Journal of the Civil Engineering Division
The Institution of Engineers, Bangladesh
Vol. CE 23 No. 1, 1995

# CONSTRUCTION RELATED ENVIRONMENTAL IMPACTS OF THE JAMUNA MULTIPURPOSE BRIDGE

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**ABSTRACT** : The river Jamuna is one of the largest rivers in Bangladesh. It is a natural barrier between the north-western and eastern parts of the country. The river acts as an impediment to economic development and social unity. Under the supervision of the World Bank, local and international experts a 4.8 Km long multipurpose bridge is under construction. The environmental impacts related to the construction of the bridge are widely varied in nature. Some of the impacts are very common and may occur in any country undertaking such an enormous project. However, some impacts are very unique and may occur only in a developing country such as Bangladesh. This paper identifies the major impacts involved with each activity related to the construction of each component of the Jamuna Multipurpose Bridge.

**KEY WORDS:** Jamuna Multipurpose Bridge, Environmental Impact, Guidelines, Pollution

## INTRODUCTION

The river Jamuna is a natural physical barrier between the north-western and eastern parts of Bangladesh. This physical barrier is seen as an impediment to economic development and social unity. As a result, there has long been a natural desire to establish this permanent link between the east and the north-west. The construction of Jamuna Multipurpose Bridge has been proposed to establish a permanent link between the two parts of the country (Fig. 1). The proposed bridge will be located about 8km downstream of the existing ferryghat near Bhuapur and provide for transfer, across the Jamuna river, of road and rail traffic and energy. The energy transfer to the west would be achieved by means of a second electricity inter-connector and a gas pipeline over the bridge. The construction of the main bridge, bridge end facilities, approach roads and river training works involves massive activities which will have both positive and negative impacts on components of the environment. These impacts will be temporary as well as permanent in nature.

An Environmental Impact Assessment (RPT-NEDECO-BCL,1989) of the Jamuna Multipurpose Bridge Project (JMBP) was prepared as an integral component of the feasibility study in order to identify and evaluate major environmental issues and incorporate measures required project area. Primary data were collected mainly on demographic and socio-economic situation in the impact area and were used in the EIA. The study included all areas around the bridge site where changes

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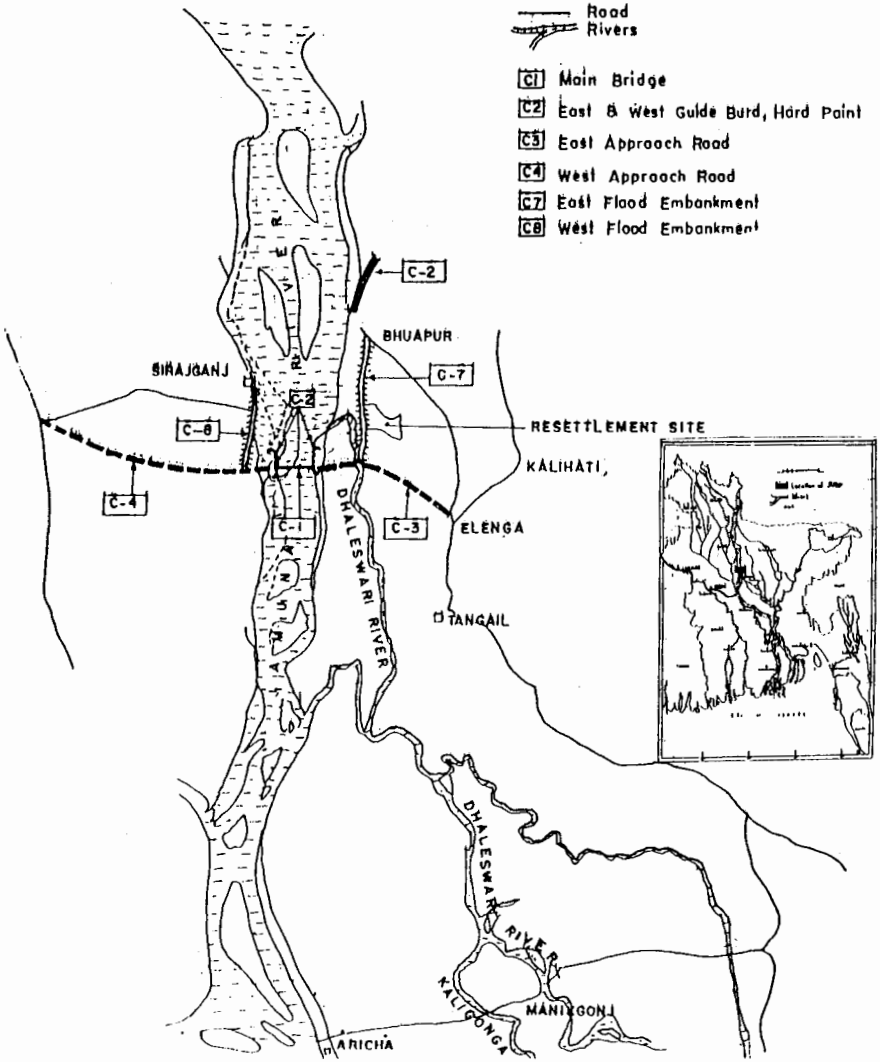


*Fig 1. Location of Jamuna Bridge and its Components*

in the to minimize or mitigate adverse environmental impacts of the project. The EIA was based primarily on data collected in 1988, but, to a large extent, on the available secondary data and information about the components of environment were expected. But it excluded more distant

areas where economic changes are expected to occur as a results of the improvement of the communication network. The Environmental Management Action Plan (Ahmed et.al.,1994 ) prepared for the above project addresses the major environmental issues related to the project and categorically provides various ways to mitigate the negative impacts and accentuate the positive ones.

**WORKS UNDER THE JAMUNA MULTIPURPOSE BRIDGE PROJECT**

The construction of the Jamuna Multipurpose Bridge includes the following major components:

- construction of the bridge;
- creation of bridge end and approach viaducts facilities at the East and West banks of to river;
- construction of approach roads, with embankments, to connect the bridge with the existing road;
- construction of the approach embankments for future railway tracks;
- river training works;
- support services and construction related infrastructure.

The Jamuna Multipurpose Bridge will create an important infrastructual link between the eastern and western parts of Bangladesh. Apart from a four lane road, the bridge will accommodate a single railway track and will have provision for a high tension electricity line, a gas pipeline, and ducts for telecommunication cables. The works under the jamuna Multipurpose Bridge Project is presented in Fig. 2.

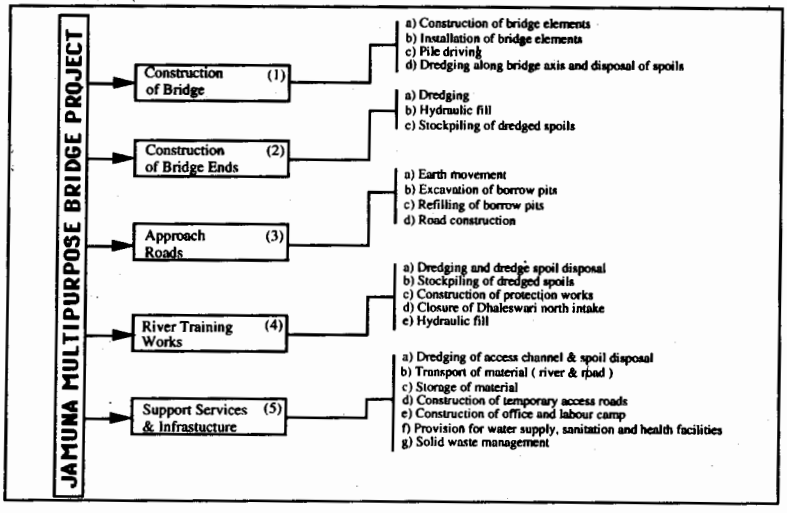


*Fig 2. Summary of Main Activities and Construction Works Related to the Realization of the Jamuna Multipurpose Bridge Project*

**Bridge Construction**

The main bridge is a multi-span box-girder structure with spans of around 100m and a total length of 4,800m (with provision for an additional 500m depending on the location of the guide bunds). The bridge will have a pile foundation consisting of groups of 90m long steel tubular piles in 2-pile or 3-pile bents. The superstructure of the bridge consists of pre-stressed concrete box girders. Precast sections, typically 4m length, will be fabricated on the eastern bridge end, and installed in place by a lunch gantry positioned over the bridge piers. Some of the main activities involved in the bridge construction are briefly described below:

Piling works: The foundation of the piers will be prepared through driving long tubular steel piles in the river bed by piling hammers of rigs mounted on barges.

Fabrication of bridge elements: The superstructure of the bridge is proposed to consist of precast sections forming pre-stressed concrete box girders. Fabrication of the bridge elements in segments of spans will take place at the eastern bridge end.

Installation of bridge elements: The bridge elements will be transported overland along the bridge on a launch gantry positioned over the bridge piers. As each span is completed the launch gantry will be moved forward for the next span. Progress will be from the East end to the West end.

Dredging and disposal of spoils: To provide safe passage to barges carrying the cranes, piling machine and construction materials, local dredging may be required between the Bay of Bengal along the Meghna-Jamuna River up to the bridge site. Dredging along the bridge axis to provide access for the piling equipment may be required, especially where the bridge will cross chars.

**Creation of Bridge Ends**

The creation of bridge ends on both sides of the bridge will involve reclamation of land located within the Jamuna flood plain. During construction of the bridge these bridge ends will accommodate the work site for the contractors for bridge construction and river training works: After completion, this will accommodate facilities for proper operation and maintenance of the bridge. These end facilities are expected to enhance smooth traffic flow, provide travelers aid, have bus stations, a railway station at the East bridge end, parking and rest areas, toll booths, staff housing, etc. The total length of the two bridge ends will be about 6,000m. Some of the major activities involved are:

Dredging and disposal of spoils: The bridge ends will be reclaimed from the flood plain using dredge spoil; to create flood free conditions the ground level has to be raised by about 5m. This spoil may be derived from different sources: from the harbor to be created on the east bank, from

dredging for navigational purposes and dredging for the river training works. The spoils will be directly deposited on both bridge ends by hydraulic fill technique.

Stockpiling of dredge spoils: The dredged material, in excess of what is used for the bridge end, will be stockpiled in a suitable location for later use, possibly the construction of the embankments for approach road and railway track, and/or filling up on the borrow pits.

**Construction of Approach Roads and Future Railway rack**

The approach roads will have a length totalling approximately 29km. In the east the approach road will be connected to the existing Tangail - Madhupur road near Elenga; in the west it will join the Hatikamrul - Sirajgonj road at new Nalka Bridge. Some of the major activities involved are:

Closure of the northern intake of the Dhaleshwari river: The embankment construction will result in the closure of the northern intake of the Dhaleshwari River in order to prevent outflanknig of the Jamuna river.

Earth movement: To construct flood free approach roads the existing ground level has to be raised by approximately 5m. The spoils from the different dredging operations, in excess of what is used for the construction of the bridge ends and for the river training works, will be used for the approach roads and future railway embankments inside the flood plains. The material stockpiled on the bridge end will be transported in relatively dry condition to the approach road embankments and future railway embankments (both inside the flood plains).

Excavation and refilling of borrow pits: Instead of also using dredge spoil for the construction of the embankments, outside of the flood plain, the contractor has proposed to excavate soil from borrow pits along the approach road.

Construction of road pavement: The road pavement will be constructed following the usual design procedure and bituminous materials and brick khoa will be used for this purpose.

Construction of railway approach: The railway track will have a different alignment than the road pavement and the design of the track layout will be decided after the construction of bridge ends.

**River Training Works (RTW)**

River training works will be necessary to prevent outflanking channels of the Jamuna River from breaching the bridge approaches. The river training works will involve:

Dredging: Prior to the construction of the river training works, extensive dredging up to a depth of about PWD-15m, below the lowest level of scour

depth (PWD-15m), will be necessary along both river banks over a distance of about 2Km. An estimated 25 to 30 million $m^3$ of dredged materials will be generated.

Disposal of dredge spoils: Most of the material dredged will be disposed of on land, to be used later in the river training works, or for reclaiming low lying land in the surroundings. Hydraulic fill method will be used for the disposal of the dredge spoil at the designated sites.

Stockpiling of dredge spoils: Dredge spoil in excess of what is directly needed for reclamation of the bridge end will be stockpiled at designated locations.

Construction of river training works: The guide bunds will be constructed on the flood plain or on charland (west bank). The crest of the RTW will be raised above the design flood level, while the toe at the river side will be excavated to the maximum expected scour depth (PWD-15 m). To prevent erosion of the slopes and to protect the river banks geotextiles and rocks will be used. The total area needing protection is about 1 million $m^2$.

Construction of hard point at Bhuapur: In order to divert the upstream river flow under the proposed bridge a hard point has been selected at Bhuapur, slightly upstream of the bridge site. This location will be further strengthened by dumping rocks, building concrete mattresses or using geotextiles.

**Support Services and Construction Related Infrastructure**

The implementation of the project will require extensive support services and supporting (logistical) infrastructure. Those support activities which are most likely to have some bearing on the environmental conditions are presented below:

Dredging of access channel and disposal of dredged materials: To ensure a channel of sufficient width and depth, stretching from the Bay of Bengal to the construction site throughout the construction period, for transport of material and equipment, continuous local dredging may be required. The dredge material, thus generated, will be disposed of in the river or be transported to charland. Dredging along the bridge axis can be considered to belong in the same type of supporting service.

Riverine transport of equipment and construction material: On-site delivery of the construction material (particularly rocks for RTW), machinery and heavy bridge components by road or rail does not seem feasible. The most suitable mode of transportation is expected to be on barge via the Meghna-Jamuna River.

Road transport: Although most of the equipment and materials will probably be transported to the site via the Jamuna river, road transport will also be used to some extent. The already completed road on the

rehabilitated eastern flood embankment will provide temporary access to the eastern end of the bridge.

Storage of materials and equipment: Equipment, materials and consumable (including fuel and chemicals) will be stored at designated storage areas on the bridge ends and on contractor's working area for the approach roads.

Construction of temporary access roads: In order to assure easy access to various construction sites temporary roads will be essential.

Construction of infrastructure related to labor camp and offices: During bridge construction the bridge ends will accommodate office facilities for the contractors and engineer, housing facilities for their staff and for the laborers (labor camp), as well as storage facilities for equipment, material and consumable. Provision of a water supply system, a sewerage and drainage system will also be required. After the bridge construction these facilities can be converted to serve permanent purposes for operation and maintenance of the bridge.

Solid waste management: A construction project, with the size of the Jamuna Multipurpose Bridge Project, will generate a considerable amount of solid wastes (construction related wastes, waste from offices and housing facilities, from boats, etc.). An efficient solid waste collection and disposal system will have to be established. This also will include an environmentally sound pre-designated solid waste disposal site.

**Environmental Impacts and Risks**

The realization of the five main elements of the Jamuna Multipurpose Bridge Project, described earlier, can be subdivided into various activities and/ or construction works. Within each of these activities/ construction works other sub-activities can be discerned (Fig. 2).

Impacts or risks of similar nature can be caused by different activities/construction works simultaneously. In following paragraphs the potential environmental impacts or risks have not been arranged per activity or construction work. Rather the impacts and risks are described, while referring each time to the responsible activity/ activities. The impacts and risks have been grouped per agent causing environmental stress, per environmental compartment or per function affected.

Although, the works related to the construction of the bridge will certainly result in negative environmental impacts, these impacts should be viewed in their local context. For example, the current human activity in the area to be occupied by the works is already affecting the environment (agricultural activity, disposal of waste and excreta, etc.). During the construction phase about 13,000 people will have to vacate their houses in the working area. They will be replaced by some 2,000 staff and laborers. Even without the provision of sanitary facilities the

impact on e.g., ground water pollution due to excreta disposal will only diminish. Furthermore, the total amount of dredging work to be executed (approximately 30 million $m^3$) is only a fraction of the total sediment load carried annually by the river (600 million $m^3$).

**Review of Environmental Impacts or Risks**

The aggregate of environmental impacts and risks is hard to classify in a logical framework. It is impossible to cover all types of environmental impacts that may arise from the current project under a single specific condition. Some of the impacts are direct, others are indirect, derived from impacts that produce an environmental stress in itself.

Attempt has been made to structure the potential impacts to some extent, grouping these into:

- direct impacts on one of the environmental compartments;
- social impacts;
- indirect impacts affecting the living environment;
- economic impacts.

It should be noted that only the negative environmental impacts of the project have been described.

The main activities/construction works causing the impacts identified have been indicated wherever relevant (the code in between brackets, relates to Fig. 2).

Direct impacts and risks related to receiving environmental compartment (D)

D1-Soil quality:

Deterioration of soil quality at the construction site is not unlikely and may be due to accidental spillage of toxic chemicals and fuel, and prolonged storage of such chemical at certain locations. Potentially this could be compounded by the use of contaminated dredge spoils in construction of the bridge end and the approach road embankment. Another potential source of soil contamination could be the disposal of solid wastes. Sources and/or activities that may have impact on soil quality are:

i. disposal of (solid) waste (5g)
ii. storage of construction material, fuel and chemicals (5c)
iii. spillage of fuel and chemicals during usage (use of machinery)
iv. hydraulic fill/stockpiling of dredge spoil (1d, 2b, 2c, 4b, 5a)
v. construction of bridge ends, embankments and filling of borrow pits with contaminated spoils (2b, 2c, 3c)

D2-Surface water quality:

The hydraulic fill method will be used for the land based disposal of dredge spoil, during the construction of the bridge ends. In principle all dredged material placed on the land will be separated in mineral solid matter (soil) and water. The soil (mainly sand with a small silt content) will remain in the designated reclamation areas, while the transport water will be guided back into the river. If the original dredged material contain pollutants (e.g., heavy metals or other toxic chemicals) such substances could be carried back to the river by the transport water, along with silt or smaller particles which cannot be retained within the reclamation areas.

Dredging process itself and the discharge of run-off water (effluent) from the reclamation areas will cause an increase in the suspended sediment load of the river, posing a potential threat to aquatic organisms downstream. In addition, the surface water quality is liable to deteriorate if the effluents from the offices, housing facilities and labor camp are disposed of into the river without treatment. Accidental or wanton spillage or disposal of wastes from ships may further affect the river water quality. A summary of sources and/or activities that may have an impact on surface water quality are:

i. dredging operation (1d, 2a, 4a, 5a)
ii. discharge of effluent from hydraulic fill and stockpiling of dredging spoil (1d, 2b, 2c, 4b)
iii. discharge of effluent from offices, housing facilities and labor camps (5f)
iv. spills and waste disposal from ships and dredging vessels (1b, 1c, 2a, 4a, 5a, 5b)

D3-Groundwater quality:

Accidental spillage of toxic chemicals such as fuel, lubricants, thinner and solvents may contaminate the groundwater system through infiltration. If soak pits are used in the sanitation system then the groundwater quality is likely to be affected. Also leachate generated at the solid waste disposal site may contaminate the ground water system. Sources and / or activities that may have an impact on ground water quality are:

i. disposal of (solid) waste (5g)
ii. spilling of fuel, lubricants and other liquids used (use of machinery)
iii. discharge of effluent from offices and labor camp (5f)

D4- Quantitative aspects of surface and ground water:

The surface water hydrology, ground water flow and water management practices are usually interrupted by major earthworks. During construction temporary works, such as cofferdams, access roads, dredge spoil stockpiles, etc. may be built. These works could potentially

disrupt the natural cross drainage. Construction of the approach road embankment, although provisions are made for adequate cross drainage facilities, will locally impede the surface drainage, causing longer flooding periods than at present. The construction of the approach road embankment will also lead to the closure of the northern intake channel of the Dhaleswari River, causing reduced flow in its downstream section, as well as reduced risks for flooding. Similarly, one of the side channels of the Jamuna River on the West bank will be closed. A summary list of activities having potential impact on the quantitative aspects of surface water and ground water include:

i surface water drainage will be impeded by the construction of the bridge end and approach road embankment (2b,2c,4b,4d)
ii periods of flooding may last longer due to the impeded drainage
iii flow in the upstream part of the Dhaleshwari will be reduced (3a)
iv excavation of borrow pits for construction of road embankment will result in an increased extent of open water (3b)

D5-Air quality:

In and around the construction site it is expected that air pollution will occur through the use of vehicle and machinery, as well as through cleaning of iron grit and coating of construction materials. Dust, resulting from construction vehicle movement and wind blown dust, will aggravate the situation. A concrete asphalt plant will also contribute to air pollution through dust emission. Indiscriminate burning of solid wastes will add to air pollution. Sources and /or activities that may have an impact on air quality are:

i exhausts from vehicles and machinery used (use of machinery)
ii dust produced at the construction site for bridge elements (la)
iii dust from use of vehicles and machinery (use of machinery )
iv dust from hydraulic fill sites and stockpiles of dredging spoils (2b, 2c, 3a, 4b, 4c)
v dust originating from road construction (3d)
vi burning of waste

Social Impacts (S)

S1-Noise pollution:

During the construction period it is expected that noise levels will be considerably higher than the existing level. Noise pollution will be generated by the use of vehicles, pile driving operations, dredging, electricity generators, etc. Summarizing some sources and /or activities that may have impact on noise level are:

i dredging (1d,2a,4a,4a,5a)
ii pile driving (1c)
iii use of vehicles, generators and machinery
iv construction of bridge elements (1a)

S2-Occupational health hazards and safety:

Apart from being exposed to the risk of accidents, the construction workers may also be at risk of occupational health hazards due to the materials handled and the working conditions. Sources and/or activities that may pose occupational health hazards or safety risks for the project laborers and nearby population are:

i all construction related works; especially use of machinery and chemicals
ii increased traffic (5b)

S3-Other health hazards:

At the work site of the different contractors labor camp will be constructed with temporary accommodation for about 2000 persons during the peak of the construction works. Good sanitary facilities, such as an excreta disposal system, and a reliable supply of safe drinking water will be essential to reduce the risk of diseases related to unhygienic conditions. Lack of adequate drainage facilities in the camp areas and on the work site will cause accumulation of sullage water, providing breeding ground for mosquito and water-borne or water related diseases. Improper sanitary facilities may contaminate the environment in general and even the water supply system. Garbage, rubbish, construction wastes may pose an additional health threat and nuisance. Breeding of flies and some mosquito species may occur due to lack of proper collection and disposal system. Uncontrolled vending of food on the work site may also pose a risk with respect to the transmission of contagious diseases. Furthermore, immoral practices and prostitution may cause the spread of venereal diseases. A summary list of sources and/ or activities that may pose health hazards are:

i. lack of sanitary facilities and disposal system (5e, 5f)
ii. lack of drainage system for waste water (5e, 5f)
iii. lack of proper water supply system (5e, 5f)
iv. lack of proper solid waste collection and disposal system (5g)
v. uncontrolled vending of food (5e, 5f)
vi. sexual behavior

S4-Social disruption:

The construction of the bridge and related works will result in the forced departure of about 13,000 persons. This, in itself, is an enormous disruption of the social life of the local population. The resettlement of these people may further disrupt the social fabric of the population in the regions where they are settled. The influx of non-local laborers, may also result in social disruption. These outsiders, with better economic

conditions may disrupt the local economy and social order. A review of the sources and /or activities that may lead to social disruption include:

i. removal and resettlement of population
ii. influx of laborers from outside
iii. expropriation of land to allow for resettlement of population to be resettled

Various other (Indirect) Impacts (I)

I1 - Disruption of agricultural practice:

In the vicinity of the construction site agricultural practice may be disrupted as a result of temporary but unavoidable disruption of the surface water hydrology. It may further be disrupted by earth works, beyond the planned work area. Agricultural land required for stockpiling of fill, access roads and borrow pits outside the designated areas will cause loss of production during the construction period. Even after dismantling such temporary earth works agricultural production will be reduced for some time as a result of damage to the soil structure. Dust originating from the work site will also influence agricultural production in a negative way. The present agricultural practice of resettled population and other people living close to the project zone can be affected in the following ways;

i impeded drainage due to construction of bridge end and approach road embankment (2b, 2c, 3b, 3d)
ii prolonged period of flooding conditions due to impeded drainage
iii earth works beyond designated areas (2b, 2c, 3a, 4b, 5a)
iv increased amount of dust in the air covering leaves of trees and other crops (see D5).

I2 - Additional health risks:

The excavation of borrow pits for the construction of the approach road embankment will result in a larger extent of open stagnant water. This will lead to more breeding ground for mosquito and the other water-borne and water related disease vectors.

I3- Impacts on flora and fauna:

Plants and vegetation on the land required for the construction of the bridge ends and approach roads will be cleared. Excavation of borrow pits will add to the destruction of flora. Dust produced by vehicle movement and construction related activity (e.g., asphalt plant) will settle on plants and crops which will contribute to their demise. Noise by vehicles and machinery may affect the behavior of fauna. Increased turbidity in the river due to dredging and the discharge of dredge spoil effluent may affect aquatic life in the river. The inflow of pollutants that may enter the river water (potentially from dredging ooerations, from accidental spills, and from the discharge of effluents ) may affect the

river ecology. Summarizing, flora and fauna may be affected in the following ways:

i cutting and uprooting of all trees and bushes
ii increased amount of dust in the air (see D5)
iii noise produced by vehicles and machinery (see S1)
iv increased turbidity of the river water (1d, 2a, 2b, 4a, 5a)
v inflow of pollutants into the river

Economical Impacts (E)

E1 - Hindrance to navigation:

During construction considerable quantities of construction material and equipment will have to be brought in by river, using barges. Increased riverine traffic may disrupt or hinder the usual river traffic. Furthermore, piling works may interfere with the local riverine traffic. Closure of the northern intake of the Dhaleswari River will inevitably block the usual transport along this river arm, and thereby the economy of the localities and people using this transport way. Activities that may hinder or even obstruct river navigation are:

i dredging activities (1c, 2a, 3a, 4a, 5a)
ii pile driving (1b)
iii closure of Dhaleshwari River (4c, 4d)

E2 - Hindrance to road traffic:

Although most of the construction material and equipment will be transported by river, increase in road traffic to the construction site is a certainty. Due to intensification of road traffic, the circulation of the traffic, especially in the stretch between Tangail and Bhuapur, is likely to be hindered. The stretch of road between Tangail and Bhuapur is narrow. Increased use of this road by trucks and lorries will further deteriorate the existing traffic flow. Traffic bottleneck condition will prevail at the major crossings of Tangail and Bhuapur, where chaotic conditions already exist. This is caused by widespread disregard and violation of traffic laws by the bus drivers and rickshaw pullers.

For each of the activities/construction works one or more environmental impacts or risks can be identified, related to one or more compartments of the environment. In the matrix shown in Fig. 3 the potential environmental impacts of the main activities/construction works are presented in relation to the agents of environmental stress, the environmental compartment affected and the value or function affected.

**MITIGATORY MEASURES**

In view of the above discussions the mitigation measures suggested in Table 1 (in Appendix) may be adopted during the construction phase of the Jamuna Multipurpose Bridge.

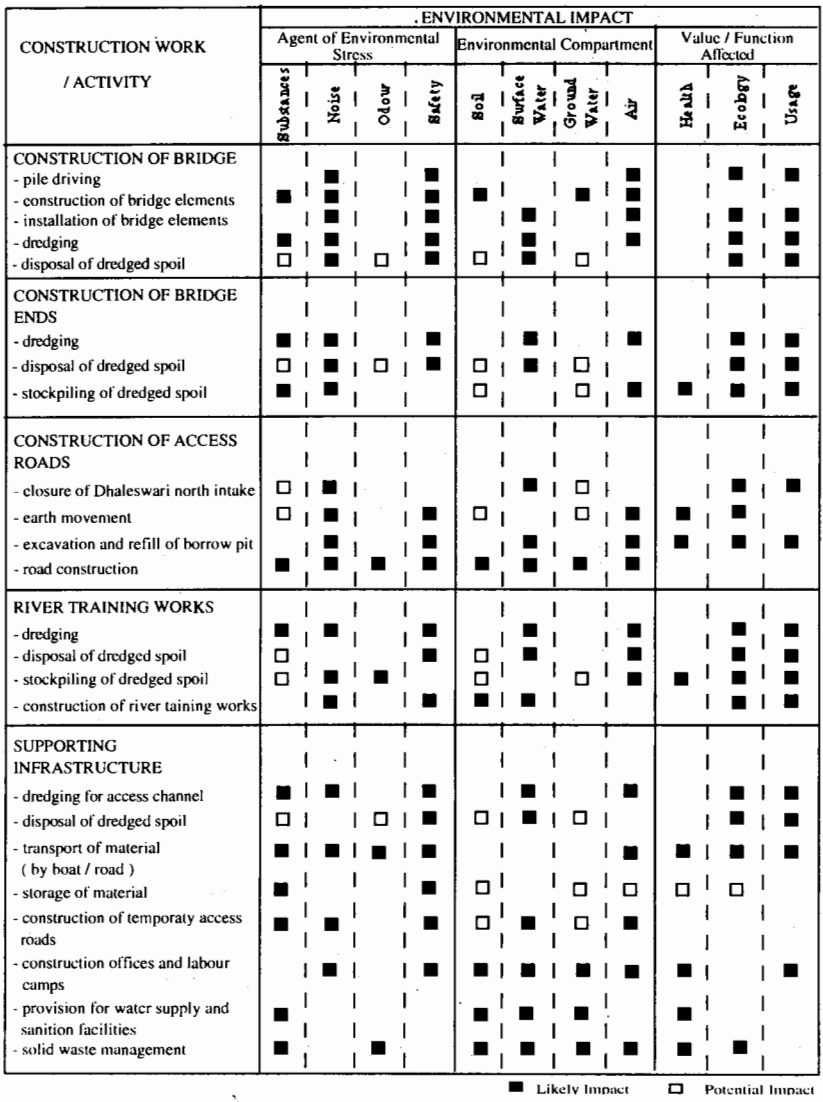


*Fig 3. Potential Environmental Impacts of Major Construction Activities*

## DISCUSSIONS AND RECOMMENDATIONS

Attempt has been made to identify the major environmental impacts related to the construction of the Jamuna Multipurpose Bridge. Some of the impacts are permanent in nature and some tend to persist during the

construction period. In this study impacts were identified qualitatively as data available from various studies were insufficient for making a quantitative assessment. Scarcity of data makes it essential to conduct further study in the impact zone. In addition, continuous monitoring of potential problem areas such as, dredged spoil storage and disposal sites, borrow pits, effluents from labor camps and solid waste disposal is imperative. Frequent testing of water, air and soil quality in the impact zone will also strengthen the quantitative impact assessment.

Planning of mitigation of impacts, caused by the construction activities, may be achieved by following the General Environmental Guidelines (Ahmed et al., 1994) prepared for the Jamuna Multipurpose Bridge project.

However, it should be remembered that the expected benefits resulting from this project by far outweigh the negative impacts which has led to realization of the Jamuna Bridge. The major positive impact of the project include improved communication between the north-western and eastern parts of Bangladesh. This will dramatically facilitate the economic development of those areas. In addition, the second electric inter connector, planned to run the bridge, is expected to supply power to the north-western regions. The Jamuna Bridge will also be used as the corridor for the gas lines. Reduced flood water level in the impact zone will also increase crop production in the vicinity of the bridge site.

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## APPENDIX

Table 1. Mitigating Measures for Possible Adverse Impacts

| Item | Possible Activity and Impact | Mitigating Measures |
|---|---|---|
| 1 | Disruption of Navigation | Maintain close liaison with the BIWTA<br>Provide proper navigational instructions<br>Place buoys and navigational lights<br>Conduct dredging operations, if required |
| 2 | Disruption of Road Transport and Traffic | Practice caution in using vehicles<br>Prevent use of private properties |
| 3. | Dredged Spoils Disposal | Dredging may be synchronized with high river flow to induce flushing<br>Outflow from hydraulic fill should have maximum retention time to enhance settling at the reclaimed site<br>Outflow water quality should not be worse than the receiving water<br>Avoid water congestion<br>Prevent spillage of filling soil on private properties. |
| 4. | Approach Roads and Bridge End Facilities | Prevent localized flooding at the borrow pits<br>Avoid drainage congestion |
| 5. | Disruption of Surface Drainage | Provide adequate drainage facilities<br>Construct cross drainage provisions |
| 6. | Disruption of Irrigation | Avoid disruption of surface water irrigation system<br>Ensure alternative source of irrigation water<br>Provide compensation if disruption is unavoidable |
| 7. | Deterioration of Surface Water Quality | Increase retention time of the outflow hydraulic fills to increase sedimentation, thus, reduce sediment load to the Jamuna river<br>Prevent discharge of untreated, inorganic, organic, and toxic wastes in surface waters |

| | | |
|---|---|---|
| 8. | Air Pollution | Maintain optimum moisture content during compaction, transportation and handling of soils<br>Regularly spray water on dry surfaces to reduce dust generation<br>Strictly regulate vehicle emissions |
| 9. | Noise Pollution | Install the power generator unit inside a soundproof room<br>Install temporary soundwalls<br>Regulate the use of horns |
| 10. | Disposal of Construction Materials and Wastes | Implement strict handling and storage practices to prevent accidental spillage |
| 11. | Disruption of Agricultural Practices | Prevent unauthorized earthworks on private properties<br>Provide alternative job opportunities<br>Provide adequate compensations |
| 12. | Disturbance of Wildlife | Prevent unplanned invasion outside the project area<br>Strictly adhere to the wildlife protection guidelines |
| 13. | Destruction of Plant and Vegetation | Spray water on existing plants to remove dust<br>Organize tree planting and landscape maintenance team<br>Provide compensation to private owners |
| 14. | Creation of stagnant water bodies in borrow pits suited for mosquito breeding | Assess vector ecology in work areas and adopt appropriate measures<br>Spray insecticide on breeding grounds |
| 15. | Lack of Excreta Disposal System | Provide good, planned sanitary facilities, septic tanks, waste treatment facility, etc. |
| 16. | Lack of Waste water Drainage System | Provide adequate facilities for disposal of sullage and wastewater |
| 17. | Contamination of Drinking Water | Establish small scale water treatment facilities<br>Install deep tubewell with provisions for post treatment for iron and manganese<br>Install proper water disinfection provisions |

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| 18. | Uncontrolled Disposal of Solid Wastes | Install proper solid waste disposal facilities<br>Organize proper collection and transportation of solid wastes |
| 19. | Transmission of Diseases among Workers | Provide regular health inspection and vaccination among workers<br>Promote health education campaign among workers |
| 20. | Social Disruption among Workers and Villagers | Reduce social tension through public outreach programs<br>Set up mosques, market, etc. near the labor camps |
| 21. | Safety of Workers | Adopt appropriate safety measures<br>Make the workers aware of hazardous materials and proper handling methods |