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**STUDIES ON THE BANGLADESH AGRO-ECOLOGICAL ZONE (AEZ) BASED
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STUDIES ON THE BANGLADESH AGRO-ECOLOGICAL ZONE (AEZ) BASED ROAD-TRANSPORTATION ENGINEERING ON AGRO-PRODUCTIVITY

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ABSTRACT

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The Road Transportation Engineering which consists the characteristics of the road/bridge design systems are known to have direct impact on the agro-productivity. Being a hydromorphic land-soil-agro-climatic, Bangladesh has been scientifically divided in to 30(thirty) Agro-Ecological Zones as per its land-soil crops and agro-climate. Keeping this view in mind a piece of research was conducted to study the Agro-Ecological Zone (AEZ) Based road-bridge-transport engineering on the agro-productivity as it influence the agro-productivity expressed by enhancement of agricultural production per unit of land using the soil resources. The studies were conducted with the major objectives such as to i. Analyze the AEZ based agro-production situation; ii. Estimate the catchments and bridge-culvert dimensions, iii. Effects of road-transport design systems on agro-productivity, iv. Develop a bridge as per command drainage keeping no mid-pier and without affecting the bio-diversity and agro-productivity of the target area. The results indicated that the AEZs studied differ in their bridges and culvert dimensions which were found volumetrically inadequate to discharge or drain out the catchments water load in time causing water stagnation. The engineering designs of the structures were found to have mid piers which obstacle streams. The total road-bridge-transport integrated system was found to have contributed positively for agro-productivity, and as indicator of environmental degradation, reducing the sustainability of the development in the country. The results showed that about 74% of the bridges on metalled rural roads of the studied AEZs lost the expected functioning even from the beginning, increasing water congestion up to 23 days. The transportation over the roads decreased and de-speeded due to side-breaking of the roads, especially of the bridges indicating about 37% under use status. The reasons of such less effectiveness of the infrastructures as expressed by the Focus Group Discussion (FGD) among others, were the non-sharing of the works with the beneficiaries and related ministries specially for the design and site selection of the structures. Finally a model non-pier bridge design was recommended which is now recently constructed typical for the southern AEZs of the country and generally for the other AEZs, which increases agro-productivity of the area by 19% in terms of crop yield.

Key words: *Transportation Engineering, Agro-Ecological Zone (AEZ), Drainage Command Area*

INTRODUCTION

The background of the piece of research work, its importance, scope of the study and the major objectives and expected results are briefly described in this chapter. The Roads and Highways of transportation engineering consisting the types and characteristics of the roads and hydrological designs and structures are reported to have direct impact on the agro-biological aspects as per its effectiveness on the bio-diversity, bio-productivity and socio-economic livelihood of the target command areas.

Bangladesh has been scientifically divided in to 30(thirty) Agro-Ecological Zones as per its topography, climate, hydrology, natural resource status, food security and other related physical developments potential factors. Keeping this view in mind the a research was conducted to study the Agro-Ecological Zone (AEZ) Based Road-Transportation Engineering on the bio-diversity and bio-productivity as it influence the Food Security in Bangladesh.

The studies were conducted with the major objectives such as i. Analyze the AEZ based drainage situation; ii. Identifying the needs; iii. Estimating the catchments and bridge/culvert dimensions, and iv. Assess the contributions of road-transport-drainage environment, bio-diversity and bio-productivity.

The results indicated that the 3(three) AEZ were studied in general and 1(one) AEZ was studied in detail, all differed in functional interactions. The bridges (small) and culverts were found insufficient to carry the transport types over them and thus lost their effectiveness before the set life of the structures. The bridges and culverts dimension were found volumetrically inadequate to discharge or drain out the catchments water load in time causing water stagnation. The engineering designs of the structures were found to have less strength relating to the transport load.

The total integrated system was found to have contributed positively for social welfare but negatively for bio-diversity and agro-bio-productivity, as indicator of environmental degradation and bio-productivity as indicator of socio-economic life in Bangladesh.

The reasons of such less effectiveness of the system as spelled out by Focus Group Discussion (FGD) among others, were the non-sharing of the work with local beneficiaries specially for the size, site and strength of the structures.

It is recommended that more detailed studies are required to reinforce Transportation Engineering and Environmental infrastructure development projects in the light of changed climate and food security need of the target areas considering the road-transport, land topography, water recession trend and AEZ based catchments/command areas in an integrated way.

It may be mentioned here that Bangladesh has been divided into 30(thirty) Agro-Ecological Zones and 89(eighty nine) Sub-zones on the basis of land elevation, water regime, drainage system, water recession after rainy season, agro climatic parameters and other hydrological factors (BARC 1989).

In this context, the present piece of research work has been undertaken to study the overall situation of the land-drainage structure productivity as per the most important Agro-Ecological Zone of the country done by United Nations Development Program (UNDP), Food and Agriculture Organization (FAO), Bangladesh Agricultural Research Council (BARC) and Soil Resources Development Institute (SRDI), which was further developed and utilized by Roads and Highways Department(RHD), Local Government Engineering Department (LGED), Department of Agricultural Extension (DAE), Planning Commission(PC) of the Government of Bangladesh as and when found necessary (Anon 2007; BARC 1989; BARI 2002).

Infrastructures such as Bridges and culverts are the most important part of rural development in Bangladesh. Under the Food for Works Program (FFWP), non-metallic road was constructed without bridges/culverts. Construction of small bridges & culverts program exerted tremendous impact in the rural economy of Bangladesh. At the Upazila level, the roads were constructed under FFWP to connect the Local markets, Growth centers, Schools and Union Parishads (UPs) with the villages and near by pucca roads. Keeping this issue in view, the current project was planned for implementation. Thus, the present work was done to study the AEZ (BARC 1989; MOA 2008), based road catchments-drainage integration as it affected Food security crops in Bangladesh.

After the independence of Bangladesh in 1971, road transportation emerged as the most important mode of communication. War-ravaged roads, as other countries (CED 2006; OECD 2007), culverts and bridges were reconstructed fast. Some new bridges on the national highways were built. All the district headquarters were connected with the national highway network. Transportation business became a thrust sector involving thousands of employees and workers.

A large number of different agencies are involved in planning the development of road transportation, management of the traffic and maintenance of roads and highways. The Ministry of Communication is the highest regulatory and policy making body of the government in this sector. The Roads and Highways Department is responsible for construction, re-construction and maintenance of national highways, regional and feeder roads. City development authorities like RAJUK, Chittagong Development Authority, Khulna Development Authority and Rajshahi Development Authority, District councils and local government bodies are responsible for the development of roads in their respective areas (David 2000; FAO 2007).

Bridges on RHD Roads in Bangladesh

Roads in Bangladesh are classified in 4(four) main groups; national highways, regional highways, feeder roads and local roads. National highways connect the national capital with district headquarters, port cities and international highways. Regional highways connect different regions and district headquarters (64 districts) not connected by national highways. Feeder roads are of two types: feeder roads type A and feeder roads type B. Type A feeder roads connect Upazila (lowest tier of administration) headquarters and important growth centers to the main arterial road network, while type B feeder roads connect growth centers with other growth centers and Upazila headquarters. Local roads include municipal roads and rural roads. There are 3(three) types of rural roads: type 1 roads that connect about 2100 growth centers with farms; type 2 roads that connect union headquarters (4551) and local markets with villages and farms; and type 3 roads that include roads within the village.

Roads and Highways Department (RHD) is the central agency of GOB, which is responsible for construction, improvement and maintenance of the national, regional and type A feeder roads (as District Roads).

Type B feeder roads and rural roads (except municipal roads) are built and maintained by the Local Government Engineering Department (LGED) in collaboration with local government bodies like district council, Upazila council and Union Parishads. Construction and maintenance of municipal and urban roads are the responsibility of municipal bodies like City Corporations and Municipalities (Pourasavas).

The arterial road network under the jurisdiction of Roads and Highways Department (RHD) in 2001 is about 20,854 km, which includes 3,144 km of national highways, 1,746 km of regional highways and 15,964 km of Type A feeder roads (District Roads). National and regional highways are almost entirely paved. Around 50% of the Type A feeder roads (District Roads) are paved.

With the expansion of road network and increase of vehicular traffic on roads, road transport has turned out to be the dominant mode in carriage of freight and passenger traffic in the country. While the traditional water and

railway transports have continued to show an overall declining trend in their performance, road transport maintains an increasing role in taking care of goods and passenger traffic movement in the country.

According to the estimate of Bangladesh Road Master Plan (BRMP) Study in 2000-2001, road transport accounts for about 66% of ton-km by mechanized transport (5 billion in number) and about 73% of passenger-km by mechanized transport (37 billion in number).

According to the estimate of Bangladesh Transport Sector Study (BTSS) carried out in 2003-2004, total output of mechanized surface transport and the percentage share of road transport in carriage of passenger and freight traffic in some selective years. It transpires the role of road transport in carriage of both passenger and freight traffic over the years had been increasing consistently.

It is very reasonably hoped that the share of road transport in carriage of passenger and freight traffic will increase further with the commissioning of Bridges and culverts.

Bangladesh is predominantly a riverine country. The country is criss-crossed by many rivers and rivulets of various lengths and dimensions. Consequently the road network in the country is bi-sected by these water courses. Either bridge is built or ferry system is provided to maintain the traffic flow on road network. Over the years, river gaps on road network are gradually being bridged. By 1990 a substantial number and length of bridges were constructed over the road network under RHD. As on that time, RHD had about 3,144 numbers of bridges and about 6,000 numbers of culverts on its road network. The lengths of these bridges and culverts were about 91,672 meters and 26,136 meters respectively.

A good number of bridges are presently under construction by RHD. Number and length of these bridges stand at about 133 and about 11,625 meter respectively. Of these bridges 61 are of permanent nature, 52 are Bailey bridge and 20 are steel bridge of various brands from different sources. But still there are quite a good number of un-bridged river gaps on the road network under RHD. Presently there are about 80 un-bridged river gaps on the RHD road network, which are provided mostly with powered ferries with all other required facilities for movement of road traffic. The number of ferry boats of different types operating on these river gaps is about 170 at present.

Major Structures

In recent years construction of a number of bridges such as Bangabandhu Multipurpose Bridge (Jamuna Bridge), Meghna Bridge, Meghna-Gumti Bridge, Bangladesh-China Friendship Bridges, Shambhuganj Bridge and Mahananda Bridge have been completed. The 4.8 km long Bangabandhu Bridge which has been opened to traffic in June, 1998, is the eleventh longest in the world. It has established a strategic link between the East and the West of Bangladesh has integrated the country, is generating multifaceted benefits to the people and promoting inter-regional trade. Apart from quick movement of goods and passenger traffic, it is facilitating transmission of electricity and natural gas and has integrated the telecommunication links.

Drainage Command Area

A culvert is a Structure either Box or Slab or Pipe that carries water from one side of a road, driveway, railway or other obstruction to the other (David 2000). Culverts will be buried at some depth below the surface, aligned so as to permit passage of water with minimum obstruction to the watercourse. Culverts also provide access to commercial development areas, homes, farms or areas with livestock facilities, or under haul roads used for mining or forestry.

Culverts are generally short in length and open at both ends and often must withstand substantial traffic loads. Its opening may be single or multiple box or vent or barrel. While the installation, it does not require a large quantity of pipe, the installed drainage structure is extremely important to the overall of the road/drainage interface.

Objectives of the Study

The Bangladesh has been divided in to 30(thirty) Agro-Ecological Zones (AEZs) on the basis of agro-climate, topography, land elevation, transitional season climate derivatives, hydrology and water regime, drainage system, water recession after rainy season, environmental parameters/factors and other hydrological systems.

In this context, the present piece of research work has been undertaken to study the over all situation of the land-drainage structure productivity as per most important (NCDP 2006) Agro-Ecological Zone of the country done by United Nations Development Program (UNDP), Food and Agriculture Organization (FAO), Bangladesh Agricultural Research Council (BARC) and Soil Resources Development Institute (SRDI).

The major objectives of the study were to: i. Identify the present need for structural drainage; ii estimate catchments and bridge-road dimensions needed for drainage; iii. Assess the contributions of road transport communication on the agro-productivity as expressed through agribusiness development and iv. Recommend a Mode Structure as per agribusiness development for some Agro-Ecological Zones of Bangladesh.

The specific parameters of the research were identified according to approved methods (DOF 2007), (GOB 2007), (Mundlak 2007) and mentioned to: i. Assess the drainage irrigation and transport status; ii. Evaluate the technical capacity of the road transport system as regards to environment and development; iii. Estimate the contributions of communication on agro-productivity as developmental agribusiness promotion; iv. Document the evidences of the past activities; and v. Recommend for road transport communication for agribusiness promotion keeping in view the long environmental safety.

MATERIALS AND METHODS

The methods and materials use in the study were briefly described in this chapter. The research was undertaken within a framework of: primary and secondary sources.

Primary Sources:

A number of short field visits were undertaken to develop further knowledge in specific areas on the basis of information gathered through the desk review and the questionnaires (Table 1-5 and Fig. 1-2). During the field visits, meetings and Focus Group Discussion (FGD) were organized with key stakeholders to discuss issues, address gaps and explore possibilities for further collaboration.

The project profiles and project reports on AEZ and drainage and irrigation structures relating to the roads and highways and rural roads were collected and directly analyzed as per methodological parameters (Fig. 3).

Secondary Sources:

The research work was conducted to establish a baseline of available public information. It took account of studies, annual reports and other relevant documentation produced by governments, academic and research institutions. The assessment of Economics of Climate Change is based on questionnaire. Information gathered was organized in such a manner to allow the sharing of data within a specific control and validation system.

The following types of reference documents were collected from authentic sources and were studied and interpreted in detail: A: Overview of Bangladesh and Roads and Highways, B: Citizen Charter of Roads and Highway, C: User Manual for the BMMS including technical design, D: Bridge designs technical aspects with base and approach foundation, E: Detailed information of roads and bridges in Bangladesh, F: RHD road Network, G: AEZ and land Drainage command area agro-productivity information, H: Detailed land use topography maps of AEZ of the Study areas, and I: Flood damage information.

Agro-Ecological Zones (AEZ) study areas and methods illustrated by maps:

Two groups of AEZ were selected for the study (Fig. 1) as per its potential resources as: Group 1: Active Char lands (AEZ 2 and AEZ 7): Resource poor and Group 2: High Floodplains (AEZ 9 and AEZ 11): Resource rich.

Maps showing the Features of Bangladesh were used as tools or materials in the study. AEZ 2-Active Tista Floodplain, AEZ 7-Active Brahmaputra Floodplain, AEZ 9-Old Brahmaputra Floodplain, AEZ 11-High Ganges Floodplain. AEZ 2 and AEZ 7: Areas having minimum transport and roads/bridges. AEZ 9 and AEZ 11: Areas having maximum transport and roads/bridges.

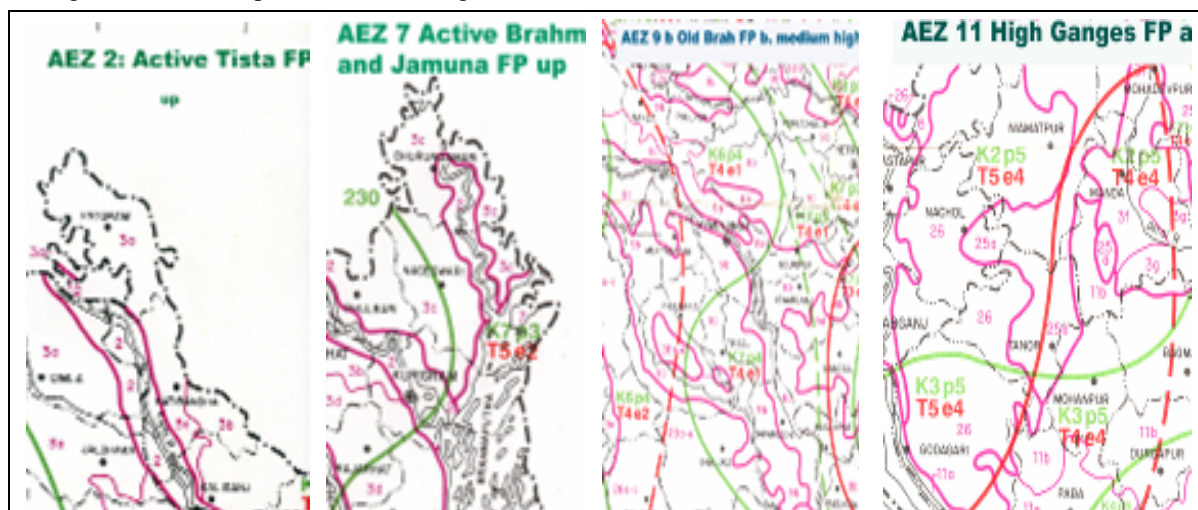


Fig. 1. AEZ(2,7,9 and 11) and road-bridge concentration

The proposed research work was conducted through a package of methodologies in a step-wise strategy. The package will include: i. Physical visit and documentation of a few Bridges and Culverts with catchments areas; ii. E-documentation of road and transport status, bio-diversity, and bio-productivity; and iii. Focus Group Discussion (FGD) at different level.

Physical Documentation:

Name and address of the structure, duration and design (Fig. 2, 3 and 4) of the structure, total Command area (sq. km), Specific site, High land, Medium High land, Medium low land, Low land, Very low land , water bodies –all in acres.

The materials for documentation were: Agro-productivity status: Previous, and Agro-productivity status; existing: types and description of structures including identity-AEZ: Division-District- structure group-total structures of the specific sites such as: Upazila-Union-Villages-Road name-Site code- year-Road and Bridge/culvert measurement; along with objectives of the road /bridge/culvert as per record about present condition of the roads, bridges and culverts.

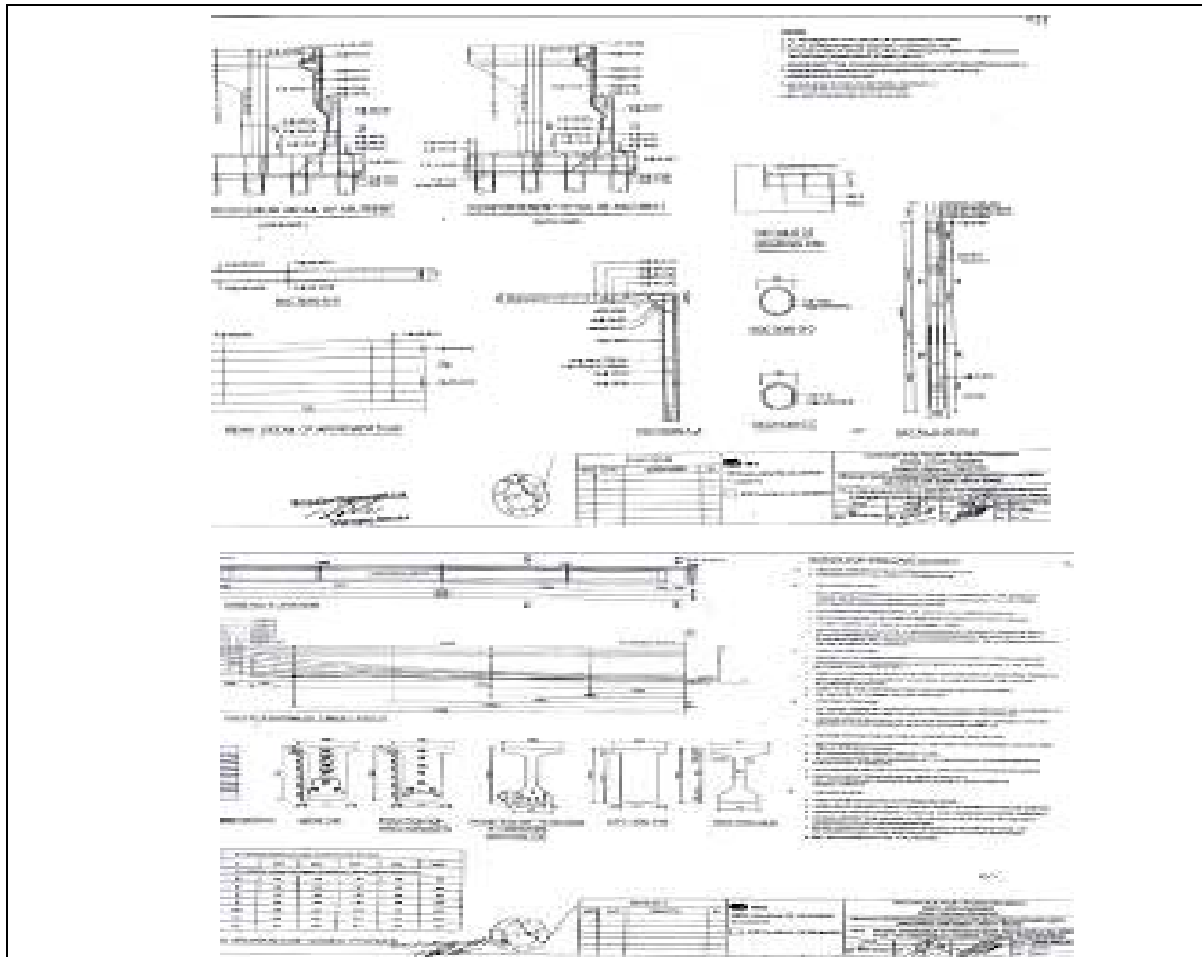


Fig. 2. A developed non-pier model bridge

RESULTS AND DISCUSSION

The salient findings of the studies done as per objectives were sequentially mentioned (Table 1 to 12) and explained here below:

AEZ 2: Active Tista Floodplain

Districts: Lalmonirhat, Nilphamari, Kurigram -Greater Rangpur

Duration of the structure 5-15 years

Catchments-900-3000 ha Command area-direct per structure

Table 1. Land characteristics of AEZ 2

| Land topography | % Area |
|------------------|--------|
| High land | 7 |
| Medium High land | 21 |
| Medium low land | 33 |
| Low land | 27 |
| Very low land | 7 |
| Water bodies | 5 |

Table 2. Agro-productivity (Bio-diversity and Bio-productivity) status of the Sites

| Item | Period | Parameters | | |
|--------------------------|----------|------------|--------|-----|
| Bio-diversity status: | Previous | High | Medium | Low |
| Range of plant species | | | Medium | |
| Range of animal species | | High | | |
| Range of crops species | | | Medium | |
| Bio-diversity status | Existing | High | Medium | Low |
| Range of plant species | | | | Low |
| Range of animal species | | | | Low |
| Range of crops species | | | | Low |
| Bio-productivity status: | Previous | High | Medium | Low |
| Range of plant species | | | Medium | |
| Range of animal species | | | Medium | |
| Range of crops species | | | Medium | |
| Bio-productivity status: | Existing | High | Medium | Low |
| Range of plant species | | | | Low |
| Range of animal species | | | | Low |
| Range of crops species | | | | Low |

Table 3. Major structure group and total structures

| Item | Bridges Dimension | Culverts Dimension | Sluice gate and dam Dimension |
|--------------------|-------------------|--------------------|-------------------------------|
| Length | 30-50 m | 10-30 m | 5-10 m |
| % of the total | 33 | 57 | 10 |
| Functioning Sites% | 63 | 23 | 9 |

Sources: ADB/WB/IMF/IDB/DFID AEZ 2: Active Tista Floodplain

Table 4. Agro-productivity: % Mean of major sites as per local vegetation

| Site 1 | Increase % | Decrease % |
|---------------------|------------|------------|
| 1. Fruits | | 22 |
| 2. Vegetables | 18 | |
| 3. Spices | | 32 |
| 4. Cereals | 15 | |
| 5. Pulses | | 17 |
| 6. Oil seeds | | 12 |
| 7. Plantations | 21 | |
| 8. Industrial crops | | 23 |
| 9. Homestead crops | 18 | |

AEZ 7: Active Brahmaputra Floodplain

District: Kurigram, Jamalpur, Tangail, Manikganj, Bogra, Sirajganj, Pabna

Duration of the structure--5-20 years

Catchments-900-3000 ha-(Command area) - direct per structure

Table 5. Land characteristics of AEZ 7

| Land Topography | % Area |
|------------------------|--------|
| High land | 4 |
| Medium High land | 19 |
| Medium low land | 32 |
| Low land | 24 |
| Very low land | 11 |
| Permanent water bodies | 10 |

Table 6. Agro-Productivity (Bio-diversity and Bio-productivity) status of the Sites

| Item | Period | Parameters | | |
|-------------------------|----------|------------|--------|-----|
| Bio-diversity status: | Previous | High | Medium | Low |
| Range of plant species | | | Medium | |
| Range of animal species | | High | | |
| Range of crops species | | | Medium | |
| Bio-diversity status: | Existing | High | Medium | Low |
| Range of plant species | | | | Low |
| Range of animal species | | | | Low |
| Range of crops species | | | | Low |
| Bio-productivity: | Previous | High | Medium | Low |
| Range of plant species | | | Medium | |
| Range of animal species | | | Medium | |
| Range of crops species | | | Medium | |
| Bi-productivity status: | Existing | High | Medium | Low |
| Range of plant species | | | | Low |
| Range of animal species | | | | Low |
| Range of crops species | | | | Low |

Table 7. Major Structure group and total structures

| Item | Bridges Dimension | Culverts Dimension | Sluice gate and dam Dimension |
|---------------------|-------------------|--------------------|-------------------------------|
| Length | 30-50 m | 10-30 m | 5-10 m |
| % of the total | 35 | 51 | 14 |
| Functioning sites % | 48 | 21 | 6 |

Sources: ADB/WB/IMF/IDB/DFID

Table 8. AEZ 7: Active Brahmaputra Floodplain

| Item | RHD | LGED | WDB | NGO | Local |
|----------------|-----|------|-----|-----|-------|
| % of the total | 17 | 48 | 2 | 11 | 22 |
| Effectiveness% | 39 | 32 | 4 | 9 | 64 |

Table 9. Agro-productivity: % Mean of major sites as per local vegetation

| Site 1 | Increase % | Decrease % |
|---------------------|------------|------------|
| 1. Fruits | | 21 |
| 2. Vegetables | 11 | |
| 3. Spices | | 33 |
| 4. Cereals | 18 | |
| 5. Pulses | | 18 |
| 6. Oil seeds | | 10 |
| 7. Plantations | 24 | |
| 8. Industrial crops | | 20 |
| 9. Homestead crops | 28 | |

AEZ 9: Old Brahmaputra Floodplain

District: Jamalpur, Sherpur, Mymensingh, Kishoreganj, Narsingdi, Tangail and Manikganj.

Duration of the structure-10-25 years, Catchments-800-2000 ha (Command area) - direct per structure

Table 10. Land characteristics of AEZ 9

| Land type | % area |
|------------------------|--------|
| High land | 10 |
| Medium High land | 25 |
| Medium Low land | 38 |
| Low land | 24 |
| Very Low land | 7 |
| Permanent water bodies | 3 |

Table 11. Agro- productivity (Bio-diversity and Bio-productivity) status of the Sites

| Item | Period | Parameters | | |
|--------------------------|----------|------------|--------|-----|
| Bio-diversity status: | Previous | High | Medium | Low |
| Range of plant species | | | Medium | |
| Range of animal species | | High | | |
| Range of crops species | | | Medium | |
| | | | | |
| Bio-diversity status | Existing | High | Medium | Low |
| Range of plant species | | | | Low |
| Range of animal species | | High | | |
| Range of crops species | | | | Low |
| | | | | |
| Bio-productivity status: | Previous | High | Medium | Low |
| Range of plant species | | | Medium | |
| Range of animal species | | Medium | | |
| Range of crops species | | | Medium | |
| | | | | |
| Bio-productivity status: | Existing | High | Medium | Low |
| Range of plant species | | | | Low |
| Range of animal species | | | Medium | |
| Range of crops species | | | | Low |

AEZ 11. High Ganges Floodplain

Divisions: Rajshahi and Khulna: Districts: Greater Rajshahi, Pabna, Jessore, Kustia and Faridpur.

Table 12. Major structure group and total structures

| Item | Bridges Dimensions | Culverts Dimensions | Sluice gates and dams Dimensions |
|---------------------|--------------------|---------------------|----------------------------------|
| Length | 30-50m | 10-30 m | 5-10 m |
| % of the total | 26 | 59 | 15 |
| Functioning sites % | 38 | 17 | 5 |

Sources of the Fund: ADBIWB/IMF/IDB/DFID

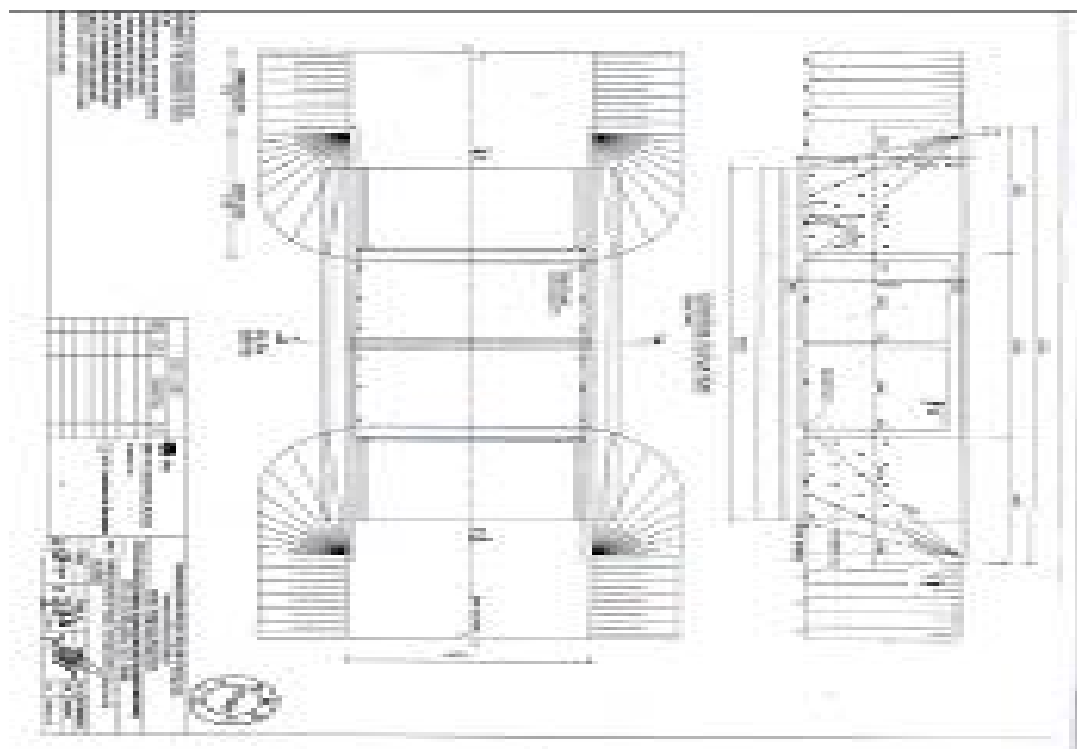


Fig. 3. Documents of different structures of a non-pier model bridge



Fig. 4. A developed non-pier model bridge

CONCLUSION

Bangladesh has been scientifically divided into 30(thirty) Agro-Ecological Zones as per its topography, climate, hydrology, natural resource status, food security and other related physical development potential factors. The Roads and Highways of transportation engineering consisting the type and characteristics of the roads and hydrological designs and structures are reported to have direct impact on the agro-biological aspects as per its effectiveness on the bio-diversity, bio-productivity and socio-economic livelihood of the target command areas. The bridges (small) and culverts were found insufficient to carry the transport types over them and thus lost their effectiveness before the set life of the structures. The bridges and culverts dimensions were found volumetrically inadequate to discharge or drain out the catchments water load in time causing water stagnation. The reasons of such less effectiveness of the system as spelled out by Focus Group Discussion (FGD) among others, were the non-sharing of the work with local beneficiaries specially for the size, site and strength of the structures. It is recommended that more detailed studies are required to reinforce Transportation Engineering and Environmental infrastructure development projects in the light of changed climate and food security need of the target areas considering the roads, transports, land topography, water recession trend and AEZ base catchments /command areas in an integrated way. Finally, recommendation is made for more detailed researches on the issues specially highlighting the agro-productivity of the structures and transportation engineering as to ensure its sustainability of the benefits.

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