ROLE OF FARAKKA BARRAGE ON THE DISASTROUS FLOOD AT MALDA (WEST BENGAL) IN 1998

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ABSTRACT

Farakka Barrage was constructed in 1971 on the river 'Ganga' for diversion of 1135 cumec (40,000 cusec) flow to the 'Hoogly' river for the navigability of the Calcutta port located on the bank of 'Hoogly' river. 'Ganga' river is developing a meander with Farakka Barrage at the centre. Upstream of the barrage, the river has moved towards left (Malda Side) and on the downstream side it has shifted towards right (Murshidabad Side). The river breached the flood embankments upstream of Farakka on several occasions after 1971. Disastrous Flood in Malda district in West Bengal occurred in 1998 due to several breaches in the flood embankments resulting in collosol loss of life and properties. Author has critically examined the various reasons of the 1998 flood and the role of Farakka barrage for the flood so that correct measures are adopted in future for the flood control including training of 'Ganga' river upstream and downstream of Farakka barrage.

1. INTRODUCTION

Farakka Barrage was constructed in the year 1971 across the mighty river 'Ganga' in order to divert part of the main flow from 'Ganga' to its tributary 'Hoogly' river (Fig. 1). With gradual silting of the Hoogly offtake near Jangipur in Murshidabad district of West Bengal, fresh upland discharge from 'Ganga' to 'Hoogly' was reducing drastically (Mookerjea' 74). Being a tidal river, Hoogly river depth was reducing due to deposition of sediments carried by the high tides from the sea of Bay of Bengal. Annual dredging costs increased to Rs. 75 million (Institution of Engineers (India), '73) for the navigability of the river on which Calcutta port is situated. Model studies at CW & PRS, Pune, as well as at River Research Institute, West Bengal, were carried out to find what amount of 'Ganga' flow must be diverted to 'Hoogly' for flushing out the sediments. From these model studies as well as some analytical studies carried out by hydraulic experts like Dr. Hansen from Germany and Er. Joglekar from India, it was finally decided to divert 1135 cumec (40,000 cusec) of flow. Accordingly, Farakka barrage and the feeder canal linking 'Ganga' with 'Hoogly' river were constructed at an approx. cost of Rs. 2000 million.

Before 1971, main flow in Ganga between Farakka and Rajmahal (Fig. 1) was more or less straight. After the completion of the barrage, 'Ganga' river upstream of Farakka started shifting gradually towards the eastern bank towards Malda due to

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deposition of sediments on the western right bank. With Farakka barrage at the centre, river 'Ganga' is developing a typical meander pattern. Upstream of the barrage, it is meandering towards Malda. Downstream of the barrage it is meandering towards Murshidabad on the opposite western bank. Being located on the outer side of the meanders, both the districts of Malda (upstream) and Murshidabad (downstream) are subjected to devastating erosion (Bandyopadhayay, 99). Properties worth several thousand crores have been already destroyed. Both the districts have highly fertile lands and are considered to be granaries of food for Bengal. Apart from loss of these agricultural lands due to erosion, occasional floods cause damage to the standing crops. In August 1998, the river breached the marginal and afflux embankments upstream of Farakka barrage causing disastrous flood in Malda district. 21,00,000 people out of total population of 26,00,000 in the district were affected. 450 people died during and after the flood. 2,00,000 houses were completely destroyed and 1,50,000 houses were damaged. Estimated loss of property is about Rs. 10,000 million.

Objective of this paper is to analyse the various reasons of '98 flood and examine the role Farakka barrage played for this disastrous flood at Malda district in West Bengal. It is of utmost importance to train the river 'Ganga' both upstream and downstream of Farakka barrage to arrest erosion. Otherwise, the river may outflank the barrage upstream and try to join river 'Mahananda' which will wash out large part of Malda district, National Highway No. 34, and railway linking North-East of India with rest of the country. Similarly, uncontrolled erosion on the downstream side of Farakka may result in destruction of feeder canal, national highway and the railway and in case it joins river 'Hoogly' it will cause disaster for both the parts of Bengal partitioned by the British govt. in 1947. Considering the national importance of the project, it is desirable that the responsibility of training the river upstream and downstream of Farakka barrage be taken over by the Central Government which is maintaining and operating the barrage.

2. BRIEF DESCRIPTION OF THE FLOOD

On 21st July, 1998, the newly constructed fifth retired embankment near Gopalpur village in Manikchak sub-division of Malda (Fig. 1) was breached resulting in flooding of several blocks in Manikchak. There was heavy downpour in the catchment areas of West Bengal lying between Ganga and Mahananda. The recorded maximum rainfall was 418 mm in 48 hrs. (24 & 25 Aug, '99). Water levels in both the rivers 'Ganga' and 'Mahananda' (table-1) (Local publication, '98) were steadily rising.

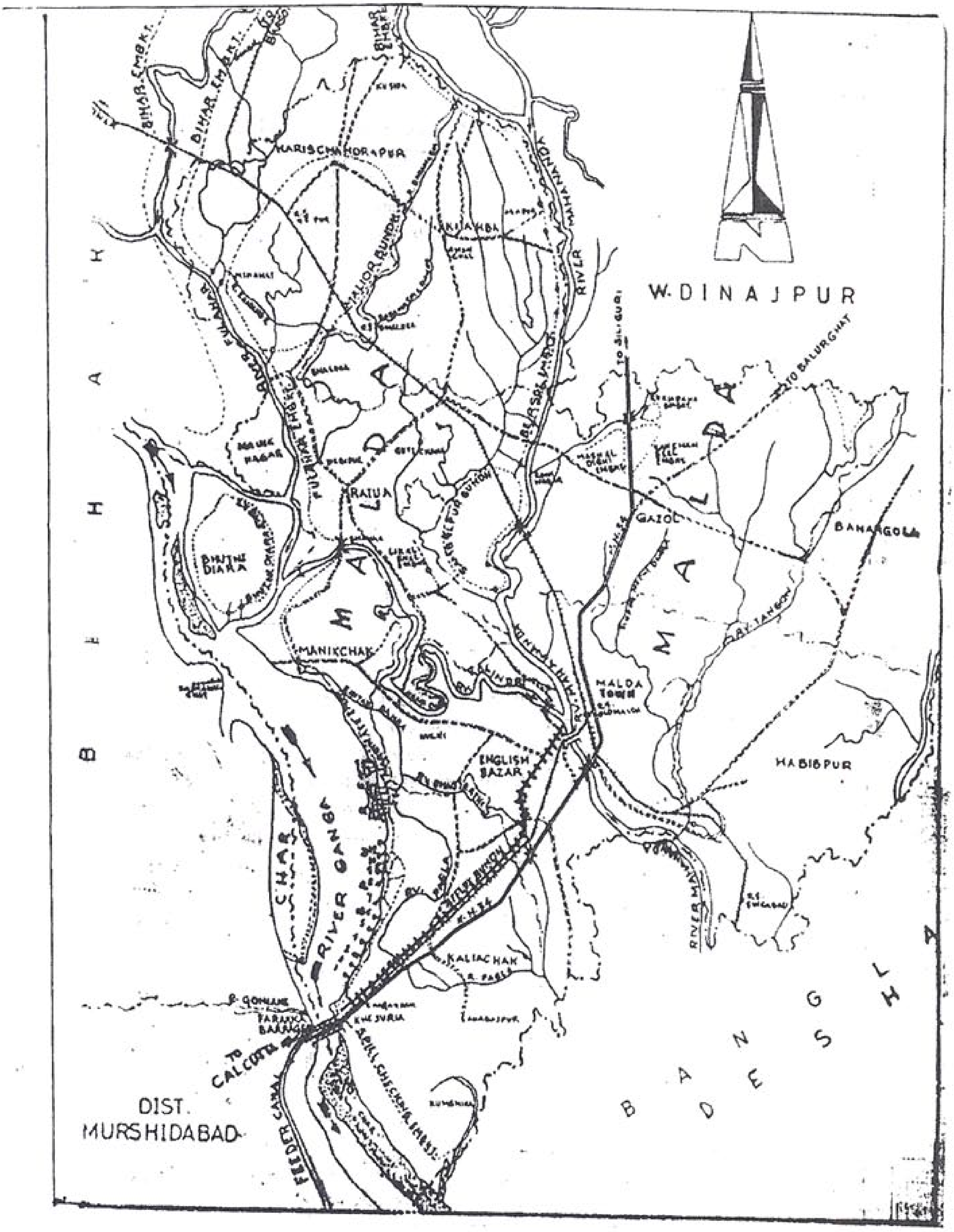

FIG. 1 PLAN OF MALDA DISTRICT

Table 1 : Water Level in Ganga & Mahananda Rivers During '98 Flood

Month	Aug		September						
Date	**30**	**31**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Ganga	26.185	26.205	26.245	26.265	26.315	26.425	26.525	**26.565**	26.545
Mahananda	23.570	23.610	23.660	23.680	23.730	24.050	24.210	24.380	24.470

Month	September								
Date	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**Danger-Level**
Ganga	26.545	26.445	26.355	26.205	26.005	25.785	25.505	24.955	25.300
Mahananda	24.560	24.600	**24.650**	24.640	24.560	24.440	24.280	23.880	23.500

On 25th August, the afflux bundh was breached near village Narasinghkuppa in Malda district. It is due to the above breaches, swollen 'Ganga' waters entered Malda district. Due to rise in water levels in both Mahananda and Ganga simultaneously, there was drainage congestion also. The tributaries of the rivers, namely Fulahar, Kalindri, Pagla etc. (Fig. 1) instead of draining the run-off from the intervening catchment, started carrying the flood waters of the Ganga & Mahananda rivers to the Malda town. Standing depth of water during August 25th to Sept. 13th varied from 2 m to 5 m. Damages had occurred earlier also due to breach in flood embankments, especially in 1996. But the flood damage of 1998 was unprecedented. It affected 21 lakh people in Malda district. 450 people have died during and after the flood. 250 cattles lost life. 2,00,000 houses were totally destroyed and 1,50,000 houses were damaged. Standing crops in 1,50,000 ha were destroyed. Estimated cost of damages of 98 flood in Malda is about Rs. 10,000 million.

3. DESCRIPTION OF FARAKKA BARRAGE

Plan view of Farraka barrage showing the Weir bays, river sluices, under sluices and western feeder canal is given in fig. 2.

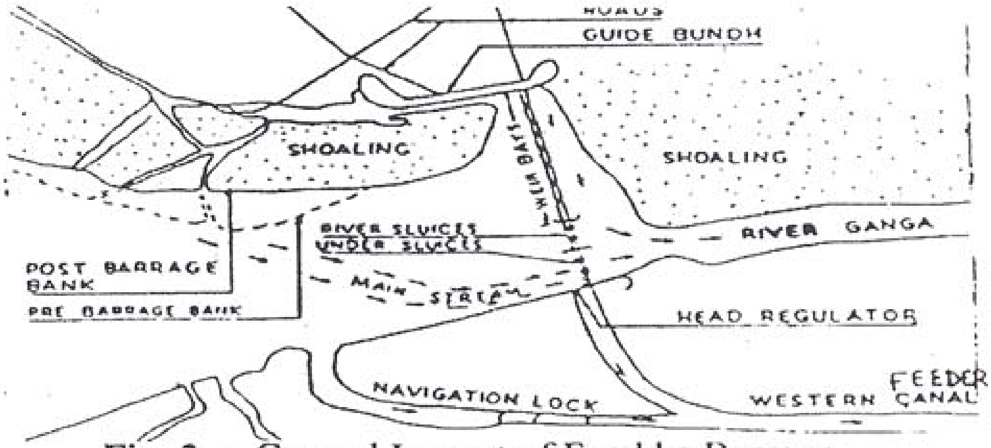

Fig. 2 : General Layout of Farakka Barrage

Some salient features of the barrage are given below

Length of the barrage	–	2,246 m
Design flood discharge	–	70,930 cumec
Maximum flood level (u/s)	–	26.1 m
Maximum flood level (d/s)	–	25.6 m
Bed slope of river	–	1 in 21,000
Clear waterway	–	1995 m
Total nos. of spillway gates (10.3 m x 6.1 m)	–	84 nos.
Total nos. of river sluices (10.3 m x 7.625 m)	–	12 nos.
Total nos. of scouring sluices (10.3 m x 7.625 m)	–	12 nos.
R.L. of spillway crests	–	15.86 m
Pond level of Farakka reservoir	–	21.9 m
R.L. of sluice crests	–	14.03 m
Total Catchment area of river Ganga u/s of Farakka	–	10, 51, 404 sq. km.
Average annual run off at Farakka	–	10,82,946 M. cu. M.
Average annual sediment load at Farakka	–	1667 x 10^6 Tons
Length of Feeder canal	–	26 km.
Length of Marginal Embankment	–	25 km.
Length of Afflux Embankment	–	25 km.
Total nos. of spurs on Marginal Embankment	–	24 nos.

4. VARIOUS CAUSES OF FLOOD & ROLE OF FARAKKA BARRAGE

4.1 Rise in High Flood Level

Principal cause of the 1998 flood was the unprecedented rise in high flood level upstream of Farakka barrage (Table-1) and consequent breaching of the flood embankments. Recorded highest flood level in Ganga was 26.656 m on September 7th as against designed maximum permissible R.L. of 26.1 m. Afflux and marginal bundhs are designed for a maximum afflux of 0.5 m i.e. the difference between the highest flood levels upstream (26.1 m) and downstream (25.6 m). Actual afflux in '98 was approximately 1 m (26.565 – 25.6) i.e. 0.5 m higher than the design afflux. Afflux occurred due to lateral and vertical constriction of waterways in the barrage and consequent head losses upstream and downstream of the structure. Had there been no barrage, there would have been hardly any afflux.

4.2 Unoperational Spillway Gates

It is reported that a large number of spillway gates on the left bank (Malda Side) are non-operational due to heavy siltation on the left side of the barrage upstream. As the river swings from left to right towards the feeder canal (fig. 2) upstream of barrage, left side of the barrage (being on the inner side of the bend) is receiving the sediments. Fig. 2 shows the shoaling immediate upstream and downstream of the barrage and the course of mainstream in the viscinity of the barrage. More the numbers of gates become non-functional, more will be the contraction of waterways resulting in more head losses and greater afflux upstream.

4.3 Deposition of Sediments upstream of Barrage

As already mentioned earlier, the average annual incoming sediment load at Farakka is estimated to be 1667×10^6 tons. Earlier to barrage construction, these sediments used to pass downstream. After the barrage construction, however, most of the incoming sediments are getting deposited in the reservoir upstream due to backwater effect. Although there are 12 silt excluders and 12 river sluices near the head regulator (Fig. 2), their effect is limited to a very small reach near the barrage. As a result vast amount of sediments are getting deposited every year upstream beyond the area of influence of the sluices. In the dry months, the flow available after diversion is insufficient to flush out the sediments deposited upstream. It is natural, therefore, that the bed level of Ganga river has risen upstream of Farakka barrage resulting in further rise in HFL. Like all other barrages (CBI & P '89), Farakka barrage has caused aggradation of the river upstream of the barrage, requiring protection of the bank through construction of embankments. Both the marginal and the afflux embankments (upstream of Farakka barrage) were constructed to protect Malda district from the agrading Ganga river floods, since the district Malda lies towards the downward slope at lower elevation. Being located on the outer (concave) side of the meandering river, the marginal embankment is subjected to erosive action of the river.

4.4 Drainage Congestion in Malda Basin

Normal mean rainfall in the Malda district during the monsoon period is about 1115 mm. In 1998, the total rainfall during monsoon months was 1321 mm i.e. 206 mm above the normal rainfall. Highest intensity of rainfall was 418 mm in 48 hrs during 24th and 25th August, 1998. Run-off resulting from the rainfall in the catchment area lying between Ganga and Mahananda (Fig. 1) is usually drained into 'Ganga' and 'Mahananda' rivers through their tributaries 'Fulahar', 'Kalindri', 'Pagla' and other drains. Due to the simultaneous rise in water levels in Ganga and Mahananda (Table-1), there was a drainage congestion. Instead of draining the run-off from the catchment area, these tributaries were carrying the flood waters from 'Ganga' and 'Mahananda' in the reverse direction due to absence of sluice gates at their outlets. The combined flood flow of the rivers and the natural run-off from the intermediate catchment caused the disastrous flood which lasted for about two-weeks (August 25th to Sept. 13th). Till the flood levels in Ganga and Mahananda were lowered and the tributaries and the drains started normal functioning, almost the entire district of Malda was submerged with flood water having depths varying from 2 m to 5 m.

4.5 Meandering of Ganga Upstream and Downstream of Farraka Barrage

Being in the alluvial flood plain with a mean flow of 34,000 cumec and a bed slope of 1 in 21,000, river 'Ganga' flows in a meandering state (Valentine '92) even before the construction of Farakka barrage. It is reported to be causing erosion of either of the banks even in the pre barrage stage. However, the stretch of the river in between Rajmahal and Farakka was more or less straight. After the construction of the barrage several 'Chars' (islands) have formed upstream of the barrage owing to deposition of the sediments in the back water reach. 'Bhutni Diara' (fig. 1) is one such char formed near the confluence of 'Fulahar' with 'Ganga' upstream of Rajmahal. Main 'Ganga' has now shifted towards the western side of 'Bhutni Diara' forming a meander. Since this meander is towards the right bank, the following meander is on the left side towards Manikchak / Malda. It is established (Garde '95) that a meandering river erodes the bank on the outer (concave) side of the bend and the eroded materials are deposited on the inner (convex) side. Fig. 1, shows that a new 'Char' is forming just upstream of the barrage in the inner side (Western side) of the river. With Farakka barrage at the centre, the river 'Ganga' is developing a new meander (Mazumder '91) with 'Malda' on the outer side of the upstream bend and 'Murshidabad' on the outer side of the downstream bend. It is mainly due to this meandering tendency (Mazumder '93) of the river that the districts of Malda and Murshidabad in West Bengal are subject to unprecedented erosion after the barrage construction. Unless the growth of this new char just upstream of Farakka is arrested (either by dredging or by flushing), the river 'Ganga' will try to move further towards Malda side by eroding the banks and the embankments.

4.6 Breaching of Marginal & Afflux Embankments

As shown in fig. 1, marginal and afflux embankments were constructed on the left bank of the Ganga river in order to protect life and properties of the people living in Malda district. But the embankments have been breached almost every year due to the erosive action of the river in its meander reach. So far five retired embankments have been constructed near Manikchak around the breached bank. Also, 24 nos. of transverse spurs have been constructed for the safety of the marginal bundh (Fig. 1). Four spurs (Nos. 18, 19, 20 & 24) were damaged during July '98 flood and the fifth retired embankment near Manikchak was breached. Subsequently, the afflux embankment also got breached on 25th August. These breaches are responsible for entry of Ganga water into Malda district. Located on the outer side of the bend, there is deep erosion near the toe of the marginal bundh. As against a normal high flood depth of 8.5 m, the depth of water measured after the flood was found to be 20 m near the river side toe of the marginal bundh. During the flood, the depth was still higher. The transverse slope of the river bed in a bend is due to the scour on the outer side and deposition of the scoured materials on the inner side of the meander bend. It has been proved (Wang '92) that the transverse slope occurs for stability of bed due to secondary current generated as a result of centrifugal force to which water is subjected on the outer side. Due to increased depth as well as centrifugal force on the outer side, the tractive stress increases rapidly leading to more and more scour. Progressive scour on the outer side and deposition on the inner side results in lateral migration of the bend on the outer side and increase in curvature of the bend. This causes still higher centrifugal effect and higher shear stress resulting in more erosion at the outer edge of the bed. No embankment can stand when such deep scour occurs near the toe, unless it is well protected with heavy stone / concrete aprons and sheet piles. Primary cause of the breach in the embankments is the formation of deep scour hole as the river starts flowing along the embankment.

24 spurs have been constructed so far to deflect the stream away from the marginal embankment. 364 spurs were constructed on Kosi river to save the flood embankments (Mazumder '85). Yet the embankments got breached. Long spurs cause more head loss and more afflux upstream. River has been found to be unstable (Mazumder '93) when too long spurs are made due to the process of initial contraction and subsequent expansion of the stream. River may deflect and start flowing along the spurs. Too much contraction and expansion may also cause strong eddy with strong back flow (Kulkarni '99) scouring on the d/s side of spur. Mainstream may also entrain the eddy fluid resulting in supercritical flow along the bank.

CONCLUSIONS

1998 disastrous flood in Malda district of West Bengal was due to the combined effect of the following :

- Rise in high flood level upstream of Farakka barrage.
- Deposition of sediments upstream of Farakka barrage.
- Unprecedented rainfall in the catchment lying between Ganga & Mahananda and drainage congestion due to rise in HFL of Ganga and Mahananda simultaneously.
- Meandering Ganga river upstream of Farakka and erosion of outer bank towards Malda.
- Failure of flood embankments due to deep scour holes near the embankments.
- Poor maintenance and low quality construction of protective works.

Considering the national importance of the project and the magnitude of the problem, the Farakka barrage authority under the Central Govt. should take over the flood control and river training works of Ganga upstreams and downstream of Farakka barrage.

5. ACKNOWLEDGEMENT

Author wishes to thank the Editor of 'Rupantarer Pathe' – a local news paper of Malda for providing valuable data regarding '98 Malda Flood. Infrastructural Support Provided by Delhi College of Engineering and financial support by All India Council for Technical Education are gratefully acknowledged.

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