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ENERGY AND ENVIRONMENTAL IMPACT FOR DEVELOPMENT OF MULTIPURPOSE PADMA BRIDGE

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ABSTRACT
The Padma Multipurpose Bridge Design Project comprises a new fixed crossing of the Padma River, of approximately 6.15 km long. In order to complement the construction of the Project, it is mandatory to plan and to develop road, railway, transmission and telecommunication networks to connect with the south western part of the country. The main purpose of this study is to harvest energy and assesses the cumulative environmental impact that has been caused by river training, construction and development works. The impacts are classified in few categories- land acquisition and resettlement, transport and economy. Energy harvesting though solar panel and speed breaker is proposed to install for sake of economic and environmental improvement. Here, the probable environmental impacts, both positive and negative are properly analyzed which represents a clear picture of the environmental impact scenario of any multipurpose bridge construction.

Keywords: Environmental, Energy harvesting, social and economic achievement.

1. INTRODUCTION

The Padma is the big river of Bangladesh and it separates the south-west region from the capital city Dhaka. The Padma Multipurpose Bridge Project (PMBP) will provide direct connectivity between the central and southwestern part of the country through a fixed link on the Padma River on Mawa-Janjira points. The distances of almost all the major destinations in the region from Dhaka will be reduced by 100 km or more and hauling time of vehicles will reduce by over 3 hours each trip resulting in huge fuel saving, reducing the air emission and passenger time-saving through the implementation of this Project ( ). A feasibility study conducted by the Japan International Cooperation Agency (JICA) anticipated that the volume of traffic on the Padma Bridge will reach 21,300 vehicles a day upon the bridge's opening and 41,600 vehicles a day by 2025 and this Bridge will save about 681,600 litter fuel in a day.

The Padma Multipurpose Bridge Project (PMBP) involves construction of about 6.15 km main bridge at Mawa- Janjira Corridor with River Training Works (RTWs) 6km at Mawa Site and 12km at Janjira Site, Approach Roads of lengths 0.273km at Mawa Site and 12 km at Janjira Site, Bridge End Facilities (BEF) at both sides, 5 resettlement sites, railway line with stations and docking facilities, high voltage power and high pressure gas transmission lines, optical fiber cable, and necessary relevant activities (Tapley, Sham, & Holmberg, 2010).

Construction of the proposed Padma multipurpose Bridge project is a very extensive project work which requires huge range of development activities. To complement the construction of Padma Multi-Purpose Bridge Project (PMBP), the Government of Bangladesh is planning to develop road, railway, transmission and telecommunication networks to connect with the south western part of the country. Some important anticipated development activities in the Project influence area, under the Government considerations are as Widening of Dhaka-Mawa Highway (N8), Bypass Road in Group B of Rajuk, Railway Network Development, Gas main Network Development, High Voltage Power Transmission Network Development (Bormudoi et al.), and Telecommunication Network Development. With the completion of the Padma Bridge and the stated proposed associated components, a rapid uncontrolled and unplanned urbanization is expected to take place around the Project area, especially along the highway and railway corridors. Apart from such urbanization, induced development activities will occur in the south-west regions of the country along these areas. Once completed, government officials estimate that the new bridge will increase Bangladesh's Gross Domestic Product (GDP) by 1.2 percent. These development activities impose a cumulative environmental and energy impact to the project influence area (S. N. Islam et al.; S. N. Islam, Singh, Shaheed, & Wei, 2010). It is expected that the Padma Bridge will have more comprehensive assessment of the impacts of the Bridge on sectors, household income-consumption, geotechnical ground and, hence, on the poverty situation at the regional level (De Silva, Wightman, & Kamruzzaman, 2010; Raihan & Khondker, 2010).
One the other hand, huge amount of energy will be needed in the Padma Bridge area. Part of the project is to consider how the construction of the crossings can be combined with devices that produce energy from the sun, wind and speed breakers. The idea is that, by using the bridge construction as part of the facility, the costs of the renewable energy power plants could be reduced

and therefore be more competitive. Blackfriars rail station is actually a bridge over the Thames River, and now it is also a renewable energy solar power station. On the roof of Blackfriars, 4,400 photovoltaic solar panels, covering over 6,000 m^2, generate 900,000 kWh of clean renewable energy to power the station. About 50% of the station's energy needs are met by these solar panels, reducing greenhouse gas emissions by over 500 metric tons of carbon dioxide, annually (Daresbury). Same as useful energy can be produced by using sun, wind etc. sources.

This paper describes the environmental and energy impact for the Padma Multipurpose Bridge. Land acquisition, transport, pollution and economy are described for environmental impact and different renewable energy sources are described for energy impact.

2. METHODOLOGY

The methodology followed is the identification of possible potential Valued ecosystem components (VECs) through an evaluation of the threat to each environmental component through a scoping exercise using an assessment of six impact attributes of each potential effect on each component (Klaassen, van Duivendijk, & Sarker, 2012). These attributes were degree of impact (nil, low, medium and high), impact direction (negative or positive), geographic extent, duration (short-term, long term), frequency, and significance. Each VEC is assessed for four scenarios: (i) existing conditions; (ii) future conditions without the Project; (iii) future conditions with the Project; and (iv) overall conditions during implementation of the Project, i.e. overall impacts of the Project. Figure 1 shows the flow chart of valued ecosystem components.

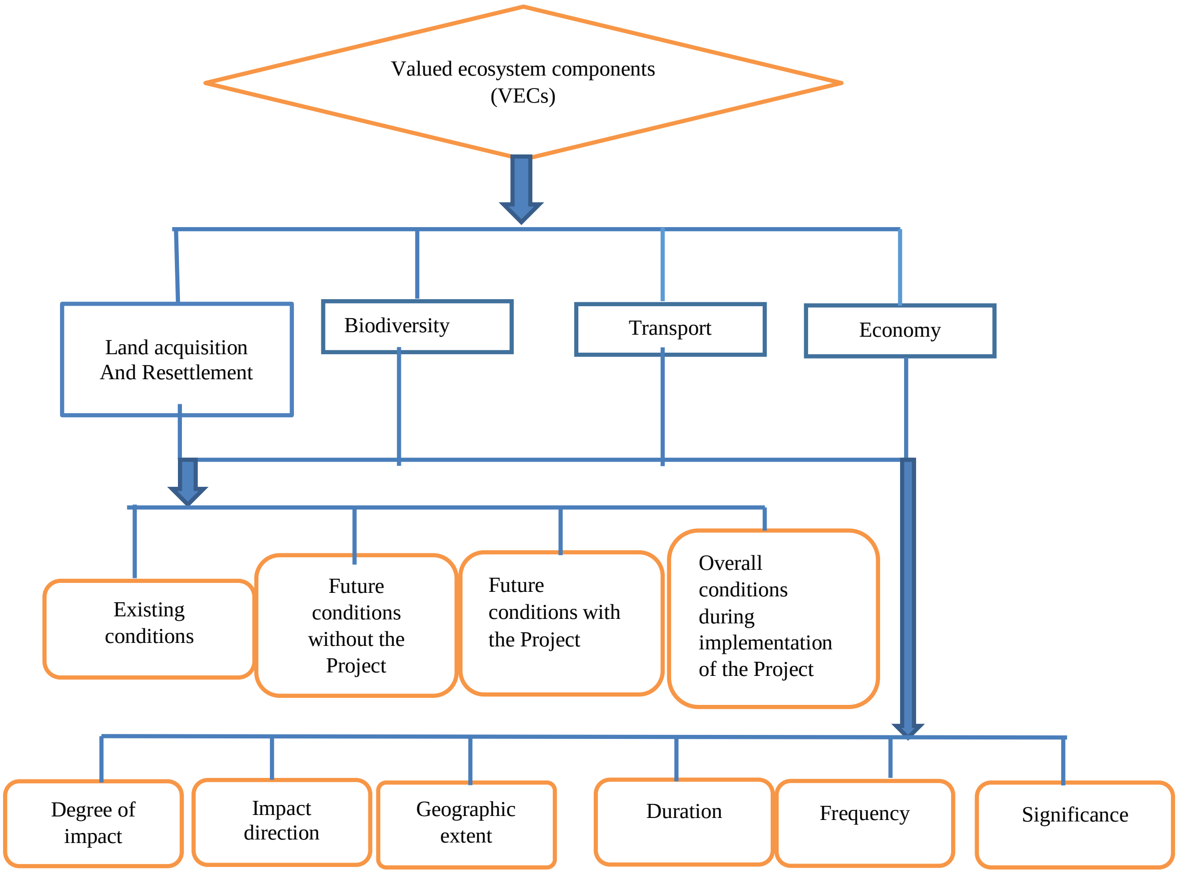

Figure 1 Flow chart of the valued ecosystem components (VECs)

3. OVERALL IMPACT ASSESSMENT

A network diagram showing the proposed development activities after completion of the PMBP (especially widening of Dhaka – Mawa Highway and railway network development) and induced impacts from these developments is given in Figure 1.

3.1 Land acquisition and resettlement

The pressure on the land under current housing practices is very high. Further the people in the Project area along the river bank on the Janjira side are vulnerable to involuntary resettlement due to continued river bank erosion (Carney & Britain, 2003). The Project area is located in the flood plain of the River Ganges/Padma. The Ganges channel is constantly shifting within its active floodplain, eroding and depositing large areas of new Char land in each flood season (Chowdhury, 2000). The right bank is (Janjira side) prone to more erosion than the left bank (Mawa side). It was found that the settlement areas have reduced in 2009 from 1999 due to erosion in right bank of the River over the years.

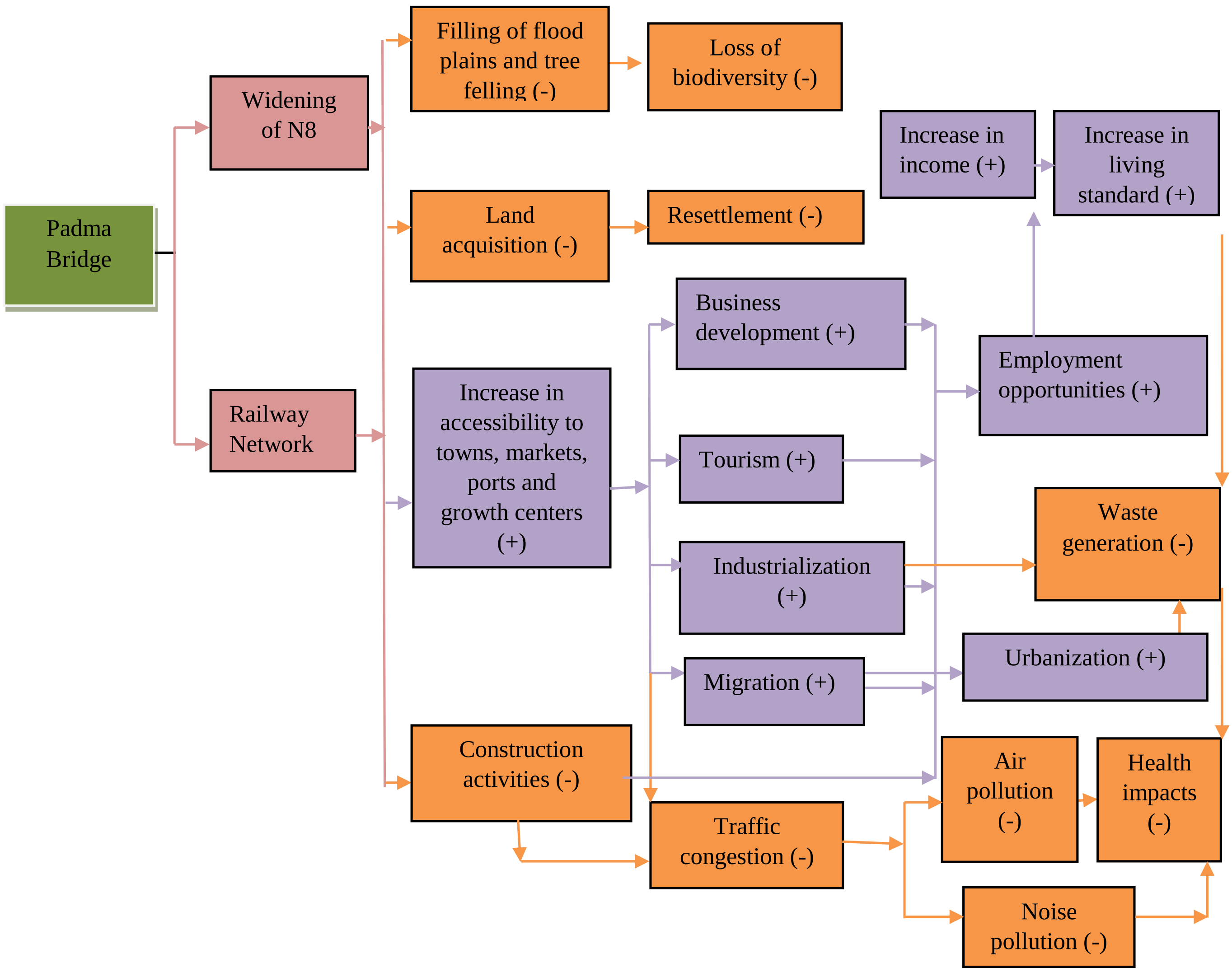

Figure 2 Impact assessments for induced development

Table 1 Assessment of Cumulative Impacts

VEC (Valued Environmental Component)	Impact	Degree of Impact	Duration	Mitigability
Land acquisition And Resettlement	Loss of land and Involuntary resettlement	High negative impact	Long term impact	Partly mitigable
Biodiversity	Loss of aquatic biodiversity	High positive impact	Long term impact	Enhancement
	Loss of terrestrial biodiversity/ vegetation	High negative impact	Medium term impact	Partly mitigable
Transport	Connectivity, traffic, and accidents	High positive impact	Long term impact	Enhancement
	Air and Noise Pollution	Medium negative Impact	Long term impact	Partly mitigable
Economy	Agriculture	High negative impact	Long term impact	Partly Mitigable
	Economic Development	High positive impact	Long term impact	Enhancement

It has also been noticed that about 500 m width of land erosion on Janjira side since the feasibility study in 2007. Only the sites designated for the construction yards in Janjira side will be requisitioned through leasing for about 6 years period. Figure 2 presents the total land required for the project. A total of 15,008 households with agricultural land, residence, business and other structures, physical and cultural resources and others will be affected by various project components. Table 2 presents the impacts of the project due land acquisition and requisition. Total affected persons by the project are 82,765 persons. This includes (i) households/persons to be physically displaced (i.e., affected by loss of residential/commercial structures);

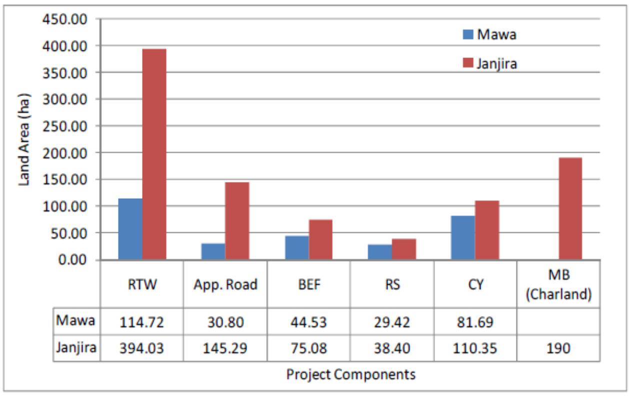

Figure 3 Land Acquisition for Various Project Components (Environmental, D., & Assessment, I. (n. d.), 2010)

(ii) those affected by loss of agricultural land only (i.e., economically affected); and (iii) indirectly affected persons (wage earners and others). According to the survey, number of households with agricultural land affected are 9,729, structures affected (includes, houses, business and other structures) 5,279, and physical and cultural resources affected are 103 (S. Islam, 2000).

3.2 Transport

Padma River forms a physical barrier in the road connection between Dhaka and the Southwest and South Central regions of Bangladesh, home of about one quarter of the Bangladesh population. Noise and air quality is another problem at the ferry Ghats with the air quality levels exceeding the national standards (Sarker & Thorne, 2009). The number of ferries, launches, speedboats and mechanized boats are about 11, 50, 220 and 1,100, respectively. About 20,000 people are directly or indirectly dependent on the different economic activities in and around the ferry Ghats. Bangladesh Inland Water Transport Corporation (IWTC) dredges navigation channel after every monsoon to keep the ferry channel operational. Ferry services are sometimes interrupted for days during fog and high floods. A number of these ferry boats are obsolete and often overloaded and frequent accidents happen with some of them resulting in a considerable loss of life. Stowage of cargo on the deck is another factor, creating top-heavy imbalance and contributing to capsizing, especially in rough weather. Some of the recent ferry accidents in Bangladesh are:

- June 2010: 12 people, including 10 children, drowned when a packed river ferry capsized in Northeastern Bangladesh
- May 2010: At least 16 people died in May 2010 in a boat accident after an overloaded ferry sank in Kishorganj district.
- November 2009: At least 85 people drowned when the overloaded triple-decker ferry capsized off Bhola Island in the country's south. A week later another boat sunk in the northeast, leaving 46 people dead.

The future condition without the project will strongly reduce the potential for socio-economic development in the entire Southwest region, where about one quarter of the Bangladesh population lives (Schmuck-Widmann, 2001). A stagnating regional economy will affect incomes and increase the number of people living below the poverty line, especially in the major urban centers such as Khulna and Barisal. Opportunities for more export through Mongla seaport and Benapole land port will be reduced because of high transport costs. Current risky and unreliable ferry services will remain in service, often resulting in long waiting times for trucks (10 hours and more) and cars (2 hours). Noise, oil pollution and hindrance of commercial navigation caused by the fleet of ferries, launches and speedboats crossing the river on daily basis will continue. After Padma Bridge this all water transport will be stopped. As a result, fuel consumption will be reduced and unexpected accident will be stopped. In addition, the distance from Dhaka to nearly all major destinations in the southwest region will be reduced by 100 kilometers (km) or more. Japan International Cooperation Agency (JICA) anticipated that about 681,600 litter's fuel will be saved in a day.

3.2.2 Future Condition with the Project

The ferry will be closed once the Project is in operation. The bridge will provide safe crossing of the river and connect southwestern part of the country to the rest of the country. Road network and railway network in the southwestern part of the country will be improved. Speedboat operators can continue to operate carrying tourists coming from Dhaka and other nearby locations.

3.2.3 Air and Noise Pollution

The cumulative impact on the air and noise pollution will be significant especially along the road and railway corridors due to increase of traffic flow. Noise levels will be increased and air quality will be deteriorated all along the road and railway networks. However, the ambient air and noise quality levels in the Padma will improve due to stoppage of ferry services.

Table 2 Project Affected People by Census (Environmental, D., & Assessment, I. (n. d.), 2010)

Types of losses	Affected households (AHs)				Affected persons (APs)			
	RS	Approach Road and BEF	RTW	Total	RS	Approach Road and BEF	RTW	Total
Agricultural land	436	6,072	2,018	8,526	2,385	33,214	11,038	46,637
Structures (includes housing business and other structures)	31	1,542	3,402	4,975	196	7,874	18,622	26,692
Total	565	7,614	5,420	13,501	2,679	41,088	31,437	73,329
Physical cultural resources	1	27	63	91				
Indirect impact (wage earners and others)					98	1007	1,777	2,882

Table 3 Indicative quantities of materials for major project components (Environmental, D., & Assessment, I.

Component	**Material**	**Unit**	**uantity**
Bridge			
	Concrete	m^3	163,000
	Reinforcement	ton	13,600
	Fabricated steel truss	ton	84,000
Approach Viaducts			
	Concrete	m^3	104,000
	Reinforcement	ton	16,000
River Training Works			
	Concrete Block	m^3	2,600,000
	Rock	ton	6,050,,000
Approach Road			
	Bitumen	ton	9,431
	Concrete	m^3	114,741
	Aggregates	m^3	296,880

4. CUMULATIVE ECONOMIC DEVELOPMENT

The operation of the Padma Bridge will result in significant economic changes to the southwest region. There will be changes in the relative prices of production of goods and services, relocation of economic activities, and generation of new activities other than related to transport sector. It is foreseen that industrial growth would be elevated due to the Bridge but these will be long term development impacts. In the short run, there may be a small amount of extra freight travel as it becomes easier for existing firms to access networks of customers and suppliers. However, in the longer run, reductions in the generalized costs of transport will:

- Increase the profitability of local firms which may lead to higher retained profits, encouraging investment in capacity expansion and increased output – resulting in increased economic activity in the region;
- Result in local firms having reduced costs and lead to a lowering of prices and an increase in output;

- Encourage financial institutions to expand lending to firms in the southwest region, as the costs of doing business for the institutions are lowered from the improved communications (through reduced time and effort).
- Induce the establishment of new firms in the region through (a) the improved competitiveness of the region as a business location, with cheaper transport; (b) the need to service the increased movement of passenger buses to/from Dhaka and of trucks carrying goods to/from India; and
- Firms may also relocate to the region to reduce the transport costs, time and to avoid the negative agglomeration effects (congestion, pollution) of locating in Dhaka.

Figure 4 shows the flow of indirect economic effects. Firms respond to the costs reduction in variety of ways, such as increasing production, shifting to higher value added production and expanding marketing areas. The lower transport costs and increased accessibility to a wider range of markets and services also affect household income and expenditure.

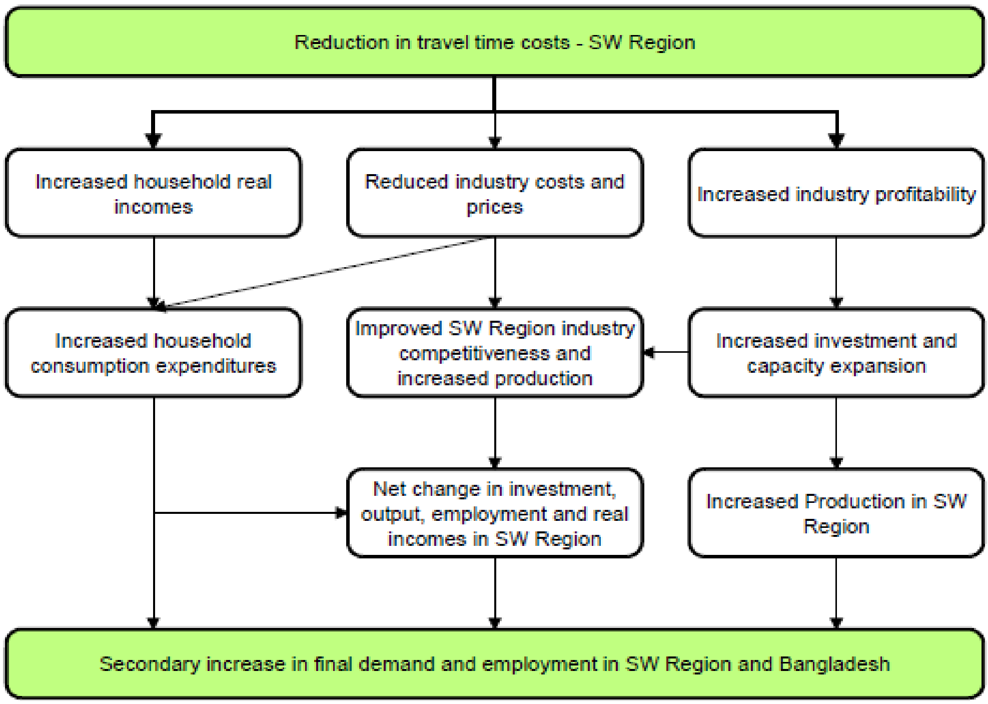

Figure 4 Indirect economic effects (Detailed Economic & F, A, R, 2010)

5 RENEWABLE ENERGY SOURCES

Bangladesh is one of the world's lowest energy producers. In 2014, from 10,289 MW installed electrical generation capacity (public, private and import), a maximum output delivered was 6,675 MW. Within the reach of the national grid Bangladesh is still reeling under 600 - 1200 MW of 'load-shedding'. Domestic and industrial sectors consume about 43% and 44% electrical energy respectively, i.e. a total of about 87% of power consumption occurs in these two sectors. Out of this, a large part of electrical energy is consumed for lighting. So, renewable energy can be used in the source of electricity. Solar energy, wind energy and others can be used as a renewable energy.

5.1 Solar energy

Bangladesh is suitable for solar energy (Rofiqul Islam, Rabiul Islam, & Rafiqul Alam Beg, 2008). In the whole year it is possible to use this solar energy in different purpose. Solar energy can be used for fulfilling the demand of electricity in the Padma Bridge. Particularly, solar floodlight, solar cell can be used. Usually 10 W light weight solar cell is used on the head of the floodlight stand. LED bulb is very efficient for solar cell. There are few hundreds of 135 W solar cell can be used in the both side of the bridge. It is called side mounted solar panels. The weight of this type of solar cell is about 2.5 kg. If 200 side mounted solar panel are used, around 25 KW electricity will be produced in a day in the summer time and about 20 KW in the winter time**.** This solar panel will be used during the next 5 – 10 years. As a result, electricity cost will be reduced. Table 4 shows the comparison between solar power generation and traditional power system. Its initializations cost is higher than traditional lighting system but after ten years its cost will be reduced than traditional. Because it has no maintenance cost and electricity consumption cost etc.

Figure 5 Padma Bridge in night time

Figure 6 Solar Floodlight

Figure 7 Solar cell

Figure 8 Solar floodlights with solar cell

Figure 9 Side mounted solar cell

Table 4 The comparison between solar street light and normal street light (in 10years)(Wu, Huang, Huang, Tang, & Cheng, 2009)

Normal street lamp				**solar street lamp**			
Item	Quantity (pcs)	Unit Price (USD)	Total Cost (USD)	Item	Quantity (pcs)	Unit Price (USD)	Total Cost (USD)
Lamp	100	600	60,000	Lamp	100	2315	231,500
Basement expense	100	120	12,000	Basement expense	100	120	12,000
Pipe line	2500 M	12	30,000				
transformer equipment	1	16500	16500				
Cable	2500M	17	42,500				
Other materials and installation cost	52250×5%		2,600				
Control cabinet	2	820	1,640				
Total Initial investment			165,240	Total Initial investment			243,500
Electricity Consumption	300W×12H×365days ×10years×100pcs/1000W.H×0.12USD		156,900	Electricity Consumption	0		0
5 new lamps in 10 years	USD37.5×5pcs×100pcs		18,750	Lighting Resources	LED’s life time ≥10years		0
Maintenance Fee	USD18×10years×100pcs		18,000				
Total Cost in 10 years			358,890	Total Cost in 10years			243,500

5.2 Wind energy

Bangladesh is fairly potential for small scale wind energy (Khadem & Hussain, 2006). Average wind speed in Bangladesh remains between 3 to 4.5 m/s for the months of March to September and 1.7 to 2.3 for remaining period of the year (Kumar Nandi & Ranjan Ghosh, 2010). But during the summer and monsoon seasons there can be very low pressure and storm wind speeds 200 to 300 kmph can be expected. As a result, small multi turbine can be suitable for power generation. There are several hundreds of small wind turbine can be used for producing electricity. This small wind turbine can be installed between the gap of the Rail Street and vehicle street. Wind power output is fully depended on air speed. Installation costs vary greatly depending on local zoning, permitting, and utility interconnection costs. Depending on these considerations, as well as the turbine size, small wind energy systems have an average cost of approximately $6,960 per kilowatt installed. Although wind energy systems involve a significant initial investment, they can be competitive with conventional energy sources when it is accounted for a lifetime of reduced or avoided utility costs (Wiser, Bolinger, & Barbose, 2012).

5.3 Other energy source

As day by day power consumption increases but electric crisis occur. So the minor needs of electricity such as street lights and traffic signals can be generated from speed breakers (Das, Hossain, & Hossan, 2013). Instead of wasting kinetic energy of vehicles at speed breakers the minimum needs can be met between converting kinetic energy to electrical energy. A feasibility study conducted by the Japan International Cooperation Agency (JICA) anticipated that the volume of traffic on the Padma Bridge will reach 21,300 vehicles a day upon the bridge's opening and 41,600 vehicles a day by 2025. There are several of speed breaker can be installed in the entrance and exit side of the bridge. “Up and down motion convert into rotary motion” in this phenomena is used in spread breaker. For one pushing force 4.087 W can be produced (Aswathaman & Priyadharshini). It is a low budget electricity production system. Its initializations cost is comparatively very low than others system and maintenance cost also low (Joardder, Kabir, Barua, & Hoque, 2011). No fuel consumption problem (Rao, Kumar, & Suresh, 2014). Less floor area required and no obstruction to traffic.

Figure 10 Wind turbine installed place in the bridge

Figure 11 Speed breaker

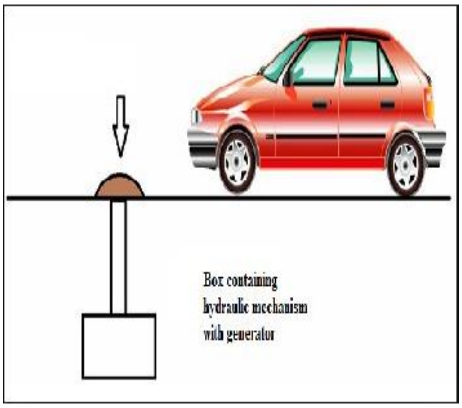

Figure 12 Speed breaker

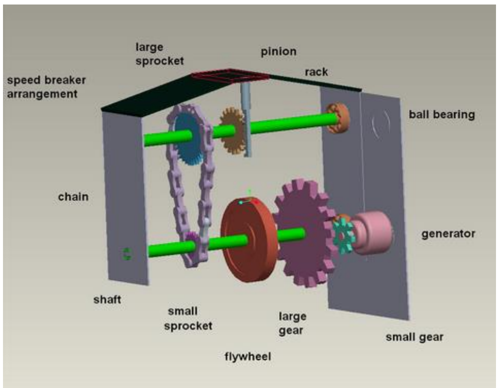

Figure 13 Speed breaker mechanis

6. CONCLUSION

In case of every wide range construction project, there are always some environmental impacts on the surrounding of the site. In this study the environmental and energy impact of Padma multipurpose bridge has discussed from where it is clearly seen that it plays an important role to develop and sometimes upgrade the environment. By implementing these useful plan and design it is possible to construct environment friendly infrastructures, protect biodiversity and vegetation and also to the proper control of economy, agriculture, transport and land management. Floods, riverbank erosion, settlement displacement and char livelihoods problems will be minimized, and make the island stable in the right bank of the Padma River. Besides the environment improvement it will save huge amount of energy such as fuel consumption by vehicle due to distance minimization. The bridge could be the source of energy where solar and wind are the major element, which are described briefly in this work. This would help the countries power generation lacking. Obviously the development of this Padma Bridge would save energy and impacts on environmental improvement.

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