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Energy Security and Disaster Risk Governance in Energy Sector of Bangladesh

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Abstract – *Bangladesh is prone to various hydrometeorological hazards due to its geophysical location. The exposures and resulting impacts of these natural hazards are aggravated by persistent social, economic and environmental status. Compounded with the country's current dependence on imported fossil fuels and other challenges, this study seeks to stimulate discussions around the complementarity of energy sector as well as its linkages with disaster risk governance and promote good governance in the sector that integrates energy policies, disaster risk governance and climate change impacts. The energy sector plays a critical role in all stages of the disaster management cycle; especially considering that all societal service systems rely on the energy sector for everyday activities, as well as for emergency response and recovery (e.g., telecommunications, health, and infrastructure). Addressing the resilience of energy systems as a component of disaster risk governance, and in response to climate change, requires considering all the components of the power supply value chain. These components should be deployed in line with relevant national policy frameworks (i.e., national development plans, energy policies, building policies, among other regulations and planning instruments), availability of technical capabilities, and financial resources, among others. However, this has been observed that energy-related measures are poorly considered in the early stages of the disaster risk governance cycle. Therefore, this study proposes to promote the resilience of the energy sector in Bangladesh through comprehensive measures. With that in mind, efforts have been made to identify challenges, gaps and recommend plausible measures for solutions.*

Keywords – *disaster risk governance, fossil fuels, natural hazards, power supply value chain, resilience.*

1. INTRODUCTION

Disasters leave adverse impacts on humans, natural ecosystem, social systems and human wellbeing. The natural and anthropogenic hazards may lead to disasters, which cause short and long term impacts on social and economic development of the country. The shocks and stress due to the disasters gradually erode assets of citizens, increase social and economic inequity, and often divert critical resources from development towards creating humanitarian goods and services for the affected people [1]. In recent decades, Bangladesh has achieved commendable success in economic and social indicators [2]. Bangladesh is one of the rapidly developing countries in South Asia [3]. The average annual GDP growth rate was 5.7% between 1996 to 2016, with a peak of 7.1% observed in 2016 [4].

One of the key indicators to measure overall economic as well as social development of the nation is energy, which has determinant influence on Human Development Index [5]. Bangladesh is ranked 136 with the Human Development Index (HDI) 0.608 which is significantly good while comparing to World HDI value 0.728 [6]. The country has been dependent on fossil fuels for its electricity generation and a continued reliance will require an increase in fossil fuel imports to satisfy the growing electricity demand, as domestic reserve is inadequate [7].

Energy sector is one of the most essential elements for achieving national vision of reaching developing country status by 2021 and developed country by 2041. Energy demand in Bangladesh has significantly increased over the past decades. A large number of Bangladesh's power plants are heavily dependent on expensive imported fossil fuel energy resources. Thus, the power supply adversely affects the socio-economic development of the country. On the other hand, a recent study titled "Bangladesh Power Review: Overcapacity, Capacity Payments, Subsidies and Tariffs are set to Rise Even Faster" by the Institute for Energy Economics and Financial Analysis (IEEFA) finds that the power sector of Bangladesh is heading towards financial disaster due to the current plan to increase power capacity based on a switch to expensive imported coal and liquefied natural gas (LNG).

In the context of disaster and development, United Nations International Strategy for Disaster Reduction (UNISDR) have identified three key variables "disaster reduction, social and economic development, and sympathetic environmental management" [8]. Apart from the sudden shocks of natural or/and anthropogenic events, there are number of underlying factors partially or fully responsible for increased vulnerability *e.g.*, growing urban population and increased density, weak local governance, insufficient participation by local stakeholders in planning and urban management, coordination challenges during emergency services, adverse effects of climate change, *etc.* [9][, 10].

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Capacity building through the creation of skilled and trained professional manpower is one of the major components in Disaster Risk Reduction, which also caters to the need of reduction of impacts of climate change through holistic developmental adaptation [11].

The enhancement of resilience to disasters through the modernization of energy systems requires monitoring and verification to determine and evaluate the real reach of their impacts. Each phase of intervention requires a set of indicators that allow evaluators to measure performance in relation to a baseline scenario. It should also be used for policy learning, guiding changes or modifications based on progress or changes in conditions. The objective of this paper is to identify key elements that would allow the integration of energy sustainability and disaster risk governance (DRG) strategies in Bangladesh.

2. BANGLADESH ENERGY PROFILE

Bangladesh is located in the heart of the Ganges-Brahmaputra-Meghna Delta in South Asia and borders India on 3 frontiers: west, north and east, Myanmar on the south-east, and the Bay of Bengal on the south. The country has an insufficient energy reserve; small amounts of oil, coal and countable natural gas reserves [12].

Disasters are frequently occurring phenomena in Bangladesh, a land of about 160 million people within its 147,570 sq. km territory. The country is exposed to several geological, hydrological, meteorological as well as human induced hazards. According to the UN World Risk Report, Bangladesh is one of the world's most disaster exposed countries. Bangladesh is one of the four countries among the highest risk countries in Asia with the risk index of 18.78 (World Risk Index 2019). It is susceptible to annual flooding, frequent cyclones, and potentially large earthquakes along with the creeping hazards like drought, saline intrusion, air quality, land degradation *etc.* The country's exposure to hazards is compounded by its population's exposure, vulnerability and lack of resources. The mostly agrarian economy and the high population density leave large sections of the population exposed to various geophysical and hydrological hazards.

The energy is prerequisite for social and economic development of Bangladesh for achieving sustainable energy systems to protect natural life-support systems on which humanity depends, and to eradicate poverty. Bangladesh has limited alternatives and will continue to rely primarily on this energy source to fuel its development [13]. Energy demand in Bangladesh is rising swiftly, which is outstripping the production and transmission and distribution capability and leads to increased power disruption and poor quality of power supply [14]. Bangladesh imports to meet most of its oil needs and remains heavily dependent on biomass for domestic energy production, particularly in rural areas [15]. Domestically produced natural gas provides majority of Bangladesh's commercial energy.

The Ministry of Power, Energy and Mineral Resources (MPEMR) are responsible for overall sector policy formulation, investment decisions and regulation of the energy sector in Bangladesh. Two independent divisions, the Energy and Mineral Resources Division (EMRD) and Power Division of MPEMR is responsible for developing the oil, gas, and coal sectors to diversify energy supply and improve energy security and subsequently implementing the power sector reforms and ensuring adequate power generation capacity.

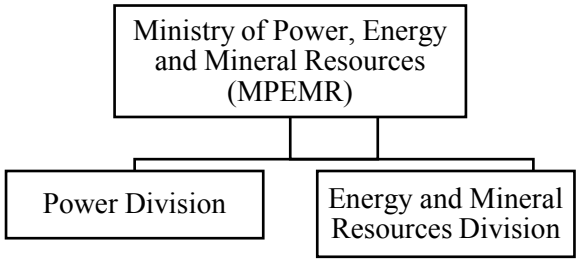

Fig. 1. Broad organizational structure of MPEMR.

Bangladesh has established two energy regulatory bodies, the Bangladesh Energy Regulatory Commission, established in 2003 to oversee tariffs and operations in electricity, gas, and oil; and the Sustainable and Renewable Energy Development Authority (SREDA), established in 2014 to promote renewable energy and energy efficiency.

2.1 Energy Scenarios 2016-2030

In the wake of heavy reliance on domestically produced natural gas, gradually diminishing gas reserves, and electricity shortages, the Bangladesh Power System Master Plan 2010 (PSMP 2010) laid out an energy sector vision for 2030. This vision included active development of domestic primary energy resources, establishment of a power system portfolio based on fuel diversification, and building of an infrastructure necessary for a stable power supply. The PSMP envisioned a fuel composition of 50% coal, 25% natural gas, and 25% other fuels/energies by 2030, with coal consumption consisting of both imported and domestically produced coal. This composition is in stark contrast to the composition in 2013 with natural gas constituting 76% of primary energy and 87% of electricity production. While coal consumption was less than 1 million Tons of Oil Equivalent (ToE) in 2013 and coal fired power plants in operation was only 250 MW in 2016, several coal fired plants are at various stages of construction and preparation. However, increased domestic coal mining and production met resistance among the local population. This was one of the factors that motivated the initiation of the Power Sector Master Plan 2015(PSMP 2015) in late 2014.

The Government of Bangladesh (GoB) has made plans to expand the energy sector consistent with Bangladesh becoming a middle income country by

2021, and by 2030 it expects to move further up the ladder. To achieve this status projection of electricity has been made to 2030 and beyond. According to the PSMP 2015, the peak electricity demand will be over 25,000 MW, and 100% of the country will be electrified. In 2015, the total consumption of commercial energy was around 32 million ToE. To achieve the target of 2030 this will have to be increased several fold to beyond 100 million ToE (Power Cell, Power Division, MPEMR).

2.2 GoB Priority

2.2.1 Energy Sub-sector

- Formulating a long-term strategy about how the growing needs of primary fuel will be met in the next 25 years and achieving Vision 2041.
- Exploring domestic gas resources, both on shore and off shore, to address the growing shortage of natural gas.

Diversifying energy supply through (1) energy imports, both LNG and coal and supporting infrastructure, (2) energy conservation measures and Demand Side Management (DSM), and (3) renewable energy sources, biogas, and Improved Cooking Stoves (ICS).

2.2.2 Spinning reserve constraints:

- Curbing increasing electricity cost and improving financial viability of the power sub-sector, through fuel diversification, economic dispatch and improving energy efficiency.
- Enhancing reliability and network quality of power supply to meet rapidly increasing power demand and higher quality of power supply.
- Increasing capacity for power transmission and distribution to keep pace with the increasing generation capacity.
- Improving power sector efficiency by (1) reducing technical and non-technical losses, and (2) improved operation and maintenance (O&M) of power plants.

2.2.3 Cross-cutting Issues

- Improving energy (gas) and power tariff setting mechanism to cover the 'true' cost of energy and power supply and reduce the burden of power subsidies on the national budget.
- Pursuing DSM in both energy and power sub-sectors, through regulatory reforms.

(Source: Power and Energy Sector Strategy Paper, 2018)

2.3 Energy Sources in Bangladesh

In Bangladesh the sources of energy consumption are Bio-mass (wood, animal and agricultural residues, municipal waste *etc.*) which contributes about 65% of the total energy consumption and the remaining 35% stands for commercial sources which are natural gas, oil, coal and hydro-electricity [16]. The major commercial energy sources consist of natural gas (from which almost half is used for electricity generation), petroleum, coal and hydro-power [17].The shares of natural gas, petroleum, coal and hydropower to total commercial energy consumption is 70.8%, 25%, 2.4% and 1.8%, respectively [18]. The petroleum and coal are mostly used for transportation and industrial purposes.

2.3.1 Natural Gas

Domestic natural gas production is less than 3,000 MMcfd (million cubic feet per day), but the demand is more than 3,500 MMcfd. From existing reserves the supply cannot be increased, and, therefore, the gap between demand and supply will widen as the demand in 2030 is projected to be more than 5,000 MMcfd. Considering a modest exploration program where the probable and possible reserves can be brought into supply, the production of gas would still fall to 2,000 MMcfd in 2030.

Table 1. Gas sector: Basic information.

Gas Reserve	1st July, 2018 (in TCF)
No. of Field	27
Total Gas Initially in Place (GIIP)	39.8
Proved (1P)	20.9
Proved + Probable (2P)	27.81
Proved + Probable + Possible (3P)	30.82
Cumulative production	15.94
Remaining Reserve (1st July, 2018)	11.92

Source: Reservoir and Data Management Division, Petrobangla, 2018.

2.3.2 Use of Coal

Local demand for coal is met up mainly by local production and partly by imported coal. At present, total coal reserve in the country is amounted to be7962 million MT (Table 2). Till date, about 8.88million MT of coal has been utilized. About two thirds of that coal is used in power plants and the rest is used in other purposes (brick field, households *etc.*). The coal policy which was prepared long back did not materialize. There was huge public protest against extraction of coal through open-mine system due its possible huge impact on environment and livelihood in the coal-belt.

Table 2. Coal reserve in Bangladesh.

Name of the Coal Field	Reserve in Million MT
Barapukuria, Dinajpur	390
Khalaspir, Rangpur	685
Jamalganj, Joypurhat	5450
Fulbari, Dinajpur	572
Digipara, Dinajpur	865
Total	7962

Source: Mines and Minerals Development Report, 2019

A 1320 MW (2x660) power plants are currently being set up in the southwest region of Bangladesh, near to the Sundarbans. Bangladesh and India have been jointly constructing this power plant. The $2 billion cost of building the Rampal power plant is likely to rise to $5 billion after river dredging and for subsiding coal. The cost will also be influenced by the price of coal. In 2010, a total of 930 acres of land were acquired to implement the project at Rampal of Bagerhat - some 14 kilometers away from the Sundarbans, a World Heritage site declared by the UNESCO. The environmental concerns have been raised by right-based groups both nationally and abroad.

2.3.3 Import of Petroleum

Petroleum constitutes a major share of fuel costs for power production and dependence on it has increased overtime. Costs for diesel and HFO have been increased significantly over the years. A large number of newly established power plants are based on imported petroleum which caused a huge import bill. There is a plan to reduce dependence on petroleum-based power plants. As part of that there is initiative to commission large scale power plants soon.

2.3.4 Renewable Energy

The expansion of the potential of wind energy is crucial in order for Bangladesh to achieve its national vision of providing electricity to all of its population by 2020 [19]. Despite having a huge coastline and relatively large area only 100 MW of huge demand is projected to come from wind power sources. The bulk of this generation is planned to be deployed in the coastal area and adjacent islands [20]. The contribution of renewable energy is at an early stage (0.01% of total energy generated). Major part is solar energy which is mostly in off-grid. The incremental contribution of hydropower, as per plan is rather discouraging. The implementation phase of biogas program in Bangladesh is also in progress since 2006 with support from the development partners.

2.3.5 Nuclear Power

Bangladesh is in the stage to become the 33rd nuclear power-producing nation after the successful construction work at Rooppur, Pabna [21]. The Rooppur Nuclear Power Plant (RNPP) is expected to generate additional 2400 MW (2x1200)of power to the national grid at a cost of US$ 12.65by the year 2024 [22].

3. DISASTER AND ENERGY SYSTEM CHALLENGES IN BANGLADESH

Energy is an essential factor for sustainable development and poverty alleviation, as recognized by a wide variety of regional and international development instruments (SDG 7, 8, 9, 11, 12 and 13). The effects of disasters and climate change on energy systems vary from affectations to infrastructure (*e.g.* generation plants, transmission and distribution networks), to disruptions in supply, and changes in demand patterns. The cascading impacts of disasters on energy system decelerate the achievements in sustainable development, especially when financial protections are missing and when DRG still follows a silo approach.

In the case of Bangladesh, gas and electricity infrastructure are the critical elements, but others are becoming important as the gas reserves of the country dwindle. In electricity infrastructure, there is generation, transmission and distribution. For gas, it is exploration, development, transmission and distribution. It has been the fact that for many years governments have struggled to provide energy security through a mix of policies that tempered demand and increased supply. Poor energy management caused severe impacts on agriculture, industry, food security and poverty. Additionally, a number of interlinked issues and challenges have appeared in recent years [23].

Table 3. Imported quantity for refined petroleum products and crude oil during 2009-2019 (quantity in M.ton).

Year	Imported Refined Petroleum Products						Imported Crude Petroleum Products	
	Gas Oil	JET A-1	MOGAS	SKO	HSFO	LUBE	ALC	Murban
2009	2343758	256576	98064	141103	0	7248	612913	425614
2010	2186597	339998	90197	107758	0	4745	620238	654832
2011	2955798	318202	95824	153598	665260	4980	627535	583960
2012	2618685	339699	95824	20380	670899	4852	682039	583494
2013	2608746	310884	97641	28376	1005104	0	592054	591091
2014	2903928	334079	35596	0	869124	0	592865	714746
2015	2974749	338315	33842	0	414451	0	697667	395006
2016	3130052	354430	150601	0	481673	0	728307	579848
2017	3716349	393918	32837	0	563856	0	497907	667861
2018	3457987	307777	32550	0	341329	0	597338	482260
2019	3410937	426745	115603	0	274915	0	592711	573717

Source: Bangladesh Petroleum Corporation 2020

Table 4. Renewable energy generation capacity (MW).

Technology	Off-Grid	On-Grid	Total
Solar	291.12	47.53	338.65
Wind	2	0.9	2.9
Hydro	-	230	230
Biogas to Electricity	0.68	-	0.68
Biomass to Electricity	0.4	-	0.4
Grand Total	294.2	278.43	572.63

Source: SREDA, 2019

Bangladesh has an insufficient energy reserve; small amounts of oil, coal and countable natural gas reserves. The country suffers an internal energy struggle, as about 93% of the country's power producing thermal plants is gas-based, but the gas is also needed for the industrial sector. Therefore, the country has to continuously make some compromises between power production and developing the industrial sector [12]. About 62.9% of Bangladeshi generated electricity comes from natural gas, while 10% is from diesel, 5% comes from coal, 3% of heavy oil, and 3.3% is of renewable sources [24].

Despite the fact that the Bangladeshi energy sector uses and covers varied products; electricity, petroleum products, natural gas, coal, biomass and solar, yet the policy and decision makers are mostly pre-occupied with electricity, as it is the most common used form of energy in the country. Thus, because there is a continuous and rapidly widening gap between electricity supply and demand, therefore it is a major challenge for the energy sector in Bangladesh. The lack of investment is also a major contributing factor to Bangladesh's energy crisis [25]. Establishment of a stable, economical, clean, and safe energy supply system is faced with significant challenges in few aspects such as severe resource constraints and low energy efficiency, natural gas and coal dominated energy consumption and environmental pressures; and imperfect market systems and weak emergency response capacity. The country does not have adequate storage facilities. Therefore, the future of energy security of Bangladesh appears bleak with gas resources depleting fast and no coal extraction in sight, while poor energy supplies could potentially stun the country's economic growth.

Due to the adverse weather system, Bangladesh becomes the worst victim of natural disasters like tropical cyclone, tidal bore, flood, tornado, river bank erosion, earthquake *etc.* occur in Bangladesh that causing colossal loss of lives and properties. The power sector is both extremely vulnerable to natural hazards and a priority for any country's recovery and reconstruction. Severe weather events, particularly storms, are among the main causes of power outages around the world [26]. The cost of power infrastructure disruptions is substantial in developing countries. The share of power outages due to natural shocks can vary from anywhere between zero and 100 percent [27].

Table 5 presents a summary of the vulnerabilities; it categorizes the importance of considering a given disaster when designing an asset to avoid physical damages or service interruptions. During a natural hazard, three main types of incidents can lead to system breakdowns: transmission and distribution grid failure, generation plant failure, and fuel and maintenance supply chain failures.

In order to understand the legal procedure relating to any aspect of a nation, it is crucial to look into the country's regulatory structure and hierarchy. Therefore, Figure 2 shows the structure and hierarchy of the laws in Bangladesh to construct a comprehensive regulatory idea about the energy sector for the country.

The Energy Action Plan (2009-2013) of the country included a series of actions, measures, programs and targets to be met to achieve greater energy efficiency and conservation awareness, together with reductions in CO2 emissions. The Bangladeshi Energy Strategy of 1996 with its actualization in 2002 is the main document of the promotion of renewable energy (RE). It focuses on energy supply in rural areas. In December 2009 the Renewable Energy Policy for Bangladesh was ratified. It was intended to integrate this policy paper into the New Energy Policy (NEP). The NEP was developed in 2006 by the "Renewable Energy and Energy Efficiency Programme" in cooperation with the UNDP. In the Intended Nationally Determined Contributions (INDC), the GoB announced to install 3000 Mega Watts of solar energy and continue to promote off-grid solar energy as well as ICS. It looks like the GoB is following a parallel strategy: on the one hand, increase power generation based on coal, on the other hand offer projects in the field of on-grid and off-grid solar electrification and stoves to be supported by development partners. The Private Sector Power Generation Policy adopted to attract private investment for installing new power generation capacity on build-own-operate (BOO) basis. The Renewable Energy Policy provides incentives for RE. The Power Division of MPEMR has announced and published the Country Action Plan for Clean Cookstoves (CAP) in November 2013. The target of CAP is to disseminate cookstoves to over 30 million households in the country by 2030.

Table 5. Power sector vulnerability to natural disasters.

Type	Earthquake	Cyclone	Flood	Tsunami	Wildfire	Drought	Extreme Heat
Thermal plants	High	High	Medium	High		High	Medium
Hydropower plants	High	Low	Medium	Low		High	Medium
Nuclear Plants	High	Medium	Medium	High		High	Medium
Solar (PV)	Low	High	Medium	Medium		Medium	Very lw
Wind	High	Medium	Low	Medium		Very low	Very low
T&D lines	Medium	High	Low	Medium	High	Medium	Medium
Substations	High	High	High	Medium	High	Low	Medium

Source: Nicolas, et al., 2019

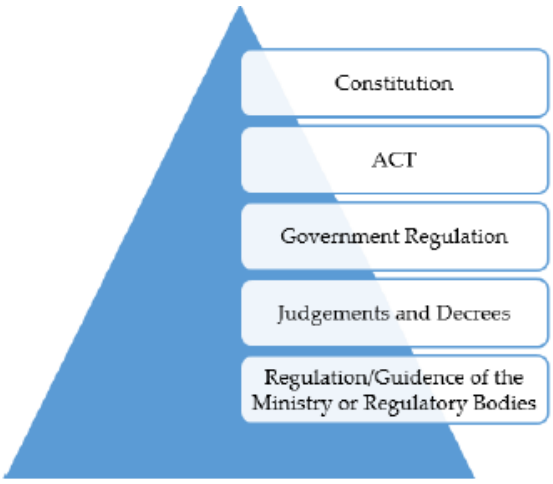

Fig. 2. Hierarchy of laws in BD. *(Source: Karim, et al., 2018).*

Table 6. Public expenditure in power and energy sector (in Crore Tk.)

Division	Year	Non-Development Expenditure	Development Expenditure	Total Expenditure
Power	2009-10	4	2024.54	2028.54
	2010-11	5	6189.92	6194.92
	2011-12	6	7179.65	7185.65
	2012-13	6	8868.01	8874.01
	2013-14	7	7843.99	7850.99
	2014-15	11	8030.78	8241.78
	2015-16	18	15558.46	15576.46
	2016-17	29	18136.89	18165.89
	2017-18	63	22757	22820
	2018-19	43	22893	22936
	Total (FY10-FY19)	192	119682.20	119874.20
Energy and Mineral Resources	2009-10	33	1367.64	1400.64
	2010-11	214	990.02	1204.02
	2011-12	39	746.02	785.02
	2012-13	40	1629.82	1669.82
	2013-14	35	1832.38	1867.38
	2014-15	33	1879.71	1912.71
	2015-16	51	2008.34	2059.34
	2016-17	43	2435.90	2478.90
	2017-18	95	1346	1441
	2018-19	165	1820	1965
	Total (FY10-FY19)	748	16055.80	16803.80

Source: Bangladesh Economic Review, 2018

4. ENERGY SECURITY CONTEXT AND RESILIENCE

Access to and promotion of sustainable energy remains persistent challenges in Bangladesh. The country continues to be heavily dependent on imported fossil fuels, which impacts national finances, restricting investment capacity and development opportunities, while posing major threats to environmental damage and long-term ecosystem resilience. An important opportunity to overcome some of these issues is exploring and exploiting the country's potential for green growth, along with measures to promote low emission and climate resilient development initiatives, which can result in lower investment and operation costs and create economies of scale, thus facilitating financing opportunities [28].

Bangladesh is ranked 114th out of 128 countries in the2019 (having score of 41.1) World Energy Trilemma Index by the World Energy Council. Conceptually, 'energy trilemma' involves the complex trade-offs among three core dimensions, *i.e.* energy security, energy equity and environmental sustainability. A large number of countries of the developing economy, including in Bangladesh, domestic energy (*e.g.* for cooking, heating or lighting) is still obtained from the energy-inefficient and toxic burning of biomass such as wood, charcoal or agricultural waste which is traditionally a women's work [29]. Women are the major consumers of energy in rural areas as they are responsible for gathering fuel for cooking and heating. More than 100 million people in Bangladesh, about 63 percent of the population, live in rural areas, where annual per capita commercial energy consumption averages less than 100 kilograms of oil equivalent (kgoe), considerably lower than the average international levels [30].

Bangladesh is standing at historical crossroads with respect to energy policy. Past decades of relatively abundant natural gas supported a set of policies that are not sustainable in future decades. The country still faces widespread poverty and the potential of conflict to arise as a result of energy shortage. The major challenges in the power sector of Bangladesh are: (i) providing universal access to power; (ii) providing good quality and reliable power supply; (iii) ensuring gas availability for generation; (iv) long-term energy security and fuel diversity; (v) cost recovery and financial sustainability of power sector agencies; and (vi) mainstreaming renewable energy [31].

It is a challenging task for Bangladesh to meet its increasing demand of energy while its economy is rapidly growing. Though prices of oil, coal, and fossil fuels around the world have been volatile, the price trend in Bangladesh demonstrates a persistent rise in the immediate past. This is further exacerbated by depleting reserves of natural gas. Cumulatively, these two effects heighten Bangladesh's energy needs. In the country as electricity is the most widely used form of energy, so future economic growth significantly depends on the availability of electricity [32]. However, consequently, due to scarcity of natural gas, oil and coal resources, nuclear power surfaces as a palatable strategic option for Bangladesh's future development agenda [22].

4.1 Components of a Resilient Energy Sector

To achieve the resilience of energy systems for disasters and climate change is a complex process. Resilience building can be better attained through the multi-sectoral synergies between adaptation and mitigation. Both types of approaches, as well as other pertinent measures, should necessarily take local conditions, such as priorities, governance frameworks, available funding, infrastructure, capabilities, access to information, and awareness.

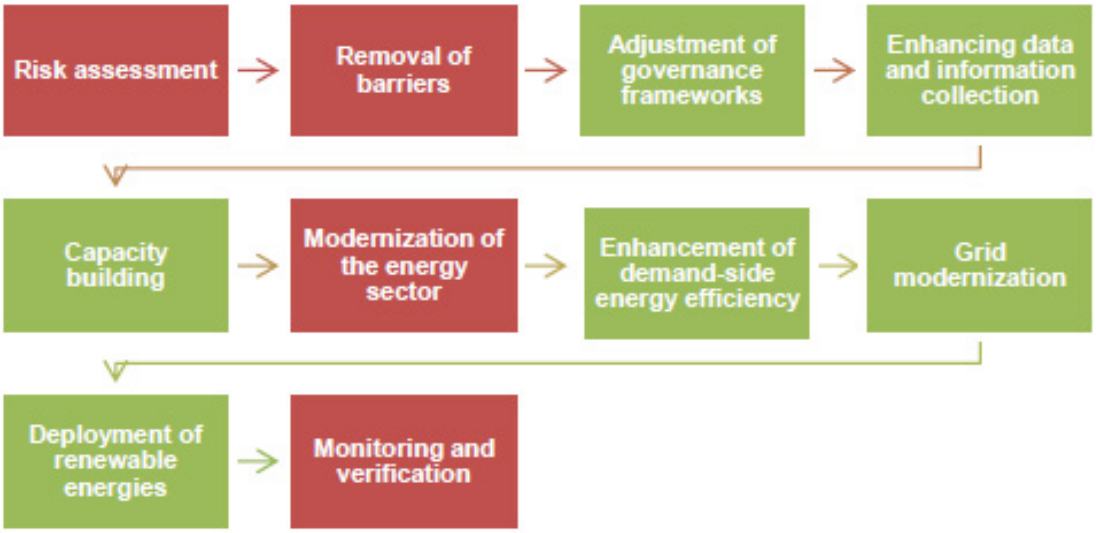

Fig. 3. Components of a resilient energy sector.
(Source: Flores and Peralta, 2020)

According to GFDRR, DRG should be founded on five pillars: risk identification, risk reduction, preparedness, financial protection, and resilient recovery [33].

Table 7. Pillars of action of disaster risk governance.

Serial	What the Pillar is?	How to Achieve?
Pillar-1	Risk Identification	Improved identification and understanding of disaster risks through building capacity for assessments and analysis
Pillar-2	Risk Reduction	Avoided creation of new risks and reduced risks in society through greater disaster risk consideration in policy and investment
Pillar-3	Preparedness	Improved capacity to manage crises through developing forecasting and DRR capacities
Pillar-4	Financial Protection	Through financial protection strategies of governments, private sector and households
Pillar-5	Resilient Recovery	Through support for reconstruction planning

Source: GFDRR, 2013.

5. CHALLENGES AND WAY OUT FOR ENERGY SECTOR IN DISASTER RISK GOVERNANCE

5.1 Adjustment of Policy and Govenance Framework

Governance frameworks refer to modern energy policies and plans that include measurable RE and energy efficiency (EE) targets, assign responsibilities, establish timetables and communication and accountability mechanisms, allocate resources (financial and non-financial), and be based on conceptual budgetary provisions. They should promote multi-stakeholder participation and provide moments for policy learning. Modern energy policies must be accompanied by a regulator responsible for creating an enabling environment for all stakeholders, and to ensure transparency, accountability and fair-conditions. The most relevant challenge of adjusting governance frameworks is coordination among a diversity of institutions and regulations.

5.2 Enhancing Data and Information Collection

Data and quality information are required to guide decision making, to monitor and verify future scenarios and improvements. Inadequate or insufficient baseline data could hinder efforts to make reliable assessment, identify and reduce risks, as well as to assess the effects and impacts of disasters on infrastructures (including that of energy systems), ecosystems and populations. Inadequate baseline data could also result in over or underestimations of the efforts needed. The generation and dissemination of information requires strong institutions providing leadership and guidance for the generation and use of resources, as well as a platform to keep it available to stakeholders. The analysis of DRG frameworks also evidenced the importance of updated and readily available data and information for decision making.

5.3 Capacity Building

The incorporation of new technologies and activities demands specialized skills and knowledge. Local and regional capacities must be created and/or improved to face the challenges posed by the modernization of energy systems in view of increasing resilience to disasters. Although the country is permanently supported by multiple capacity building initiatives, important knowledge gaps and barriers to institutional effectiveness remain, including duplication of efforts, high staff mobility, loss of institutional memory and expertise, and lack of coordination, which often hinder effectiveness. To address this situation government institutions and related stakeholders must develop shared databases, networks, and collaboration frameworks to guide institutional structure and operation.

6. MODERNIZATION OF THE ENERGY SECTOR

6.1 Enhancing Demand-Side Energy Efficiency

Efforts to address the challenges of the energy sector cannot rely exclusively on the incorporation of RE. Demand-side EE and other energy saving measures are crucial, as they consist of the most cost-effective and fastest way to lessen the environmental and socioeconomic costs associated with energy systems. Demand-side EE is achieved when less energy input is used to deliver the same service or when the same amount of energy input delivers more services. This concept is relevant in light of climate change challenges in two ways: (i) the less energy used, the fewer emissions produced, and (ii) cost effective EE achieves environmental benefits at low cost, and thus could reduce the economic costs of achieving climate change policy goals [34].

6.2 Incorporation of Renewable Energies

RE deployment is a widely discussed topic and the overall potential for RE sources is high. Although estimations point out that the global energy supply will remain dominated by fossil fuels over the next decades, countries should seek to develop and disseminate cost-effective and efficient low or zero-carbon emitting technologies [35]. Nowadays, RE cost-effective supply is in continuous growth due to an increase in the investments and advancement in technologies and features. While the cost of RE technologies has

decreased in recent years (*i.e*., between 33 and 80 per cent depending on the technology), they are still not comparable to subsidized fossil fuel energy sources. However, if we take into consideration the associated socio economic and environmental externalities of conventional energy generation, the opportunity cost to switch the energy paradigm is exposed. Proper integration between energy and land use and zoning policies should be done.

6.3 Grid Modernization

Due to the broad availability of RE resources and the wider need to decentralize generation systems (*i.e.,* to enhance energy access), adjustments in their design and technical features are required if full RE potential is to be achieved. Additionally, after a disaster takes place, the bulk of the damage is absorbed by infrastructure (*i.e.,* especially overhead power lines, utility poles, transformers, as well as power generation stations), making the adjustments more imperative.

7. DISCUSSIONS AND RECOMMENDATIONS

Resilience is not a one-dimensional issue- there is a need for holistic solutions that cut across sectors. To be resilient, infrastructure of tomorrow must cope with, and adapt to a complex, extensive and evolving mix of hazards, risks and threats. Assessments of multi-hazards risks should be an essential component of every project across its entire life cycle - integrated from the planning and design phase - and not just added on as a last-minute feature. Having early-stage conversations such as meeting about risk management in future infrastructure projects makes it easier to customize a resiliency strategy-knowing which assets to protect, understanding the function of those assets and the potential cost of losing those assets from shocks like natural disasters and extreme weather [36], [37].

The occurrence of natural hazards and their impact on electric power system functioning has been experienced by many countries worldwide, particularly in relation to earthquakes, cyclone, tsunami and floods. Several countries such as Chile, China, Haiti, Indonesia, Italy, Japan, Mexico, the Philippines, Turkey, and the United States have experienced severe earthquakes that resulted in serious damage to their energy supply infrastructure, in addition to the loss of lives and property. Drought/water stress can also pose a substantial risk in the energy sector, particularly for hydropower.

It is evitable to experience disruptions in the power system at various stages during major disasters, but adequate mitigation measures and response plans can help the system to return to its original functionality. Risk governance at various levels, starting from power generation sector to the local government, need to function in line with the preparedness and crisis management plans. Resilience not only depends on equipment, building codes, seismic micro zonation maps of the city for resilience planning and technology but more on the organization and pre-defined emergency preparedness of well-structured electricity companies [38].

8. CONCLUSION

Increasing risk of natural and anthropogenic hazards and climate-induced extreme events necessitates the improvement of disaster risk management (DRM) and governance mechanism at multi-stakeholder level across jurisdictions. DRG through integrated approach with development provides opportunities for stronger incentives when DRM visibly contributes to improved economic and resilient society. Power and energy sectors of Bangladesh cannot get free flow of urgently required private sector investment without stronger and truly functional regulator. The BERC and SREDA must be manned by qualified and experienced professionals. These statutory authorities must function absolutely independently creating level playground for public and private sector companies. It must police enforcement and compliance of acts, laws, policies and regulations through stakeholders' engagement and efficiency auditing.

The GoB policies in the energy sector will be critical to the country's national security, economic development, and environmental sustainability. Bangladesh's energy and power sector needs to shift its activities from the 'emergency management' (initiated in early 2010s) to 'market-led' management (needs to be initiated towards 2021-2030). It needs to reduce lack of transparency, accountability, efficiency, irregularities and corruption. It is high time to pay attention to the primary energy sector particularly to gas and renewable generation and energy efficiency from an economic and environmental perspective to minimize debt and fiscal impacts. The potential for private investment in generation, transmission, and demand management should be fully pursued as the government proceeds with the implementation of its ambitious scheme to establish industrial and export zones. Finally, developing countries like Bangladesh face enormous challenges in attaining the UN SDGs. The energy sector is central to realizing these aspirations. It is precisely for this reason that Bangladesh should chart a course that can lead to a more efficient, clean, affordable, and sustainable power and energy system.

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