UNIVERSITY of WASHINGTON

The Climate-Energy Nexus: Assessing Power Quality & Reliability and Climate Vulnerability Hotspots in Accra.

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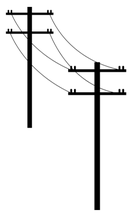
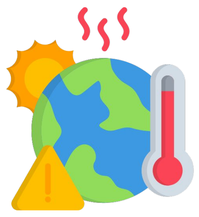
Background



In 2021, the utility in Ghana experienced **29.84%** distribution losses and the average customer had **27 interruptions**, more than **4 times** regulatory benchmark.



In February 2024, Accra experienced its hottest day ever: **38°C/100°F**. Recent **upward trend** in temperature levels.

Rapid urbanization has led to an increase in disadvantaged population residing in informal and overcrowded settlements, where they have limited capacity to **adapt to the harmful effects of extreme weather**.

Study Area

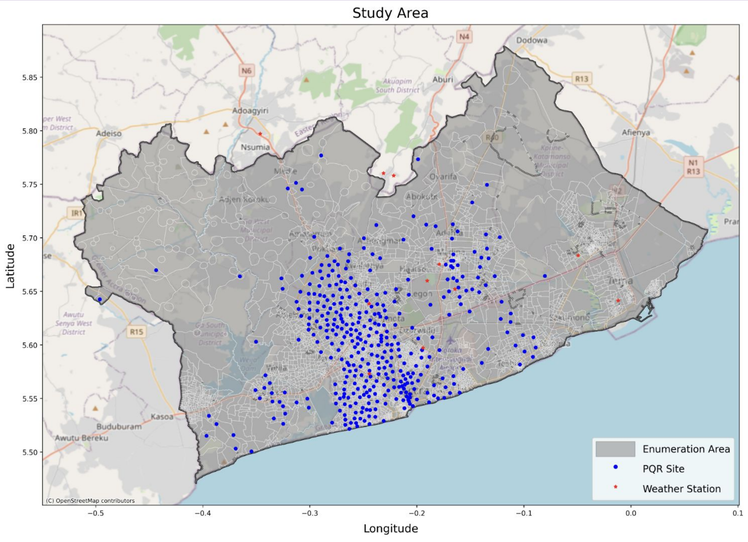
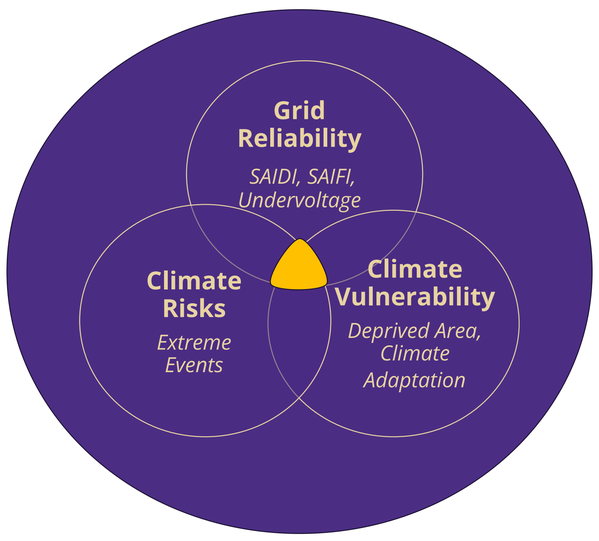


Figure 1: Spatial plot showing the Enumeration Area (EA) boundaries, Weather Stations (11) and sites (376). A site represents a collection of 2 or 3 PowerWatch sensors powered by a common Low Voltage Distribution Transformer. Study Period (2019 to 2024) - Greater Accra, Ghana.

Motivation



Research Objectives

1. To analyze the spatio-temporal correlation between extreme weather events and power quality & reliability in Accra through a longitudinal study.
2. To identify climate & grid vulnerable hotspots to inform targeted and equitable resilience planning.

Methods

Figure 2: The PowerWatch sensor plugs into a customer's electrical outlet and measures power quality & reliability data every 2 minutes.

Climate Vulnerability Indicators

Indicator Category	Components
Climate Exposure	• Extreme Temperatures • Flood Risk • Air Quality
Climate Sensitivity	• Informality
Climate Adaptive Capacity	• Access to Health Facility
Power Quality & Reliability	• Outage Duration • Outage Frequency • Under Voltages

Preliminary Results

Figure 3: Map of Total Power Outage Duration over the study period & Climate Vulnerability Index (CVI) across EAs. CVI comprises climate exposure, sensitivity and adaptive capacity components. Least impacted areas are shown in white and the most affected areas in dark brown.

Total Customer Hours without power ranged from 300 to as high as 5,800 hours.
For context, average total customer outage duration in the US over the same period was about 40 hours.

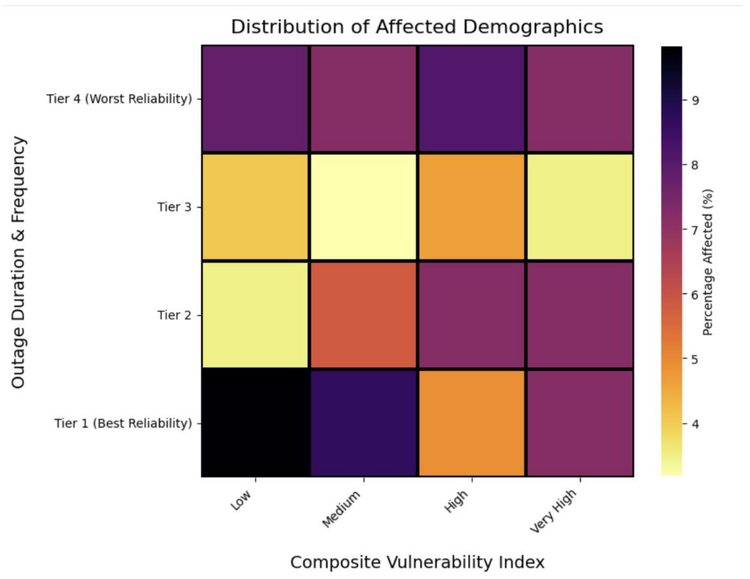


Figure 4: Percentage of Enumeration Areas a function of combined outage duration & frequency and Composite Vulnerability Index during the study period.

10% of all EAs, which are the least vulnerable, experience the highest power reliability, while about 7% of all EAs, which are the most vulnerable, have the worst reliability. The lack of a clear pattern could suggest a generally weak grid.

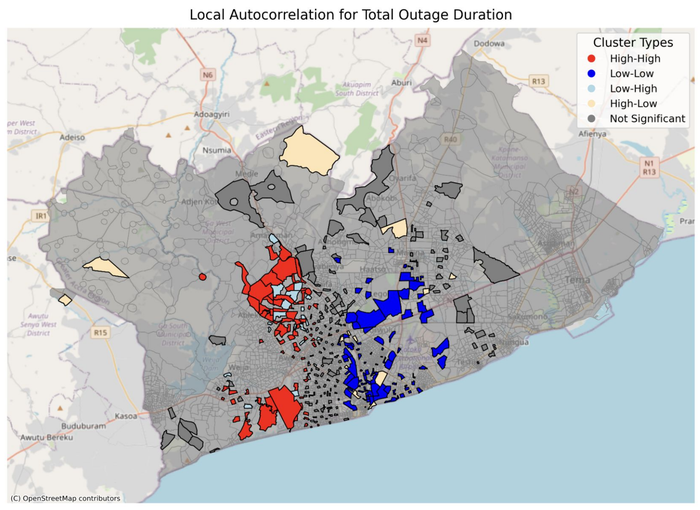


Figure 5: Plot showing clustering of Enumeration Areas by total power outage duration during the study period. For instance, High-High clusters are areas that have relatively high outage duration and are surrounded by other high outage duration areas.

78 Enumeration Areas, accounting for 37% of significant clusters, are identified as hotspot areas—regions experiencing high outage durations surrounded by similarly high-outage areas.

Future Work

Conducting a temporal analysis and studying possible trends and seasonality of power outages and frequency.

Investigating correlations between power outages/poor quality periods and extreme weather events.