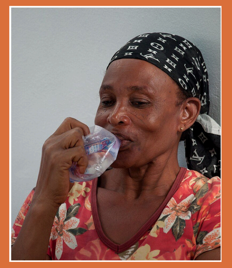
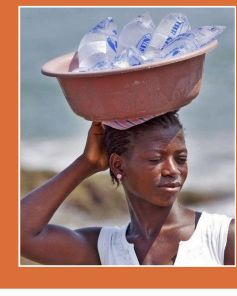




AC HACKING

Fulfilling Drinking Water Demand Through Air Condensate Harvesting

GHANA



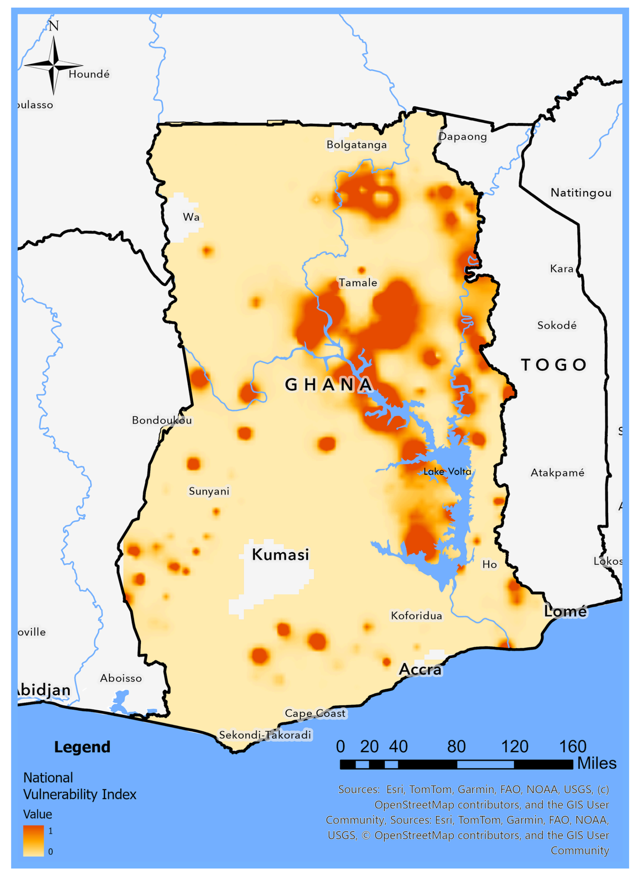


★ BACKGROUND ★

The WHO defines safely managed drinking water as *"...water from an improved source located on premises, available when needed, and free from fecal and priority chemical contamination..."*

In water-scarce contexts, many water sources do not meet this standard. Globally, **unsafely managed drinking water accounts for an estimated 1.2-3.5 million deaths each year**. The burden of collecting drinking water is primarily borne by women and girls, with an estimated expenditure of **200 million hours daily.** Ghana has high national water vulnerability, as visualized in Map 1.

UN Sustainable Development Goal 6 aims to **ensure availability and sustainable management of water and sanitation for all** by 2030. It aims to address water scarcity, and one way to work towards this goal is through **Atmospheric Water Harvesting (AWH). AWH extracts water vapor from the air and produces potable water, and works best in areas with high humidity and existing electricity infrastructure.** Current AWH technologies include fog collectors, vapor compression, and solar chimneys, among other innovations



Map 1: water vulnerable areas

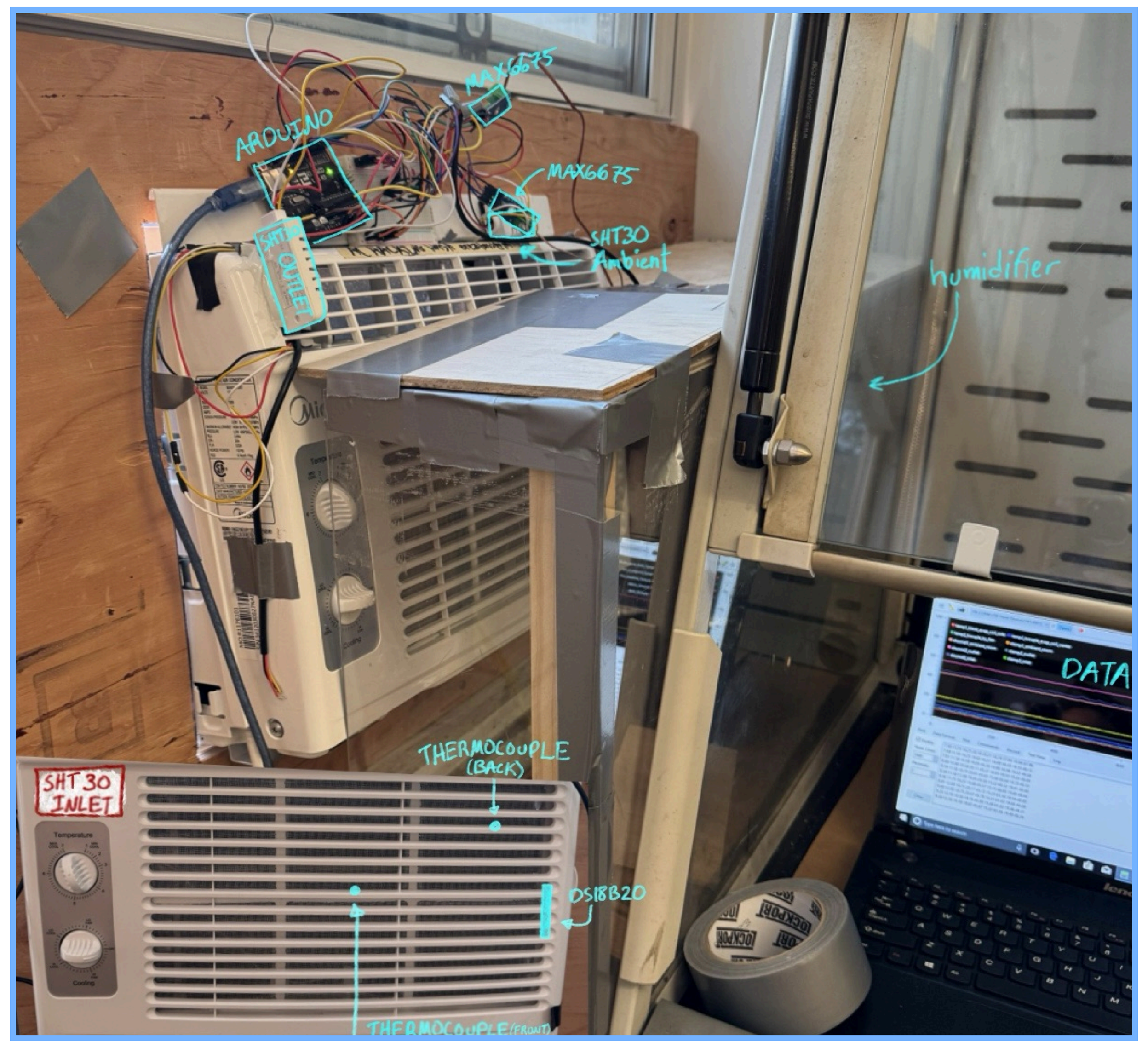
The AC Hacking team worked in coordination with Cynthia Acquaye, a PhD candidate at TU Delft, to explore the potential fulfilment of drinking water demand **using AC units to create clean drinking water**. This project aims to demonstrate the feasibility of this solution through the **modification of a typical AC unit** used in Ghana. This project **visualizes the feasibility of this solution** through mapping water vulnerability and determining the optimal locations for the solution across Ghana, where water need and AC infrastructure viability intersect.

★ RESEARCH QUESTIONS ★

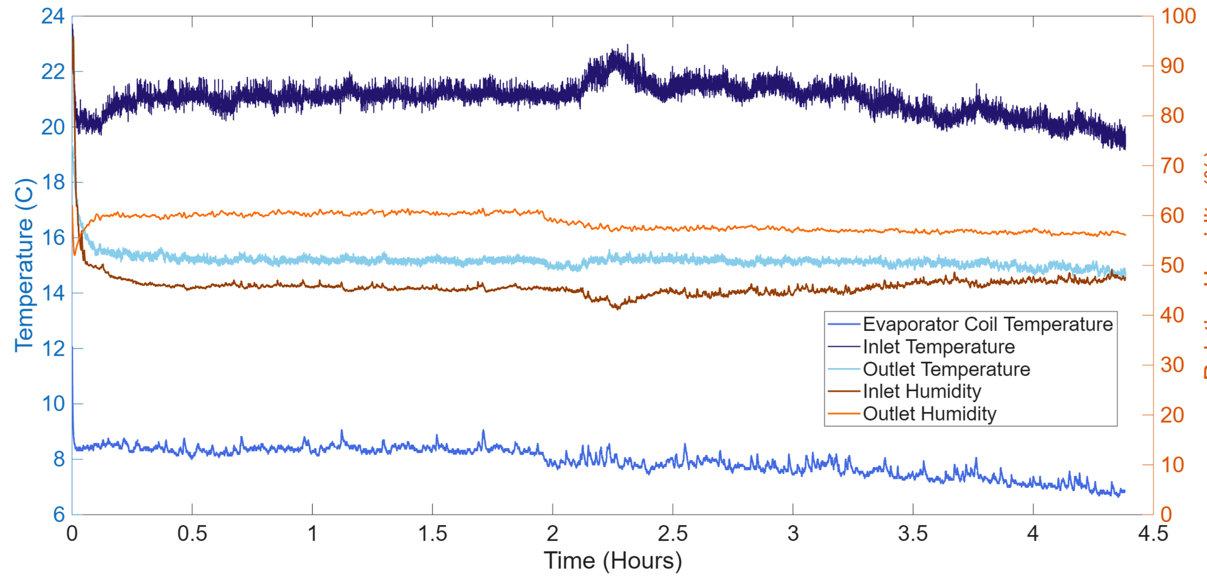
1. **Can existing household AC units in Ghana be hacked to produce safe drinking water, and where should this solution be deployed to address the greatest water need?**
   a. How can a standard window AC unit used in Ghana be modified to maximize water condensate production while maintaining adequate cooling performance?
   b. Where in Ghana do climate and infrastructure conditions make AC condensate harvesting technically feasible, and which households would most benefit from a pilot program?

★ PHYSICAL MODEL AND GOVERNING EQUATIONS ★

EXPERIMENTAL SETUP



EXPERIMENTAL DATA FROM AC UNIT RUN



GOVERNING EQUATIONS

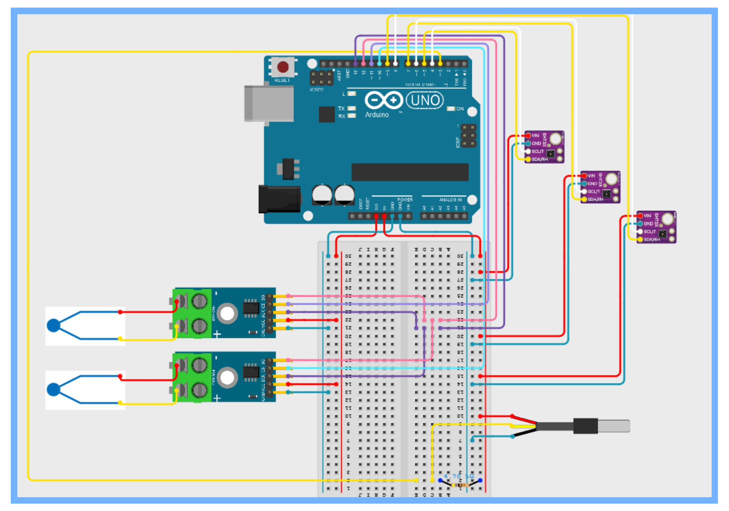
$$\dot{m}_{water}[kg/s] = \dot{m}_{air}[kg/s] * (\omega_{in} - \omega_{out})[kg/kg]$$

$$\omega_{in} = f(RH_{in}, T_{in})$$

$$\omega_{out} = f(RH_{out}, T_{out}, T_{coil})$$

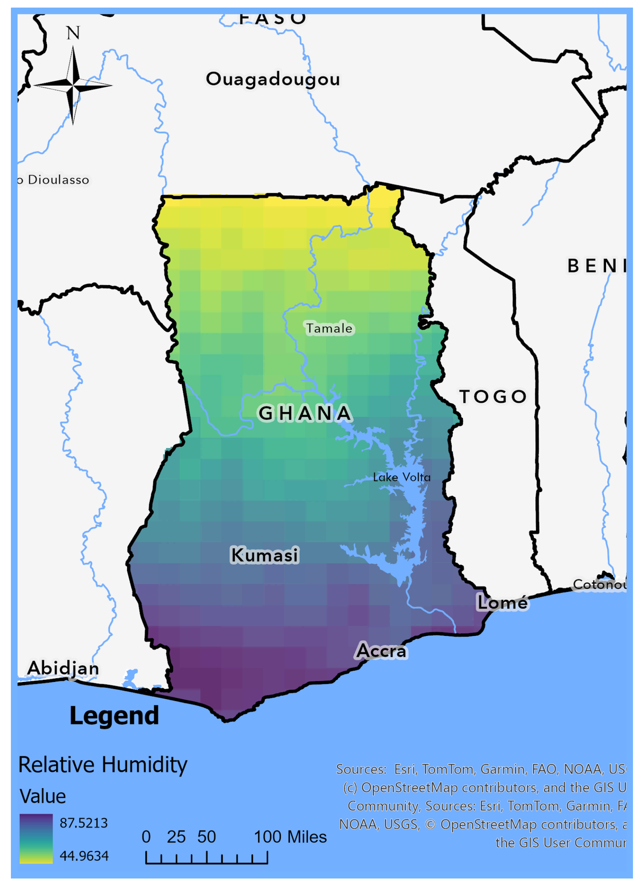
Nomenclature	Full Variable Name
RHin	Relative Humidity at the Inlet
Tin	Temperature at the Inlet [°C]
RHout	Relative Humidity at the Outlet
Tout	Temperature at the Outlet [°C]
Tcoil	Temperature of the Coil [°C]
ωin	Humidity Ratio at the Inlet [kg/kg]
ωout	Humidity Ratio at the Outlet [kg/kg]
ṁwater	Water Production Rate [kg/s]
ṁair	Air Mass Flow Rate [kg/s]

CIRCUIT DIAGRAM



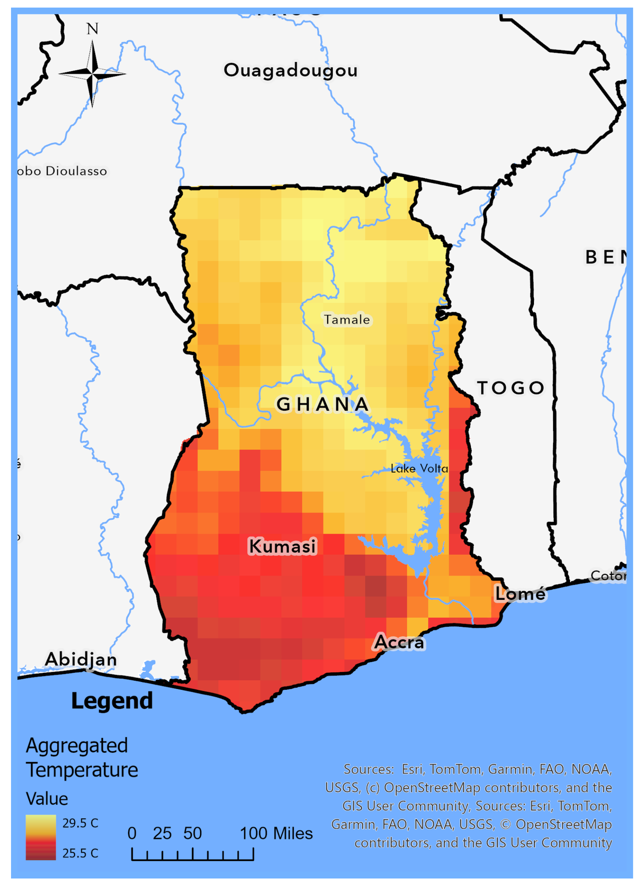
Based on sensor accuracy, the predicted water collection was 1.1–1.28 L. The actual collection of 1.5 L represents a 15% error relative to the maximum predicted value.

RELATIVE HUMIDITY



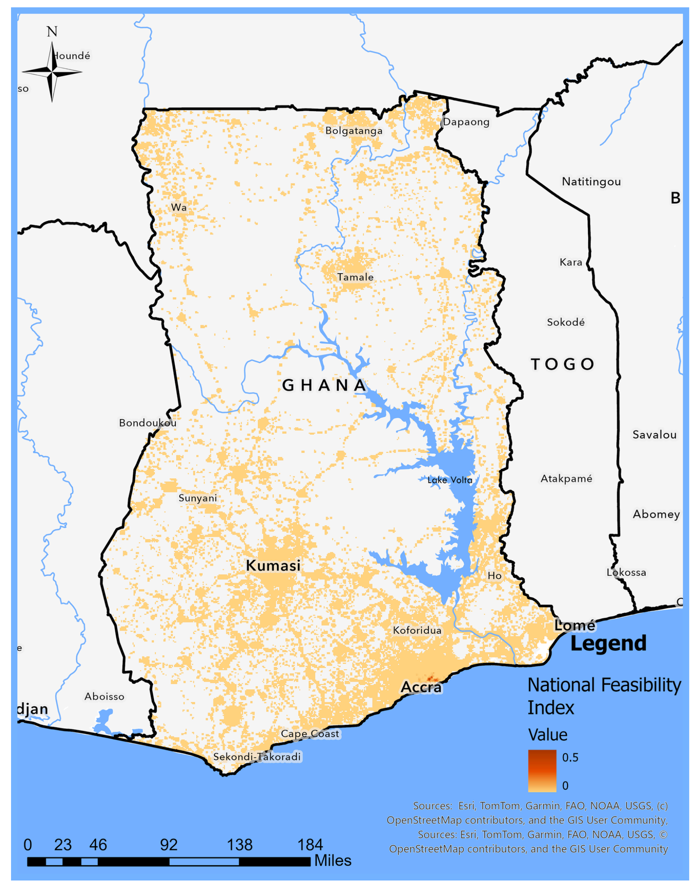
Humidityis greater in Southern Ghana, ranging from an **average of ~45% to ~90% humidity**

AGGREGATED TEMPERATURE



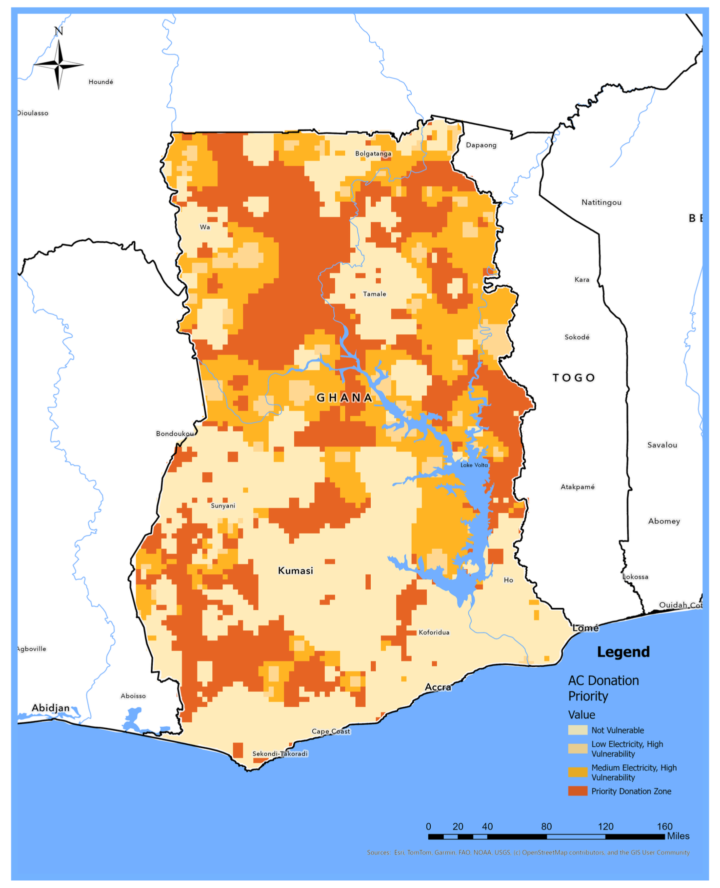
Temperature is greater in Southern Ghana, ranging from an **average of 25.5°C to 29.5°C** on average, aggregated

SOLUTION FEASIBILITY



Takes into account **temperature, humidity, and 2 electricity proxies** to calculate ideal implementation areas

AC DONATION: PRIORITY AREAS



Index composed of **vulnerability (WHO standard + low wealth index) and high electricity access** to determine donation priority areas

★ METHODS ★

Overview

We created a data-collection system for the temperature and humidity values at different locations on the window AC-unit. We also installed a **condensation collection system** to track the water generated by the window AC-unit. The current system is built from an **arduino**, three **SHT30** humidity and temperature sensors, a **DS18B20** waterproof temperature sensor, and two **thermocouples** using **MAX6675** amplifiers. A humidifier was placed in front of the air inlet to increase the incoming humidity levels. The data is logged to an external laptop for **active monitoring/graphing of the data and long term storage of the data**. This collected information is then transformed into a readable format and plugged into our model for comparison.

GIS Methods

- Inverse Distance Weighting Interpolation and Fuzzy Membership for vulnerability and feasibility maps
- Data cleaned using R studio

Error / Experimental Limitations

- The hole drilled into the bottom of the AC unit collects a portion of the water, some still goes to cool the condensation coils.
- All of the sensors have margins of error described below.

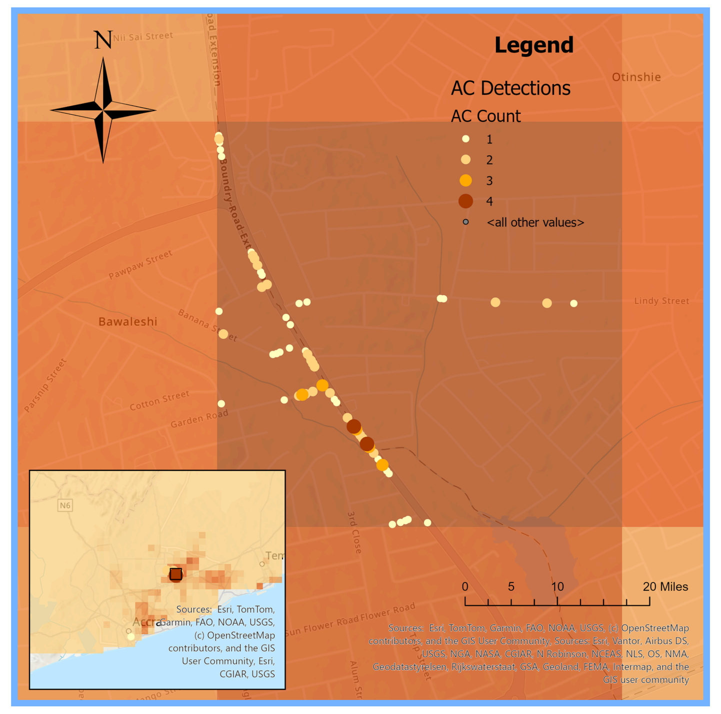
Sensor Information

- DS18B20 temperature sensor (-10°C to +85°C with ±0.5°C accuracy)
- Thermocouples (0°C to 700°C with ±1.5°C accuracy)
- SHT30 humidity and temperature sensor (0% to 100% with a ±2% accuracy and 0°C to 65°C with a ±0.2°C accuracy)

★ CONCLUSION & FUTURE WORK ★

This project concludes that there is high water vulnerability in many areas in Ghana, particularly in the center and north of the country. These areas overlap with areas of high priority for this solution, based on electricity availability and climate.

Future work on this topic could include an analysis of Google Maps Street View photos, using AI to identify AC units on buildings. A test case was evaluated and is shown in Map 2. Additionally, further AC experimental runs are needed to negate run inter-run dependence.



Map 2: AI & Google Maps AC Detection

Furthermore, some contaminates and debri are occasionally present in the condensated water. Future work could focus on understanding exactly what water treatments are needed to make sure condensate is always safe to drink.

GIS Data Sources:

DHS Household Recode 2022 | DHS Household Clusters
https://dhsprogram.com/data/available-datasets.cfm

VIIRS Nighttime Lights
https://eogdata.mines.edu/products/vnl/

ERA5 Copernicus Climate Data Store
https://cds.climate.copernicus.eu/

Model Sources:

Elbrashy, A., Vafai, K., Elshennawy, A., Ayman, M., Elgebaly, A., & Rashad, M. (2025). Harvesting of Condensate Water from Air Conditioners in Large Institutions as a Sustainable Resource. Water Resources Management, 39(10), 5289–5312. https://doi.org/10.1007/s11269-025-04203-9

All Maps Use World Geodetic System 1984 (WGS 84)

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