Manuscript Title: *Landfalling Tropical Cyclones Significantly Reduce Bangladesh's Energy Security*

Summary of the Manuscript

This manuscript examines the impact of landfalling tropical cyclones on Bangladesh's energy security, using a combination of daily metered electricity demand data for Bangladesh's nine power zones with meteorological and hazard datasets. The authors argue that landfalling tropical cyclones cause an average 20% reduction in national electricity supply, with coastal zones disproportion affected, experiencing drops of up to 38%. Finally, authors highlight the need for continued investment in climate-resilient energy infrastructure in the region, as well as adaptation to such extremes, which are projected to become more severe with climate change. The topic is timely, policy-relevant, and empirically important. The paper makes a valuable contribution to understanding the climate–energy nexus in a highly vulnerable country. It addresses a critical gap — the intersection of DRR and energy security — particularly within the West Bengal and Bangladesh context. However, the manuscript requires substantial clarification, data transparency, and necessary refinement to reach publishable standard. The argument is compelling, but methodological rigor and framing could be improved to meet international expectations.

We thank the reviewer for their positive assessment of our manuscript. We respond to their concerns in red, point-by-point below. Changes to the manuscript are marked in blue.

Major comments

- The concept of "energy security" is not clearly defined in introduction section.

We agree, we now explain it explicitly in the introduction:

"In Bangladesh, these storms strike an electricity grid (Fig. 1) that, while rapidly expanding, remains structurally fragile (World Bank, 2021, 2024), impacting its energy security. Here, energy security is used in the specific sense of security of electricity supply, i.e., the ability of the power system to deliver electricity to consumers when needed, including during short35 lived extreme events (International Energy Agency)."

We have also added text to the beginning of the methods section to contextualise the datasets we use:

"Because our focus is on operational disruption during cyclones (hours to days), we emphasise the availability and reliability components of energy security and treat daily demand met and its shortfalls as a proxy for these supply-security impacts, rather than attempting to quantify affordability or long-term adequacy (consistent with The World Bank Group, 2005)."

- Authors should clarify how cyclone impacts are mapped onto diverse dimensions.

We agree that energy security has multiple dimensions. We have clarified this by adding a short paragraph to the end of our introduction, explaining how the various components of energy security are investigated:

"Energy security is multi-dimensional and can be framed in terms of availability, affordability, accessibility and acceptability, or more generally as the vulnerability of energy systems to disruption. In this study, we present an initial investigation into these questions by combining metered demand data across the nine power-planning zones of Bangladesh with data on landfalling tropical cyclones and depressions over the last decade.

We focus on short-term electricity supply security during extreme events: (i) availability, quantified using observed shortfalls in daily demand met; (ii) reliability and resilience, quantified using the frequency, magnitude and recovery time of these shortfalls; and (iii) interdependence, assessed via the co-occurrence of deep dips in Bangladesh and West Bengal that sets the value of cross-border imports during cyclones. We do not attempt to quantify affordability or long-run adequacy."

- The introduction overlooks key comparative studies: for example, Southeast Asian energy systems and Bangladesh's coastal energy vulnerability. How this study can contribute to the existing literature?

We agree, and have added one new paragraph in the introduction explaining previous work on Southeast Asian energy systems and their response to hazardous weather; and one on the vulnerability of coastal Bangladesh:

"Recent work has quantified how extreme weather can negatively affect electricity systems across tropical coastal Asia. For Southeaast Asia, the International Energy Agency has stated that increasingly intense tropical cyclones, flooding and sea-level rise are growing threats to energy infrastructure and reliability, and urge the need for climate-aware planning (International Energy Agency, 2024). Prior estimates of cyclone-driven risks to power-grid assets across East and Southeast Asia average about 0.07% of GDP across the region and are substantially higher in some countries (0.20% in Japan; 0.17% in Laos) (Ye et al., 2024). Night-time lights have also been used to explore disruption and recovery after hazards across South and Southeast Asian countries, although reliability is limited by noise and cloud cover (Skoufias et al., 2021).

"For Bangladesh, previous studies have quantified extreme exposure to cyclonic storm surge and coastal flooding in the Ganges–Brahmaputra–Meghna delta. For example, Bernard et al. (2022) found 1-in-50-year cyclone-surge inundation heights reached ~8 m above mean sea level near the Ganges–Meghna junction, with widespread exposure of coastal islands. Recent work has further shown shows that climate hazards threaten infrastructure service delivery in coastal Bangladesh. Using a dataset of 8.2 million households, Adshead et al. (2024) estimated that, for a baseline 1-in-50-year hazard, cyclonic winds could disrupt ~94.5% of the coastal population (across essential services on average), compared with ~39.5% for coastal flooding (including storm surge) and ~22.7% for riverine flooding, with the poorest disproportionately threatened in 69% of coastal subdistricts"

- In method part, causal relationship using robust statistics is missing. I suggest to specify whether regression, correlation, or event-based impact assessment.

We agree and have clarified our approach in the revised methods section:

"Our primary methods are event-based impact assessment and compositing conditional on event types. We compute demand-met anomalies relative to a centred running-mean baseline and then analyse these anomalies around independently dated landfall events (tropical cyclones and depressions) to estimate the mean/median day-0 impact and recovery trajectory."

We have also added confidence intervals to our composite impact values:

"Using bootstrapping, the 95% confidence intervals are, for tropical cyclones [−32.0% 235 to −8.7%] and for depressions [−15.6% to −2.2%]."

We have also conducted some simple regression analysis for cyclone intensity and demand met:

"We also tested whether cyclone intensity is a useful predictor of day-0 electricity supply change. For each named tropical cyclone (Table 1), we used the IMD-reported storm class at landfall as a proxy for intensity and computed the total national day-0 demand-met deficit (again relative to the 60-day running mean). Over these 14 cyclones, deficits range from 0–69%. There is no statistically significant relationship between cyclone class and the magnitude of the day-0 deficit (Pearson $r = -0.21$, $p = 0.48$; Spearman $\rho = -0.11$, $p = 0.70$), implying that intensity class alone cannot explain the event-to-event variation in demand loss. This is consistent with the expectation that outages also depend on landfall location relative to exposed coastal infrastructure, storm size, translation speed, storm surge magnitude and location, and rainfall magnitude and location."

- I also found some missing details about data sources, for example, Cyclone dataset (JTWC, IMD, or BMD?); Energy data (BPDB, WAPDA, or open-source?); Time resolution (monthly, daily, event-based?

Our energy data sources and resolutions are already stated in Sec 2.1.1 (BPDB for Bangladesh) and Sec 2.1.2 (Grid-India for West Bengal) respectively. Both are daily.

We also already state the source of cyclone data in Section 2.3.3: "The Emergency Events Database (e.g., Delforge et al., 2025) maintained by the Centre for Research on the Epidemiology of Disasters provides a homogenised catalogue of natural hazards and their reported impacts. We queried EM-DAT for the period December 2015–May 2025 and retained all events whose affected country list contains Bangladesh. We then subset to hydrometeorological classes potentially relevant to the power system: lightning, floods, coldwaves, heatwaves, and wildfires. For tropical cyclones and depressions, we additionally verified the reported event dates against the India Meteorological Department (IMD) Regional Specialized Meteorological Centre metadata (https://rsmcnewdelhi.imd.gov.in/report.php?internal_menu=MzM=) to ensure that the disturbance made landfall over, or had a clearly documented direct impact on, Bangladesh."

No changes have been made here.

- I suggest that spatial analysis (GIS or remote sensing) could greatly strengthen the results.

We agree that further spatial analysis would strengthen our results and add further insight into hazard footprints and heterogeneous infrastructure impacts. However, the aim of this paper is to be an empirical quantification of impacts on delivered electricity across each zone and we therefore focus on event-based frameworks. As part of this, we do already include some spatial analysis: (i) maps of Bangladesh's power zones and electricity infrastructure and (ii) meteorological composites for a set of case studies. No change has been made here.

- The conclusion is currently descriptive and too much.

We have now split this into a separate discussion and conclusions section, such that the latter can be properly devoted to summarising the paper, leaving the former to contextualise our results.

- In the discussion section, this study lacks scholarly discussion for example, how landfalling tropical cyclones significantly impacted Bangladesh's energy security

We think the reviewer is referring to our conclusions section (as our original submission did not have a discussion section). Therein, we explicitly stated: "Using almost a decade of daily, zone-resolved metered demand data, we have shown that landfalling tropical cyclones systematically and severely depress Bangladesh's demand met. On the day of landfall, national demand met falls by an average of ~20%, with coastal zones bearing the brunt (mean deficits up to 38%). The most extreme event in our record, Cyclone Remal (28 May 2024), reduced national demand met to 4253 MW—a 67% drop relative to the previous day and 71% relative to two days prior. Landfalling depressions are less destructive in aggregate, but still material: they reduce national demand met by about 8% on average on the day of landfall. We also identified a large class of short, sharp "dip" days unrelated to TCs or depressions that produce even larger composite deficits (28% on day 0). These dip days are too frequent and too deep to be explained by the weekly cycle (Bangladesh's Friday minimum is only ~6% below the weekly mean) or public holidays (average ~5.5% reduction), implying a mixture of other weather hazards, prolonged flood-driven constraints, operational curtailment, and grid-internal issues"

It is not clear what else the reviewer would like us to add.

- What is the key message for reader? Authors should connect findings to SDG 7 (Affordable and Clean Energy) and SDG 13 (Climate Action).

In our revised discussion, we now include the following subsection explicitly linking our results to these two SDGs:

"Our key result is that Bangladesh's power system is already experiencing cyclone-driven supply shocks large enough to measurably undermine short-term electricity security, and that such events disproportionately impact coastal zones while also limiting the utility of cross-border imports through correlated regional hazards. This means that continued expansion of capacity is necessary but not sufficient. Instead, ensuring that electricity is reliably delivered during extremes must be the highest priority.

This relates to both SDG 7 (Affordable and Clean Energy) and SDG 13 (Climate Action). SDG 7 is typically discussed in terms of expanding access and adequacy, but here we demonstrate the importance of the reliability of modern energy services during disasters, since large, multi-day supply shortfalls can disrupt health care, water supply, communications, education, and livelihoods even in places that nominally have grid access.

SDG 13 focuses on adaptation and resilience. Cyclone-driven electricity disruptions of the magnitude we document here are clearly an immediate adaptation challenge for the energy sector. Resilience is a requirement for maintaining essential services during climate-related hazards and for preventing repeated disaster-driven setbacks."

Minor Comments

1. Authors clarify units for energy loss (MW vs. MWh).

We now use MW throughout.

2. I suggest to provide cyclone names and years in a new Table for reader clarity.

We agree, and have added the following table covering each of the cyclones along with their impacts to our revised manuscript:

Cyclone	Landfall (date)	IMD category	Deaths	Damage (US$ 1 million)	Max wind speed (knots)	Min pressure (hPa)	National dip (%, max)	(date)	Zone dip (%, max)	Worst_zone (zone)	Storm surge (m, max)
Roanu	21/05/2016	CS	28	600	60	978	-22.3	21/05/2016	-73.8	Comilla	6.40
Maarutha	17/04/2017	CS			50	985	-33.4	19/04/2017	-87.9	Comilla	2.52
Mora	29/05/2017	SCS	7		80	963	-3.3	31/05/2017	-34.5	Chittagong	4.69
Titli	11/10/2018	VSCS			105	944	-21.0	12/10/2018	-30.3	Sylhet	3.08
Fani	04/05/2019	ESCS	39		150	900	-31.8	03/05/2019	-78.4	Barisal	6.47
Bulbul	09/11/2019	VSCS	40	5.8	75	976	-33.0	10/11/2019	-97.1	Barisal	5.41
Amphan	20/05/2020	SCS	26	1500	145	901	-33.5	20/05/2020	-96.1	Barisal	9.51
Yaas	26/05/2021	VSCS	3		75	970	-3.3	26/05/2021	-41.6	Barisal	8.72
Jawad	06/12/2021	CS			40	1000	-8.0	06/12/2021	-14.8	Comilla	1.90
Sitrang	24/10/2022	CS	35		45	994	-53.3	24/10/2022	-91.4	Barisal	5.36
Mocha	14/05/2023	ESCS	3	1	145	908	-11.1	16/05/2023	-56.2	Khulna	7.10
Hamoon	24/10/2023	VSCS	3	250	90	970	-10.2	24/10/2023	-40.3	Chittagong	3.42
Midhili	17/11/2023	SCS			50	995	-37.9	17/11/2023	-89.6	Comilla	3.87
Remal	28/05/2024	SCS	16	90.7	60	977	-69.4	28/05/2024	-95.1	Mymensingh	7.06

Table 1. Summary of landfalling tropical cyclone impacts over Bangladesh (2016–2024). Landfall dates and IMD categories are from the IMD/RSMC catalogue. Deaths and damages (US$ million) are from EM-DAT where available. Maximum wind speed and minimum central pressure are taken from IBTrACS best-track data. National and zonal electricity dips are the most negative percentage anomalies in demand met relative to a centred 60-day running-mean baseline, evaluated within ± 2 days of landfall. 'Worst zone' indicates the power-planning zone with the largest dip. Storm surge is taken as the maximum ERA5 significant wave height (combined wind waves and swell) within a coastal box (89–92°E, 20.5–23°N) in a -3 to $+5$ day window around landfall.

3. Authors should improve figure readability (especially cyclone track map).

We have added latitude and longitude markers to Figure 6, and added cyclone tracks to the precipitation/wind maps. The revised figure is shown below:

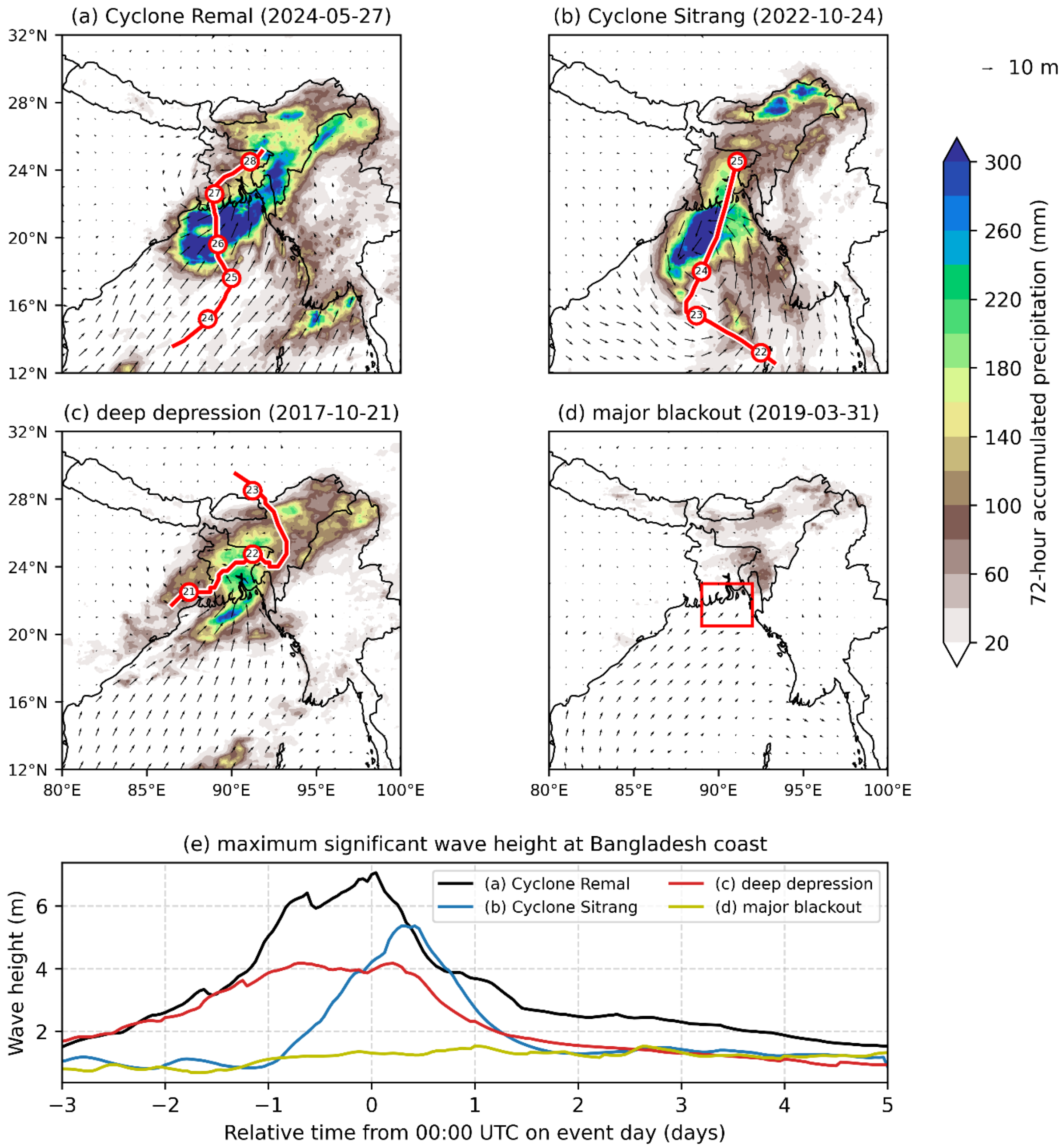

Figure 6. Composite weather maps, showing instantaneous 00UTC 10-m winds (vectors) and 72-hour precipitation (accumulated from 00UTC the day before to 00UTC two days later; filled contours) for four case studies: (a) Cyclone Remal, (b) Cyclone Sitrang, (c) a landfalling deep depression, and (d) a major blackout not related to weather. Tracks for the two cyclones and deep depression are given in red, with the location at each 00Z marked. (e) shows the maximum hourly significant wave height in ERA5, relative to the event day, in a box surrounding the Bangladeshi coast (89°--92°E, 20.5°--23.0°N; marked in red in (d)) as a proxy for storm surge strength.