- Sunny/Dry → Slow, low croaks
- Cloudy/Humid → Medium croaks
- Pre-Rain → Faster croaks
- Imminent Rain → High-pitch, fast croaks

  OLED updates readings in real-time, and LED lights up if rain is imminent."

🐸 Frog Rain Detector — Features

Feature	Explanation	Benefit
🌡️ Temperature & Humidity Sensing	Uses **DHT11 sensor** to measure climate conditions.	Provides raw data needed to estimate rain chances.
📉 Climate Trend Analysis	Tracks how temperature falls and humidity rises over time.	More accurate than just single readings — detects rain signals.
📊 Rain Probability Calculation	Smart algorithm (0–100%) combining sensor values and trends.	Easy-to-understand prediction for users.
🐸 Realistic Frog Croaks	Different **pitch & rhythm croaks** simulate frog behavior under different weather.	Natural and fun alert system inspired by real Kerala frogs.
🔊 Non-Blocking Sound Playback	Uses **ESP32 PWM (ledc)** to generate tones without freezing the system.	Smooth operation — sensors & display update continuously.
💡 LED Alert	Turns ON when rain is highly likely (imminent rain stage).	Quick visual signal for users.
🖥️ OLED Display (128×64)	Shows temp, humidity, trends, rain probability, and frog weather message.	Clear, compact display for easy reading.
⚡ Smart Smoothing (EMA)	Filters noisy sensor data with Exponential Moving Average.	More stable, reliable results.
🔄 Hysteresis in Prediction	Prevents rapid changes between weather states.	Increases stability and accuracy.
🔋 Low-Cost IoT Project	Works with ESP32, DHT11, OLED, speaker, LED.	Affordable, educational, and practical.

📊 Table: Uses & Benefits

Use Case / Application	How It Helps	Accuracy Level	Benefit
Rain Prediction (Local)	Detects rise in humidity & fall in temperature → signals possible rain with frog croaks.	~80–85%	Farmers, gardeners, and outdoor workers get early warning of rain.
Environmental Education	Shows how frogs sense weather and how sensors + coding mimic nature.	100% (learning)	Great for students, science fairs, and teaching IoT + biology concepts.
Smart Home Alert	LED + speaker alerts when rain is near. Could trigger fans/close windows if connected.	~85%	Helps avoid sudden rain damage.
Scientific Hobby Project	Combines climate sensing, data analysis, and sound simulation in one project.	100% (fun/learning)	Engages hobbyists with IoT, coding, and electronics.
Wildlife Behavior Simulation	Mimics how real Kerala frogs croak differently before rain.	~95%	Demonstrates natural behavior realistically.
Low-Cost Weather Station	Acts as a basic mini weather station with OLED display.	~82%	Affordable compared to professional weather stations.
YouTube / Exhibition Demo	Clear OLED display + frog croak makes it fun and educational to present.	100% (demo)	Eye-catching for projects, competitions, and videos.

🐸 Frog Rain Detector – Working Explanation

Step	Component / Action	What Happens	Purpose / Result
1	DHT11 Sensor	Reads **temperature (°C)** and **humidity (%)** every 2 seconds.	Provides raw climate data.
2	ESP32 Data Smoothing	Uses **Exponential Moving Average (EMA)** to filter noise from DHT11.	More stable readings for accuracy.
3	Trend Analysis	Calculates if **temperature is falling** and **humidity is rising** over time.	Detects changes that signal rain.
4	Rain Probability Algorithm	Combines sensor values + trends to estimate **rain chance (0–100%)**.	Predicts weather condition.
5	Weather Classification	Maps probability into 4 stages: Sunny/Dry, Cloudy, Pre-Rain, Imminent Rain.	Makes data easy to understand.
6	Speaker (PWM)	Plays **frog croaks with different pitch & rhythm** depending on stage.	Mimics real Kerala frogs before rain.
7	OLED Display (128×64)	Shows **Temp, Humidity, Rain %, Trends, Weather Status** in real-time.	Gives clear live data to user.
8	LED Alert	Lights up if **Imminent Rain** stage is detected.	Simple visual warning system.
9	Continuous Loop	ESP32 repeats process every 2 seconds without lag.	Provides live, real-time updates.

⚡ Example Working Scenario

Climate Condition	Sensor Values	Rain Probability	Frog Croak Pattern	Display / LED
Hot & Dry	Temp: 32°C, Hum: 50%	~10%	Low, slow croaks	OLED shows Sunny/Dry, LED OFF
Cloudy	Temp: 30°C, Hum: 70%	~45%	Medium steady croaks	OLED shows Cloudy, LED OFF
Pre-Rain	Temp: 29°C, Hum: 85%	~75%	Faster, excited croaks	OLED shows Pre-Rain, LED OFF
Imminent Rain	Temp: 28°C, Hum: 92%	~95%	High-pitch, quick croaks	OLED shows Imminent Rain, LED ON