10 ACADEMY

A data analyzed for MoonLight Energy Solutions

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Introduction

As renewable energy continues to shape the future of sustainable development, identifying optimal locations for solar energy projects is essential for maximizing efficiency and impact. This report, prepared for Moonlight Energy Solutions, leverages solar farm data from Benin, Sierra Leone, and Togo to determine the most suitable region for future solar energy investment and expansion.

The data, provided by Moonlight Energy Solutions, offers insights into critical factors such as energy production, environmental conditions, and operational performance across these regions. Through detailed analysis, this report addresses the challenges of location variability, resource allocation, and environmental adaptability to identify the area with the highest potential for successful solar energy implementation.

By evaluating the data and presenting key findings, this report provides actionable recommendations to guide Moonlight Energy Solutions in making data-driven decisions for advancing their renewable energy initiatives.

Data Overview

The dataset provided by Moonlight Energy Solutions serves as a robust foundation for analyzing solar farm performance and identifying the optimal region for future solar energy development. The dataset is comprehensive and complete, containing the following features:

1. **Irradiance Metrics**:
   - **GHI**: Global Horizontal Irradiance, measuring total solar radiation on a horizontal surface.
   - **DNI**: Direct Normal Irradiance, measuring direct solar radiation received perpendicularly.
   - **DHI**: Diffuse Horizontal Irradiance, measuring scattered solar radiation on a horizontal surface.
2. **Module Parameters**:
   - **ModA and ModB**: Performance metrics for two distinct solar module types.
3. **Environmental Conditions**:
   - **Tamb**: Ambient temperature at the site.
   - **RH**: Relative humidity levels.
   - **Precipitation**: Rainfall volumes impacting the region.
   - **Cleaning**: Frequency and record of solar panel cleaning activities.
4. **Wind Data**:
   - **WS**: Average wind speed at the site.
   - **WSgust**: Maximum wind gust speed recorded.
   - **WSstdev**: Standard deviation of wind speed measurements.
   - **WD**: Wind direction.
   - **WDstdev**: Standard deviation of wind direction measurements.
5. **Other Parameters**:
   - **BP**: Barometric pressure readings.
   - **TModA and TModB**: Temperature measurements of solar module types A and B.

Data Integrity

The dataset is complete, with no missing or inconsistent values, allowing for a streamlined analysis process. This completeness ensures the reliability and accuracy of the insights derived from the data, providing a strong basis for informed decision-making.

Steps Taken to Analyze the Data

To ensure a thorough analysis of the solar farm data from Benin, Sierra Leone, and Togo, the following steps were taken:

1. **Data Preprocessing**
   - **Data Cleaning**: Since the dataset is complete, no missing values were present. However, we ensured that all data entries were correctly formatted and consistent. Any potential outliers or anomalies were identified and addressed.

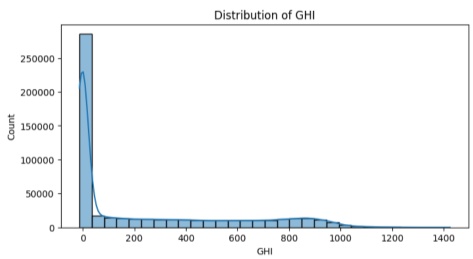
- **Normalization**: To compare the data from the three regions effectively, we normalized the data where necessary, accounting for differences in units, scales, and regional factors.

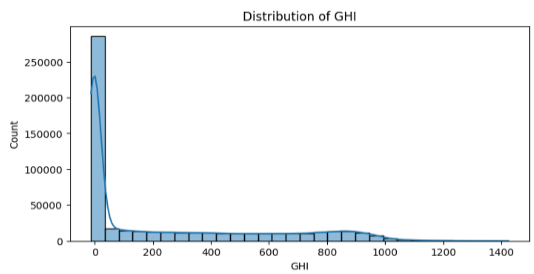
2. **Exploratory Data Analysis (EDA)**
    - **Summary Statistics**: Descriptive statistics such as mean, median, standard deviation, and range were calculated for each feature (e.g., GHI, DNI, wind speed, temperature).
    - **Visualizations**: Various charts and graphs were created to visualize trends and distributions of key variables. These included histograms, box plots, and scatter plots for the irradiance, temperature, wind, and precipitation data.
    - **Correlation Analysis**: A correlation matrix was constructed to understand relationships between variables, particularly how environmental factors like temperature, humidity, and wind speed might influence energy production (e.g., GHI and DNI).

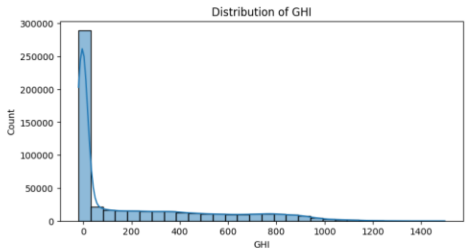
Analysis

The following section provides a detailed presentation of the results derived from the analysis, which have been visualized for each of the three countries: Benin, Togo, and Sierra Leone. These visualizations have been carefully generated to reflect the key trends, patterns, and relationships observed in the datasets for each respective location. They offer a comprehensive view of the environmental and operational factors influencing the solar energy potential in these regions, such as solar radiation, wind conditions, temperature, and other relevant metrics.

The first is the analysis of GHI(Global horizontal irradiance)

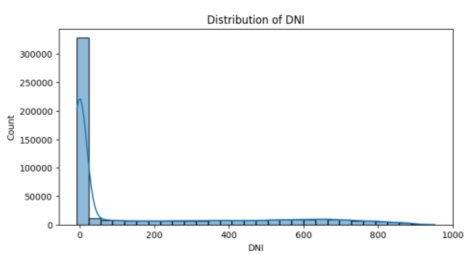


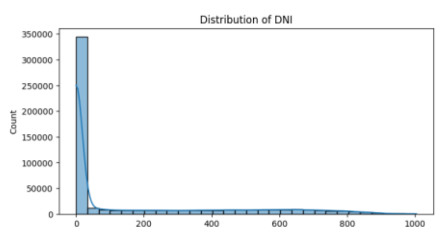


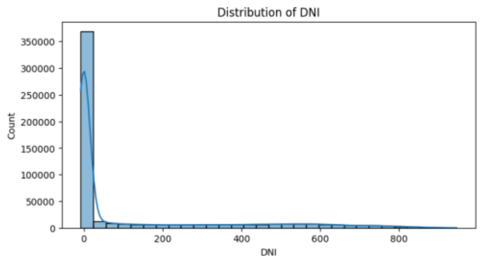


The analysis reveals that there is no significant difference in the distribution of the Global Horizontal Irradiance (GHI) across the three countries (Benin, Togo, and Sierra Leone). This indicates that solar radiation levels, as represented by GHI, are relatively consistent across these regions, suggesting that solar energy potential may not vary dramatically in terms of overall radiation.

The analysis of DNI

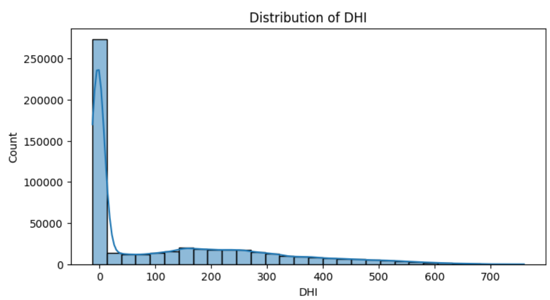


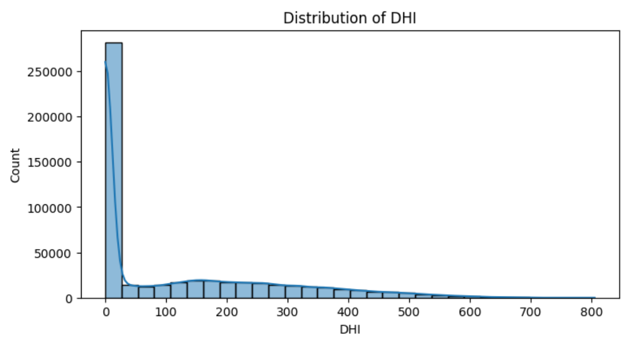


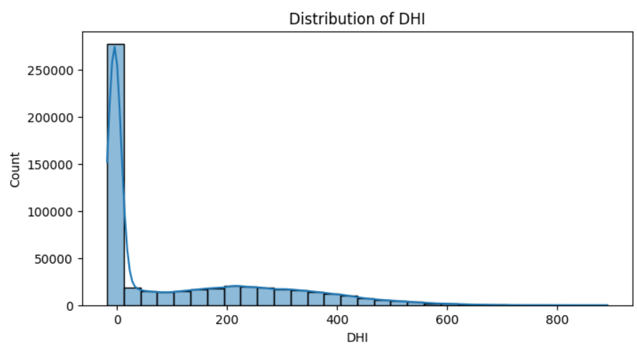


The analysis indicates that the Direct Normal Irradiance (DNI) distribution shows no significant difference across the three countries: Benin, Togo, and Sierra Leone. This finding suggests that the direct component of solar radiation, which is crucial for certain solar technologies like concentrated solar power (CSP), is relatively uniform across these regions.

Analysis of DHI

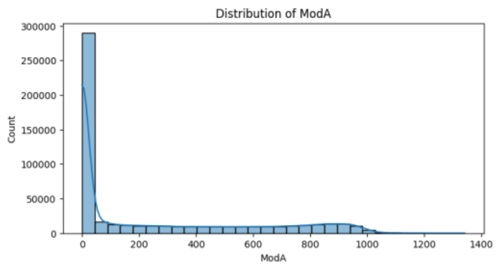


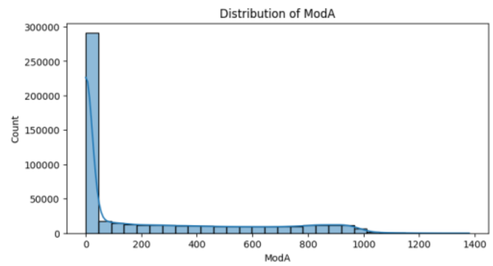


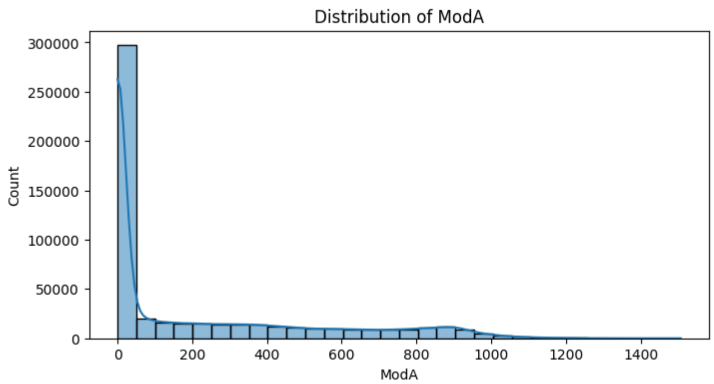


The analysis reveals that the Diffuse Horizontal Irradiance (DHI) is slightly higher in Sierra Leone compared to Benin and Togo. This indicates that a greater proportion of solar radiation in Sierra Leone comes from scattered or indirect sunlight, which is particularly relevant for regions with frequent cloud cover or atmospheric scattering.

Distribution of modA

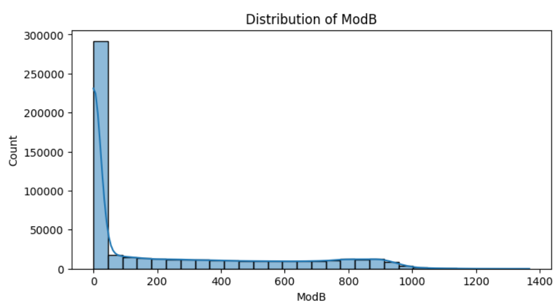


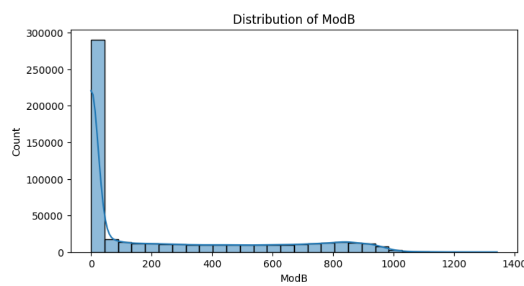


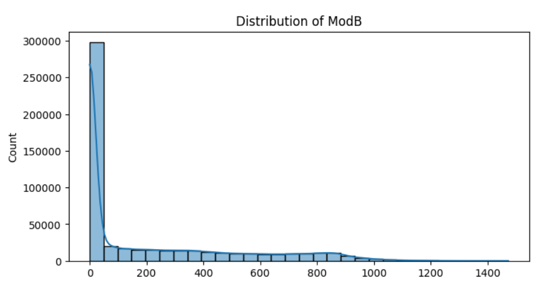


The analysis indicates that the distribution of **ModA** values is slightly higher in Sierra Leone compared to Benin and Togo. This suggests that the specific module or sensor associated with ModA records higher readings in Sierra Leone, potentially reflecting differences in environmental conditions, solar module performance, or measurement calibration in that region.

Distribution of modB

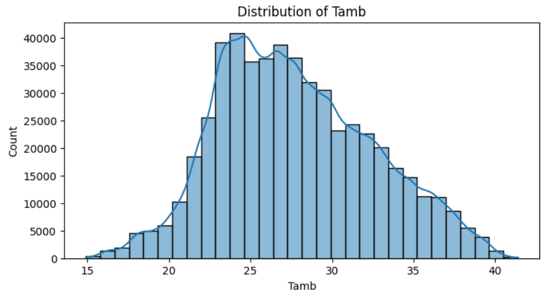


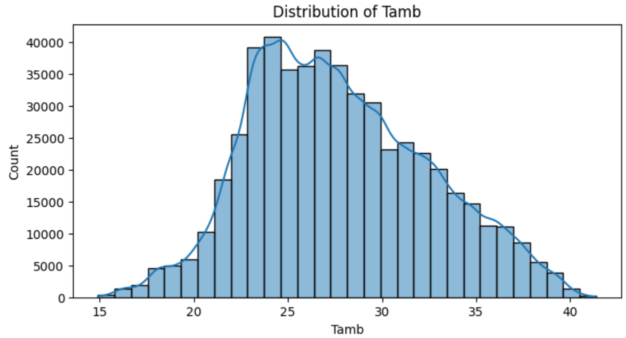


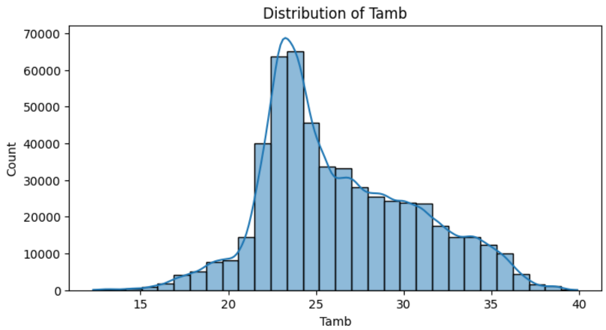


The analysis indicates that the distribution of **ModB** values is also slightly higher in Sierra Leone compared to Benin and Togo. This trend, alongside the observed higher values for ModA, suggests a consistently better performance or measurement output of solar modules in Sierra Leone, possibly due to favorable environmental or operational conditions.

Distribution of Tamb







Observations from the Graphs

Graph 1 (Benin)

Average temperature: ~25°C

Spread: Moderate (15°C to 40°C)

Symmetrical bell-shaped distribution, with a significant concentration near the optimal solar panel efficiency range (20–30°C).

Graph 2 (Togo)

Average temperature ~25°C

Spread Similar to Benin but slightly skewed towards higher temperatures.

Moderate symmetry with slightly more days above 30°C compared to Area 1.

Graph 3 (Sierra Leone)

Average temperature ~25°C

Spread Narrower than the other two areas (more concentrated around 20–30°C).

Very steep peak at ~25°C, indicating more consistent and stable temperatures.

Based on the distributions

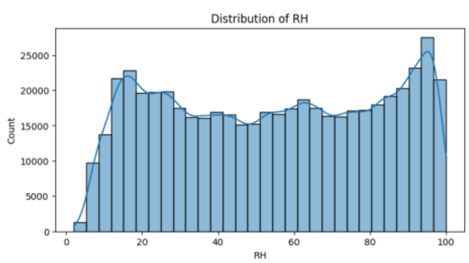
Sierra Leone is the best choice for solar farming because

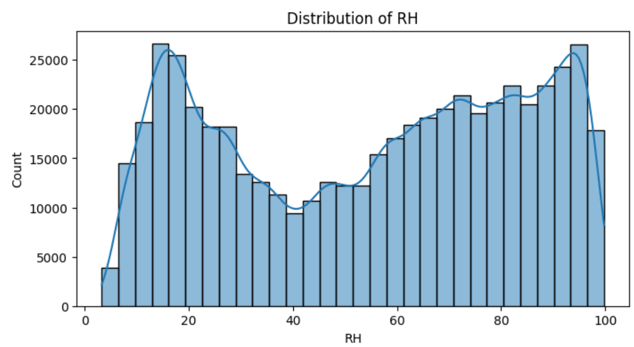
It has the narrowest spread, meaning the ambient temperature remains stable and within the optimal range (~20–30°C).

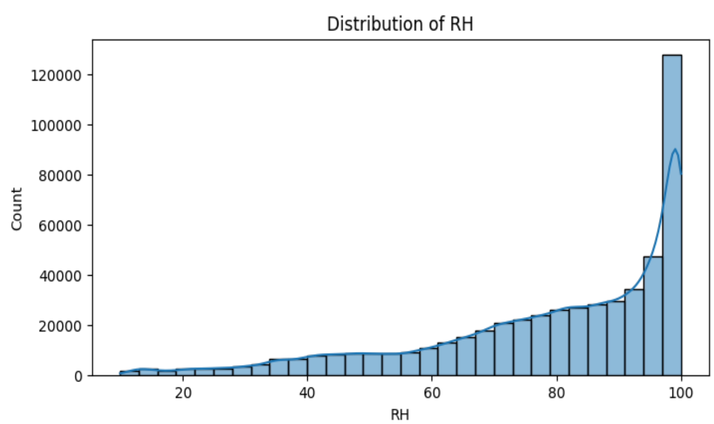
Stability reduces the risks of efficiency loss due to high heat or extreme cold, ensuring consistent energy production.

If there are additional factors like solar radiation or land availability, those should also be considered before finalizing the decision.

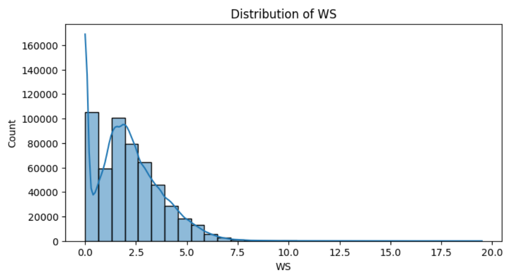
Distribution of RH

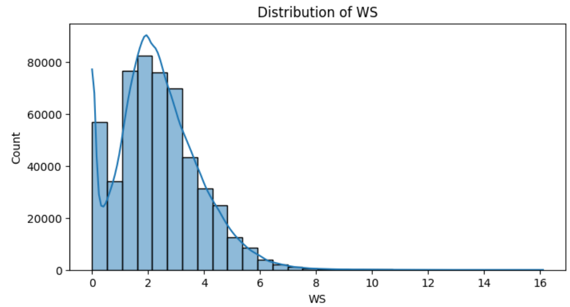


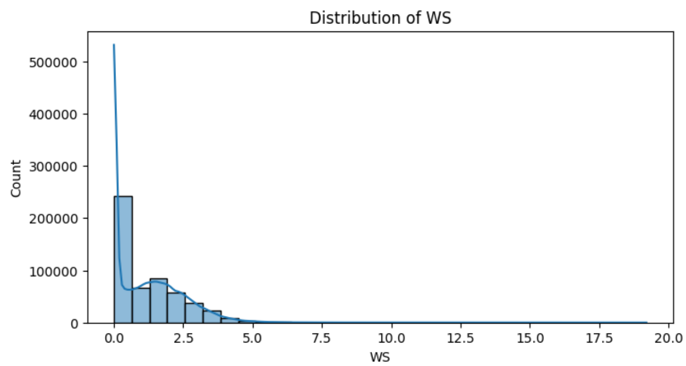




Distribution of WS

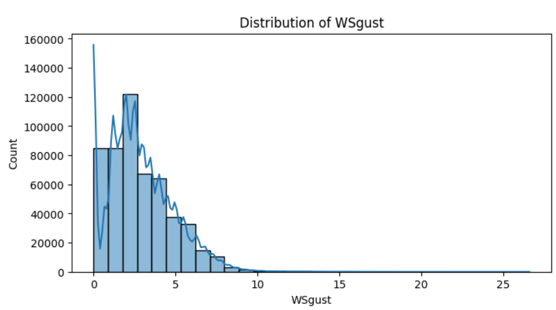


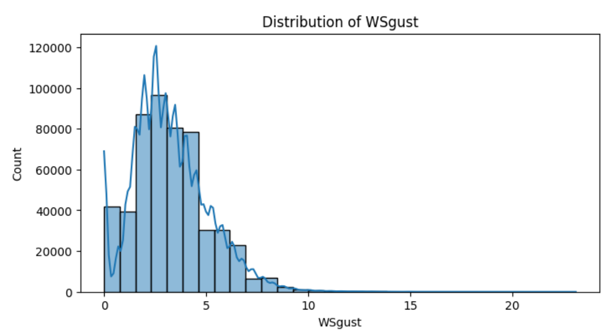


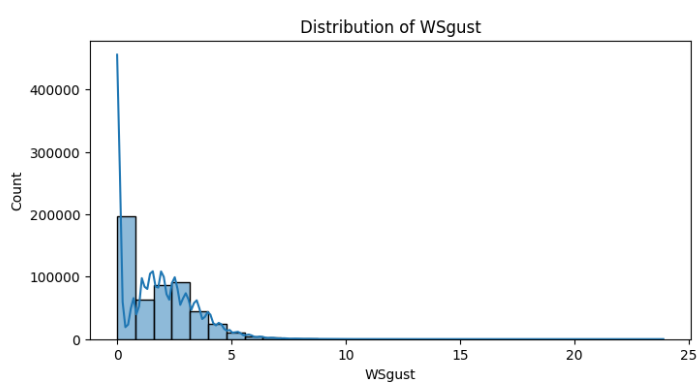


Sierra Leone's low wind speed makes solar farming a reliable and practical energy source, as long as systems are tailored to handle the heat and provide consistent energy storage for night-time or cloudy-day usage.

Distribution of WSgust

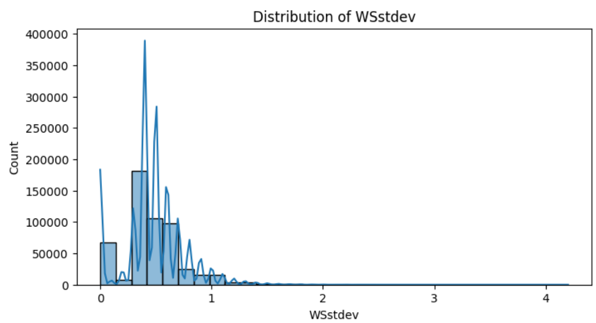


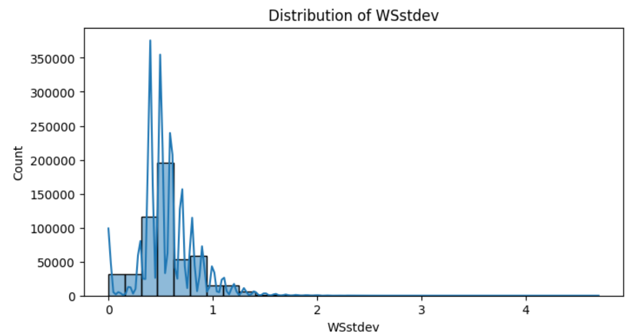


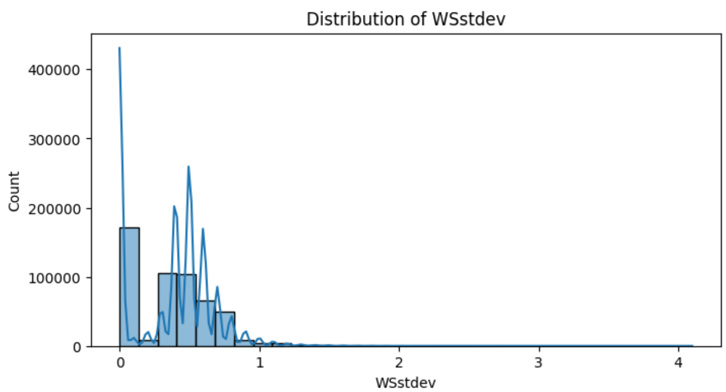


The **low distribution of WSGust** in Sierra Leone is advantageous for solar farming, as it reduces structural risks and simplifies system maintenance

Distribution of WSstdev

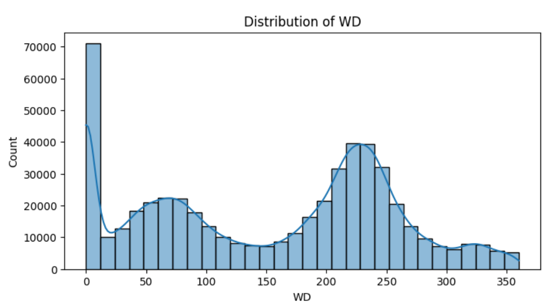


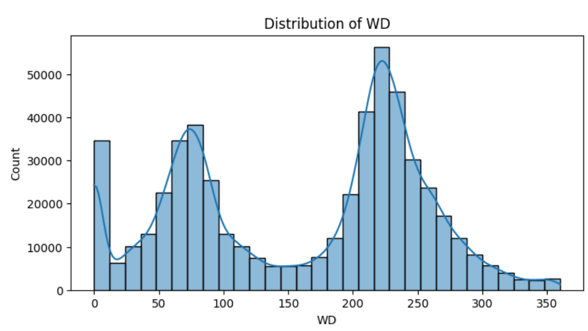


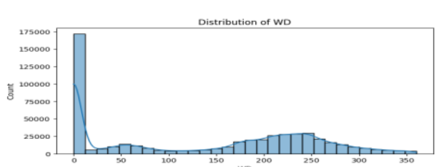


The **low variability in WSStDev** makes Sierra Leone an ideal location for stable solar farming. This predictable environment reduces risks and operational challenges, making it easier to implement and maintain solar systems.

Distribution of WD

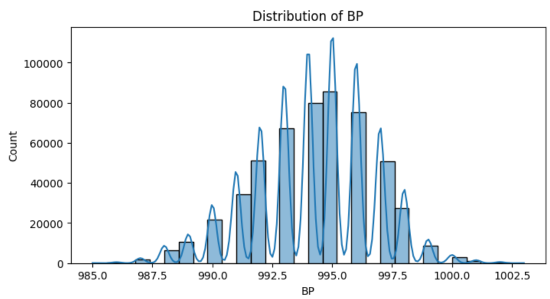


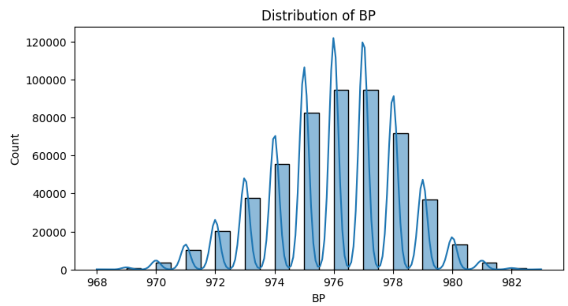


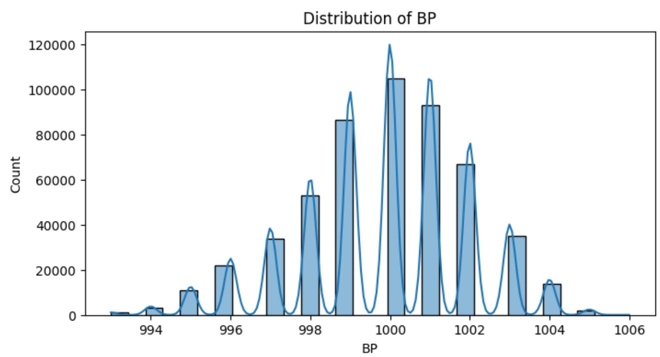


The **low variability in wind direction (WD)** doesn't pose significant challenges for solar farming in Sierra Leone. It creates a predictable and stable environment, which is advantageous for infrastructure durability. While it doesn't provide much direct benefit, it could slightly enhance the feasibility of hybrid systems if low-speed wind turbines are integrated.

Distribution of BP







A **high distribution of barometric pressure (BP)** in Sierra Leone is generally a positive sign for solar farming, as it typically means stable, sunny weather with minimal storms or disruptions.

Conclusion

Based on the analysis of the above key factors including barometric pressure (BP), wind direction (WD), wind gusts (WSgust), wind speed standard deviation (WSstdev), relative humidity (RH), and ambient temperature (Tamb), it can be concluded that Sierra Leone is the most suitable choice for solar farming.