Karkhe Dam Simulation

A Real-Time Monitoring and Control System using Wokwi, Node-RED, and React.js

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Motivation & Problem Statement

- Why Dam Monitoring?

  Prevent floods, and manage water resources efficiently

  Traditional methods lack real-time data & automation

  Need for smart water management solutions

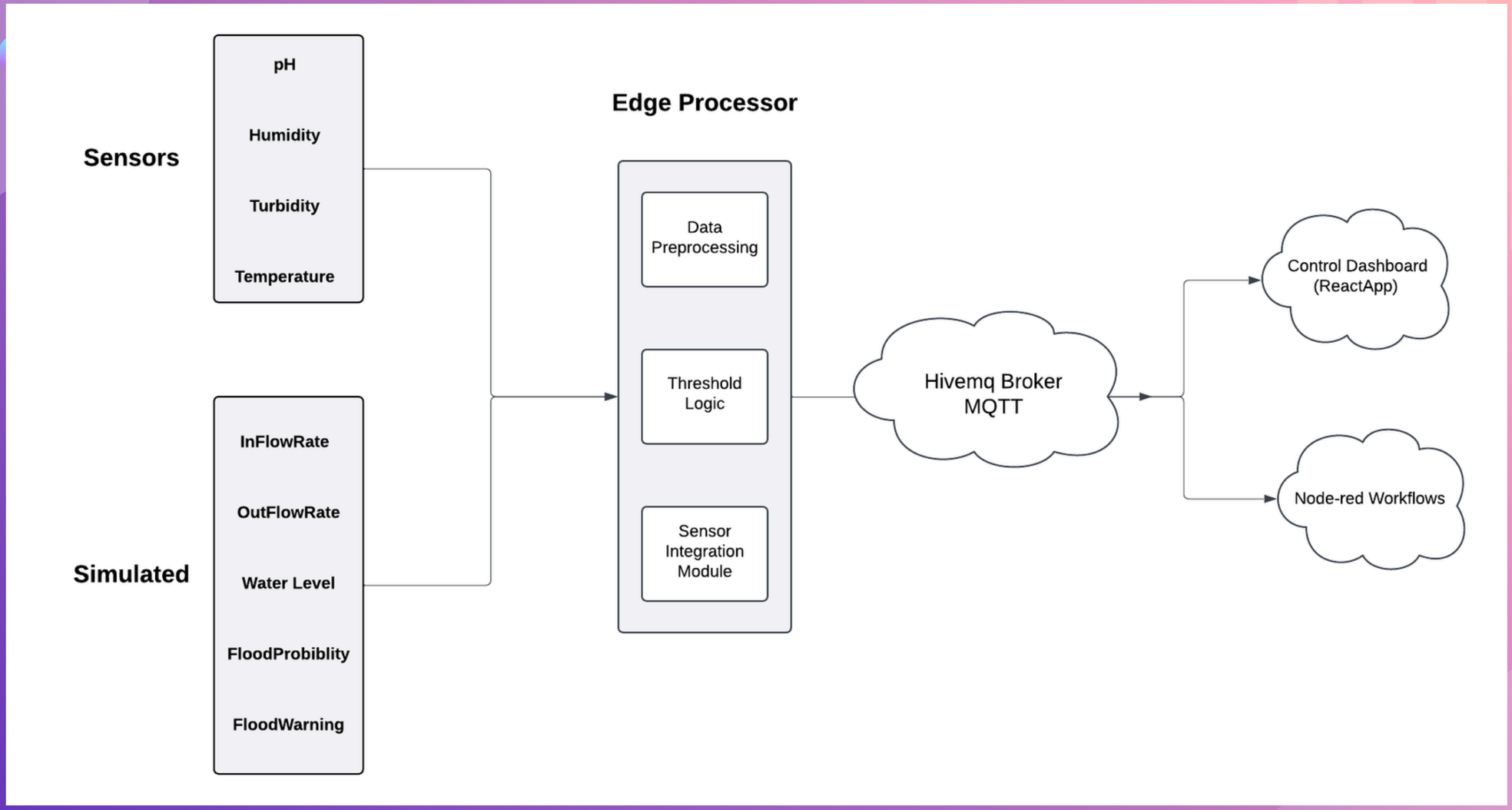
- Solution: IoT-Based System

  Uses ESP32 + Sensors for real-time data collection

  Publishes data to MQTT Cloud (HiveMQ)

  Dashboards (Node-RED & React.js) for monitoring & remote control

System Architecture

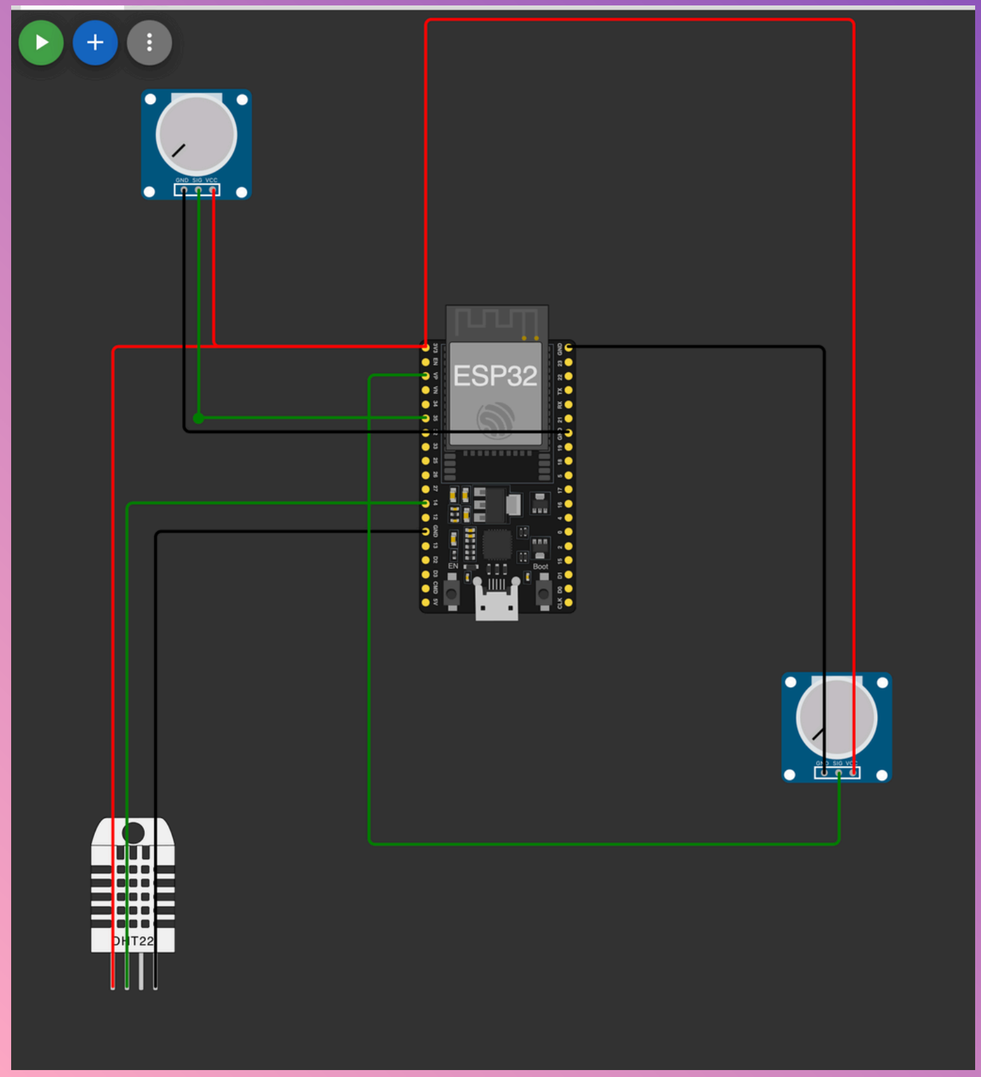


Sensors

Sensors	Type	Measurement
DHT22	Digital	Temperature & Humidity
pH Sensor	Analog	Water pH Level
Turbidity Sensor	Analog	Water Clarity

```
// Define sensor pins
    #define DHTPIN 14          // DHT22 Sensor Pin
    #define DHTTYPE DHT22      // DHT22 Sensor Type
    #define TURBIDITY_PIN 35    // Analog for turbidity
    #define PH_PIN 36           // Analog pH sensor


// Read sensor data
    float temperature = dht.readTemperature();
    float humidity = dht.readHumidity();
    float pH = analogRead(PH_PIN) > 0 ? analogRead(PH_PIN) / 4095.0 * 0.7 + 7.5 : random(75, 82) / 10.0;
    int turbidityRaw = analogRead(TURBIDITY_PIN);
```

Wokwi Diagram



Wokwi Setup

```
void connectToWiFi() {
  Serial.print("Connecting to WiFi");
  WiFi.begin(ssid, password);
  while (WiFi.status() != WL_CONNECTED) {
    delay(100);
    Serial.print(".");
  }
  Serial.println(" Connected to Wokwi-
GUEST!");
}
```

```
void connectToMQTT() {
  while (!client.connected()) {
    Serial.print("Connecting to MQTT
Broker at ");
    Serial.print(mqttServer);
    Serial.print(":");
    Serial.println(mqttPort);

    if (client.connect("ESP32Client",
mqttusername, mqttpassword)) {
      Serial.println(" Connected to MQTT
Broker!");

 client.subscribe("KarkheDam_Simulation/o
penDam");
    } else {
      Serial.print(" Failed to connect,
state: ");
      Serial.println(client.state());
      delay(2000);
    }
  }
}
```

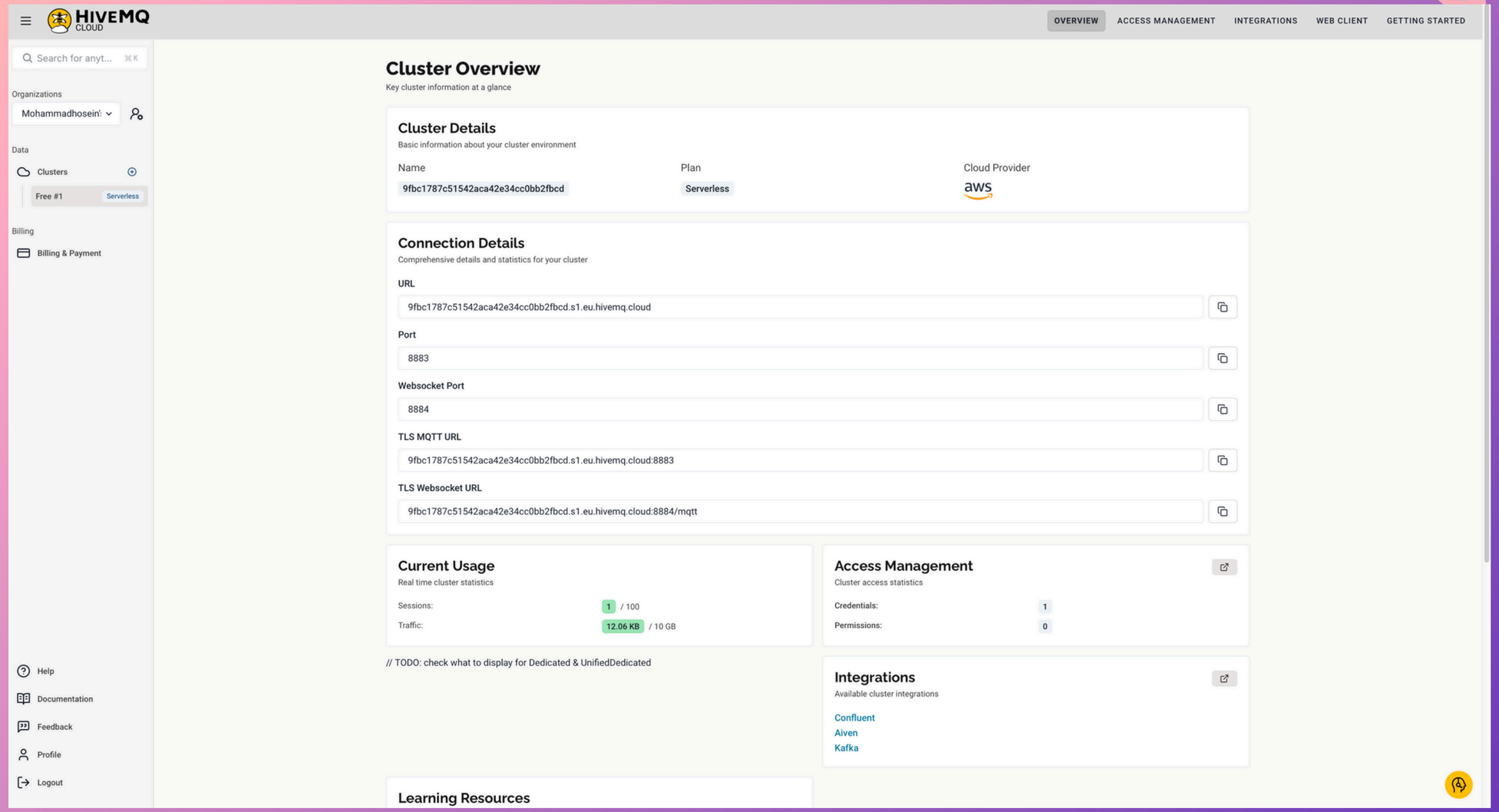
```
void publishData(const char* topic, float value) {
  char payload[50];
  sprintf(payload, "%.2f", value);
  if (client.publish(topic, payload)) {
    Serial.printf("Published %s: %.2f\n", topic,
value);
  } else {
    Serial.printf("Failed to publish %s\n", topic);
  }
}
```

```
void mqttCallback(char* topic, byte* payload,
unsigned int length) {
  String message;
  for (unsigned int i = 0; i < length; i++) {
    message += (char)payload[i];
  }
  if (String(topic) ==
"KarkheDam_Simulation/openDam") {
    openDam = (message == "true");
    Serial.printf("Dam control received: %s\n",
openDam ? "Open" : "Closed");
  }
}
```

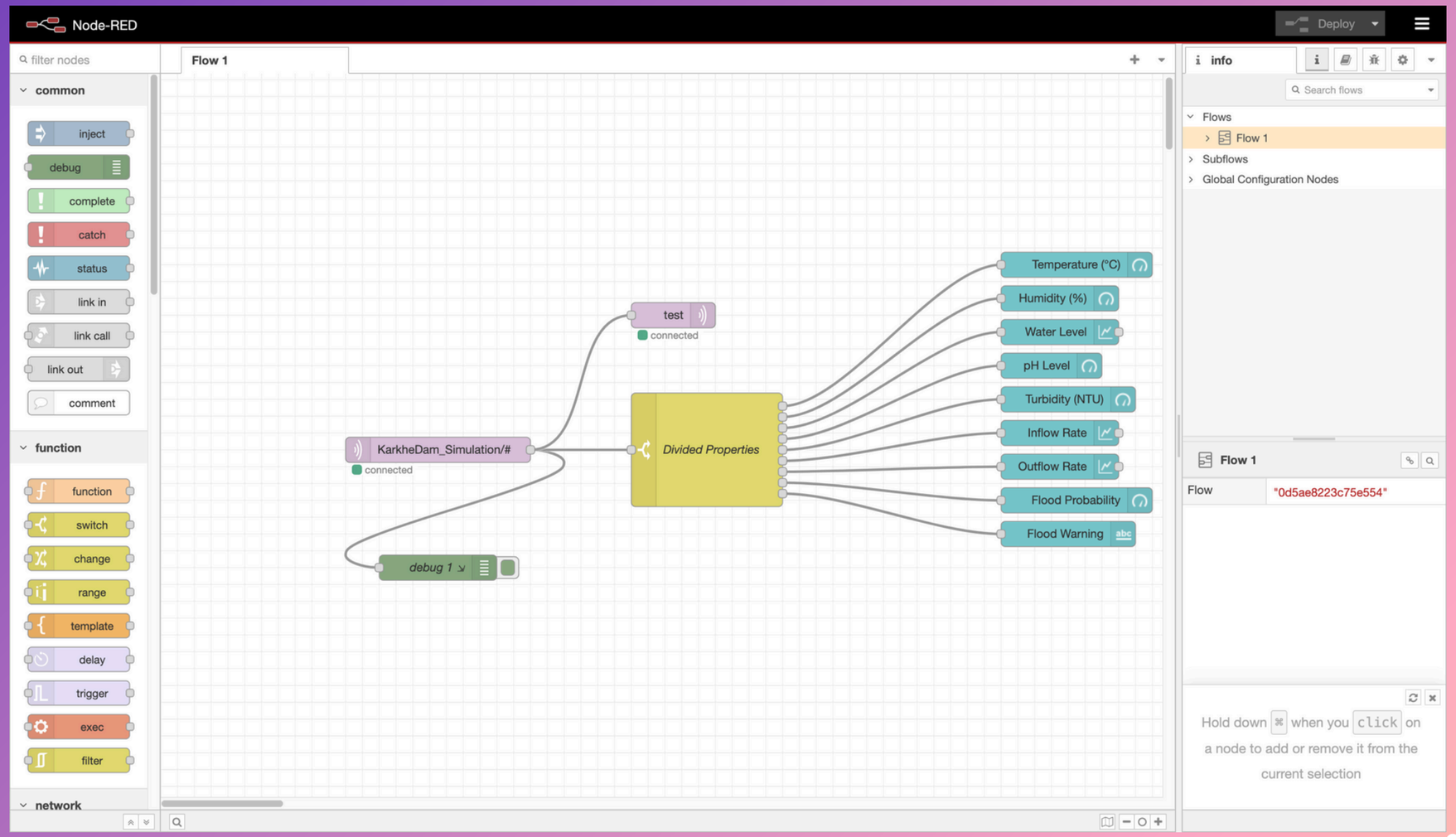
Data Preprocessing and Threshold Logic

```
bool openDam = false; // Variable to store dam status
float waterLevel = 250;

// Adjust turbidity based on other parameters
  if (temperature > 30) turbidity += 20;
  if (pH < 7.0 || pH > 8.0) turbidity += 15;
  if (humidity > 80) turbidity -= 10;
  if (waterLevel > 260) turbidity += 25;
  turbidity = fmax(fmin(turbidity, 400), 50); // Clamp turbidity between 50 and 400 NTU

  // Rainfall logic: dynamically adjust attributes if rainfall occurs
  if (temperature < 18) {
    float rainfallIncrease = random(5, 15) * 0.1f; // Increase by a small, random value
    waterLevel = fmin(waterLevel + rainfallIncrease, 280.0f); // Clamp water level to a max of 280 meters
    turbidity -= turbidity * 0.1;                              // Reduce turbidity by 10%
    pH += (7.5 - pH) * 0.1;                                   // Adjust pH towards neutral (7.5)
    humidity += (80 - humidity) * 0.1;                        // Gradually increase humidity towards 80%
  }

  // Calculate inflow and outflow rates dynamically
  float inflowRate = (humidity > 60) ? random(300, 400) : random(100, 250);
  float outflowRate = openDam ? random(400, 500) : random(100, 250); // Higher outflow if dam is open

  // Calculate actual water level
  waterLevel += (inflowRate - outflowRate) * 0.05; // Adjust scale for simulation realism
  waterLevel = fmax(fmin(waterLevel, 280.0f), 160.0f); // Clamp water level between 160 and 280 meters

  // Close dam if water level is below 160 meters
  if (waterLevel <= 160) {
    openDam = false;
    outflowRate = random(100, 250); // Reset to default outflow rate
  }

  // Calculate flood probability
  float floodProbability = 0;
  if (waterLevel > 260) floodProbability += 50;
  if (inflowRate > 300) floodProbability += 30;
  if (turbidity > 300) floodProbability += 20;
  floodProbability = std::min(floodProbability, 100.0f;
  bool floodWarning = floodProbability > 60;
```

MQTT (HiveMQ Cloud)



Node-Red


Node-RED
Deploy
filter nodes
Flow 1
common
inject
debug
complete
catch
status
link in
link call
link out
comment
function
function
switch
change
range
template
delay
trigger
exec
filter
network
test
connected
KarkheDam_Simulation/#
connected
Divided Properties
debug 1
Temperature (°C)
Humidity (%)
Water Level
pH Level
Turbidity (NTU)
Inflow Rate
Outflow Rate
Flood Probability
Flood Warning
info
Search flows
Flows
Flow 1
Subflows
Global Configuration Nodes
Flow 1
Flow
"0d5ae8223c75e554"
Hold down ⌘ when you click on a node to add or remove it from the current selection

Flow Explanation

MQTT-IN

Receive the data from the broker

DIVIDED PROPERTIES

Divides the properties to UI Elements

Dashboard

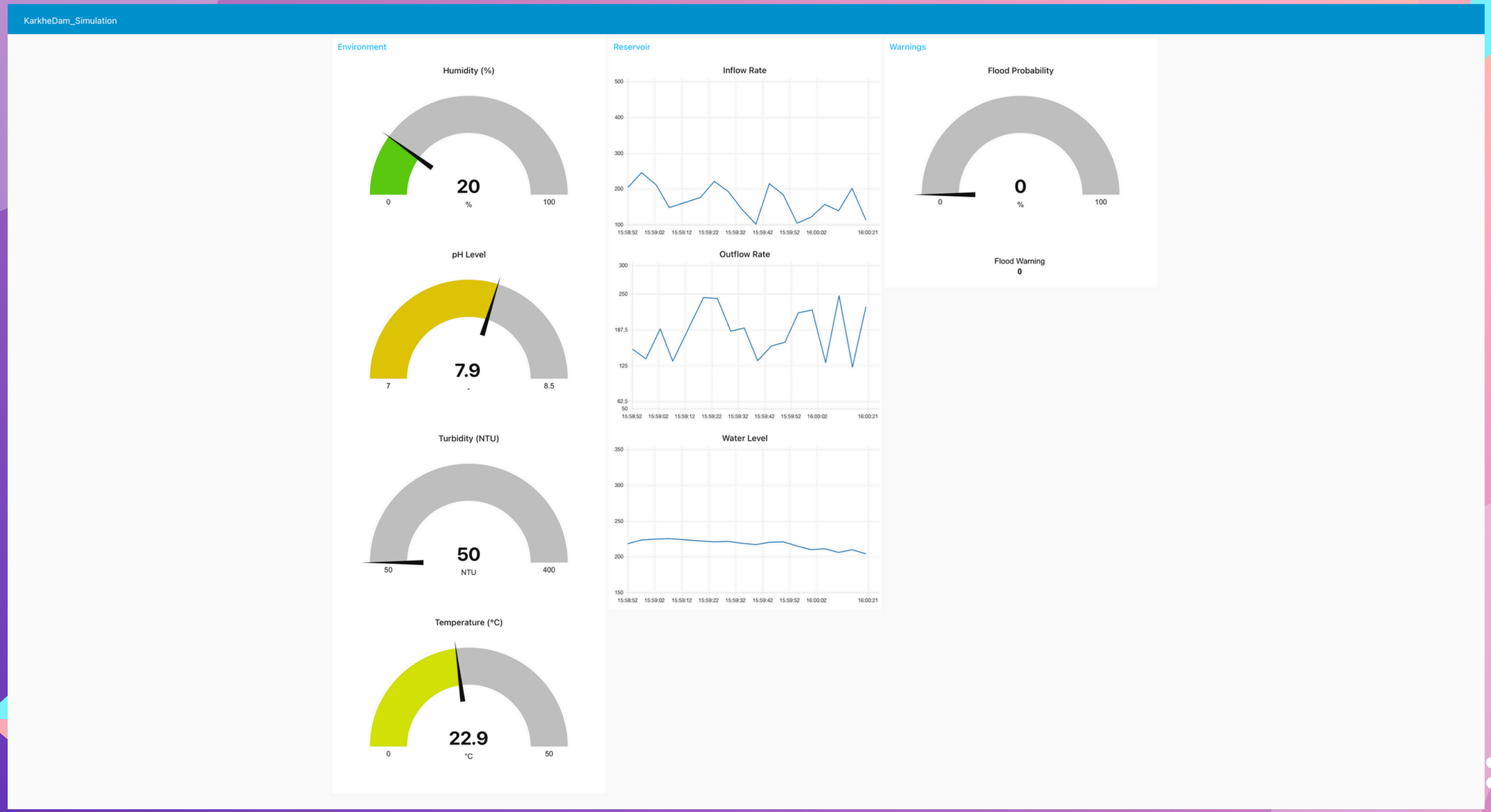
Show the values in the proper way

Node-RED Dashboard UI Elements

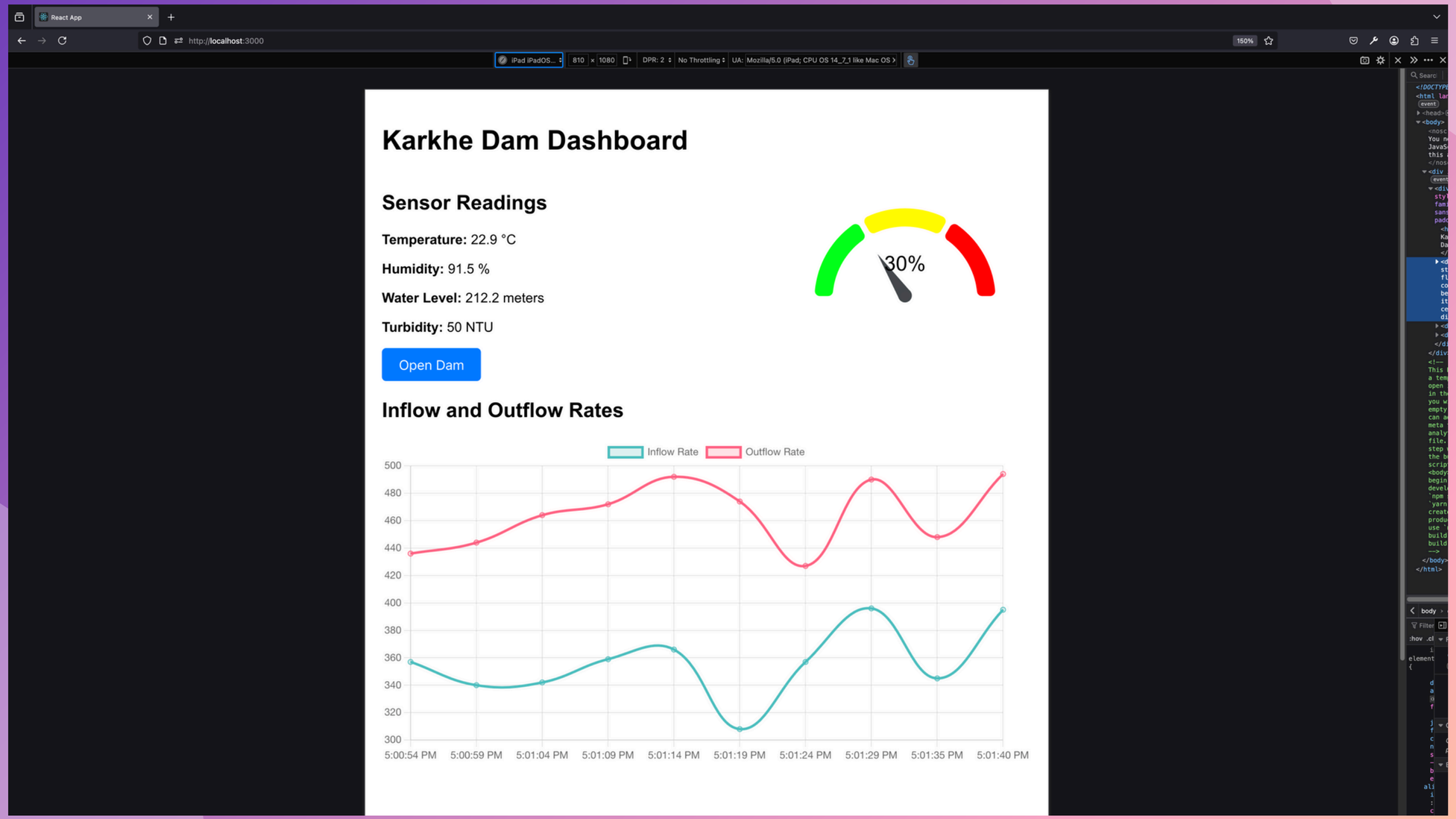
Component	Node Type	Topic (MQTT)	Title on UI	Min Value	Max Value	Description
Temperature Gauge	ui_gauge	KarkheDam_Simulation/temperature	Temperature (°C)	0	50	Displays the current temperature from the DHT22 sensor
Humidity Gauge	ui_gauge	KarkheDam_Simulation/humidity	Humidity (%)	0	100	Displays the relative humidity measured by the DHT22 sensor
Water Level Chart	ui_chart	KarkheDam_Simulation/waterLevel	Water Level	150	350	Line graph showing water level changes over time
pH Level Gauge	ui_gauge	KarkheDam_Simulation/pH	pH Level	7	8.5	Indicates the water's acidity or alkalinity level

Component	Node Type	Topic (MQTT)	Title on UI	Min Value	Max Value	Description
Turbidity Gauge	ui_gauge	KarkheDam_Simulation/turbidity	Turbidity (NTU)	50	400	Displays water clarity (higher values mean murkier water)
Inflow Rate Chart	ui_chart	KarkheDam_Simulation/inflowRate	Inflow Rate	100	500	Line graph tracking the inflow rate of water into the dam
Outflow Rate Chart	ui_chart	KarkheDam_Simulation/outflowRate	Outflow Rate	50	300	Line graph showing the dam’s outflow rate
Flood Probability Gauge	ui_gauge	KarkheDam_Simulation/floodProbability	Flood Probability	0	100	Displays the real-time flood probability percentage
Flood Warning Text	ui_text	KarkheDam_Simulation/floodWarning	Flood Warning	0(No)	1(Yes)	Displays "Flood Warning: Yes"when flood probability exceeds 60%

Node-Red Dashboard UI



Control Dashboard



Subscribing Data

```
clientRef.current.on("message", (topic, message) : void  => {
  const value : number  = parseFloat(message.toString());
  const now : string  = new Date().toLocaleTimeString();
  console.log(`Received message on topic ${topic}: ${value}`);

  switch (topic) {
    case "KarkheDam_Simulation/temperature":
      setTemperature(value);
      break;
    case "KarkheDam_Simulation/humidity":
      setHumidity(value);
      break;
    case "KarkheDam_Simulation/waterLevel":
      setWaterLevel(value);
      break;
    case "KarkheDam_Simulation/turbidity":
      setTurbidity(value);
      break;
    case "KarkheDam_Simulation/floodProbability":
      setFloodProbability(value);
      break;
    case "KarkheDam_Simulation/floodWarning":
      setFloodWarning( value: value === 1);
      if (value === 1 && !isDamOpen) {
        sendNotification( title: "Flood Warning!",  body: "Flood warning! Please open the dam!");
      }
      break;
    case "KarkheDam_Simulation/inflowRate":
      setInflowData( value: (prev : any[] ) => [...prev.slice(-9), value]);
      setTimestamps( value: (prev : any[] ) => [...prev.slice(-9), now]);
      break;
    case "KarkheDam_Simulation/outflowRate":
      setOutflowData( value: (prev : any[] ) => [...prev.slice(-9), value]);
      if (value > 300) {
        setIsDamOpen( value: true);
        sendNotification( title: "Dam Opened",  body: "The dam is open, releasing water.");
      }
      break;
    default:
      console.warn( message: `Unhandled topic: ${topic}`);
```

Links to Project

Wokwi

Github

Control Dashboard Demo