN (n=50)	
	AVERAGE CATCH (KG/HH/YEAR)	TOTAL CATCH (T/YEAR)	AVERAGE CATCH (KG/HH/YEAR)	TOTAL CATCH (T/YEAR)
RIVER	468	244	117	2
FLOODPLAIN & KHAL	888	27	122	3
BEEL	156	11	39	1
BORROW PITS	220	18	55	1
TOTAL		300		7

Source: Fisheries Household Survey FAP 20

The major part of the fish (80 %) is caught outside the project area in the Jamuna and Ichamati river. Within the project area 10 % of the production is caught at the floodplain/Khal systems. Within all production system the professional fishermen are providing the bulk (95 %) of the catch (see Figure 11)

FIGURE 11: Fisheries production of the Sirajganj CPP project area



7 AQUACULTURE

The decline in inland fisheries production has been compensated by an increased aquaculture production. The Fisheries Resources Survey System estimated the number of fish ponds at approximately 1.3 million, covering a total area of 147.000 ha.
Ponds are classified as:

(a) Cultured: Ponds which are artificial stocked, which have good embankments and retain water throughout the year.

(b) Culturable: Ponds which are ready for culture but have multiple ownership problems and are only stocked by nature.

(c) Derelict: Ponds which are not suitable for culture, they are to shallow, dry up in summer or need major repair.

A subdivision of the different type of ponds and their production for Bangladesh and Sirajganj district is given in Table 7.

TABLE 7: The total area and production by type for Bangladesh and Sirajganj district as estimated in 1983/84.

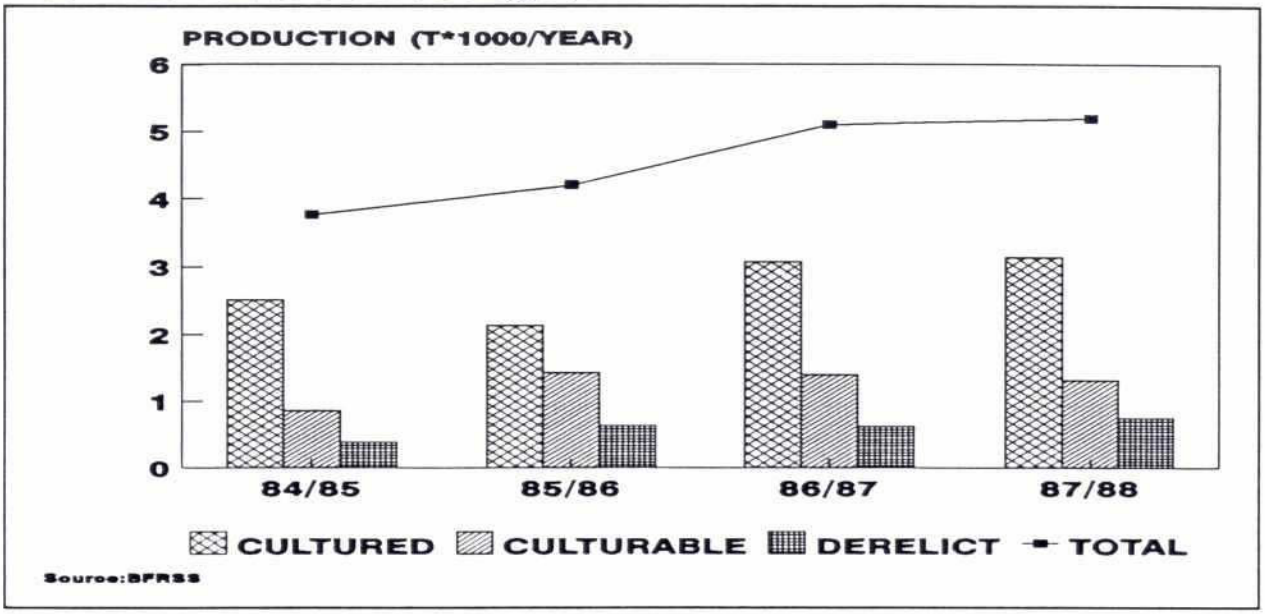
	CULTURED		CULTURABLE		DERELICT	
	Area (ha)	Production (kg/ha/y)	Area (ha)	Production (kg/ha/y)	Area (ha)	Production (kg/ha/y)
BANGLADESH	77,754	1,161	44,997	338	25,595	148
SIRAJGANJ DISTRICT	2,259	1,114	3,321	259	1,824	212

SOURCE: BFRSS

The main species cultured in Bangladesh are: Silver carp, Common carp, Indian Carps, Grass carp and tilapia. Fry and fingerlings are mostly obtained from natural sources, but this is gradually changing due to the fact that hatchery reared fingerlings became more and more available during the last years. The rearing techniques are simple: the fingerlings are stocked and fed agriculture by products as: rice bran and mustard seed cake.

According to the statistics the number of ponds remained stable during the last decade. The incremental annual production of approximately 48.000 t has been obtained by an increased production level. Within the period 84/85 to 87/88 also in the Sirajganj district the aquaculture production increased from 3,100 t to 5,200 t (see Figure 12)

FIGURE 12: Pond culture in the Sirajganj district



A survey executed by FAP 20 indicated the existence of approximately 330 ponds within the CPP area. The distribution of these ponds within the CPP area is presented in Figure 9. The actual pond production of the CPP area is estimated at 70 ton/year, with an average pond size of 0.3 ha and a production level of 700 kg/ha/year.

8. THE TOTAL AT PRESENT FISH PRODUCTION OF THE SIRAJGANJ PROJECT AREA

The total fish production of the Sirajganj CPP project area is estimated at 383 t/year for the situation of 1992/1993, an extremely dry year without a flood. The at present situation for a "breach" flood year is given in Chapter 9.G. The production level for the different habitats and fishermen is presented in Table 8, and it is clear that the professional fishermen are the major producers and that the river and the river its major source.

TABLE 8: The total estimated fish production of the Sirajganj project area for **the 1992/1993 situation**, (which is comparable with the without case Stable BRE & no CPP)

HABITAT	PRODUCTION (T/YEAR)			TOTAL
	PROF	OCCAS	SUBSIS	
RIVER	244	2	5	251
FLOODPLAIN & KHAL	27	3	1	31
BEEL	11	1	0	12
PITS	18	1	0	19
AQUACULTURE				70
TOTAL	300	7	6	383

Source: CPP House Hold survey and CPP Special Fisheries study

9 DESIGN AND OPERATIONAL CRITERIA FOR OPTIMAL FISHERIES PRODUCTION

Within the development options 1A, 2A and 2B the construction of three new water inlet structures are proposed. The structures will have a multi purpose function;

* The intake of water for agriculture purposes
* The intake of water for the enhancement of fish production.

It should be realized however that agriculture and fisheries are in principle conflicting production systems when water requirements are concerned. To serve agriculture as well as fisheries as stated in page 3 of the ToR can only be achieved when compromises are made between the two systems. Unfortunately it can be stated that traditionally in the decision making process the balance mostly was in favour of agriculture production systems. Therefore the design and operation of "fish friendly" structures has been included in this chapter in order to provide ideas and design criteria needed for the implementation of CPP as given by the ToR.

One of the major concerns with the design ,construction and management of regulators must be the impact on natural fish resources. They should be constructed and operated in such a way that adult carp can migrate upstreams at the beginning of May (not the case in the CPP area) and that hatchlings can enter the floodplain in june/july.

The migration of carp fry and fingerlings is more or less passively, at a certain moment thousands of young of the year are drifting downstream. This phenomena occurs within a peak periods during the month may-july (see Figure 15). At a certain moment the concentration of hatchlings/fry per cubic meter of river water is extremely high. This is the moment in which the inlets should be open in order to have a maximum fisheries output.
From a fisheries point of view there is some flexibility, it is a question of weeks and flood water should enter in the peak period of june/july.

From a fisheries point of view the concept of gated openings is accepted , as long as the regulators/sluices are build in such a way that (passive) fish migration will not be hampered. The structures should be completely open from the bottom to the top layer of the water. This to facilitate all fish to enter. The Special fisheries Study of the CPP project investigated the hatchling migration in the Lohajang river during the 1992 season and one of its findings was that hatchlings are equally distributed over the water column (see Figure 13)

The operation of gated structures will probably be influenced by the more economic powerful people in the project area. These forces are not found among the landless, marginal farmers and fishermen and it can be expected that the operation still will be dominated by agriculture.

Water velocity is not considered as a major factor to be considered for the CPP Area, as it is believed that no upstream migration takes place from the area into the river at the beginning of the pre-monsoon. But it should be realized that most hatchlings are found along the shore line of the river were currents are relatively low (0.5-1.5 m/sec) and is probably optimal for

migration and feeding behaviour.

A major concern in the design of regulators is the occurrence of pressure differences. Fish can not withstand abrupt and high differences in pressure, it causes eruption of the swim bladder.

Design criteria

The following design and operation rules criteria for "fish friendly" structures are formulated

* Free surface flow through the regulator (not submerged outside & not submerged inside)
* water velocities not exceeding 1.5 m/sec
* Structures open during the first 4-5 weeks when the flood arrives, normally the period mid June - Mid July

10. OPTIONS FOR FUTURE DEVELOPMENTS

A Introduction

At present several water management scenario's for the project area are discussed by the CPP pilot project. In this chapter the consequences on fisheries are given for each scenario. Four major effects will influence the fisheries production in a certain area;

(a) Drainage of the rain water congestion around the beels will cause a reduction of raise in water-level during the pre-monsoon. Consequently, reproduction and recruitment of "beel" fish will be hampered.

(b) Retardation of the incoming river-flood will affect the migration of carp hatchlings and adults into the floodplain.

(c) The total fish production of a floodplain is determined by its flooded area and productivity, reduction of this area will consequently leads to a reduction of the total fish production.

(d) A shortening of the inundation period will reduce the grow-out period of the carp spp, as most of them are caught when the flood recedes to the river.

B Methodology used in the assessment of fish losses

A three step analyses is used in the assessment of fish losses under the different scenario's:

(a) With the mathematical model for the CPP-area, the hydrological environment for the different options is simulated, resulting in the total area of beels and inundated floodplain for each decade during the period of 1st May up to 31st of November. Outside this period the Floodplain/Beel area is gradually reduced to the minimum dry season level of 20 ha.

(b) A fisheries spreadsheet model was developed. This model was calibrated with the hydrological data of A stable BRE without CPP and the floodplain-/khal fisheries production, beel fisheries production and beel fishing intensity obtained through the Fisheries Household Survey and the Special Fisheries Study of the CPP project, as the 1992/1993 season can be compared with such a situation as no flood entered the CPP area. Within

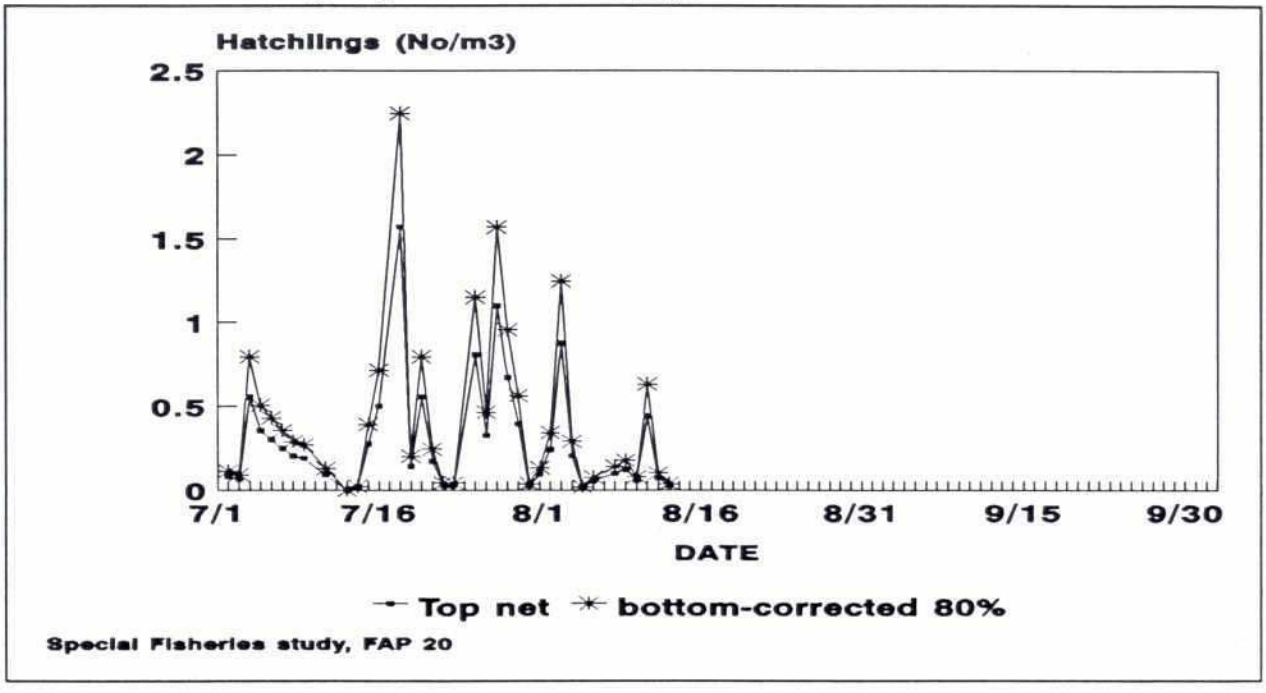
this model it is assumed that the total production from the floodplain and the khals is caught during the period of 20st of June to 10st of November, the period when floodplain/beels are connected with the river system and the total beel production is caught in the remaining period and area. The effect of reduced inundated floodplain area is calculated by multiplying the simulated inundated area with the calibrated floodplain production of 0.94 kg/ha/decade. It is assumed that there is a linear relation ship between "beel" fish production and the available reproductive area (which is a minimum concept). The effect of the reduced reproduction area for "Beel" fish is brought into the model by taking the Beel area of the 10st of june, under the option stable BRE/no CPP as a standard. A reduction of this area under the different options leads to a proportional reduction in total "beel" fish production.

(c) In order to facilitate an economic analysis of the different scenario's, the total fish production is sub-divided species wide. The species distribution for the different habitats is obtained from the Sirajganj district fisheries statistics of the year 1988/1989.

From the theoretical concept, only Beel area reduction and inundated floodplain area reduction are used in the impact assessment. The other factors could not be included quantitively due to the following reasons;

* The mathematical hydrological simulations of the different scenario's indicated that the retardation of the incoming flood water is a question of days. The reproduction of carp spp and the larval densities in the major rivers of Bangladesh has a regular pattern; it starts in May and increases rapidly with a peak in June/July after which it gradually decreases to zero in september (see Figure 13). It is expected that a retardation of several days will have a marginal effect on total carp production, as long as the floodplain inundates during the high larval density period of June/July.

FIGURE 13 Hatchling Migration in the Lohajang River



* It is known that shallow waters are more productive than deep waters. The main reason is that primary production is higher in shallow waters due to the availability and recycling of nutrients for photosynthesis. The Morpho Edaphic Index (MEI), in which waterdepht and fertility are expressed, has been used successfully in predicting fisheries production of large and deep waterbodies. The usefulness of the Morpho Edaphic Index for floodplain fisheries in the CPP area, as has been done in the Jamalpur priority project can be doubted. At present base line information on floodplain fisheries production is rather scarce and information on the distribution of these figures among the different water depth (F0 to F4) is completely absent. Even if these figures are present, the interpretation will be difficult due to the fact that the floodplain is an active system, the water depth fluctuates over the year and due to the fact that the highest fishing effort takes place in these shallow waters, mixing catch with production figures.

* A shortening of the inundation period could reduce the growth period and consequently the average size of the fish when caught. At present no information is available on the natural growth rates of the carp spp in the CPP area, even if growth rates were available, the calculation of this impact is difficult because we are dealing with a multispecies fisheries system. The hydrological model indicated that for all scenario's the water recedes to the river between 10st and the 30st of september and it can be expected that losses due to growth reduction will be marginal as most of the fish are caught during this backwards migration.

C The without case, Stable BRE & no CPP

DESCRIPTION WITHOUT CASE

A STABLE BRE & NO COMPARTMENTALIZATION PROJECT

This option consists of stabilizing the BRE only and no water regulation. Production figures for fish under this option are presented in Table 9 and more details are presented in Appendix 1.1 & 1.2

TABLE 9: Total fish production of the Sirajganj CPP area in the **without case**

SPECIES	PRODUCTION IN TON/YEAR					
	PRINCIPAL RIVER	BEEL	FLOODPLAIN	PONDS	PITS	TOTAL
MAJOR CARP	5.0	1.0	0.1	49.9	0.1	56
MINOR CARP	2.9	1.0	0	3.0	0	7
CATFISH	36.4	1.5	0.1	3.8	0.1	42
LIVE FISH	5.6	0.8	0.2	0	0.1	7
HILSA	15.5	0	0	0	0	15
MACROBRACHIUM	2.2	0	0	0	0	2
SMALL SHRIMP	4.2	0.5	0	0	0.	5
MISCELLANEOUS	179.0	7.3	30.5	13.2	17.7	248
TOTAL	251	12	31	70	18	382

The total production in the without case, A stable BRE & NO CPP is estimated at 382 Ton/year, representing a value of 165 lahk (423,000 US$)

D Option 1

DESCRIPTION OPTION 1

COMPARTMENTALIZATION WITHOUT THE ICHAMATI EMBANKMENT

This option consists of improved drainage, construction and/or rehabilitation of (BRE) inlet structures, water retention structures, irrigation and internal water management control structures. Production figures for fish under this option are presented in Table 10 and more details are presented in Appendix 1.3 & 1.4

TABLE 10: Total fish production of the Sirajganj CPP area under **option 1**.

SPECIES	PRODUCTION IN TON/YEAR					
	PRINCIPAL RIVER	BEEL	FLOODPLAIN	PONDS	PITS	TOTAL
MAJOR CARP	5.0	2.5	0.1	49.9	0,1	58
MINOR CARP	2.9	2.6	0	3.0	0	8
CATFISH	36.4	3.8	0.1	3,8	0.1	44
LIVE FISH	5.6	1.9	0.2	0	0.1	8
HILSA	15.5	0	0	0	0	15
MACROBRACHIUM	2.2	0	0	0	0	2
SMALL SHRIMP	4.2	1.1	0.1	0	0	5
MISCELLANEOUS	179.0	18.1	31.5	13.2	17.7	260
TOTAL	251	30	32	70	18	401

The total production under option 1, Compartmentalization without the Ichamati embankment is estimated at 401 Ton/year, representing a value 173 lahk (442.000 US$)

E Option 2A

DESCRIPTION OPTION 2A

COMPARTMENTALIZATION PROJECT WITH Ichamati DYKE SYSTEM ALIGNMENT I (EXISTING ROAD SYSTEM)

This option consists of measures for flood protection, improved drainage, construction and/or rehabilitation of (BRE) inlet structures, water retention, BRE post-breach control, irrigation, internal water management structures and Ichamati embankment (alignment I) in this option an alignment is proposed which actual follows existing infrastructure. Production figures for fish under this option are presented in Table 11 and more details are presented in Appendix 1.5 & 1.6

TABLE 11: Total fish production of the Sirajganj CPP area under **option 2A** .

SPECIES	PRODUCTION IN TON/YEAR					
	PRINCIPAL RIVER	BEEL	FLOODPLAIN	PONDS	PITS	TOTAL
MAJOR CARP	5.0	0.8	0.1	49.9	0.1	56
MINOR CARP	2.9	0.8	0	3.0	0	7
CATFISH	36.4	1.1	0.1	3.8	0.1	42
LIVE FISH	5.6	0.6	0.2	0	0.1	6
HILSA	15.5	0	0	0	0	15
MACROBRACHIUM	2.2	0	0	0	0	2
SMALL SHRIMP	4.2	0.3	0	0	0	5
MISCELLANEOUS	179.0	5.4	30.5	13.2	17.7	246
TOTAL	251	9	31	70	18	379

The total production under option 2A, Compartmentalization project with Ichamati dyke system, alignment I is estimated at 379 Ton/year, representing a value of 164 lahk (420,000 US$)

F Option 2B

DESCRIPTION OPTION 2B

COMPARTMENTALIZATION PROJECT WITH Ichamati DYKE SYSTEM ALIGNMENT II (ALONG RIVERBANK)

This option consists of measures for flood protection, improved drainage, construction and/or rehabilitation of (BRE) inlet structures, water retention, BRE post-breach control, irrigation, internal water management structures and Ichamati embankment (alignment II).
In this option an alignment is proposed which actual follows the Ichamati river bank closely. Production figures for fish under this option are presented in Table 12 and more details are presented in Appendix 1.7 & 1.8

TABLE 12: Total fish production of the Sirajganj CPP area under **option 2B** .

SPECIES	PRODUCTION IN TON/YEAR					
	PRINCIPAL RIVER	BEEL	FLOODPLAIN	PONDS	PITS & PONDS	TOTAL
MAJOR CARP	5.0	0.8	0.1	49.9	0.1	56
MINOR CARP	2.9	0.8	0	3.0	0	7
CATFISH	36.4	1.1	0.1	3.8	0.1	42
LIVE FISH	5.6	0.6	0.1	0	0.1	6
HILSA	15.5	0	0	0	0	15
MACROBRACHIUM	2.2	0	0	0	0	2
SMALL SHRIMP	4.2	0.3	0	0	0	5
MISCELLANEOUS	179.0	5.4	15.8	13.2	17.7	231
TOTAL	251	9	16	70	18	364

The total production under option 2B, Compartmentalization project with Ichamati dyke system, alignment II is estimated at 231 Ton/year, representing a value of 159 lahk (408,000 US$)

G Option with breaching of the BRE

DESCRIPTION OPTION BREACHING OF THE BRE

A NON STABLE BRE
REGULAR BREACHING AND FLOODING OF THE PROJECT AREA WITH RIVER WATER

This option reflects the at present situation, when assumed that 1992/1993 was a abnormal year when the flood is considered. Production figures for fish under this option are presented in Table 13 and more details are presented in Appendix 1.9 & 1.10

TABLE 13: Total fish production of the Sirajganj CPP area under **option BRE & BREACHING**

SPECIES	PRODUCTION IN TON/YEAR					
	PRINCIPAL RIVER	BEEL	FLOODPLAIN	PONDS	PITS	TOTAL
MAJOR CARP	5.0	10.9	0.4	49.9	0.1	66
MINOR CARP	2.9	11.2	0	3.0	0	17
CATFISH	36.4	16.3	0.6	3.8	0.1	57
LIVE FISH	5.6	8.1	0.6	0	0.1	14
HILSA	15.5	0	0	0	0	15
MACROBRACHIUM	2.2	0	0	0	0	2
SMALL SHRIMP	4.2	4.9	0.2	0	0	9
MISCELLANEOUS	179.0	78.6	120.2	13.2	17.7	409
TOTAL	251	130	122	70	18	591

The total production under the at present situation with breaching of the BRE, is estimated at 591 Ton/year, representing a value of 240 lahk (616,000 US$)

H Remarks and the influence of the new inlet structures in the BRE on hatchling migration and fish production.

Three important remarks must be made regarding the quantification of the development options;

* **Under Option 2B** approximately 600 ha of floodplain yearly inundated by the Ichamati/Koratia river system will be sealed of from hatchling migration. Quantification of this effect is not easy due to the fact that this Bangali river system is not comparable with the Jamuna/Brahmaputra system. Losses can be expected to be in the order of 15 t/year (10-15 kg/ha/year) when recruitment is not taken into consideration and this quantity has been subtracted in option 2B and makes this option rather unattractive

* **Under option 1** the beel fish production increases from 12 t/year to 30 t/year if compared with the without case. This is mainly caused by an increased inundated area during the pre-monsoon as indicated by the hydrological model. This increase in inundated area does not occur within option 2A and 2B and seems to be in conflict with the proposed drainage measures in the pre monsoon. The calculated incremental production will be zero or negative once this inundated area equals the inundated area under option 2A and 2B.

* The floodplain production could be regarded as a minimum production and is from a theoretical point of view probably somewhat under estimated due to the fact that the "fisheries" model does not take into account the "new situation" of hatchling migration through the constructed regulators. In the without case (BRE & no CPP) all flooding is caused by rainwater congestion and no riverine hatchlings are present in the floodplain. Under option 1, 2A and 2B, flooding is caused by rainwater congestion and by river water containing riverine hatchlings. The direct effect is difficult to quantify as recruitment/yield figures are not yet known which limits at present the use of the hatchling migration data obtained through the Special Fisheries Study (see Figure 13). However an exercise has been done to quantify this effect using production levels on a hectare bases.

The exercise

In order to estimate the effect of the new inlet structures in the BRE the following assumption were made:

(a) **Hydrological**

The average inundated area for each option is calculated with the hydrological model and is 2100, 2297, 2233, 2233 and 8670 for respectively the without case, option 1, option 2A, option 2B and the present situation with breaches. With an average inundation level of 1.5 m the total quantity of water needed to inundate the area can be calculated.

(b) **Technical**

The inlet structure will have a sill level at 9 m. (m + PWD), free surface flow and water velocities not exceeding 1.5 m/sec. The maximum capacity of the structure will be 10 m^3/sec. This maximum capacity can only be maintained during 10 days a month at the peak levels of the river. Consequently the regulator operates at 33 % of its maximum capacity and on the average 3.3 m^3/sec will pass through the regulator. With a one month operation period this would mean a passage of 8.6 million m^3 per structure, giving 26 million m^3 when 3 structures are build. This volume is related to the volume needed to inundate the area completely and will give the percentage of inundation which **in theory** can be done with river water.

(c) **Biological**

A Floodplain production of approximately 15 kg/ha/year is obtained in the CPP project area in the without case. This production level is rather low in comparison with levels of 30-60 kg/ha/year obtained other floodplains of South East Asia (Mekong River, Red River, Indus). Therefore it is assumed that a maximal incremental production of 10 kg/ha/year can be obtained due to the opening up of the old migration routes of the hatchlings. The floodplain production still does not equal other floodplain production levels but it is realistic to take into account that the overall situation of the floodplain in Bangladesh decreased during the last decade. Therefore future production levels will be sub optimal. This maximal incremental production is multiplied with the proportion of water from the river and the total of inundated area in order to obtain the total incremental fisheries production.

The incremental floodplain productions for the different options are presented in Table 14 and details are given in Appendix 2.

TABLE 14: Results of the exercise on the influence of new inlet structures in the BRE on fish production.

	WITH OUT CASE	OPTION 1	OPTION 2A	OPTION 2B	BRE WITH BREACH
AREA INUNDATED (ha)	2,100	2,297	2,233	2,233	8,670
VOLUME (million m^3)	31.5	34.5	33.5	33.5	130.1
MAX INCREMENTAL PRODUCTION (t/year)	21	23	22.3	22.3	86.7
% RIVER WATER	0	75	75	75	100
TOTAL INCREMENTAL PRODUCTION (t/year)	**0**	**17.3**	**17.3**	**17.3**	**86.7**

The produced figures should be interpreted carefully and should be used as an indicator only, as too many assumptions are made which makes the estimates of "economic" benefits disputable . The main obstacle is the continuous decline of the hatchlings density in the major rivers which makes the sustainability rather difficult to predict and which is outside the scope of the CPP project.

The construction and operation of the structures are however still strongly recommended as the positive effect is clearly.
Where possible the assumption will be cross-checked in the near future with the results of the Special Fisheries Study and the results FAP 17.

I Summary and conclusions

A summary of the impact assessment for the different options is presented below,in Table 15:

TABLE 15: A summary of the production figures of the different development option for the Sirajganj CPP project area.

OPTION	TOTAL FISH PRODUCTION T/YEAR	INCREMENTAL PRODUCTION T/YEAR	TOTAL VALUE (US$/YEAR)	DECREMENTAL VALUE (US$/YEAR)
Present situation, breaching of BRE	591	+209	616.000	+193.000
Without case, stable BRE & no CPP	382	-	423.000	
Option 1	401	+19	442.000	+19.000
Option 2A	379	-3	420.000	-3.000
Option 2B	364	-18	408.000	-34.000

Options 2A and 2B have a negative impact on fisheries and the production under option 1 increases somewhat when compared with the without case. Incremental production, under option 1, takes place in the group of "beel' fish, mainly due to an increased inundation of the beel area in the pre monsoon and has been discussed in Chapter 9.H.

The incorporation of the positive effect of the construction of new inlet structures in the BRE could lessen the negative impact for option 2A and 2B a little. It has however the same relative effect on option 1, which therefore remains the best of the proposed options.

All options have a negative impact on fisheries production within the CPP-area when compared with the at present situation with breaches in the BRE but this should be considered an artificial situation.

Within the impact analysis the data are presented in tons/year or on a financial basis. It should however be realized that the major part of the losses consists of small and miscellaneous fish, the source of nutrition of poor households.

11. MITIGATION MEASURES

A Introduction

The mitigation measures are aiming at the restoration of the fisheries losses which will occur after the implementation of the proposed water management schemes. The losses are found in captured fisheries only. with the highest impact at subsistence fisheries level.
It is realised that these losses are of utmost importance for the people concerned, mainly landless and marginal farmers, it is their main source of animal protein and the nature of free access to the common resources guarantees access to this relatively cheap source of protein. Within this respect it has been decided to aim the mitigation measures not only at the restoration of fish on a kilogram bases but to include the two principles that mitigation measures must aim at those people who suffered the most from the proposed measures and to safe guard free access to the common resources as much as possible.

The proposed mitigation measures will take place in the two production systems; fisheries and aquaculture. From a philosophical point of view the actions under taken within fisheries can be considered as "real" mitigation measures as within this production system the losses take place. Action undertaken in the aquaculture production system will increase the production of fish but in the real sense it is not a mitigation measure as it does not affects the natural fish stocks. The development of aquaculture can be considered as a potential sources which until now not used at its full extend within the CPP area. The following mitigation measures are proposed and are summarised in the coming chapters;

* **Culture based fisheries**; the enhancement of the floodplain through the stocking of fish.
* **Pond culture**; the improvement of semi intensive carp farming in existing ponds.
* **Borrow pit culture**: the introduction of "Thaiputi" rearing in borrow pits and homestead ponds.
* **Integrated farming**; the combined farming of rice and fish.
* **The Beel concept**; the protection of reproductive area of 'Beel' fish in order to guarantee recruitment of this group.

B Culture based fisheries

The stocking of the floodplain with reared carp fingerlings has been introduced recently in Bangladesh by the Third Fisheries Program and the Second Aquaculture Project. The idea behind culture based fisheries is to enhance the natural fish production by stocking the water bodies with

fast growing fish species (450-500 fingerlings/ha). The stocked fish will grow under natural condition in the floodplain and are caught by the fishermen. The main species stocked at present in Bangladesh are: catla, ruhi, silver carp and common carp.

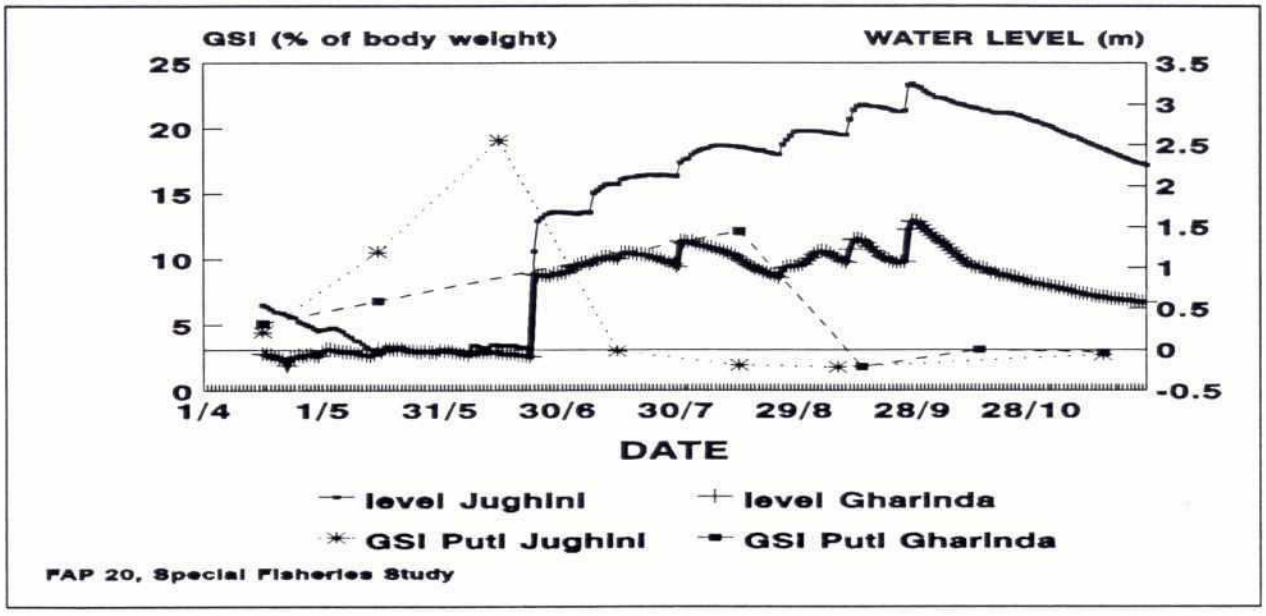
After implementation of the CPP project, approximately 2000-2500 ha of floodplain will be inundated by flooded every year (the area depends on the chosen option). This floodplain could be stocked with fingerlings, if the are indication that the natural recruitment is not sufficient. Stocking should be done just before or just after the flood enters the project area. Earlier stocking of the Beel/floodplain will be not possible due to the fact that rainwater congestion will be drained of during this time period and consequently the stocked fish would be drained of. Free access to the floodplain must be maintained which means that harvesting of the fish will take place throughout the monsoon resulting in the fact that some of the fish will be caught at a small size and others later in the season.

The fish yield obtained from the stocked fish only is estimated at 7 kg/ha/year or 58 ton/year when a survival rate of 20 % is assumed.

C The beel concept

The early water rise in the beel, due to rainwater congestion is probably the triggering factor for reproduction of "Beel" fish. Preliminary results of the Special Fisheries of the CPP-project, covering the reproduction strategies of this type of fish seems to confirm this for Puti (*Puntius sophore*).
Figure 14 presents the reproductive stage of *Puntius sophore*, within two beels located in the CPP area, during the period April 1992 - January 1993 together with the daily measured waterlevel.

FIGURE 14: The Gonado Somatic Index of *Puntius sophore* measured in Jughini Beel and Gharinda Beel during the 1992 season (n=1800) and the daily measured waterlevels.



Source: Special fisheries study, CPP-project, FAP 20

Within the monsoon season of 1992 the river flood water did not entered the flood plain and the area can be considered as under complete flood protection. The raise in waterlevel on the 24 th of June was caused by run off water from the surrounding area after the heavy rains on 23/24th of June. The further raise in water level during the monsoon had the same origin. In Jughini beel the water rises on the 24th of June with 1.7 m followed by a second rise to 2,5 m in mid July. In Gharindha Beel the water level rises only 0.9 m on the 24th of june fluctuates a little around 1 m till a further raise in september.

The reproduction of *Puntius sophore* took place in Jughini Beel within the period mid June till mid July, as can be seen from the sharp decrease of the GSI (the eggs have been released). In Gharinda Beel it seems that the reproduction of *Puntius sophore* has been delayed as they release their eggs only after mid August. The major registered difference between Jughini Beel and Gharinda Beel is the difference in the raise of the waterlevel.

From these first results it can be concluded that an early water rise indeed could be essential for the reproduction of "Beel" fish and that a water rise of 1 m is not enough to trigger the immediate reproduction of *Puntius sophore*, which can be considered as a typical "Beel" fish. It is therefore proposed to design and construct the drainage systems throughout the Sirajganj CPP project area in such a way that a minimal water level raise of 1.5 meter above average dry season beel water level will be guaranteed.

Within the study on the reproductive strategies of beel fish 5 other species were covered and the reproduction strategies of these will be taken into account also for the final recommendations and will be presented in the Interim report of The Special Fisheries Study (July, 1993)

D Aquaculture development

Within the CPP area approximately 300 ponds and an even larger number of borrow pits can be found which are or can be used for the rearing of fish. The actual used pond rearing method is based on traditional methods (production 600-1000 kg/ha/year) and from the burrow pits the trapped natural fish is caught by subsistence fisheries (production 300 kg/ha/year). Consequently the production from these systems is low and there is a scope for improvement.

The last decade aquaculture production increased substantially in Bangladesh through the "silver revolution" or the introduction chinese carps. Gradually the polyculture concept of major and chinese carps was developed several research stations and implemented in large area's of Bangladesh. The implementation of the rearing techniques has been carried out mainly through extension programmes. The Myamensingh Aquaculture Extension Project (MAEP), executed from july 1989 to april 1992 is an example of such a program.

The objectives of the MAEP were; "***To develop an extension system which will spread the results of aquaculture research to fish farmers in order to increase the production of fish and create employment***". It can be concluded that the MAEP attained its objectives: the aquaculture production increased from 700 kg/ha/year to an average of 2000 kg/ha/year, all implemented systems were profitable for the farmers and the recovery rate of given credits was 93%. It is therefore recommended to use the MAEP extension model as a guideline for an aquaculture development plan of the Sirajganj CPP area.

12 REFERENCES

Ali, S.M.I. and Zaman. 1989. Some aspects of environmental degradation of the inland open water fisheries of Bangladesh. Darjeeling University.

Bangladesh Bureau of Statistics. 1989. Statistical Yearbook of Bangladesh, Statistic Division, Ministry of Planning, Dhaka.

Bangladesh Bureau of Statistics, 1980. A report on the Household expenditure survevey of Bangladesh 1973-1974, Vol II. Statistic Division, Ministry of Planning, Dhaka.

Bangladesh Bureau of Statistics, 1986. A report on the Household expenditure survevey of Bangladesh 1981-1982, Vol II. Statistic Division, Ministry of Planning, Dhaka.

Department of Fisheries. 1990 (and previous years). Fish Catch Statistics of Bangladesh, Bangladesh Fisheries Resources Survey System, Dhaka.

World Bank, 1991. Bangladesh Fisheries Sector Review. Report No.8830-BD.

APPENDIX I: DETAILS OF THE IMPACT ASSESSMENT

FLOODPLAIN PRODUCTION & KHAL	0.94	KG/HA/10 DAYS
TOTAL FLOODPLAIN PRODUCTION	31	TON/YEAR
BEEL PRODUCTION	12	TON/YEAR
BEEL FACTOR	1	

APPENDIX 1.1
WITHOUT CASE (BRE & NO CPP PROJECT)

MONTH	DECIMAL	AREA FLOODPLAIN (HA)	BEEL AREA (HA)	FLOODPLAIN PRODUCTION (TON)	BEEL PRODUCTION (TON)	BEEL FISHING INTENSIT (%)	REL BEEL PRODUCTIO (KG/HA/10 Days)	HABITAT
JAN	10	0	50	0.0	0.6	2.3	11.50	BEEL
JAN	20	0	50	0.0	0.6	2.3	11.50	BEEL
JAN	30	0	50	0.0	0.6	2.3	11.50	BEEL
FEB	10	0	40	0.0	0.6	2.3	14.38	BEEL
FEB	20	0	40	0.0	0.0	0.0	0.00	BEEL
FEB	30	0	40	0.0	0.0	0.0	0.00	BEEL
MAR	10	0	30	0.0	0.0	0.0	0.00	BEEL
MAR	20	0	30	0.0	0.6	2.3	19.44	BEEL
MAR	30	0	20	0.0	0.6	2.3	29.17	BEEL
APR	10	0	25	0.0	0.6	2.3	23.33	BEEL
APR	20	0	25	0.0	1.2	4.7	47.00	BEEL
APR	30	0	154	0.0	1.2	4.7	7.64	BEEL
MAY	10	0	143	0.0	1.2	4.7	8.19	BEEL
MAY	20	0	149	0.0	0.6	2.3	3.85	BEEL
MAY	30	0	149	0.0	0.6	2.3	3.86	BEEL
JUN	10	0	190	0.0	0.6	2.3	3.02	BEEL
JUN	20	198	0	0.2	0.0	0.0	0.00	FLOODPLAIN
JUN	30	332	0	0.3	0.0	0.0	0.00	FLOODPLAIN
JUL	10	604	0	0.6	0.0	0.0	0.00	FLOODPLAIN
JUL	20	1239	0	1.2	0.0	0.0	0.00	FLOODPLAIN
JUL	30	5700	0	5.4	0.0	0.0	0.00	FLOODPLAIN
AUG	10	8497	0	8.0	0.0	0.0	0.00	FLOODPLAIN
AUG	20	8388	0	7.9	0.0	0.0	0.00	FLOODPLAIN
AUG	30	5960	0	5.6	0.0	0.0	0.00	FLOODPLAIN
SEP	10	556	0	0.5	0.0	0.0	0.00	FLOODPLAIN
SEP	20	205	0	0.2	0.0	0.0	0.00	FLOODPLAIN
SEP	30	238	0	0.2	0.0	0.0	0.00	FLOODPLAIN
OCT	10	462	0	0.4	0.0	0.0	0.00	FLOODPLAIN
OCT	20	371	0	0.3	0.0	0.0	0.00	FLOODPLAIN
OCT	30	221	0	0.2	0.0	0.0	0.00	FLOODPLAIN
NOV	10	200	0	0.2	0.0	0.0	0.00	FLOODPLAIN
NOV	20	0	180	0.0	0.6	2.3	3.19	BEEL
NOV	30	0	160	0.0	0.6	2.3	3.59	BEEL
DEC	10	0	140	0.0	0.6	2.3	4.11	BEEL
DEC	20	0	120	0.0	0.6	2.3	4.79	BEEL
DEC	30	0	60	0.0	0.6	2.3	9.58	BEEL

APPENDIX 1.2
WITHOUT CASE, BRE & No CPP

PRODUCTION FIGURES SIRAJGANJ

TOTAL PRODUCTION MAIN RIVER	251	TON/YEAR
TOTAL PRODUCTION MINOR RIVER	0	TON/YEAR
TOTAL PRODUCTION FLOODPLAIN	31	TON/YEAR
TOTAL PRODUCTION BEEL	12	TON/YEAR
TOTAL PRODUCTION PITS	18	TON/YEAR
TOTAL PRODUCTION PONDS	70	TON/YEAR
TOTAL	382	TON/YEAR

SPECIES WIDE PRODUCTION FIGURES

SPECIES	PRODUCTION PRINCIPAL RIVERS (%)	PRODUCTION BEEL (%)	PRODUCTION FLOODPLAIN (%)	PRODUCTION PONDS (%)	PRODUCTION TOTAL HABITATS (%)
MAJOR CARP	1.1	8.4	0.4	71.3	4.7
MINOR CARP	14.5	8.6	0.0	4.3	7.6
CATFISH	2.2	12.5	0.5	5.5	9.2
LIVE FISH	6.2	6.3	0.5	0.0	5.1
HILSA	0.9	0.0	0.0	0.0	0.3
MACROBRACHIUM	1.7	0.0	0.0	0.0	0.0
SMALL SHRIMP	71.3	3.8	0.2	0.0	0.6
MISCELLANEOUS	71.3	60.4	98.5	18.9	72.5
TOTAL	100	100	100	100	100

SPECIES	PRODUCTION PRINCIPAL RIVERS (TON/YEAR)	PRODUCTION BEEL (TON/YEAR)	PRODUCTION FLOODPLAIN (TON/YEAR)	PRODUCTION PONDS (TON/YEAR)	PRODUCTION PITS (TON/YEAR)	PRODUCTION TOTAL HABITATS (TON/YEAR)
MAJOR CARP	5.0	1.0	0.1	49.9	0.1	56
MINOR CARP	2.9	1.0	0.0	3.0	0.0	7
CATFISH	36.4	1.5	0.1	3.8	0.1	42
LIVE FISH	5.6	0.8	0.2	0.0	0.1	7
HILSA	15.5	0.0	0.0	0.0	0.0	15
MACROBRACHIUM	2.2	0.0	0.0	0.0	0.0	2
SMALL SHRIMP	4.2	0.5	0.0	0.0	0.0	5
MISCELLANEOUS	179.0	7.3	30.5	13.2	17.7	248
TOTAL	**251**	**12**	**31**	**70**	**18**	**382**

SPECIES WIDE PRODUCTION VALUES

SPECIES	PRICE TK/KG	ECONOMIC VALUE US$ 1000	TK (lhk)
MAJOR CARP	80	115	45
MINOR CARP	70	12	5
CATFISH	45	48	19
LIVE FISH	45	8	3
HILSA	100	40	15
MACROBRACHIUM	100	6	2
SMALL SHRIMP	30	4	1
MISCELLANEOUS	30	0	0
TOTAL		**232**	**91**

FLOODPLAIN PRODUCTION & KHAL	0.94	KG/HA/10 DAYS
TOTAL FLOODPLAIN PRODUCTION	32	TON/YEAR
BEEL PRODUCTION	30	TON/YEAR
BEEL RAISING FACTOR	2.18	

APPENDIX 1.3
SIRAJGANJ OPTION 1

MONTH	DECIMAL	AREA FLOODPLAIN (HA)	BEEL AREA OPTION 1 (HA)	BEEL AREA WITHOUT CASE (HA)	FLOODPLAIN PRODUCTION (TON)	BEEL PRODUCTION (TON)	BEEL FISHING INTENSITY	REL BEEL PRODUCTION (KG/HA/10 Days)	HABITAT
JAN	10	0	50	50	0.0	1.3	2.3	11.50	BEEL
JAN	20	0	50	50	0.0	1.3	2.3	11.50	BEEL
JAN	30	0	50	50	0.0	1.3	2.3	11.50	BEEL
FEB	10	0	40	40	0.0	1.3	2.3	14.38	BEEL
FEB	20	0	40	40	0.0	0.0	0.0	0.00	BEEL
FEB	30	0	40	40	0.0	0.0	0.0	0.00	BEEL
MAR	10	0	30	30	0.0	0.0	0.0	0.00	BEEL
MAR	20	0	30	30	0.0	1.3	2.3	19.44	BEEL
MAR	30	0	20	20	0.0	1.3	2.3	29.17	BEEL
APR	10	0	25	25	0.0	1.3	2.3	23.33	BEEL
APR	20	0	25	25	0.0	2.6	4.7	47.00	BEEL
APR	30	0	260	154	0.0	4.3	4.7	7.64	BEEL
MAY	10	0	307	143	0.0	5.5	4.7	8.19	BEEL
MAY	20	0	474	149	0.0	4.0	2.3	3.85	BEEL
MAY	30	0	388	149	0.0	1.3	2.3	1.55	BEEL
JUN	10	0	393	190	0.0	0.3	2.3	0.32	BEEL
JUN	20	520	0	0	0.5	0.0	0.0	0.00	FLOODPLAIN
JUN	30	1059	0	0	1.0	0.0	0.0	0.00	FLOODPLAIN
JUL	10	1254	0	0	1.2	0.0	0.0	0.00	FLOODPLAIN
JUL	20	2345	0	0	2.2	0.0	0.0	0.00	FLOODPLAIN
JUL	30	5046	0	0	4.7	0.0	0.0	0.00	FLOODPLAIN
AUG	10	6943	0	0	6.5	0.0	0.0	0.00	FLOODPLAIN
AUG	20	6843	0	0	6.4	0.0	0.0	0.00	FLOODPLAIN
AUG	30	4936	0	0	4.6	0.0	0.0	0.00	FLOODPLAIN
SEP	10	1090	0	0	1.0	0.0	0.0	0.00	FLOODPLAIN
SEP	20	954	0	0	0.9	0.0	0.0	0.00	FLOODPLAIN
SEP	30	450	0	0	0.4	0.0	0.0	0.00	FLOODPLAIN
OCT	10	1378	0	0	1.3	0.0	0.0	0.00	FLOODPLAIN
OCT	20	917	0	0	0.9	0.0	0.0	0.00	FLOODPLAIN
OCT	30	512	0	0	0.5	0.0	0.0	0.00	FLOODPLAIN
NOV	10	215	0	0	0.2	0.0	0.0	0.00	FLOODPLAIN
NOV	20	0	200	180	0.0	0.3	2.3	0.58	BEEL
NOV	30	0	150	160	0.0	0.3	2.3	0.96	BEEL
DEC	10	0	150	140	0.0	0.6	2.3	1.92	BEEL
DEC	20	0	100	120	0.0	0.8	2.3	3.83	BEEL
DEC	30	0	55	60	0.0	1.2	2.3	9.58	BEEL

PRODUCTION FIGURES SIRAJGANJ

TOTAL PRODUCTION MAIN RIVER	251	TON/YEAR
TOTAL PRODUCTION MINOR RIVER	0	TON/YEAR
TOTAL PRODUCTION FLOODPLAIN	32	TON/YEAR
TOTAL PRODUCTION BEEL	30	TON/YEAR
TOTAL PRODUCTION PITS	18	TON/YEAR
TOTAL PRODUCTION PONDS	70	TON/YEAR
TOTAL	401	TON/YEAR

APPENDIX 1.4
OPTION 1

SPECIES WIDE PRODUCTION FIGURES

SPECIES	PRODUCTION PRINCIPAL RIVERS (%)	PRODUCTION BEEL (%)	PRODUCTION FLOODPLAIN (%)	PRODUCTION PONDS (%)	PRODUCTION TOTAL HABITATS (%)
MAJOR CARP	2.0	8.4	0.4	71.3	4.7
MINOR CARP	1.1	8.6	0.0	4.3	7.6
CATFISH	14.5	12.5	0.5	5.5	9.2
LIVE FISH	2.2	6.3	0.5	0.0	5.1
HILSA	6.2	0.0	0.0	0.0	0.3
MACROBRACHIUM	0.9	0.0	0.0	0.0	0.0
SMALL SHRIMP	1.7	3.8	0.2	0.0	0.6
MISCELLANEOUS	71.3	60.4	98.5	18.9	72.5
TOTAL	100	100.0	100	100	100

SPECIES	PRODUCTION PRINCIPAL RIVERS (TON/YEAR)	PRODUCTION BEEL (TON/YEAR)	PRODUCTION FLOODPLAIN (TON/YEAR)	PRODUCTION PONDS (TON/YEAR)	PRODUCTION PITS (TON/YEAR)	PRODUCTION TOTAL HABITATS (TON/YEAR)
MAJOR CARP	5.0	2.5	0.1	49.9	0.1	58
MINOR CARP	2.9	2.6	0.0	3.0	0.0	8
CATFISH	36.4	3.8	0.1	3.8	0.1	44
LIVE FISH	5.6	1.9	0.2	0.0	0.1	8
HILSA	15.5	0.0	0.0	0.0	0.0	15
MACROBRACHIUM	2.2	0.0	0.0	0.0	0.0	2
SMALL SHRIMP	4.2	1.1	0.1	0.0	0.0	5
MISCELLANEOUS	179.0	18.1	31.5	13.2	17.7	260
TOTAL	251	30	32	70	18	401

SPECIES WIDE PRODUCTION VALUES

SPECIES	PRICE TK/KG	ECONOMIC VALUE US$ 1000	TK (lhk)
MAJOR CARP	80	118	46
MINOR CARP	70	15	6
CATFISH	45	51	20
LIVE FISH	45	0	0
HILSA	100	0	0
MACROBRACHIUM	100	0	0
SMALL SHRIMP	30	0	0
MISCELLANEOUS	30	0	0
TOTAL		184	72

FLOODPLAIN PRODUCTION & KHALS	0.94	KG/HA/10 DAYS
TOTAL FLOODPLAIN PRODUCTION	31	TON/YEAR
BEEL PRODUCTION	9	TON/YEAR
BEEL RAISING FACTOR	0.99	

APPENDIX 1.5
SIRAJGANJ OPTION 2A

MONTH	DECIMAL	AREA FLOODPLAIN (HA)	BEEL AREA OPTION 2A (HA)	BEEL AREA WITOUT CASE (HA)	FLOODPLAIN PRODUCTION (TON)	BEEL PRODUCTION (TON)	BEEL FISHING INTENSITY (%)	REL BEEL PRODUCTION (KG/HA/10 Days)	HABITAT
JAN	10	0	50	50	0.0	0.6	2.3	11.50	BEEL
JAN	20	0	50	50	0.0	0.6	2.3	11.50	BEEL
JAN	30	0	50	50	0.0	0.6	2.3	11.50	BEEL
FEB	10	0	40	40	0.0	0.6	2.3	14.38	BEEL
FEB	20	0	40	40	0.0	0.0	0.0	0.00	BEEL
FEB	30	0	40	40	0.0	0.0	0.0	0.00	BEEL
MAR	10	0	30	30	0.0	0.0	0.0	0.00	BEEL
MAR	20	0	30	30	0.0	0.6	2.3	19.44	BEEL
MAR	30	0	20	20	0.0	0.6	2.3	29.17	BEEL
APR	10	0	25	25	0.0	0.6	2.3	23.33	BEEL
APR	20	0	25	25	0.0	1.2	4.7	47.00	BEEL
APR	30	0	153	154	0.0	1.2	4.7	7.64	BEEL
MAY	10	0	134	143	0.0	1.1	4.7	8.19	BEEL
MAY	20	0	149	149	0.0	0.6	2.3	3.85	BEEL
MAY	30	0	148	149	0.0	0.2	2.3	1.55	BEEL
JUN	10	0	189	190	0.0	0.1	2.3	0.32	BEEL
JUN	20	198	0	0	0.2	0.0	0.0	0.00	FLOODPLAIN
JUN	30	337	0	0	0.3	0.0	0.0	0.00	FLOODPLAIN
JUL	10	601	0	0	0.6	0.0	0.0	0.00	FLOODPLAIN
JUL	20	1217	0	0	1.1	0.0	0.0	0.00	FLOODPLAIN
JUL	30	5715	0	0	5.4	0.0	0.0	0.00	FLOODPLAIN
AUG	10	8619	0	0	8.1	0.0	0.0	0.00	FLOODPLAIN
AUG	20	8419	0	0	7.9	0.0	0.0	0.00	FLOODPLAIN
AUG	30	6009	0	0	5.6	0.0	0.0	0.00	FLOODPLAIN
SEP	10	732	0	0	0.7	0.0	0.0	0.00	FLOODPLAIN
SEP	20	226	0	0	0.2	0.0	0.0	0.00	FLOODPLAIN
SEP	30	261	0	0	0.2	0.0	0.0	0.00	FLOODPLAIN
OCT	10	464	0	0	0.4	0.0	0.0	0.00	FLOODPLAIN
OCT	20	366	0	0	0.3	0.0	0.0	0.00	FLOODPLAIN
OCT	30	233	0	0	0.2	0.0	0.0	0.00	FLOODPLAIN
NOV	10	107	0	0	0.1	0.0	0.0	0.00	FLOODPLAIN
NOV	20	0	100	180	0.0	0.1	2.3	0.58	BEEL
NOV	30	0	90	160	0.0	0.1	2.3	0.96	BEEL
DEC	10	0	80	140	0.0	0.2	2.3	1.92	BEEL
DEC	20	0	70	120	0.0	0.3	2.3	3.83	BEEL
DEC	30	0	60	60	0.0	0.6	2.3	9.58	BEEL

PRODUCTION FIGURES SIRAJGANJ		
TOTAL PRODUCTION MAIN RIVER	251	TON/YEAR
TOTAL PRODUCTION MINOR RIVER	0	TON/YEAR
TOTAL PRODUCTION FLOODPLAIN	31	TON/YEAR
TOTAL PRODUCTION BEEL	9	TON/YEAR
TOTAL PRODUCTION PITS	18	TON/YEAR
TOTAL PRODUCTION PONDS	70	TON/YEAR
TOTAL	379	TON/YEAR

APPENDIX 1.6
OPTION 2A

SPECIES WIDE PRODUCTION FIGURES

SPECIES	PRODUCTION RINCIPAL RIVER (%)	PRODUCTION BEEL (%)	PRODUCTION FLOODPLAIN (%)	PRODUCTION PONDS (%)	PRODUCTION TOTAL HABITATS (%)
MAJOR CARP	2.0	8.4	0.4	71.3	4.7
MINOR CARP	1.1	8.6	0.0	4.3	7.6
CATFISH	14.5	12.5	0.5	5.5	9.2
LIVE FISH	2.2	6.3	0.5	0.0	5.1
HILSA	6.2	0.0	0.0	0.0	0.3
MACROBRACHIUM	0.9	0.0	0.0	0.0	0.0
SMALL SHRIMP	1.7	3.8	0.2	0.0	0.6
MISCELLANEOUS	71.3	60.4	98.5	18.9	72.5
TOTAL	100	100.0	100	100	100

SPECIES	PRODUCTION RINCIPAL RIVER (TON/YEAR)	PRODUCTION BEEL (TON/YEAR)	PRODUCTION FLOODPLAIN (TON/YEAR)	PRODUCTION PONDS (TON/YEAR)	PRODUCTION PITS (TON/YEAR)	PRODUCTION TOTAL HABITATS (TON/YEAR)
MAJOR CARP	5.0	0.8	0.1	49.9	0.1	56
MINOR CARP	2.9	0.8	0.0	3.0	0.0	7
CATFISH	36.4	1.1	0.1	3.8	0.1	42
LIVE FISH	5.6	0.6	0.2	0.0	0.1	6
HILSA	15.5	0.0	0.0	0.0	0.0	15
MACROBRACHIUM	2.2	0.0	0.0	0.0	0.0	2
SMALL SHRIMP	4.2	0.3	0.0	0.0	0.0	5
MISCELLANEOUS	179.0	5.4	30.5	13.2	17.7	246
TOTAL	251	9	31	70	18	379

SPECIES WIDE PRODUCTION VALUES

SPECIES	PRICE TK/KG	ECONOMIC VALUE US$ 1000	TK (lhk)
MAJOR CARP	80	115	45
MINOR CARP	70	12	5
CATFISH	45	48	19
LIVE FISH	45	7	3
HILSA	100	40	15
MACROBRACHIUM	100	6	2
SMALL SHRIMP	30	4	1
MISCELLANEOUS	30	189	74
TOTAL		420	164

FLOODPLAIN PRODUCTION & KHALS	0.94	KG/HA/10 DAYS
FLOODPLAIN PRODUCTION	31	TON/YEAR
LOSSES ICHAMATI FLOODPLAIN	15	TON/YEAR
TOTAL FLOODPLAIN PRODUCTION	16	TON/YEAR
BEEL PRODUCTION	9	TON/YEAR
BEEL RAISING FACTOR	0.99	

APPENDIX 1.7
OPTION 2B

MONTH	DECIMAL	AREA FLOODPLAIN (HA)	BEEL AREA OPTION 2B (HA)	BEEL AREA WITHOUT CASE (HA)	FLOODPLAIN PRODUCTION (TON)	BEEL PRODUCTION (TON)	BEEL FISHING INTENSITY (%)	REL BEEL PRODUCTION (KG/HA/10 Days)	HABITAT
JAN	10	0	50	50	0.0	0.6	2.3	11.50	BEEL
JAN	20	0	50	50	0.0	0.6	2.3	11.50	BEEL
JAN	30	0	50	50	0.0	0.6	2.3	11.50	BEEL
FEB	10	0	40	40	0.0	0.6	2.3	14.38	BEEL
FEB	20	0	40	40	0.0	0.0	0.0	0.00	BEEL
FEB	30	0	40	40	0.0	0.0	0.0	0.00	BEEL
MAR	10	0	30	30	0.0	0.0	0.0	0.00	BEEL
MAR	20	0	30	30	0.0	0.6	2.3	19.44	BEEL
MAR	30	0	20	20	0.0	0.6	2.3	29.17	BEEL
APR	10	0	25	25	0.0	0.6	2.3	23.33	BEEL
APR	20	0	25	25	0.0	1.2	4.7	47.00	BEEL
APR	30	0	153	154	0.0	1.2	4.7	7.64	BEEL
MAY	10	0	134	143	0.0	1.1	4.7	8.19	BEEL
MAY	20	0	149	149	0.0	0.6	2.3	3.85	BEEL
MAY	30	0	148	149	0.0	0.2	2.3	1.55	BEEL
JUN	10	0	189	190	0.0	0.1	2.3	0.32	BEEL
JUN	20	198	0	0	0.2	0.0	0.0	0.00	FLOODPLAIN
JUN	30	337	0	0	0.3	0.0	0.0	0.00	FLOODPLAIN
JUL	10	601	0	0	0.6	0.0	0.0	0.00	FLOODPLAIN
JUL	20	1217	0	0	1.1	0.0	0.0	0.00	FLOODPLAIN
JUL	30	5715	0	0	5.4	0.0	0.0	0.00	FLOODPLAIN
AUG	10	8619	0	0	8.1	0.0	0.0	0.00	FLOODPLAIN
AUG	20	8419	0	0	7.9	0.0	0.0	0.00	FLOODPLAIN
AUG	30	6009	0	0	5.6	0.0	0.0	0.00	FLOODPLAIN
SEP	10	732	0	0	0.7	0.0	0.0	0.00	FLOODPLAIN
SEP	20	226	0	0	0.2	0.0	0.0	0.00	FLOODPLAIN
SEP	30	261	0	0	0.2	0.0	0.0	0.00	FLOODPLAIN
OCT	10	464	0	0	0.4	0.0	0.0	0.00	FLOODPLAIN
OCT	20	366	0	0	0.3	0.0	0.0	0.00	FLOODPLAIN
OCT	30	233	0	0	0.2	0.0	0.0	0.00	FLOODPLAIN
NOV	10	107	0	0	0.1	0.0	0.0	0.00	FLOODPLAIN
NOV	20	0	100	180	0.0	0.1	2.3	0.58	BEEL
NOV	30	0	90	160	0.0	0.1	2.3	0.96	BEEL
DEC	10	0	80	140	0.0	0.2	2.3	1.92	BEEL
DEC	20	0	70	120	0.0	0.3	2.3	3.83	BEEL
DEC	30	0	60	60	0.0	0.6	2.3	9.58	BEEL

PRODUCTION FIGURES SIRAJGANJ

TOTAL PRODUCTION MAIN RIVER	251	TON/YEAR
TOTAL PRODUCTION MINOR RIVER	0	TON/YEAR
TOTAL PRODUCTION FLOODPLAIN	16	TON/YEAR
TOTAL PRODUCTION BEEL	9	TON/YEAR
TOTAL PRODUCTION PITS	18	TON/YEAR
TOTAL PRODUCTION PONDS	70	TON/YEAR
TOTAL	364	TON/YEAR

APPENDIX 1.8
OPTION 2B

SPECIES WIDE PRODUCTION FIGURES

SPECIES	PRODUCTION PRINCIPAL RIVERS (%)	PRODUCTION BEEL (%)	PRODUCTION FLOODPLAIN (%)	PRODUCTION PONDS (%)	PRODUCTION OTAL HABITATS (%)
MAJOR CARP	2.0	8.4	0.4	71.3	4.7
MINOR CARP	1.1	8.6	0.0	4.3	7.6
CATFISH	14.5	12.5	0.5	5.5	9.2
LIVE FISH	2.2	6.3	0.5	0.0	5.1
HILSA	6.2	0.0	0.0	0.0	0.3
MACROBRACHIUM	0.9	0.0	0.0	0.0	0.0
SMALL SHRIMP	1.7	3.8	0.2	0.0	0.6
MISCELLANEOUS	71.3	60.4	98.5	18.9	72.5
TOTAL	100	100.0	100	100	100

SPECIES	PRODUCTION PRINCIPAL RIVERS (TON/YEAR)	PRODUCTION BEEL (TON/YEAR)	PRODUCTION FLOODPLAIN (TON/YEAR)	PRODUCTION PONDS (TON/YEAR)	PRODUCTION PITS (TON/YEAR)	PRODUCTION TOTAL HABITATS (TON/YEAR)
MAJOR CARP	5.0	0.8	0.1	49.9	0.1	56
MINOR CARP	2.9	0.8	0.0	3.0	0.0	7
CATFISH	36.4	1.1	0.1	3.8	0.1	42
LIVE FISH	5.6	0.6	0.1	0.0	0.1	6
HILSA	15.5	0.0	0.0	0.0	0.0	15
MACROBRACHIUM	2.2	0.0	0.0	0.0	0.0	2
SMALL SHRIMP	4.2	0.3	0.0	0.0	0.0	5
MISCELLANEOUS	179.0	5.4	15.8	13.2	17.7	231
TOTAL	251	9	16	70	18	364

SPECIES WIDE PRODUCTION VALUES

SPECIES	PRICE TK/KG	ECONOMIC VALUE US$ 1000	TK (lhk)
MAJOR CARP	80	115	45
MINOR CARP	70	12	5
CATFISH	45	48	19
LIVE FISH	45	7	3
HILSA	100	40	15
MACROBRACHIUM	100	6	2
SMALL SHRIMP	30	4	1
MISCELLANEOUS	30	178	69
TOTAL		408	159

FLOODPLAIN PRODUCTION & KHALS	0.94	KG/HA/10 DAYS	**APPENDIX 1.9**
TOTAL FLOODPLAIN PRODUCTION	122	TON/YEAR	**BRE WITH BREACHING**
BEEL PRODUCTION	130	TON/YEAR	
BEEL RAISING FACTOR	6.50		

MONTH	DECIMAL	AREA FLOODPLAIN (HA)	BEEL AREA WITH BREACH (HA)	BEEL AREA WITOUT CASE (HA)	FLOODPLAIN PRODUCTION (TON)	BEEL PRODUCTION (TON)	BEEL FISHING INTENSITY (%)	REL BEEL PRODUCTION (KG/HA/10 Days)	HABITAT
JAN	10	0	50	50	0.0	3.7	2.3	11.50	BEEL
JAN	20	0	50	50	0.0	3.7	2.3	11.50	BEEL
JAN	30	0	50	50	0.0	3.7	2.3	11.50	BEEL
FEB	10	0	40	40	0.0	3.7	2.3	14.38	BEEL
FEB	20	0	40	40	0.0	0.0	0.0	0.00	BEEL
FEB	30	0	40	40	0.0	0.0	0.0	0.00	BEEL
MAR	10	0	30	30	0.0	0.0	0.0	0.00	BEEL
MAR	20	0	30	30	0.0	3.8	2.3	19.44	BEEL
MAR	30	0	20	20	0.0	3.8	2.3	29.17	BEEL
APR	10	0	25	25	0.0	3.8	2.3	23.33	BEEL
APR	20	0	25	25	0.0	7.6	4.7	47.00	BEEL
APR	30	0	357	154	0.0	17.7	4.7	7.64	BEEL
MAY	10	0	342	143	0.0	18.2	4.7	8.19	BEEL
MAY	20	0	344	149	0.0	8.6	2.3	3.85	BEEL
MAY	30	0	370	149	0.0	3.7	2.3	1.55	BEEL
JUN	10	0	1773	180	0.0	3.7	2.3	0.32	BEEL
JUN	20	5639	0	0	5.3	0.0	0.0	0.00	FLOODPLAIN
JUN	30	8665	0	0	8.1	0.0	0.0	0.00	FLOODPLAIN
JUL	10	8439	0	0	7.9	0.0	0.0	0.00	FLOODPLAIN
JUL	20	10339	0	0	9.7	0.0	0.0	0.00	FLOODPLAIN
JUL	30	10876	0	0	10.2	0.0	0.0	0.00	FLOODPLAIN
AUG	10	10779	0	0	10.1	0.0	0.0	0.00	FLOODPLAIN
AUG	20	10258	0	0	9.6	0.0	0.0	0.00	FLOODPLAIN
AUG	30	9821	0	0	9.2	0.0	0.0	0.00	FLOODPLAIN
SEP	10	9570	0	0	9.0	0.0	0.0	0.00	FLOODPLAIN
SEP	20	7123	0	0	6.7	0.0	0.0	0.00	FLOODPLAIN
SEP	30	10303	0	0	9.7	0.0	0.0	0.00	FLOODPLAIN
OCT	10	8950	0	0	8.4	0.0	0.0	0.00	FLOODPLAIN
OCT	20	7500	0	0	7.1	0.0	0.0	0.00	FLOODPLAIN
OCT	30	6400	0	0	6.0	0.0	0.0	0.00	FLOODPLAIN
NOV	10	5400	0	0	5.1	0.0	0.0	0.00	FLOODPLAIN
NOV	20	0	3000	180	0.0	11.2	2.3	0.58	BEEL
NOV	30	0	1000	160	0.0	6.2	2.3	0.96	BEEL
DEC	10	0	800	140	0.0	10.0	2.3	1.92	BEEL
DEC	20	0	400	120	0.0	10.0	2.3	3.83	BEEL
DEC	30	0	100	60	0.0	6.2	2.3	9.58	BEEL

PRODUCTION FIGURES SIRAJGANJ

TOTAL PRODUCTION MAIN RIVER	251	TON/YEAR
TOTAL PRODUCTION MINOR RIVER	0	TON/YEAR
TOTAL PRODUCTION FLOODPLAIN	122	TON/YEAR
TOTAL PRODUCTION BEEL	130	TON/YEAR
TOTAL PRODUCTION PITS	18	TON/YEAR
TOTAL PRODUCTION PONDS	70	TON/YEAR
TOTAL	591	TON/YEAR

APPENDIX 1.10
BRE WITH BREACHING

SPECIES WIDE PRODUCTION FIGURES

SPECIES	PRODUCTION PRINCIPAL RIVER (%)	PRODUCTION BEEL (%)	PRODUCTION FLOODPLAIN (%)	PRODUCTION PONDS (%)	PRODUCTION TOTAL HABITATS (%)
MAJOR CARP	2.0	8.4	0.4	71.3	4.7
MINOR CARP	1.1	8.6	0.0	4.3	7.6
CATFISH	14.5	12.5	0.5	5.5	9.2
LIVE FISH	2.2	6.3	0.5	0.0	5.1
HILSA	6.2	0.0	0.0	0.0	0.3
MACROBRACHIUM	0.9	0.0	0.0	0.0	0.0
SMALL SHRIMP	1.7	3.8	0.2	0.0	0.6
MISCELLANEOUS	71.3	60.4	98.5	18.9	72.5
TOTAL	100	100	100	100	100

SPECIES	PRODUCTION PRINCIPAL RIVERS (TON/YEAR)	PRODUCTION BEEL (TON/YEAR)	PRODUCTION FLOODPLAIN (TON/YEAR)	PRODUCTION PONDS (TON/YEAR)	PRODUCTION PITS (TON/YEAR)	PRODUCTION TOTAL HABITATS (TON/YEAR)
MAJOR CARP	5.0	10.9	0.4	49.9	0.1	66
MINOR CARP	2.9	11.2	0.0	3.0	0.0	17
CATFISH	36.4	16.3	0.6	3.8	0.1	57
LIVE FISH	5.6	8.1	0.6	0.0	0.1	14
HILSA	15.5	0.0	0.0	0.0	0.0	15
MACROBRACHIUM	2.2	0.0	0.0	0.0	0.0	2
SMALL SHRIMP	4.2	4.9	0.2	0.0	0.0	9
MISCELLANEOUS	179.0	78.6	120.2	13.2	17.7	409
TOTAL	251	130	122	70	18	591

SPECIES WIDE PRODUCTION VALUE

SPECIES	PRICE TK/KG	ECONOMIC VALUE US$ 1000	TK (lhk)
MAJOR CARP	80	136	53
MINOR CARP	70	31	12
CATFISH	45	66	26
LIVE FISH	45	0	0
HILSA	100	0	0
MACROBRACHIUM	100	0	0
SMALL SHRIMP	30	0	0
MISCELLANEOUS	30	0	0
TOTAL		233	91

APPENDIX 2
THE INFLUENCE OF THE SLUICE IN THE BRE ON FLOODPLAIN FISHERIES PRODUCTION
AN EXCERSISE

HYDROLOGICAL	STABLE BRE & NO CPP	OPTION 1	OPTION 2A	OPTION 2B	BRE & BREACH
INUNDATED AREA (HA)	2100	2297	2233	2233	8670
AVG DEPTH (MTR)	1.5	1.5	1.5	1.5	1.5
AVG QUANTITY OF WATER (MILLION M3)	31.5	34.4	33.4	33.4	130.1
% RIVER WATER	0	75	77	77	100
BIOLOGICAL	**STABLE BRE & NO CPP**	**OPTION 1**	**OPTION 2A**	**OPTION 2B**	**BRE & BREACH**
INCREMENTAL FLOODPLAIN PRODUCTION (KG/HA/YEAR)	10	10	10	10	10
MAX INCREMENT WITH 100 % RIVER WATER (T/YEAR)	21	23	22	22	87
TOTAL INCREM FLOODPLAIN PRODUCTION (T/YEAR)	0	17.3	17.3	17.3	86.7
FLOODPLAIN WITHOUT EFFECT OF RECRUITMENT (T/YEAR)	31	32	31	16	122
TOTAL FLOODPLAIN PRODUCTION (T/YEAR)	31	49	48	33	209
TECHNICAL					
SILL LEVEL	9	MTR			
MAX SLUICE CAPACITY	10	M3/SEC			
NO DAYS MAX CAPACITY	10	DAYS			
AVG SLUICE CAPACITY	33	%			
AVG SLUICE PASSAGE	3.3	M3/SEC			
OPERATION PERIOD	1	MONTH			
TOTAL PASSAGE PER SLUICE	8.64	MILLION M3			
NO SLUICE	3				
TOTAL RIVER WATER PASSAGE	25.9	MILLION M3			
ECONOMIC					
CONSTRUCTION COST 1 SLUICE	30	LAKH			
TOTAL COSTS	90	LAKH			
PRICE FISH	60	TK/KG			
ECONOMIC RATE OF RETURN (30 years)	11	%			