

# **Environmental and Operational Insights from a Pilot Agrivoltaic System in Ghana: A Statistical Analysis**

## **Introduction**

Agrivoltaic systems — integrating photovoltaic (PV) energy generation with crop cultivation — offer a promising strategy for maximizing land use efficiency and promoting renewable energy adoption in agricultural economies. In tropical regions like Ghana, optimizing these dual-use systems requires understanding the environmental and operational factors that affect both solar energy output and crop microclimates.

This project proposes a detailed, descriptive and statistical analysis of the publicly released Agrivoltaic Dataset (Ghana) from the Responsible AI Lab (RAIL), Ghana. The dataset captures environmental variables (irradiation, temperature, relative humidity, soil moisture, and rainfall) across different experimental plots (agrivoltaic fields, control fields, and ground-mounted PV systems). The aim is to derive operational insights into the relationship between PV structures, microclimatic conditions, and weather variability.

## **Project Objectives**

The primary objective of this project is to perform a statistical analysis of environmental data from a pilot agrivoltaic system in Ghana to understand:

- Patterns in solar irradiation and temperature under different PV setups.
- Variations in relative humidity and rainfall across agrivoltaic and control plots.
- The influence of panel-mounted PV structures on local microclimate conditions.
- Temporal patterns in environmental variables across different months of data collection.
- Data-driven operational recommendations for agrivoltaic system optimization in tropical climates.

## **Research Questions**

The analysis will address the following questions:

1. How do solar irradiation and ambient temperatures vary between agrivoltaic plots, control fields, and ground-mounted PV installations?
2. What are the relative differences in humidity and soil moisture between shaded (agrivoltaic) and unshaded (control) plots?
3. How do environmental parameters fluctuate over different times of day and months (May, June, July, August, October)?
4. Are there significant microclimatic effects introduced by elevated PV structures compared to control conditions?

5. What operational insights can be drawn for managing tropical agrivoltaic systems based on observed environmental patterns?

### Data Description

The project will use:

- **Agrivoltaic Dataset (Ghana)** from RAIL, Kaggle

### Key Data Features:

| Category         | Description  |
|------------------|--|
| AG-PV            | Irradiation, temperature from agrivoltaic PV panels        |
| AO-TI /<br>AO-SS | Temperature, humidity, soil moisture in control plots      |
| PO-PV            | Irradiation and temperature from ground-mounted PV systems |
| WS               | Ambient weather data (temperature, humidity, rainfall)     |
| Time             | Time of day for each measurement                           |
| Months           | Data from May, June, July, August, and October             |

**Note:** The data is in a structured format with columns like Irr ( $\text{W/m}^2$ ), T ( $^{\circ}\text{C}$ ), RH (%), and P (mm) captured per plot and time interval.

### Expected Deliverables

1. Cleaned, well-structured dataset prepared for analysis.
2. Weekly reports on project progress.
3. EDA report with time series visualizations and summary statistics.
4. Statistical comparison report detailing microclimate effects by plot type.
5. Operational recommendations for agrivoltaic systems in tropical regions.
6. Final written project report summarizing objectives, methodology, findings, and conclusions.
7. Interactive data dashboard with your choice of content

### Timeline

| Phase                       | Duration |
|-----------------------------|----------|
| Data Acquisition & Cleaning |          |
| Exploratory Data Analysis   |          |

|                                |  |
|--------------------------------|--|
| Statistical Analysis           |  |
| Insight Generation & Reporting |  |

### Potential Impact

This project will provide valuable operational insights into how agrivoltaic PV structures influence local microclimates in tropical settings. It will inform site design decisions, energy-agriculture balance strategies, and policy frameworks aimed at promoting sustainable, dual-use land management solutions in West Africa and beyond — contributing directly to SDG 2 (Zero Hunger), SDG 7 (Clean Energy), and SDG 13 (Climate Action).

### References

- Responsible AI Lab (RAIL). (2024). *Agrivoltaic Dataset (Ghana)*. Retrieved from: <https://www.kaggle.com/datasets/responsibleailab/agrivoltaic-dataset-ghana>
- Barron-Gafford, G.A., et al. (2019). *Agrivoltaics Provide Mutual Benefits Across the Food–Energy–Water Nexus in Drylands*. Nature Sustainability.