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Feasibility of Natore Rubber Dam on Mahanonda River in Bangladesh and its Performance on Irrigation

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Abstract: - Low rainfall in winter causes a great problem on irrigation. Bangladesh Agricultural Research Council (BARC) started research on this problem from 1974. In 1994-95, Rubber Dam projects have been taken by BIC (Beijing IWHR Corporation) in Bangladesh as it is very convenience and effective in both irrigation and cultivation of crops in winter. After installing, it is very important and challenging task to study the suitability and effect of Rubber Dam on agriculture. In this research work, the analysis of Rubber Dam in Natore, Bangladesh and its suitability on Mahanonda River has been analyzed and also studied its performance on irrigation. Also Bakkhali and Idgaon Rubber Dam were analyzed for the performance evaluation of Rubber Dam projects in Bangladesh for irrigation development. Then, feasibility of Natore Rubber Dam was studied and briefly discussed about its probable effect and benefit on agriculture. Reservoir capacity was also determined on the basis of a theoretical concept known as flow mass curve. Results of performance evaluation in irrigation were expressed in three groups: hydraulic, agricultural and socio-economic. Results of the analyses of hydraulic indicators showed that water supply is available. Agricultural performance, evaluated in terms of irrigated area was satisfactory. Analyses of socio-economic indicators showed that the Rubber Dam projects were financially viable in terms of profitability of farmers. Finally results were found that, it has a great probable effect on national economic and thus an alteration method of irrigation instead of uses of ground water. Thus, a comparative capital and operation and management cost analyses of different irrigation technologies has been carried out to ascertain the viability of Rubber Dam technology in irrigation development.

Keywords: *- Effect of Dam on Irrigation, Irrigation technologies, River water, Rubber Dam, Water Reservoir.*

I. INTRODUCTION

Rubber Dams being deflectable to open the full passage way of the river channel during monsoon floods are ideally feasible water conservation structures for many small and medium rivers and will thus play a vital role in enhancement of irrigation capacity. Rubber Dams can be used to conserve water in channel storages of small and medium rivers and streams in flat areas and in small reservoirs in hilly areas for the principal purpose of irrigation.

In Bangladesh, there is very low rainfall in winter. So, the requirement of water for winter irrigation must be met from groundwater source and by conserving a part of monsoon surface water in suitable storage. To use the river water in winter, Rubber Dams were introduced as a cost effective technology for retention and conservation of surface water in river channels, reservoirs and lakes for the purpose of supplying irrigation water to winter crop cultivation and Natore Rubber Dam is the most important one. It is ideally feasible for conservation of water in channel storages of rivers and channels in north zone as the Dams can be inflated to retain river flows and deflated fully to allow passage of flood flows without any obstruction whatsoever. Conservation of surface water is of immense importance to many countries to sustain growth of agriculture through better water and irrigation management in face of nature's uneven distribution of water throughout the year in one hand and prevent its environment and eco-system from plunging below dangerous level of degradation in face of artificial shortage of water in its rivers and streams created by unlawful withdrawal of lean season flow by the upstream country or region on the other. It is therefore necessary to exploit possible ways and means of surface water retention and conservation, especially the ones which are cost effective and suitable for the low and flat physiographic of some countries. Rubber Dam is one of such means of promise to retain and conserve water in reservoirs, lakes and channel storages of small and medium rivers of the countries.

II. LITERATURE REVIEW

2.1 BIC Constructed Dam in Bangladesh

The 84 m long 3.5 m high water filled Bakkhali Rubber Dam in Bangladesh was built by BIC as a two-side water retaining rubber dam. The Bakkhali River at the dam site is in a tidal environment not far from the Sea and separates downstream saline water as it impounds upstream sweet water flow in the river and tributary channels.

TABLE 1: BIC constructed Dam in Bangladesh.

No.	Rubber Dam	Construction Time
1	Bakkhali, Cox's bazar	May 1995
2	Idgaon, Cox's bazar	May 1995
3	Bhogai, Sherpur	March 1998
4	Tankhabti, Chittagong	April 2001
5	Kakhara, Dinajpur	April 2001
6	Kaoraid, Dinajpur	May2002
7	Matikata, Dinajpur	May 2002
8	Sonai, Hobigonj	May 2002
9	Atrai, Natore	May 2002
10	Brahmaputra, Narayanganj	April 2003
11	Bahara, Narayangonj	April 2003
12	Khasiamara, Sunamgonj	August 2003
13	Netai, Mymensing	February 2004
14	WRS, Dinajpur	February 2004
15	Someswari, Sherpur	March 2004
16	Sonaichari, Cox's bazar	May 2004
17	Baro Jungchhari Khal	March 2005
18	Khutakhali, Ramu	March 2005
19	Tetang khal, Ramu	March 2005
20	Talma, Panchagar	June 2006
21	Gopla, Panchagar	June 2006

The dam conserves fresh water in the upstream side and prevents flow of saline tidal water from downstream. The conserved water will be used for irrigation by lifting through low lift pumps. The dam will be operated in winter for cultivation of 6000ha Boro rice in January to May. BIC has constructed 14 Rubber Dams in Bangladesh. The construction has recommended that Rubber Dams are appropriate and cost effective water conservation structures in small and medium rivers of Bangladesh both in non-tidal and tidal locations.

2.2 Construction procedure of Rubber Dam

The rubber bag of the dam is attached with the concrete floor. At the beginning of the construction sheet pile wall or cut off wall is constructed at both the upstream and downstream side for controlling soil corrosion due to seepage. After that, the upstream, downstream, and the rubber bag is cast with concrete. At last, abutment wall, block, pump house, valve chamber etc. are constructed. But the main attached concrete structure of rubber bag is constructed very carefully. By using M.S. pipe, pad and platen; rubber bag is anchored with the floor bed.

2.3 Working principle of Rubber Dam

The main part of the Rubber Dam is rubber bag, pump house and concrete floor (with which rubber bag is attached with steel pad and platen). The water coming from the upstream side is directly entered to the pump house. Then with the help of different valve and pump motor, the water is used to inflate the rubber bag. After the use of water for irrigation purposes, the bag is then emptied by valves and the bag is sinking at the river bed. Generally gravity drainage system is used for emptied of the rubber bag. So, it does not create obstruction for the passing of water in rainy season and also passage of boat freely through the River.

2.4 Checking of Rubber Dam operation and recoding

There will be a checking routine of Rubber Dam. Before the rubber bag is inflated, complete checking must be done. Such as:

1) Is there any serious damage in Rubber Dam?
2) Is there any nut of the anchorage part become loose or not?
3) Are the inlet and outlet pipes blocked or not?

4) Is there any mechanical and electrical problem in the pump system?
5) Is there any damage and erosion in the preventive work?
6) Are any foundation settlement, water swelling and water stop and reverse filter damage or not?

2.5 Operation and maintenance of Rubber Dam

1) Before inflating the rubber bag, the pump, motor, valve, pipe line and other system which are used to make the bag emptied and inflated; should be checked well that it can function properly.
2) Anchorage part and other key point should be checked and damaged part will be repaired.
3) In front of the Dam site, the silt and sand will be removed from pipe line.
4) At the time of inflating the bag, extra pressure of water inside the bag will be abandonment and when the height of the Dam is reached at the surface level of the river, at that time inflating operation must be stopped.
5) The past flooded time will be under observation so that the Dam will be emptied at the highest flood time for the bag, air mouth of the top will be opened. For that, the inside air will be exerted fully.
6) At inflated condition, if the overflow depth exceeds a definite height (generally 20% of the Dam) then vibration effects. The Dam height and overflow depth must be maintained within 20% of the Dam height by increasing or decreasing the Dam height. But, never exceed the design Dam height.
7) The dam design for one side preservation of water should never use for two side storage. If, the downstream water level rises above the upstream level at that time the rubber bag must be emptied.

2.6 Repair of Rubber Dam

2.6.1 Repair of rubber bag

The main component of the Rubber Dam is rubber bag. After the bag is inflated by water or air it is used as Dam. The Rubber Dam bag may be cut off bluest out or defected due to different causes and may damage many part of the Dam.

The defect area and extra area around it will be cleaned by rubbed with zhama brick or other material used for the same purpose. A piece of rubber sheet (provided for repair of rubber bag) cut according to cut area is cleaned by the same procedure. Best quality glue is applied on the both cleaned area and paste on the defected area. At the time of repair the bag by glue it should never be wetted. If repair is essential in wetted condition, at that time the defected area is cut sufficiently in addition of some extra area of the defected places. Hole will be done at the outside of the Rubber Dam bag at some suitable points. Same hole will be done also at the cut rubber sheet. Bolt will be place in the hole of Rubber Dam bag by using gasket and the cut rubber sheet is placed and then nut is fixed on the bolt water tightly.

2.6.2 C.C. block

C.C. block will be provided after the end of main sub-base structure of the Rubber Dam. Because, it prevent erosion of river bed due to flow of river water. There may be openings at downstream side and after the sheet pile. Thus, C.C. block also provides side slope and river bed to prevent erosion.

Sometimes, C.C. block is displaced from their position for the action of the river stream. Many times, small sizes C.C. block is also displaced from sides slope due to water action. If the soil at the slope of side slope is displaced then settlement of slope will occur. For, all the above reason it is necessary to repair C.C. blocks.

2.6.3 Repair of C.C blocks

Useless C.C. blocks should be removed and new C.C. blocks will be placed at their position. Displaced C.C. blocks should be settled at their right position levelly. Firstly the settled C.C. block will be picked up from their position. The settled places will fill with soil and sand and then, completed and level. After leveling and compacting C.C block will set at the position.

2.6.4 Sedimentation

While the flowing water gets contact with the Dam section, the velocity of water reduces. The silt will be take place at the upstream side for decreasing river flow. Thus, problem may occur in operation process of the Dam. This sedimentation of silt will removed by pipe, at the time of inflated of the rubber bag. Observe that no damage occur in the Dam.

III. FEASIBILITY OF NATORE RUBBER DAM

3.1 Location

The Rubber Dam is set up in the River Atrai at Jogendra Nagor village under Gurudaspur upozila in Natore.

3.2 Short description of the project

The rubber dam structure is composed of four parts: rubber bag, anchorage, filling and emptying system (pump house) and foundation, as shown in Figure 1. Water is impounded by inflating the rubber bag with water. When deflated, the body of the dam lies flat on the river bottom without causing any obstruction to the river flow. As there are no gates or lifting structures, the operation and maintenance (O&M) of the dam are simple and cheap. The span of the dam can be as long as 100 m without any dividing piers and the height of the dam can be adjusted to regulate the flow.

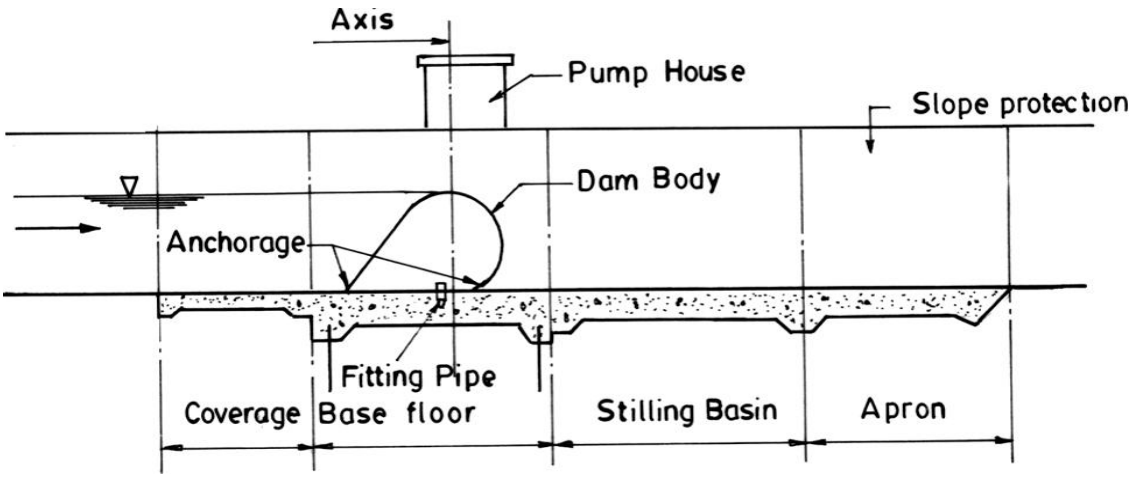

Figure 1: Cross section of a Rubber Dam

At the Natore Rubber Dam project the river is tidal and the dam conserves fresh water at upstream. It was estimated that about 25 million-m3 of water would be conserved by the Rubber Dam during January which would be lifted by LLPs and delivered through to irrigate 2500 ha of Boro (winter) rice. Two rice crops are given in both the project Irri and Boro.

3.3 Principle of the project

1) The main purpose of project supply of irrigation water by construction of Rubber Dam at Atrai River.
2) Whole operation and maintenance, arrangement of water, collection of irrigation tax etc. are operated by the beneficial community of this Dam project.
3) By accumulating the farmer at the projected area opportunity will create by giving share and money of water controlling co-operative organization.

3.4 Summary and socio-economic condition of the project

3.4.1 Structure related to the project

1) Rubber Dam- Length 45m* Height 4.5m : preserve water during dry season.
2) Construction of bridge- Length 45m : create opportunity with the people living on both side of the river.

3.4.2 Engineering parameters of the project

1) Length of the rubber bag : 45m
2) Height of the rubber bag : 4.5m
3) Thickness of rubber bag : 8mm
4) Construction procedure of rubber bag : attached above the concrete casting with Steel pad anchored bolt and nut.
5) Life time of the bag : 15-20 years
6) Duration of water filling in the bag : 12-15 hour
7) Pump capacity : 100 m3/s
8) Engineering concern of construction of rubber bag : IWHR, China.
9) Establishing committee : Local Government Engineering Department
10) Financing organization : Agriculture Department of Bangladesh Department
11) Operation & maintenance : The water maintenance committee from the beneficial community.

3.4.3 Socio-economic condition of the project

1) Name of the project : Atrai river Rubber Dam project.
2) Location of the project : Union-Subgari,upazila-Gurudaspur
District- Natore
3) The number of union under the project : 3
4) The number of village under the project : 21
5) The number of beneficial family under the project : 2900
6) The area under the project : 2500 ha (Net: 2460 ha)
7) The beneficial area under the project : 2257 ha
8) Irrigation type : Low lift pump + Gravity flow
9) Target of extra crop production : 2500 metric ton (yearly)

IV. DATA COLLECTION AND ANALYSIS

4.1 Collection of Data

Data has been collected from Local Government Engineering Department, Water Development Board, local people, projects farmers, etc. Information about structural and socio economic was collected from L.G.E.D and information to determine the capacity of the Dam was collected from Water Development Board. Benefit from Rubber Dam project was collected from local farmers.

4.2 Analysis of Data

4.2.1 Determination of Reservoir Capacity

TABLE 2: Mass flow

Year	Mass inflow in (100 ha-MTs)
1997	21.52
1998	45.22
1999	83.04
2000	90.84
2001	109.74
2002	134.54
2003	140.31

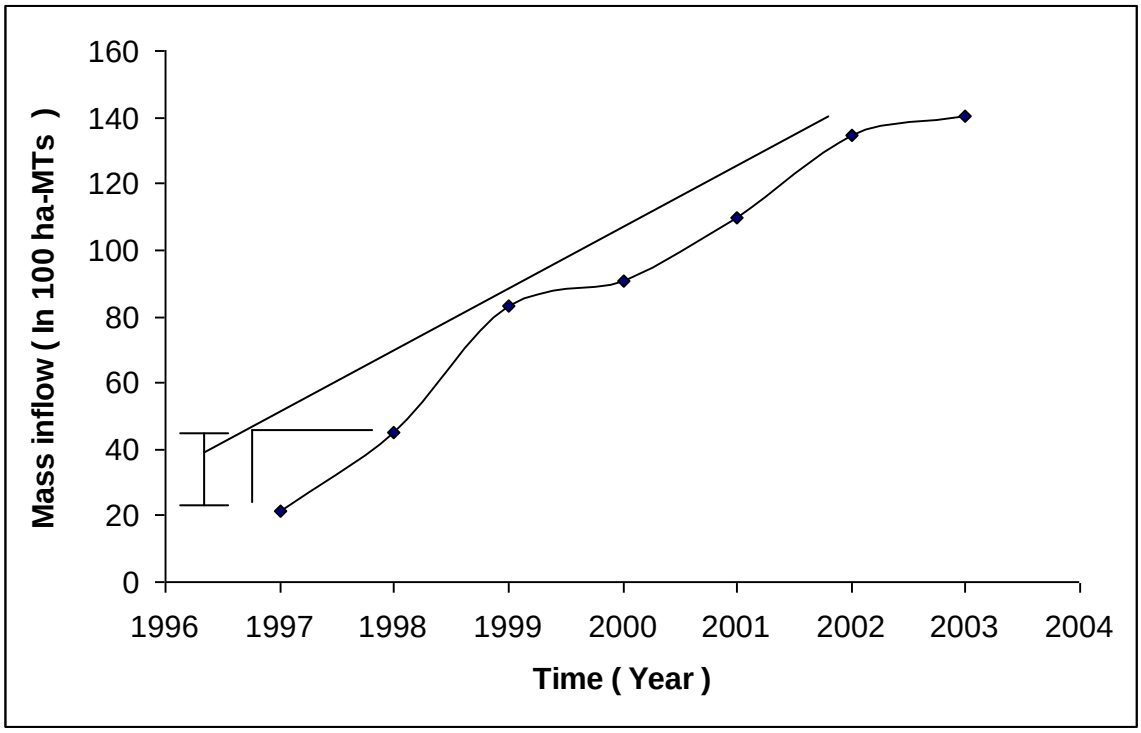

FIGURE 2: Mass inflow curve.

The capacity of the reservoir is founded from the flow mass curve shown in fig-2. From the triangle of the curve we get the capacity of the reservoir. The vertical distance of the triangle is the reservoir capacity and thus capacity is 2200ha-m.

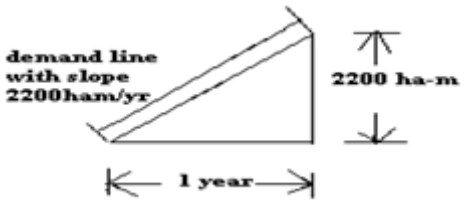

FIGURE 3: Triangular portion of Mass inflow curve.

4.2.2 Performance evaluation in agriculture

1) Hydraulic indicators

Hydraulic indicators deal with lifting/diversion and conveyance of irrigation water from the source to the farmers' fields by management of irrigation facilities. The hydraulic indicators used in the performance evaluation were as follows.

II) Water delivery performance

This indicator determines the extent to which water is delivered (total volume) as planned during the irrigation season and is defined as: Water delivery performance = Actual volume delivered / Target volume

The average discharge of the LLPs was 40litres per second (lps). Data on LLP operating hours during different months of the 2002-2003 Boro seasons were collected from the block managers. The pump discharge was multiplied by the operating hours to obtain lifted volume and hence total lifted volume (7.2 million m3). To compute water delivery performance, the target volumes of water planned for lifting/diversion were taken as 25 million m3. The water delivery performance of Natore Rubber Dam was found as 0.29 respectively and was very low.

III) Agricultural indicators

Agricultural indicators measure the contribution of the irrigation activity to the economy in relation to consumption of the increasingly scarce resource, water. The main outputs (actual irrigated area, crop yield) of the major inputs (water, land and finances) in an irrigated agricultural system are directly reflected by these indicators. The agricultural indicators used in the performance evaluation were as follows.

IV) Irrigated area performance

This indicator becomes more important where water is a limiting resource towards irrigation development. The indicator is expressed as:

$$\text{Irrigated area performance} = \frac{Actual\ irrigated\ area}{T\ \text{arg}\ et\ area}$$

The actual command areas of Natore Rubber Dam project during the 2002-2003 Boro seasons were 3200 ha. The target command areas were 2500 ha. Irrigated area performance was found 0.78. Thus, the irrigated area performance of the project was good.

V) Socio-economic indicators

TABLE 3: Cost and benefit (tk ha-1) of crop production from farmers' perspectives in the Natore Rubber Dam project.

Name of item	Natore Rubber Dam project
Total input cost (a)	12,550
Total labour cost (b)	2,600
Labour cost excluding family labour (c)	1,500
Irrigation fee (d)	2,500
Total cost (d)	15,150
Gross benefit (e)	22,500
Net benefit (e-a-b)	7,350
Net benefit excluding family labour (e-a-c)	8,450

VI) Profitability of farmers

This indicator deals with the profitability of farmers at the individual farm level. The indicator is expressed as:

Profitability of farmers = Benefit of irrigation per Ha / Irrigation fee per Ha

The cost and benefit of Boro production from farmers' perspectives are given in TABLE 3. The profitability of farmer was found dividing net benefit by the corresponding irrigation fee. Thus, profitability of farmers was found to be 2.94. The higher profitability in Natore was due to the lower irrigation fee in the former project.

TABLE 4: Comparison the condition of projected area before and after construction of the Rubber Dam.

Item	Previous irrigation facilities (Earth Dam)	Present irrigation facilities (Rubber Dam)
Construction authority	Water Development Board	Local Government Engineering Department
Construction time	1984	2002
Cultivated area	1000 ha	2500 ha
Extra crop production	6,350 ton	10,000 ton
Irrigation cost per bigha	1.000 tk	300 tk
Beneficial family	987	2900
Condition during rainy season	Flooded at upstream side.	No risk of flooded.
No of villages under project	5	12
Economical increasing rate	No absolute information.	7%
Crops grow in years.	Only one crop in a year.	More than one crops
Adverse effects of dam.	Sand covered huge area causes of damaging the dam in rainy season.	It has no as few adverse effects.

V. RESULTS AND DISCUSSION

The target volume of water availability, as mentioned earlier, estimated in feasibility reports were 25 million m3 for Natore Rubber Dam projects. It was found from reanalysis of the discharge data of the Atrai River that this estimation was probably based on 75% dependability, which has no risk of uncertainty in the available water availability.

TABLE 5: Comparative costs (tk ha-1) of irrigation development by Rubber Dam and previous technology.

Project	Capital cost	O&M cost	O&M fee
Previous Earth Dam in Natore	60,000	1000	300
Present Rubber Dam in Natore	90,000	500	150

A comparison of the costs of irrigation development by Rubber Dam and the previous technology in Natore was made and the costs are given in Table-6.1. The earlier technology has command areas of 1000 ha and present technology has 2500 ha. It is evident from the Table- that per hectare irrigation development costs using a Rubber Dam are better than the previous Earth Dam technology. The table- 5.1 also shows that the operation and maintenance cost of Rubber Dam is low compared to Earth Dam technology and also have large irrigated area under the Rubber Dam project. Thus, if found technically feasible and considering the lower operation & management cost, Rubber Dam technology is more economically viable option than the other irrigation technologies adopted in the small and medium river projects of Bangladesh.

VI. CONCLUSIONS AND RECOMMENDATIONS

6.1. CONCLUSIONS

The performance of Natore Rubber Dam projects in terms of socio-economic, agriculture and hydraulic indicators can be considered satisfactory. Considering both the capital and the lower operation and management costs of irrigation development, Rubber Dam technology is more economically viable than the previous traditional technology and if found technology feasible, the technology is recommended in the small and medium river projects of Bangladesh.

To consider all sides of rubber dam project we can say that rubber dam project on Mahanonda River will have to a great step to change socio-economic condition of that region.

6.2. RECOMMENDATIONS

I) Continuing study of Rubber Dam analysis and updating results will be proved to be useful, as more data become available in future.

II) During such study special attention may be paid for evaluation of Rubber Dam project in irrigation.

III) Possible of this project on the entire irrigated area the surrounding environment and also on the river may also be studied.

IV) If all the studied are done attentively then it may be a great project having vast effect on agriculture evaluation in the entire area.

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