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PAPER TITLE	Harnessing Unused Road Corridors for Solar Energy: A Decarbonization Strategy in Bangladesh.		
TRACK	T4- Towards Zero Emissions: Strategies for Decarbonizing Road Transport		
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KEYWORDS:

Unused road corridors, decarbonization, solar panel, right of way (ROW), revenue generation

ABSTRACT:

The transition towards zero emissions in road transport infrastructure is essential for sustainable development. This paper explores a strategic approach to decarbonizing road transport in Bangladesh, focusing on the SASEC Road Connectivity Project-2. Covering 190.4 kilometers, the project identified 495.9 acres of unused land in the right of way (ROW) or other precincts, suitable for solar energy generation, with the potential to produce 250.8 MW of electricity, thereby reducing carbon emissions by approximately 4.8 million tons. Inspired by the MASSDOT Public-Private Partnership and similar initiatives in California, this project seeks to harness state-controlled land along highways for solar installations. This method not only mitigates conflicts and accelerates development but also leverages proximity to existing transmission lines, enhancing energy reliability. The project idea includes using solar power to illuminate 54 local markets, providing sustainable energy for communities and contributing to the national grid. Utilizing median areas for solar panels further optimizes land use. The paper emphasizes the benefits of such an approach, including reduced pollution, enhanced energy security, and potential revenue from lease payments. It also highlights the reduced need for roadside maintenance, as solar developers manage their installations. This case study demonstrates a replicable model for integrating renewable energy into transportation infrastructure, offering a pathway to a carbon-neutral future. By leveraging untapped road corridors, this project idea might contribute significantly to national and global environmental goals.

Harnessing Unused Road Corridors for Solar Energy: A De-carbonization Strategy

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1. Introduction

The transport sector is a significant contributor to global greenhouse gas emissions, accounting for nearly one-quarter of the total (ESCAP 2023). To reduce this environmental impact, various strategies, including renewable energy solutions like solar power, have been explored. One innovative approach is utilizing unused road corridors for solar energy generation, which can contribute to the decarbonization of the transportation sector. Solar energy is expanding rapidly worldwide and can help mitigate the transport sector's growing demand (Arduin et al., 2022). Numerous studies have examined the application of solar energy systems for electrified urban transportation (Bartłomiejczyk 2018).

Bangladesh has made notable progress in solar energy development, with initiatives such as solar parks and Solar Home Systems (SHS). The country receives an average daily solar radiation of approximately 4.5 kWh/m^2, making solar energy a viable option. As of mid-2023, solar energy accounts for 650 MW of the total installed capacity of 22,215 MW, representing about 80% of the renewable energy capacity (Hossain 2023, United Nations 2024). However, land scarcity presents a significant challenge, as solar installations often compete with agricultural and urban development needs. For instance, producing one megawatt of solar power typically requires about three acres of land, a substantial constraint in densely populated Bangladesh (Khan 2021, BSS 2024).

There is considerable potential for solar energy generation in unused road corridors, such as medians, roadsides, and abandoned railway tracks. These areas, often underutilized, can be repurposed for solar photovoltaic (PV) installations, mitigating land-use conflicts and contributing to the decarbonization of the transport sector (ESCAP 2023). Utilizing existing road corridors minimizes the need for additional land, reduces conflicts with other land uses, and enhances energy security by decreasing dependence on centralized power generation (Govindarajan et al., 2023). Additionally, increased solar energy use in transportation can improve air quality and create new economic opportunities, such as job creation and local economic development (ESCAP 2023).

While the concept of using road corridors for solar energy generation is relatively unexplored in Bangladesh, it presents a viable solution to the land scarcity issue. Successful examples from South Korea and the Netherlands, where solar canopies over highways have been implemented, could serve as models for Bangladesh (Khan 2021). Integrating solar panels into road infrastructure could enhance the sustainability of transport systems and boost energy generation, especially in urban areas where space is limited.

Bangladesh has set ambitious renewable energy targets, aiming to generate 15% of its electricity from renewable sources by 2030 and 40% by 2041. Achieving these goals requires innovative strategies for energy generation and land use. Policymakers are encouraged to consider frameworks that support installing solar panels along roadways as part of the national energy strategy (Kabir and Al-Zayad 2024, United Nations 2024). This proposal suggests using the right of way (ROW) or other precincts for solar power plants to decarbonize road transport in Bangladesh. The paper aims to calculate annual electricity generation, select appropriate spaces, and install PV panels. It will also conduct cost and environmental analyses, propose a grid-tie structure, and estimate the system's payback period, return on investment, and CO2 emissions savings. The study's findings could guide policymakers and stakeholders in achieving a more sustainable future for Bangladesh, with the SASEC Road Connectivity Project-2 alone potentially producing 250 MW of electricity from 495.9 acres of unused land.

1.1 Study Area:

The Elenga-Hatikamrul-Rangpur Highway, an important segment of the SASEC Corridor (Corridors 4 and 9), Asian Highway, BIMSTEC Corridor, and SAARC Highway, is vital for connecting capital city Dhaka with 16 northern districts of Bangladesh. However, the current 2-lane highway is insufficient for the growing demand for passenger and goods transport, posing challenges to the nation's sustainable development. The highway's numerous sharp bends and the mix of slow-moving vehicles with heavy traffic contribute to frequent accidents, highlighting the need for improvement. To enhance sub-regional connectivity, increase transport capacity, and improve road safety, a project to upgrade this highway to a 4-lane road with separate lanes for Slow-Moving Vehicular Traffic (SMVT) has been initiated. The feasibility study and detailed design, supported by ADB under the Sub-regional Road Transport Project Preparatory Facility, were completed in 2015. The SASEC Road Connectivity Project-2 involves multiple work packages, each covering specific segments of the Elenga-Hatikamrul-Rangpur Highway. WP-05 through WP-13 collectively focus on upgrading various sections of this highway to a 4-lane standard. WP-05 covers 13.6 km from Elenga to the east side of Bangabandhu Bridge, with 30% progress. WP-06 extends 19.8 km from the west side of Bangabandhu Bridge to Hatikamrul, with 79%

completion. WP-07 stretches 28.3 km from Hatikamrul to Mirzapur, 67% complete. WP-08 runs 22.5 km from Mirzapur to Banani (Bogra), at 82% progress. WP-09 covers 25.3 km from Banani to Mokamtala, achieving 81% progress. WP-10 extends 29.9 km from Mokamtala to Polashbari, with 79% progress. WP-11 covers 27.2 km from Polashbari to Borodargah Bus Stand, at 80% completion. WP-12 involves 23.8 km from Borodargah to Rangpur, also with 82% progress. Finally, WP-13 involves constructing a 1.5 km Hatikamrul Interchange, with 35% progress achieved (Figure 1).

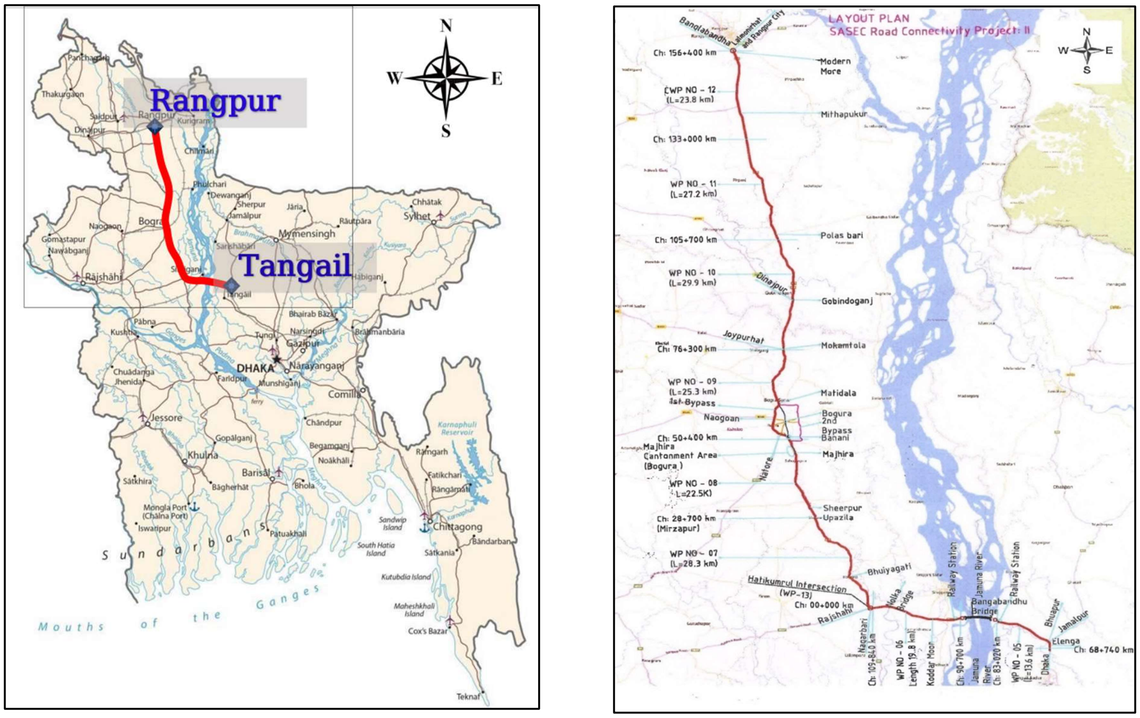

Figure 1 The SASEC Road Connectivity Project-2 Work Area

An example of site access for solar installations in the project is illustrated in Figures 2, 3, & 8. The travel lanes appear to provide access to the solar installation sites in the project, as illustrated in Figures 2, 3, & 8.

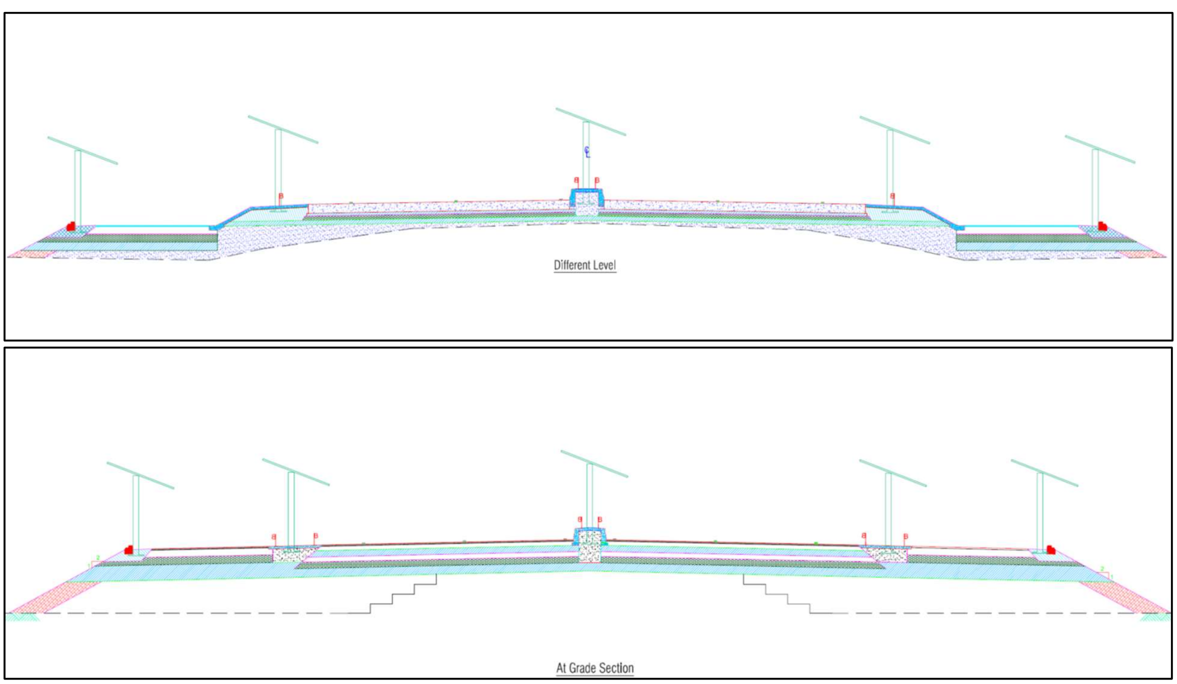

Figure 2 The SASEC Road Connectivity Project-2 typical road cross section for Solar Setting

1.2 Preliminary Screening:

To narrow down the number of potential sites for solar projects, we conducted a preliminary screening process (Figure 4). This approach is generally used when there are multiple possible locations to choose from (Oregon Department of Transportation 2016). Since our right-of-way (ROW) data is limited, we focused on sites within a specific geographic area. The screening considered factors such as safety, solar energy potential, utility access, competing land uses, site access, land requirements, natural features, and nearby community activities (Good Company 2016, Oregon Department of Transportation 2016). It's crucial to ensure that selected sites comply with relevant ASSHTO guidelines (Oregon Department of Transportation 2016). Assuming that the solar panels will be installed with a southern orientation (n23º in Bangladesh), the screening process should prioritize sites with favorable southern exposure to maximize sunlight capture and optimize electricity generation (Poe and Filosa 2012, Good Company 2016). Sites may be further refined by excluding areas affected by shading from nearby vegetation, buildings, or topographic features (Good Company 2016). The screening process evaluated the current and future uses of the ROW, including potential changes to highway alignment (Good Company 2016, Oregon Department of Transportation 2016). Any competing interests in the ROW's use should be considered in this assessment (Oregon Department of Transportation 2016). One key finding from interviews was that most people prefer to preserve scenic views over installing solar equipment (Good Company 2016). However, this does not mean that all solar installations will obstruct scenic views, as some ROW areas may not impact any views (Good Company 2016). Major natural features, such as lakes and vistas, should also be considered when assessing natural views.

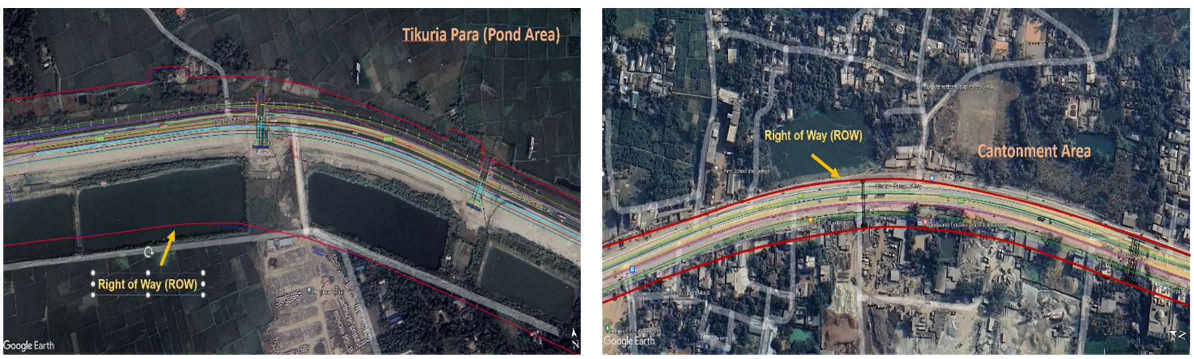

Figure 3 Land area screening for the unused right of way (ROW) along the SASEC-2 Project

In this study, considering the reference studies all the project alignments have been undergone table reviews in overlaying maps with Google© and on-spot pictures taken from the project library as well from fresh snapshots. Parameters has been used to find out the whole available land which was acquired before or from the project. Toe to toe land or highway precinct has been deducted from the available land for finding area for solar installation. Table and site reviews were done on the basis of the Table 1 parameters to find out useable land area for solar installation. Approximately 302.4 acre land area (38%) has been deducted due to the presence of ponds, natural features, site access problems, sites on inner or outer curves, presence of geographically critical areas, key point installations, cantonment area, panel orientation problems, etc. Figure 3 shows the exclusion of area in the consideration of solar installations.

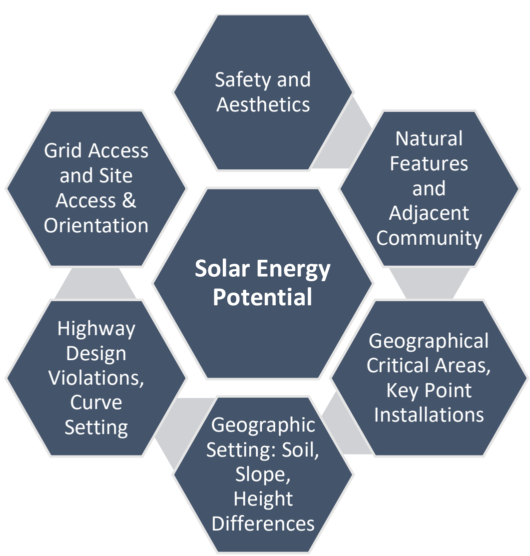

Figure 4 Site Selection Criteria used in the study

Table 1 Land Calculation and Utilization Summary for SASEC Road Connectivity Project - 2

Contract package	Total Acquired Land in Acre	Total Road Land in Acre	Remaining Land in Acre	Actual Useable Land in Acre
WP - 05	490.39	152.58	337.81	270.25
WP - 06	324.15	224.21	99.94	59.96
WP - 07	424.92	342.03	82.89	41.44
WP - 08	256.32	213.86	42.45	12.74
WP - 09	338.40	260.32	78.08	27.33
WP - 10	390.06	337.40	52.66	21.07
WP - 11	327.81	290.15	37.67	11.30
WP - 12	320.11	253.66	66.44	39.87
WP - 13				11.95
	2,872.15	**2,074.21**	**797.94**	**495.90**

Table 1 provides a detailed breakdown of land acquisition, allocation, and usage for the SASEC Road Connectivity Project - 2. It includes the total acquired land, the distribution in square meters and acres, the remaining land after initial allocation, and the actual usable land. The data is categorized into the following columns:

Contract Package: Identifies the specific contract under the project.
Total Acquired Land in acre: Indicates the total amount of land acquired for the project.
Total Road Land in acre: The portion of acquired land designated for road construction.
Remaining Land in acre: The land left after allocating the portion for road construction.
Actual Usable Land in acre: The portion of remaining land that is usable for solar project purposes.

This structured approach allows for an effective assessment of land utilization across different stages of the project.

Table 2 List of Structures with Corresponding Chainage and Length along the SASEC Road Connectivity Project - 2 Route

Serial	Name	Chainage		Length in meters
		Start Chainage (in km)	End Chainage (in km)	
1	Kodda Flyover	95+228.41	95+992.25	763.84
2	Jhaol	97+004.654	98+094.533	1089.88
3	B.Block	43+448.544	44+099.019	650.48
4	Bogura Railoverpass	54+941.613	55+646.480	1004.87
5	Gobindaganj Flyover	88+710.319	90+305.908	1595.59
6	Polashbari	106+354.531	107+054.404	699.87

Table 2 presents a list of various structures identified along the SASEC Road Connectivity Project - 2 route, categorized by serial number, name, chainage (start and end points), and the length of each structure. The structures include flyovers, bridges, and other significant infrastructural elements, with their respective positions along the route detailed by chainage coordinates. The length of each structure is also provided, offering insight into the scale and extent of the engineering works involved.

We also detailed specifications and performance estimates for various solar photovoltaic (PV) systems across the selected locations in Table 2. Each section outlines parameters such as latitude, longitude, PV nameplate capacity, inverter efficiency, DC-to-AC ratio, tilt angle, azimuth angle, system losses, ground coverage ratio, system size, module efficiency, and the annual energy output of the systems. Each solar plant is located at a latitude of 24° and longitude of 89°. The PV Nameplate Capacity varies significantly among locations, ranging from 188.37 kWdc at Medical College to 1883.87 kWdc at Sherpur Dhunot More and Gaibandha More. The inverter efficiency is consistently reported at 96% across all sites. The DC-to-AC ratio varies, with the highest being 27.2 for Sherpur Dhunot More/Gaibandha and the lowest at 2.5 for several smaller installations. The tilt angles are generally between 20-23°, with a consistent azimuth of 180°. System losses estimated at 14% across all installations. The ground coverage ratio is maintained at 0.2, indicating a standardized area utilization. Finally, the annual energy output ranges from 231 MWh/y for Medical College to 2244 MWh/y for the largest installations.

Table 3 Summary of Solar Plant Parameters and Annual Energy Output

Location	PV Capacity (kWdc)	DC-to-AC Ratio	System Size (m^2)	Annual Energy Output (MWh/y)
Sherpur Dhunot More/Gaibandha More	1883.87	27.2	14000	2244
Mahasthan/Palasbari	1412.77	12.6	10500	1735
Kodda/Matidali/Biman More/Mokamtola	941.85	8.4	7000	1157
Charmatha/Pirajganj	659.29	5.9	4900	810
Raiganj	565.11	8.2	4200	673
Noimaile Bazar/Baluya Bazar/BRAC More	376.74	3.4	2800	462
Medical College	188.37	1.7	1400	231
Others	282.55 to 753.48	2.5 to 6.8	2100 to 5600	336 to 897

2. PVsyst analysis

2.1. PVsyst simulation parameters

A software utility that is frequently employed to simulate the performance of grid-connected photovoltaic (PV) systems is PVsyst. By taking into account a variety of parameters, including meteorological data, solar panel information, system configurations, orientation, the tilt angle of the PV panel, and various types of losses, the software can be employed to design, analyze, and optimize the performance of a solar power plant (Mérida García, Gallagher et al. 2019, Baqir and Channi 2022). In this context, it is essential to comprehend the various parameters that influence the performance of a PV system in order to create a solar power plant that is both cost-effective and efficient. Consequently, this section will address the PVsyst simulation parameters employed in this investigation, which include the data set, load data, and system configuration.

Data Set: It is essential to collect essential data that affects the performance of a grid-connected photovoltaic system in order to develop it. Geographical data and load data are the two data sets that have a substantial influence on system constraints. In grid-connected solar systems, capacity data calculation is indispensable to prevent oversizing or undersizing, which results in an increase in the system's cost.

Tilt Angle: In order to maximize the output of the designed system, it is crucial to identify and implement the optimal inclination angle for the chosen site. The following sum can be employed to determine the optimal inclination for solar panels: The optimal fixed year-round setting is 90◦ — your latitude (Talavera, Muñoz-Cerón et al. 2019). For the fixed-axis system, the optimal tilt angle for the project is 20-23◦, and the azimuth angle is 180◦, indicating a south-facing panel (Boxwell 2010).

Losses in Detail: The functionality of a solar power facility may be compromised by a variety of losses.
These losses can be classified into three fundamental categories: thermal losses, electrical losses, and mechanical losses. The losses of the fixed-axis grid-tied solar tracking system are illustrated in Figure 9 (Awasthi, Shukla et al. 2020).

3. Simulation and Results

Normalized Production (Per Installed kWp): The graph shows the total energy generated per installed kWp, reflecting the contribution of each component and the monthly variation in the solar power plant's performance. In Figure 5 the consistent and stable production output per installed kWp indicates that the system is performing efficiently and meeting expectations, confirming its viability.

Daily Input and Output Diagram: This diagram compares the energy injected into the grid with the global incidence on the collector plane for the solar power system. It helps assess whether the system is meeting energy demands and identify periods of surplus or deficit. The steady increase in the daily input/output in Figure 6 shows the system's consistent performance, suggesting potential for optimizing component sizes and energy storage solutions.

System Output Power Distribution: The graph displays the energy output distribution, highlighting when the system generates the most and least energy. This data informs decisions on system design, grid connection, and energy storage needs. Figure 10 shows consistent high energy output during peak demand periods, indicating the necessity of grid connection to sell excess energy.

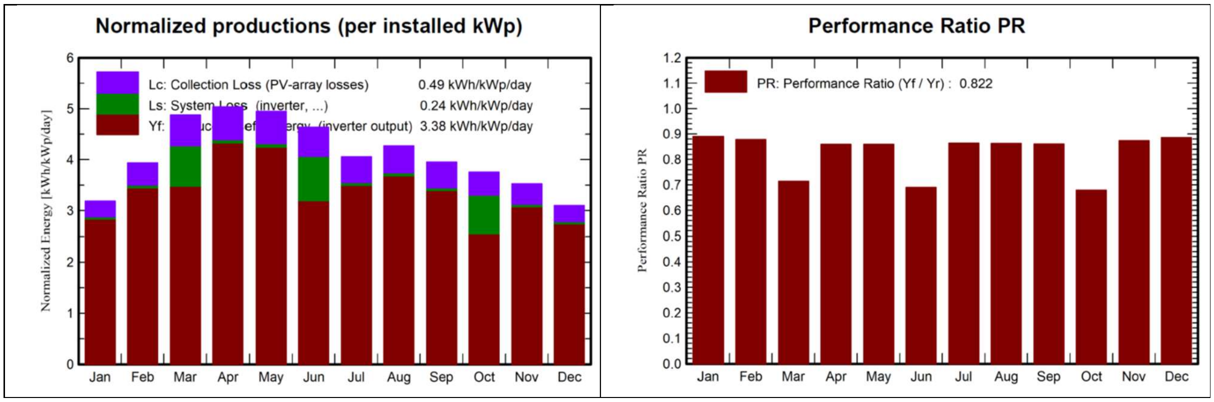

Figure 5 Normalized Production for 250 MW Solar Plant: Monthly performance graph, includes inverter output (3.38 kWh/kWp/day), system loss (0.24 kWh/kWp/day), and collection loss (0.49 kWh/kWp/day).

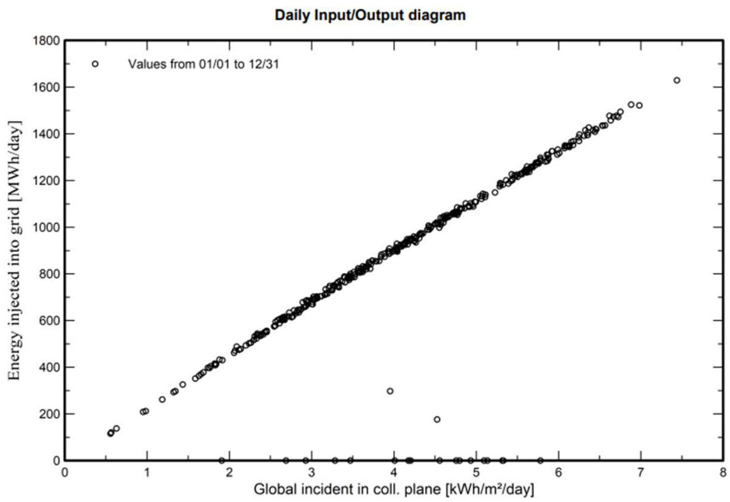

Figure 6 Daily energy input/output diagram for proposed solar power system

Balances and main results

	GlobHor	DiffHor	T_Amb	GlobInc	GlobEff	EArray	E_Grid	PR
	kWh/m²	kWh/m²	°C	kWh/m²	kWh/m²	kWh	kWh	ratio
January	102.5	60.89	17.03	98.9	95.2	22351260	22020506	0.891
February	114.2	62.16	20.96	110.2	106.4	24563578	24188836	0.878
March	156.7	83.09	25.87	151.2	146.1	33141411	26996152	0.714
April	156.7	90.79	27.77	151.1	146.0	32966988	32467345	0.860
May	159.4	96.44	28.45	153.4	148.3	33468266	32951211	0.859
June	144.7	96.61	28.27	139.1	134.4	30514986	24015211	0.691
July	130.9	89.49	28.55	125.7	121.5	27572222	27147896	0.864
August	137.7	93.14	28.69	132.3	127.8	28997272	28563422	0.863
September	123.2	72.60	28.01	118.6	114.5	25916989	25510849	0.861
October	121.0	72.80	27.14	116.6	112.5	25648333	19819520	0.680
November	109.7	56.44	22.97	105.8	102.0	23458812	23101308	0.873
December	99.5	58.46	18.86	96.1	92.6	21618629	21299138	0.886
Year	1556.2	932.91	25.23	1499.0	1447.4	330218745	308081394	0.822

Figure 7 Yearly variations of the proposed solar power system

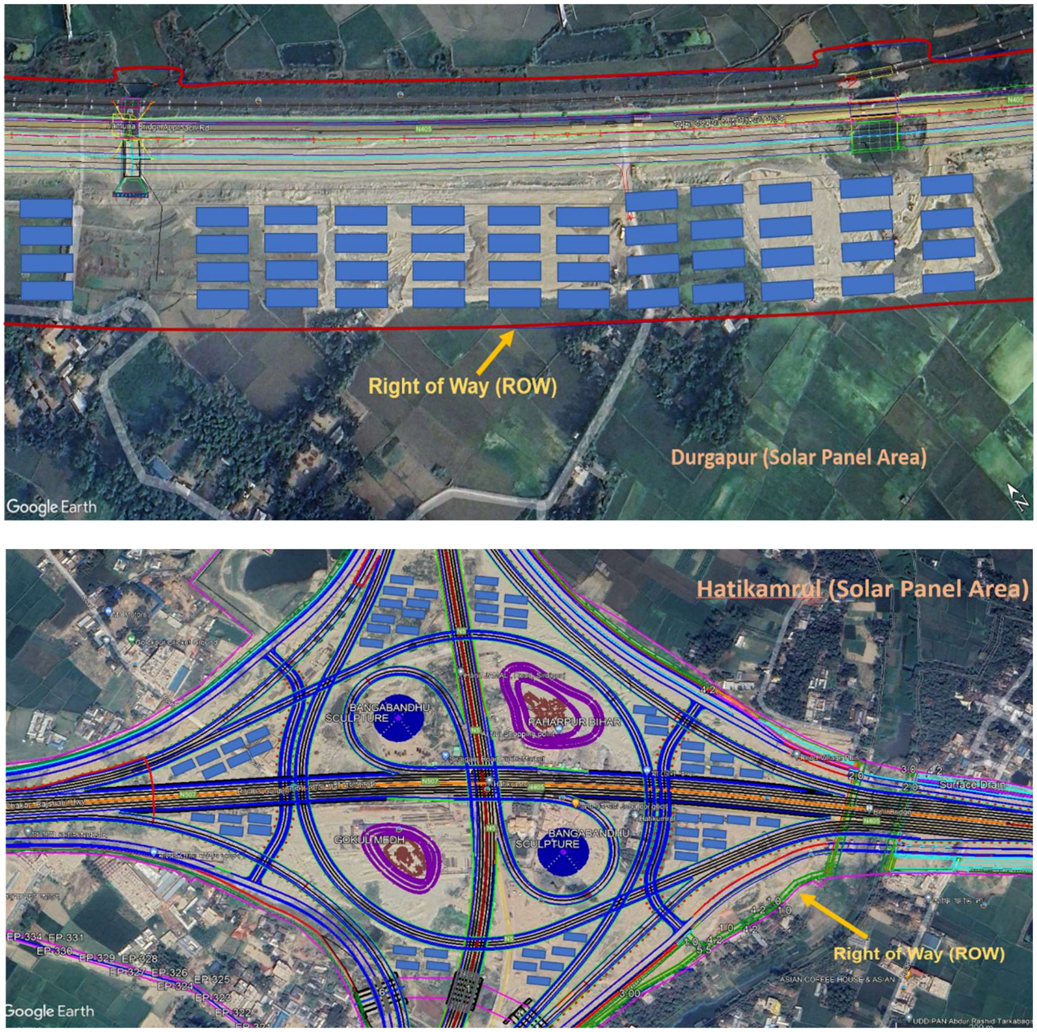

Figure 8 Aerial View of Proposed Solar Site The SASEC Road Connectivity Project-2 (Source: Google Earth)

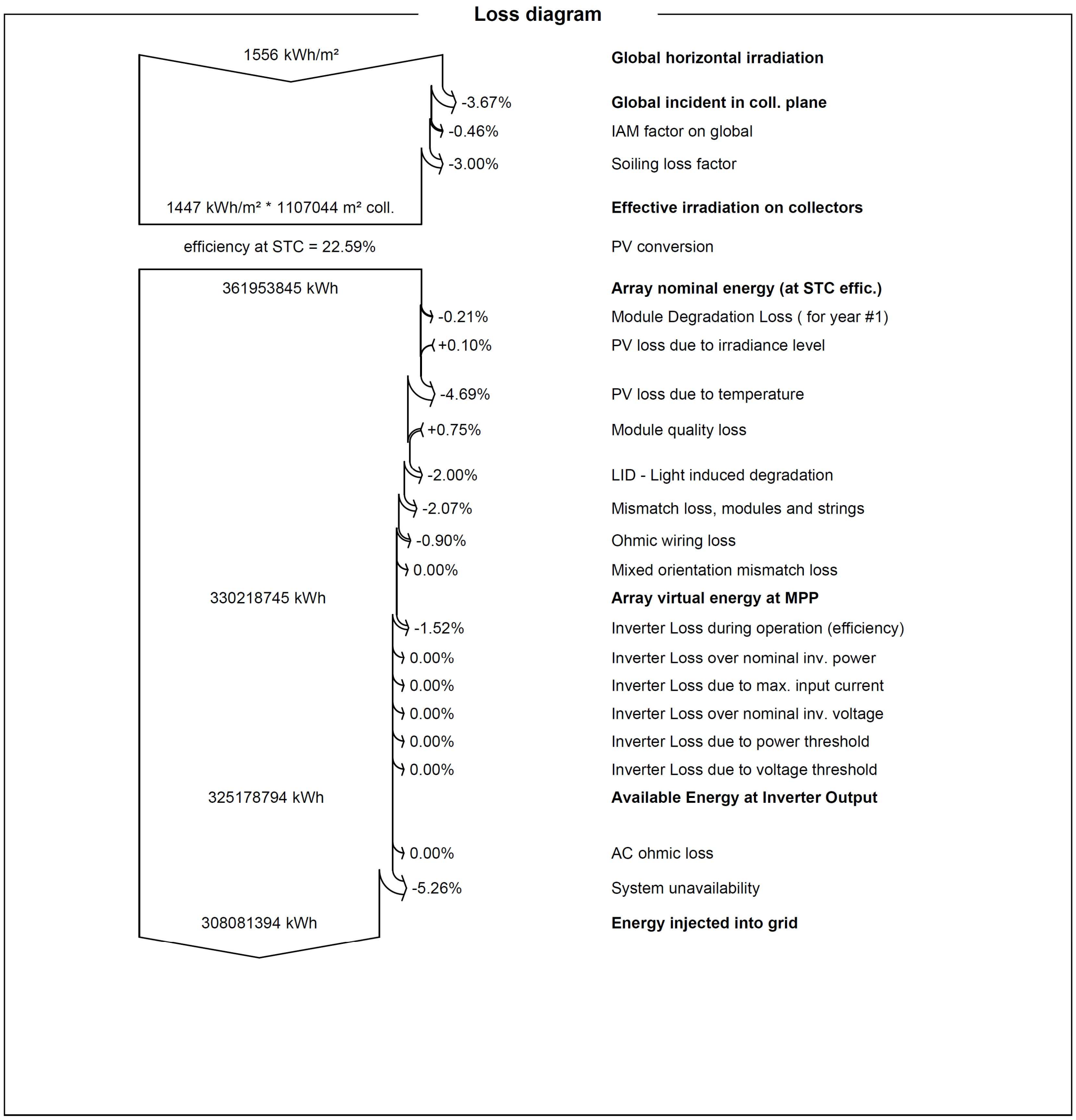

Figure 9 Loss diagram for fixed axis grid tie solar tracking system

4. Cost-Benefit Analysis

Energy Generation: The project is designed to generate a substantial amount of electricity over 25 years, with a total expected generation of 16.8 billion kWh annually.
Financial Overview: Based on a rate of 9.36 BDT per unit, the project will generate significant annual revenue, with slight variations across different years. The project includes detailed cost considerations such as annual installment payments, operation and maintenance costs, and service charges over the project's 25-year lifespan. The net profit for each year is calculated by subtracting the combined costs of installments and maintenance from the total revenue. The profitability increases over time, leading to a cumulative net profit across the 25 years. The analysis shows a detailed breakdown of when the initial investment will be recovered, with ongoing profits expected after this period.
Cost-Benefit Analysis: The comparison of the cost per unit of solar energy with the current electricity rates (both peak and off-peak) shows that the solar project is economically viable, providing a cheaper alternative to conventional energy sources. The project also highlights the environmental benefits, particularly in terms of reduced CO2 emissions, which are significant over the project duration.
Investment and Loan Structure: The paper details the loan amount, interest rate, and repayment structure, which is critical for understanding the financial feasibility and sustainability of the project.
Operational Considerations: The document outlines the expected operational efficiency, including inverter replacement costs and service charges that will be incurred over the 25-year period.

In summary, the findings suggest that the Hatikumrul Solar Project is not only financially viable but also environmentally beneficial, with a positive impact on reducing carbon emissions while providing a cost-effective energy solution over the long term (Figure 11).

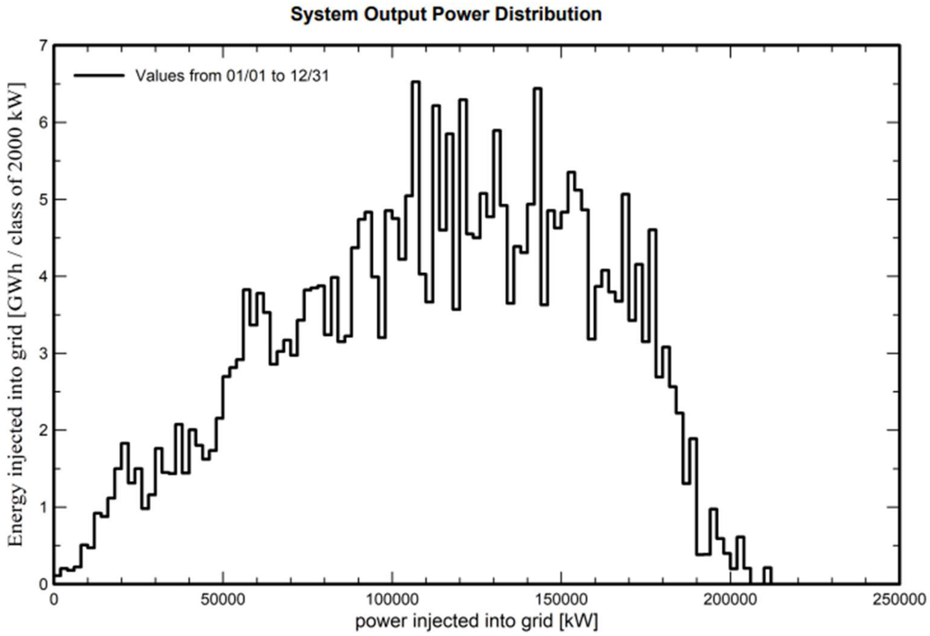

Figure 10 System Output Power Distribution for Proposed Solar Power System. The x-axis shows the power injected into the grid in kW, while the yaxis displays the energy injected into the grid in MWh per class of 2000 kW.

5. Discussion:

The results of this analysis emphasize the substantial potential of utilizing unused road corridors for solar energy generation in Bangladesh, particularly in the context of the SASEC Road Connectivity Project-2. This innovative approach not only addresses the urgent need for renewable energy sources but also provides a sustainable solution to the land scarcity challenges that the country is currently facing. The transport sector is a significant contributor to greenhouse gas emissions, and the integration of solar energy into this sector can be instrumental in de-carbonization efforts. By utilizing solar power along roadways, we can decrease our dependence on fossil fuels for electricity generation, thereby reducing overall emissions. The proposed solar installations are expected to generate 250 MW, which could make a substantial contribution to Bangladesh's renewable energy targets of 15% by 2030 and 40% by 2041. This is consistent with the global trend toward sustainable energy and underscores the significance of innovative land-use strategies. This undertaking has significant economic implications. The creation of employment opportunities in the installation, maintenance, and operation of solar facilities can stimulate local economies through the development of solar energy initiatives in road corridors. Furthermore, the government and local communities are presented with new revenue streams by the potential for generating renewable energy credits. The analysis of the repayment period and return on investment suggests that these projects are not only financially viable but also environmentally beneficial, which makes them appealing to both investors and policymakers. For the successful implementation of solar energy projects along road corridors, it is imperative to resolve a number of challenges, despite the promising prospects. The preliminary screening process identified the necessity for sufficient infrastructure to support solar installations, safety concerns, and potential conflicts with existing land uses. In order to resolve these challenges, policymakers must establish frameworks that facilitate the integration of solar technologies into transportation infrastructure. Additionally, valuable insights into the most effective methods for incorporating solar canopies over highways can be gained from the successful implementations in countries such as the Netherlands and South Korea. These models can serve as a blueprint for the implementation of comparable initiatives in Bangladesh, guaranteeing that the projects are both sustainable and effective. Bangladesh is presented with a transformative opportunity by the potential to harness solar energy in unused road corridors. This strategy has the potential to establish a more resilient and environmentally friendly future by sustainably addressing energy demands, promoting economic development, and contributing to environmental objectives.

250.8 MWp Solar project Cost Benefit Analysis Report for 25 Years(Solar Panel Life Time-30 Years)

Date: 15-08-2024

Project Name	Hatikumrul Interchange Project (SASEC-2, 190.4 KM)
Address	Sirajgonj
Existing Electricity Rate	Pick Rate/Unit-12.37TK and Off-pick Rate/Unit-8.91TK-Ref.: REB Electricity Rate (without VAT)
Project Type	Grid Connected
Project Value (BDT)	16,800,000,000
Project Capacity(kWp)	250878

PROJECT SUMMERY	
Generation(kWh) Per kWp/day = G	**3.4**
Loan amount of project value for 242MWp = C	**16,800,000,000**
Inverter Replace = D1	**1,344,000,000.00**
Service Charge for 25 years = D2	**1,512,000,000.00**
Total Investment for 25 years (C+D1+D2) = T	**19,656,000,000.00**
Loan Period (Month) = F	**108**
Monthly Installment (C1+C2)/F = G	**155,555,555.56**
Total Generation (kWh) = A	**7,346,880,929.35**
Existing REB Rate per Unit in Tk = REB Rate	**9.36**
Total Generation Bill-TK(A x REB Rate) = B	**68,766,805,498.74**
Solar Power Unit Cost(T/A) = H	2.68
Net Profit after 25 years(B-T) = E	**49,110,805,498.74**
Net Profit from Each Unit(REB Rate-Solar unit Cost)	6.68
Each Month Power Generation from solar(KWH)	25685516.84
Net Profit Each Month(BDT)	171,696,864.77
Monthly Solar Generation Bill considering REB Rate(BDT)	240416437.58
Monthly Average Net profite After finishing the Bank loan	213,029,872.81
Payback Period(Years)	6.8
CO2 Emmission(Ton)	4845342.91
Total Area(Sft)	**19,243,066**

Years	Generation (kWh per Year)	Generation Bill (9.36TK per Unit)	Installment Amount Each Year (TK)	Operation & Maintenance(Cost)	Savings Each Year(TK) = (B-(C+D)
0	0	-		-	-
1	308226202.02	2,884,997,250.91	1,866,666,666.67	60,480,000.00	957,850,584.24
2	306993297.21	2,873,457,261.90	1,866,666,666.67	60,480,000.00	946,310,595.24
3	305765324.02	2,861,963,432.86	1,866,666,666.67	60,480,000.00	934,816,766.19
4	304542262.7	2,850,515,579.12	1,866,666,666.67	60,480,000.00	923,368,912.46
5	303324093.7	2,839,113,516.81	1,866,666,666.67	60,480,000.00	911,966,850.14
6	302110797.3	2,827,757,062.74	1,866,666,666.67	60,480,000.00	900,610,396.07
7	300902354.1	2,816,446,034.49	1,866,666,666.67	60,480,000.00	889,299,367.82
8	299698744.7	2,805,180,250.35	1,866,666,666.67	60,480,000.00	878,033,583.69
9	298499949.7	2,793,959,529.35	1,866,666,666.67	60,480,000.00	866,812,862.68
10	297305949.9	2,782,783,691.23		1,404,480,000.00	1,378,303,691.23
11	296116726.1	2,771,652,556.47		60,480,000.00	2,711,172,556.47
12	294932259.2	2,760,565,946.24		60,480,000.00	2,700,085,946.24
13	293752530.2	2,749,523,682.46		60,480,000.00	2,689,043,682.46
14	292577520.06	2,738,525,587.73		60,480,000.00	2,678,045,587.73
15	291407210	2,727,571,485.38		60,480,000.00	2,667,091,485.38
16	290241581.1	2,716,661,199.44		60,480,000.00	2,656,181,199.44
17	289080614.8	2,705,794,554.64		60,480,000.00	2,645,314,554.64
18	287924292.4	2,694,971,376.42		60,480,000.00	2,634,491,376.42
19	286772595.2	2,684,191,490.91		60,480,000.00	2,623,711,490.91
20	285625504.8	2,673,454,724.95		60,480,000.00	2,612,974,724.95
21	284483002.8	2,662,760,906.05		60,480,000.00	2,602,280,906.05
22	283345070.8	2,652,109,862.43		60,480,000.00	2,591,629,862.43
23	282211690.5	2,641,501,422.98		60,480,000.00	2,581,021,422.98
24	281082843.7	2,630,935,417.28		60,480,000.00	2,570,455,417.28
25	279958512.4	2,620,411,675.61		60,480,000.00	2,559,931,675.61
	7346880929	**68,766,805,498.74**	**16,800,000,000.00**	**2,856,000,000.00**	**49,110,805,498.74**
	A	**B**	**C1 + C2 = C**	**D1 + D2 = D**	**Net Profit = E**

Figure 11 Financial and Environmental Impact Analysis of the 250MW Hatikumrul Solar Project: A 25-Year Cost-Benefit Assessment

6. Conclusion:

To conclude, this research underscores Bangladesh's significant potential to harness solar energy by repurposing unused road corridors, addressing the critical challenge of land scarcity while advancing the nation's renewable energy goals. The SASEC Road Connectivity Project-2 alone demonstrates this potential, with the capability to generate 250 MW of electricity from 495.9 acres of underutilized land. This approach not only minimizes land-use conflicts associated with traditional solar installations but also enhances energy security and creates new economic opportunities. The feasibility of such initiatives is validated by successful examples from the Netherlands and South Korea, where similar strategies have been effectively implemented. To realize this potential, it is crucial for policymakers to establish supportive frameworks that facilitate the installation of solar panels along roadways. Such frameworks should be designed to ensure compliance with relevant guidelines, prioritize sites with optimal solar exposure, and consider the current and future uses of the right-of-way. By adopting these strategies, Bangladesh can take significant strides toward achieving its ambitious renewable energy targets, contributing to a more sustainable and resilient energy future.

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