Prospect of Renewable Energy as the Solution of the Existing Energy Crisis of Bangladesh

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Abstract— Energy has always been a major necessity for the day-to-day human life. For the socio-economic development, continuous supply of sufficient energy is very important. As a developing country, Bangladesh is finding it difficult in recent times to produce and transmit enough energy to fulfill the ever-growing demand. The natural resources are limited and are being exhausted at such an alarming rate, it is feared that natural gas, which is the main energy source of Bangladesh will be depleted by the year 2020. So it is now the best time to find alternative energy sources if the inevitable energy crisis is to be avoided. Renewable energy can be the solution to this problem as the climate and infrastructure of the country is very much favorable for harnessing renewable energy. In this paper we have tried to analyze the prospect of using renewable energy as a solution for the current energy crisis in Bangladesh. We have talked about different forms of renewable energy, their prospect in Bangladesh and how far it can contribute to solve the problem.

Index Terms— energy crisis, renewable energy, bio-gas, solar energy, wind energy, tidal power, geo-thermal power, hydro power

1 INTRODUCTION

Now is the era of science and technology. Human civilization is moving forward. So is Bangladesh. But the biggest obstacle on its way perhaps is the lack of sufficient and reliable energy sources. The main source of energy in Bangladesh is Natural gas (24%) which is likely to be depleted by the year 2020 [1]. Another effective energy source is hydro power, but one cannot set up a hydro power plant anywhere he likes, simply because it needs certain environmental conditions which cannot be set up artificially. The last source would be oil which has to be imported and costs a lot of foreign currency. Ministry of Power, Energy and Mineral Resources is responsible for power generation in Bangladesh and recently it is struggling to satisfy the rapidly increasing demand. Other related organizations are Bangladesh Power Development Board (BPDB), Rural Power Company Limited (RPCL), Ashuganj Power Station CO. Ltd (APSCL), Electricity Generation Company of Bangladesh (EGCB) and some other rented private power plants. The country's per capita annual energy consumption in 1997 was about 77 kgoe, and it was much below the world average of 1474 kgoe (ADB, 2001)[2]. But recently the demand has increased very rapidly, so much so that now only 47% of the total population has access to electricity and in the near future the situation is likely to become much worse [3]. Renewable energy can be a very good solution to the current energy crisis and has the potential to solve the problem effectively. Different forms of renewable energy can be harnessed to produce power. It can reduce the pressure on the current sources and can be a step forward towards a new era where renewable energy itself will be enough for satisfying the total energy demand.

2 Current Conditions:

Bangladesh is facing difficulties in recent times to fulfill its demand of energy. Among them the most severe is the scarcity of electricity. The total capacity of power generation now is 6727 MW (up to June 15, 2011) [4], of which 3534 MW is from the public sector & 3193 from the private sector, which is 53% and 47% of the total power generation capacity respectively [5]. Although the capacity is increasing day by day, it's not enough to fulfill the increasing demand. As a result load shedding has become a very common phenomenon. In the rural areas the demand is about 2,400 MW per day but the Rural Electrification Board (REB) can barely supply half of it. In Dhaka City alone, the demand is about 1400 MW but the supply is only about 600 to 650 MW (2010) [6]. Lack of power supply is causing a lot of problems all over the country. Especially in the city areas, supply of pure water is affected, in both quantity and quality. Without proper supply of safe drinking water, the people are suffering in their homes and businesses. Water- borne diseases are spreading as a result. In the rural areas insufficient supply of water creates problems in irrigation. Sometimes power is diverted to the city areas causing more frequent load shedding in the rural areas and so the agricultural activity is hampered greatly. As a developing country Bangladesh is looking to make progress in the economic field, especially the garments sector is really progressing, exporting quality products all over the world. For these to operate successfully, continuous electricity supply is a must. Unfortunately the prevailing power shortage is obstructing further growth of this important sector of the Bangladeshi economy, but the obstruction is not exclusive to this sector only as the whole economy of the country is suffering due to similar problems. As new power plants are being setup throughout the country, at same time the existing plants are also losing their production capacity as they have been running for a long time. Here in Table-1 [7] the age of some power plants are shown and in Table-2[8] present power generation capacity is shown.

Table-1
Age of power plant

Age group (years)	No of power plants	MW
40+	7	140
31-40	6	318
21-30	26	1399
11-20	10	1113
1-10	50	2480

Table -2

PRESENT GENERATION CAPACITY.

S/N	**Public Sector**	**Generation Capacity (MW)**
1	BPDB	2620
2	APSCL	659
3	EGCB	255
	Subtotal	3534 (53%)
S/N	**Private Sector**	**Generation Capacity (MW)**
1	IPPs	1271
2	SIPPs (BPDB)	99
3	SIPPs (REB)	226
4	15 YR. Rental	168
5	3/5 YR. Rental Quick Rental	441 988
	Subtotal	3193 (47%)
	Total	**6727**

3 Bio-gas:

Bio-gas is mainly the composition of methane (60%-70%) and carbon-dioxide (30%-40%) [9]. It is a combustible gas produced by anaerobic fermentation of organic materials by the action of methanogenic bacteria. The anaerobic digestion process consists of three steps. They are-

1. The fermentation bacteria ferment and hydrolyze the complex organic materials, carbohydrates, protein and lipid into fatty acid, alcohol, carbon-dioxide, hydrogen, ammonia and sulfides.
2. The acetogenic bacteria consume the primary products and produce hydrogen, carbon-dioxide and acetic acid.
3. Then two types of methanogenic bacteria work. First reduces carbon-dioxide to methane and the second decarboxylates acetic acid to methane and carbon-dioxide. [10].

From a bio-gas plant we can get methane. Methane is odorless and does not produce smoke when burnt. So it is suitable to be used for cooking. Methane can also be used for power generation. Small family power plant can be set up using methane. Bangladesh has a very bright prospect of producing and utilizing bio-gas. The climate, infrastructure, etc. favour the production process of bio-gas and its subsequent utilization. The ideal temperature needed for bio-gas production is about 35°C. In Bangladesh the temperature varies in between 6°C to 40°C throughout the year, thus the inside temperature of the bio-gas digester typically remains between 22°C-30°C which is quite close to the optimum temperature[10]. Commonly, most of the families in the rural areas have a cow or two, sometimes even more. So usually there is an abundant source of cow dung available. In Bangladesh there are over 22×10^6 cattle head, and assuming 80% collection of cow dung, the total gas obtainable maybe approximated as $2377 \times 10^6\ m^3$ (0.037 per kg fresh dung) per year [9].

In the urban areas there is not enough space to keep cattle or cows, so instead of cow dung, the municipal waste can be utilized for bio-gas production. Table-3 [11] shows the increasing rate of municipal waste in the urban areas.

Table-3
Growth rate of minicipal waste in the urban areas.

Year	Urban Population	Total Urban Waste Generation (kg/Day)	Per Capita Waste Generation Rate in Urban Areas Kg/cap/day
1991	20.8 million	6,493000	0.31*
2005	32.76million	13,332000	0.41**
2025	78.44million	47,000000	0.60***

Source: * World Bank ,1998 ** Waste concern,2005, ***UMP,1999 [4]

About 7690 tons of municipal waste in total is produced in the six major cities of Bangladesh daily. The composition of the waste seam is about 74.4% organic matter, 9.1% paper, 3.5% plastic, 1.9% textile and wood, 0.8% other waste. This huge amount of waste can be utilized to produce bio-gas [10]. Fig 1 shows the composition of typical municipal waste in Bangladesh.

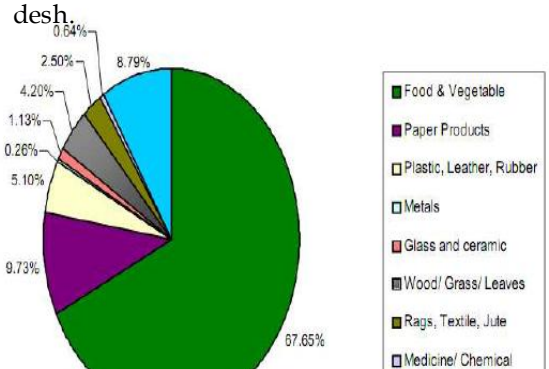

Fig-1: Average physical composition of urban solid waste. [12]

So we can see that bio-gas production is quite a promising option for Bangladesh in terms of being a reliable source of energy. Total potential of biogas from cow-dung, human excreta and urban wastes is about 3675 x 10^6 m^3 which is equivalent to 1.95 million ton of oil (1 m^3 biogas = 22.31 x 10^6 Joules). [10]
Table-4 [9] shows the of bio-gas potential in Bangladesh.

Table-4 Bio-gas potential in Bangladesh

Raw Material	Yearly Gas Production (million cubic meter
Cow/Buffalo dung	2971.10
Poultry droppings	191.60
Human Excreta	1226.40
Garbage	115.0
Water hyacinth	740.00
Pressed mud	384.00

4 Solar Energy

Solar Energy can be a source of cheap and clean power. It is pollution free and inexhaustible. The most suitable area for harnessing solar energy is between the two broad bands encircling the earth between 15" and 35" latitude north and south. Bangladesh is situated between 20"43' north and 26"38' north latitude [13]. So geographically, Bangladesh lies in a very advantageous location, suitable for the harnessing and utilization of solar energy. Typically the radiation in Bangladesh varies between the range 1840 to 1575 kwh/m^2, which is 50%-100% higher than Europe.
If we assume that the average energy radiation per area is 1900 kwh per square meter, the total annual radiation in Bangladesh is found to be 1010 X 10^{18} J. If 0.07% of this energy can be utilized the total energy demand of the whole country can be met. At present energy utilization in Bangladesh is about 0.15 watt/sq. meter land area, whereas the availability is above 208 watt/sq. meter [13]. So we can easily comprehend that solar energy, by itself, has the potential of becoming the remedy for the ever-escalating power problem in Bangladesh. Fig-2 shows the amount of hours of sunlight available each day throughout a year and Fig-3[14] shows the highest and the lowest intensity of direct radiation in W/m².

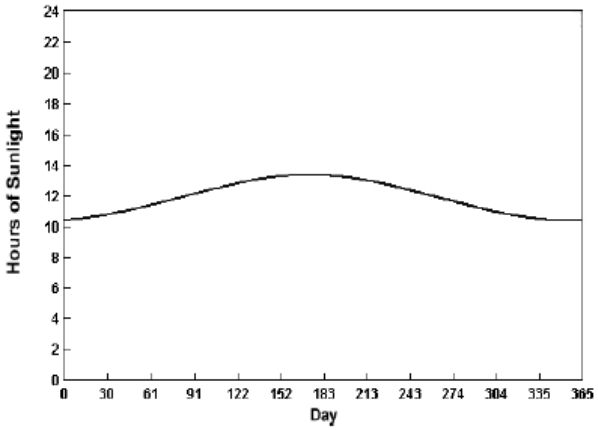

Fig-2: Amounts of hours in sunlight [14]

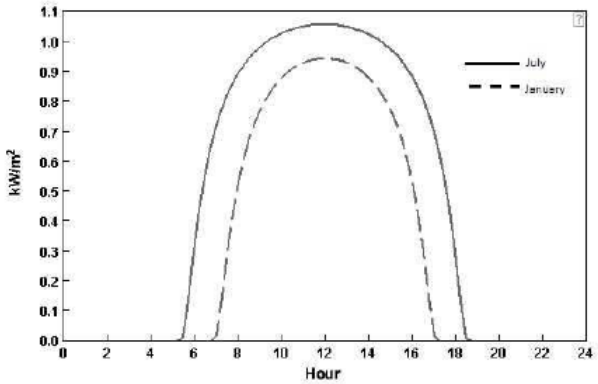

Fig-3:The highest and the lowest intensity of radiation W/m^2.[14]
The average solar radiation daily varies between 4 to 6.5 kWh per square meter. Maximum amount of radiation is available in the month of March-April and minimum on December-January. Realizing the prospect of solar energy in Bangladesh, different NGOs, governmental and semi-governmental agencies, universities and business institutions are coming forward to develop effective systems to utilize the solar energy as much as possible. Among the major contributors to this thrust are Grameen Shakti, BRAC, Rahimafrooz Solar, Bangladesh Power Development Board (BPDB), Rural Electrification Board (REB), Local Government Engineering Department (LGED), Thengamara Mohila Shabuj Shangha (TMSS), Bangladesh Centre for Advanced Studies (BCAS), COAST Trust, Centre for Mass Education in Science (CMES), Srijony Bangladesh, BAPA (Bangladesh Poribesh Andolan), Bangladesh Institute of Fuel Research and Development of BCSIR, Renewable Energy Research Centre of the Department of Applied Physics and many more. IDCOL (Infrastructure development company limited) promotes dissemination of solar home system (SHS) in the remote rural areas of Bangladesh through its

Solar Energy Program with the financial support from the World Bank, Global Environment Facility (GEF), KfW, Asian Development Bank and Islamic Development Bank. They started the program in January 2003 and their initial target was to finance 50,000 SHSs by the end of June 2008. The target was achieved in September 2005, 3 years ahead of schedule and US $ 2.0 million below estimated project cost. IDCOL then revised its target and decided to finance 200,000 SHSs by the end of 2009. This was also achieved by May 2009. Now IDCOL's target is to finance 1 million SHSs by the end of year 2012. Up to August 2010, a total of 645,033 SHSs have already been installed under the program [15]. It just goes to show how successful solar energy is in Bangladesh and how far it can go.

4.1 Solar Cookers: Institute of fuel Research and Development (IFRD) of BCSIR and Centre for mass Education in Science (CMES) are working for developing solar cookers. They have successfully made one cooker which is low in cost and very light (probably about 2-3 KGs) in weight. But it has one limitation, as it has to track down the sun manually. On a bright sunny day it will take only three hours to cook for a family of 5-6 members [3].

4.2 Solar Oven and Dryer: The institute of Food Science and Technology (IFST) is working on developing Solar Dryer. Recently they have developed a cabinet dryer for drying fruits, vegetables etc.

4.3 Solar Water Heater: This heater is designed and constructed by IFRD. It has a coated flat plate which absorbs solar radiation, converts into heat and transfers the resulting heat to circulating water. This type of heater is useful for supplying low grade thermal energy at temperatures below 90°C [13].

5 Wind Energy:

Wind energy is the kinetic energy of the moving air mass. The power is directly proportional to the velocity of the wind. That means more the wind velocity more the power generation. Bangladesh has a coastal line of 724 km along the Bay of Bengal. The south/south westerly monsoon enters into Asia over the coastal area of Bangladesh. It blows over Bangladesh from March to September with a average speed 3 m/s to 6 m/s [16]. The speed of the wind is increased when it enters the V-shaped coastal region of the country. Primary Study shows that (done by meteorological department, BCAS, LGED, and BUET) winds are available in Bangladesh mainly during the monsoon and around one to two months before and after the monsoon (7 months, March to September)[16], and from October to February wind speed remains either calm or too low. The peak wind speed occurs during the months of June and July [16]. The maximum amount of power is produced by the Kaptai Hydro-electric power station which is very close to the coastal area. So from March to September wind power plant can be used to support the Kaptai power plant as the load is critically high during this period. There are many islands along the Bay of Bengal where the wind speed is quite high. Kuakata, Sandwip and St. Martin are among those which have huge potential as ideal location for wind turbines. The people living in this area are mostly fisherman. There is very little chance that they can get electricity from the national power grid as it is very hard to carry the line through to this area. Wind energy can be the solution to this problem. The wind speed in these areas is good enough for power generation and hence fulfillment of the demand of this particular area. Recently the wind rotor aerodynamics has developed so much that it is now possible to extract energy from wind speeds as low as 2.5 m/s. Bangladesh has a lot of hilly and remote areas where the wind speed usually remains within 2 to 5 m/s. Wind energy is thus another great alternative for energy generation in Bangladesh. In table-5[17], average wind speed at different locations in coastal region of Bangladesh is shown and in table-6 [17]the theoretical energy that can be generated from them is shown.

Table-5
Wind speed in different locations

Locations	Month						
	Mar	Apr	May	Jun	Jul	Aug	Sep
Teknaf	2.85	2.56	2.39	4.71	2.83	4.14	3.11
Kutubdia	3.78	12.02	2.37	4.71	5.73	4.78	2.92
Sandwip	6.23	8.34	2.28	3.93	5.44	4.44	5.18
Kuakata	3.07	5.26	3.10	3.69	4.28	3.37	2.03
Mongla	3.07	2.41	2.94	4.23	4.34	4.44	2.92

Table-6
Theoretical energy available

Locations	Months	Avg. wind speed (m/s)	Theoretical Available power (W/m^2)
Teknaf	March to Sep.	3.23	20.17
Kutubdia		5.19	83.74
Sandwip		5.12	80.53
Kuakata		3.54	26.68
Mongla		3.48	25.26

6 Tidal Power:

Tidal Power is a smart alternative to meet the current energy demands although it is not a new concept as it has been used in Britain and France since the 11th century for milling grains. Tidal energy is generated due to the variation of the sea level. Bangladesh is a flood plain delta having a 710 km coastline with the Bay of Bengal. According to the coastal zone policy (CZPo, 2005), Bangladesh has its 19 districts in the coastal zone in which 12 are in direct contact with the sea [18]. Tidal

power projects can be established along these coastal areas such that they can serve the energy demands when running simultaneously and may as well be used as protective measure of the coastal regions from cyclones. Bangladesh has experienced several disastrous cyclones (e.g. Sidr, Aila, etc.) at the coastal regions during the last few years. Infrastructures (embankments, barrages, sluice gates) for fighting these calamities have been made and are being improvised at present. These infrastructures can also be used to utilize the tidal head of about 2-8m at the Bay of Bengal to produce electricity. So the capital-cost for Tidal power projects are quite reasonable as almost all the engineering work needed for its setup have already been done. Here three elements are needed – an undershot paddlewheel to propel the water, a generator coupled or geared with the wheel to generate electricity and some electric controllers to control the power output with variable water flow. Tidal power is renewable as well as predictable. It can be shut down quickly when needed and restored without significant losses. Projects for harnessing tidal power can lead the coastal regions to sustainable development as various employment opportunities will be generated and moreover tourism opportunities may be created. So, tidal power can be a great source of renewable energy for Bangladesh.

7 Geothermal Power:

The thermal energy stored in the earth's crust is known as geothermal energy. The Temperature of the earth's crust increases with varying depth depending on the location. Actually geothermal energy is the decay of radioactive matters in the earth's mantle and crust. Geothermal energy recovered as steam or hot water can be used for space heating, industrial heating and electricity production. Geothermal energy provides electricity in about 24 countries and day by day it is becoming a popular source of electricity in more countries [19].
Bangladesh has the lowest per capita energy consumption (240 kg oil equivalents) in the world and is dependent on additional environment friendly renewable energy resources [20]. Geothermal energy harnessing can be a possible means to meet the energy challenge of the coming years. The northern part of the country has good potential for geothermal exploration. Also there is a hot salt water spring known as Labanakhya at Sitakunda (40 kilometer from chittagong) which has the possibility to be an excellent location for the extraction of geothermal energy, and so further investigation is required to fully evaluate its potential. Recently, the Ministry of Power, Energy and Mineral Resources has approved the establishment of the first ever geothermal power plant (200MW) in the country. A Dhaka based private company named Anglo MGH Energy has initiated this project at Saland of Thakurgaon district [21]. The Rangpur saddle, Bogra shelf potentially offers good conditions for geothermal power projects. Although the cost of setting up a geothermal power plant is high due to the high cost of drilling wells, it can be reduced by using the abandoned on-shore dry wells which have sufficient high temperature gradient (like over 30K/km). Geothermal energy can provide a suitable energy solution for Bangladesh as it is green, indigenous, abundant, continuously available and independent of climate changes.

8 Hydro Power:

Bangladesh is a plain delta with having three of the world's major rivers the Ganges, the Brahmaputra and the Meghna flowing through it. The Jamuna-Padma-Meghna river system divides it into east and west and creates an average water flow of 1.3 trillion m^3 in a year throughout the country. Many other rivers flow throughout the country which are actually the tributaries of these rivers. Out of all the rivers about 57 rivers are transboundary originating from India and Myanmar [22].
During monsoon the flow rate of most of the rivers is high but it reduces substantially during winter. Hence the scope of hydropower generation is very limited in Bangladesh except in some hilly regions in the northeast and southeast parts of the country. However there are a lot of tributaries, canals, tiny waterfalls which have good potential for setting up hydro power plants. Hydro power plants convert the Hydro power of the fluid into mechanical power which is further converted to electrical energy. Many types of hydro power plants can be setup according to the generation capacity.

Pico-Hydro	up to 5 kW
Micro-Hydro	>5<300kW
Mini-Hydro	>300kW<3 MW
Small-Hydro	>3MW<10MW

The Karnafuly Hydro Power Station is the only hydropower plant in the country (located at kaptai, about 50 km from the port city of Chittagong), having a capacity of 230 MW by 5 units. It is operated by BPDB (Bangladesh Power Development Board). BPDB is considering the increase of production up to 330MW. Two sites have been chosen for another two Hydro power plants at the Sangu and Matamuhuri rivers, one named The Sangu project (140MW) and the other The Matamuhuri Project (75MW). BPDB has designed a 20kW microhydro power plant with the help of RETScreen, developed by CANMET Energy Diversification Research Laboratory of Canada (CEDRL) at Barkal (a sub-district in the Chittagong Hill tracts) waterfall [22].
The Water Development Board (BWDB) and Power Development Board (BPDB) carried out a joint study on Micro-Hydro power potential in the country. In Table-7[21] it's given in detail.

Table-7
Potential small hydro sites identified from the study:

District	River/Chara/Stream	Potential of Electrical energy in kW
Chittagong	1.Foy's Lake	4

Chittagong	2.Choto Kumira	15
Chittagong	3.Hinguli Chara	12
Chittagong Hill Tracts	4.Sealock	81
Chittagong	5.LungiChara	10
Chittagong	6.Budiachara	10
Sylhet	7.Nikhari Chara	26
Sylhet	8. MadhabCha-ra1500ft. from fall	78
Sylhet	9.Ranga pani gung	616
Jamalpur	10. Bhugai-Kongsa at 2 miles U/S. of Nalita-bari P.S.	69kw for 10 months 48 kw for 2 months
Jamalpur	11. Marisi at Duka-bad near Jhinaigati Thana Head Quarter	35Kw for 10 months 20 kw for 2 months
Dinajpur	12. Dahuk at Burabari	24
	13. Chawai at U/S. of Chawai L.L.P	32
	14. Talam at U/S. of Talam L.L.P	24
	15. Pathraj at Fulbari	32
	16. Tangon at D/S of Nargun L.L.P	48
	17. Punarbhaba at Singraban	11
Rangpur	18. Buri Khora Chikli at Nizbari	32
	19. Fulkumar at Rai-ganj Bazar.	48

There are many rivers with high flow rate in monsoon but low in winter. It would be a good idea to create a diversion structure across the river channel, diversion channel along the bridge and the powerhouse at a suitable location that offers a suitable head.

The Teesta Barrage, the largest irrigation project of the country has several sites with sufficient head. BPDB has submitted a proposal to the government to install a 25kW power plant at the Teesta barrage. Further investigation can open the door to more success in this regard.

Hydro energy is a sustainable renewable energy. Bangladesh has good potential for the utilization of this energy in order to meet the demand. It can bring remarkable development in the energy sector in near future.

9 Conclusion:

The major energy sources in the world today are all being depleted rapidly and the inevitable energy crisis approaching is one of the most serious concerns among all societies, countries and world organizations. Almost all of us are aware of the danger ahead of us and so all of us must also understand that alternative energy sources must be researched, developed, marketed and established as quickly as possible to avoid it. The possible forms of renewable energy in Bangladesh and the various methods of extracting them have been discussed in this paper and it is obvious that they are worthy of further research and inspection at least. The energy crisis is no longer an issue based on a single country or two, but a far larger phenomenon concerning the whole of humanity. So it is the responsibility of all the countries including Bangladesh, to contribute to the ongoing extensive research and development of Renewable Energy Sources, as the new technologies and results will benefit everyone. Moreover all must realize that Bangladesh is one of the few countries in the world, which are geographically and also inherently suitable for the harnessing of energy from various types of renewable sources. The variety, abundance, vast number of prospective locations and widespread availability of the renewable energy sources alone are good reasons why they deserve efforts for their extensive research and development, also it is true that Bangladesh being a developing country and in desperate need for alternative power sources, greatly motivates such ventures towards non-traditional means. As it is clear that renewable energy seems to be the most reliable, safe and green alternative to the conventional energy sources prevailing in the world today, and for Bangladesh which is facing the energy crisis earlier than most other countries, it seems to be the only hope for Bangladesh in averting the crisis ahead. Hence we can conclude that the foreign countries and organizations must also come forward and participate in renewable energy projects in Bangladesh to ensure their mutual benefit and survival.

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