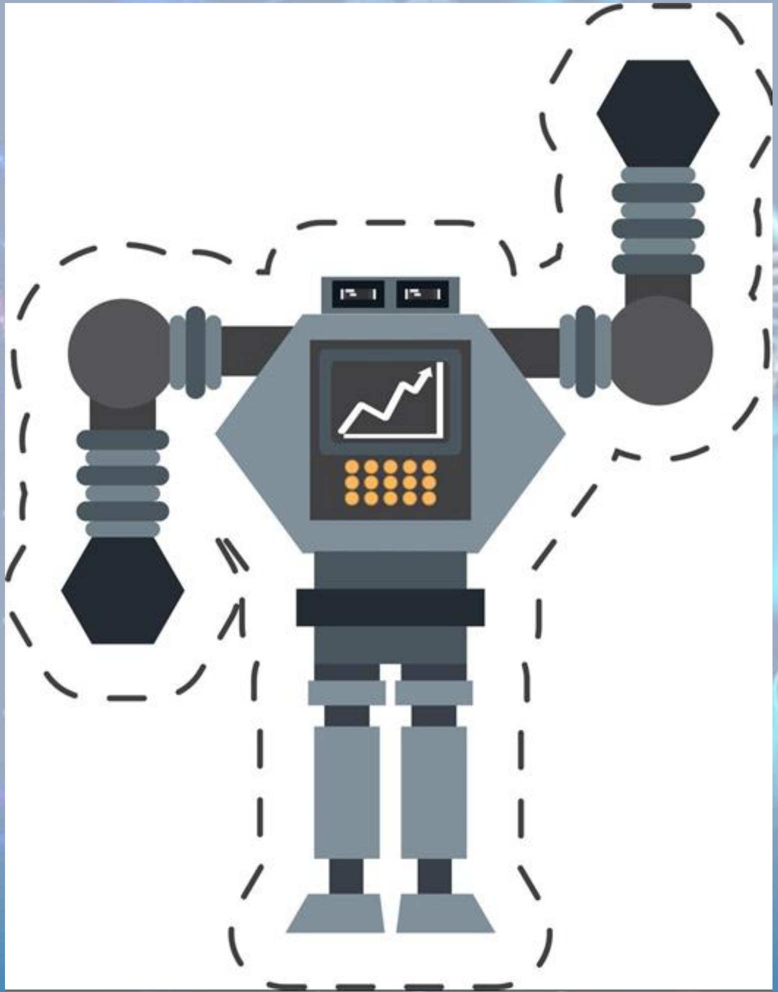


Water Quality Control in Industrial Fish Hatcheries

Content

Project Overview

An IoT-Enabled Water Quality Solution for Fish Hatcheries

Domain relevance

Industrial IoT + Aquaculture Tech

- Bridges embedded systems with cloud analytics for precision aquaculture
- Addresses UN SDG 14 (Life Below Water) by preventing fish mortality

Technical Fusion

- **Embedded Systems** (ESP32 + Sensors) + **Cloud ML** (ThingSpeak Analytics)
- Real-time sensor data → Edge processing → Predictive maintenance alerts
- Future ML integration for water quality forecasting

Purpose of combining Embedded Systems with ML

Prevent Losses: 24/7 monitoring of critical parameters (temp, turbidity, humidity)
Automate Decisions: Trigger corrective actions via embedded control logic
Enable Scalability: Modular design for additional sensors (dissolved oxygen/pH)

Problem Statement

What real-world problem are you solving?

- Industrial hatcheries lose **20-30% of fish stocks** annually due to:
- Undetected water quality fluctuations (temperature/turbidity)
- Delayed response to hazardous conditions
- Manual monitoring inefficiencies

Why is it important?

Economic Impact: Prevents $Million+ losses from fish mortality

Ecological Protection: Reduces disease outbreaks in aquatic ecosystems

Food Security: Ensures stable supply for growing protein demand

Project Goal & Objectives

Main project goal

- Develop an **automated early-warning system** to prevent fish mortality by maintaining optimal water conditions through real-time IoT monitoring.

Measurable objectives

- **Achieve 95% sensor data accuracy** (vs manual measurements)
- **Reduce fish mortality by 30%** through timely hazard detection
- **Cut manual monitoring costs by 50%** via automation
- **Enable <15-minute response time** to critical water parameter changes

Proposed Solution

System Architecture

1. ESP32 reads temperature, humidity, water turbidity, and soil moisture levels.
2. Data is processed and formatted.
3. ESP32 connects to a Wi-Fi network.
4. Data is sent to ThingSpeak via HTTP.
5. ThingSpeak displays the data as graphs on the cloud dashboard.

How embedded system + ML are integrated

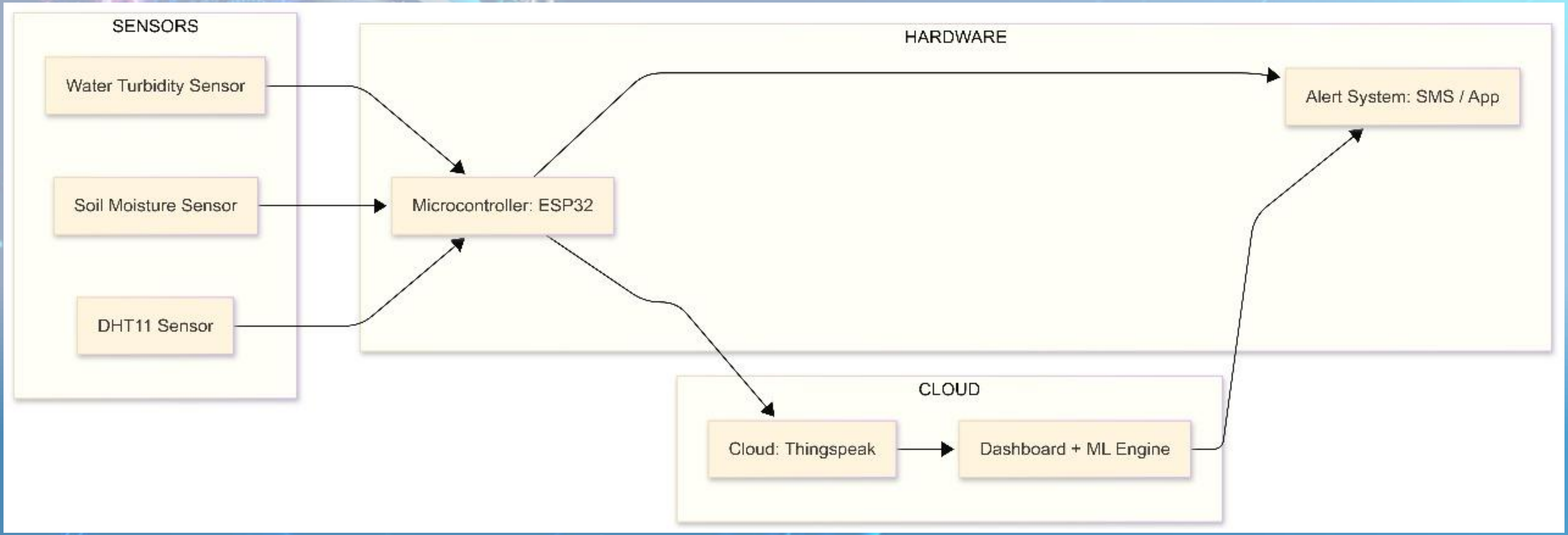
1. Edge (ESP32):
Sensors → Real-time data → Rule-based alerts
2. Cloud (ThingSpeak + ML):
Trains model → Predicts hazards → Sends insights to edge
3. Hybrid Control:
Local: Immediate actions (e.g., activate aerator)
Cloud: Long-term optimizations (e.g., feeding schedule)

Resources Utilized

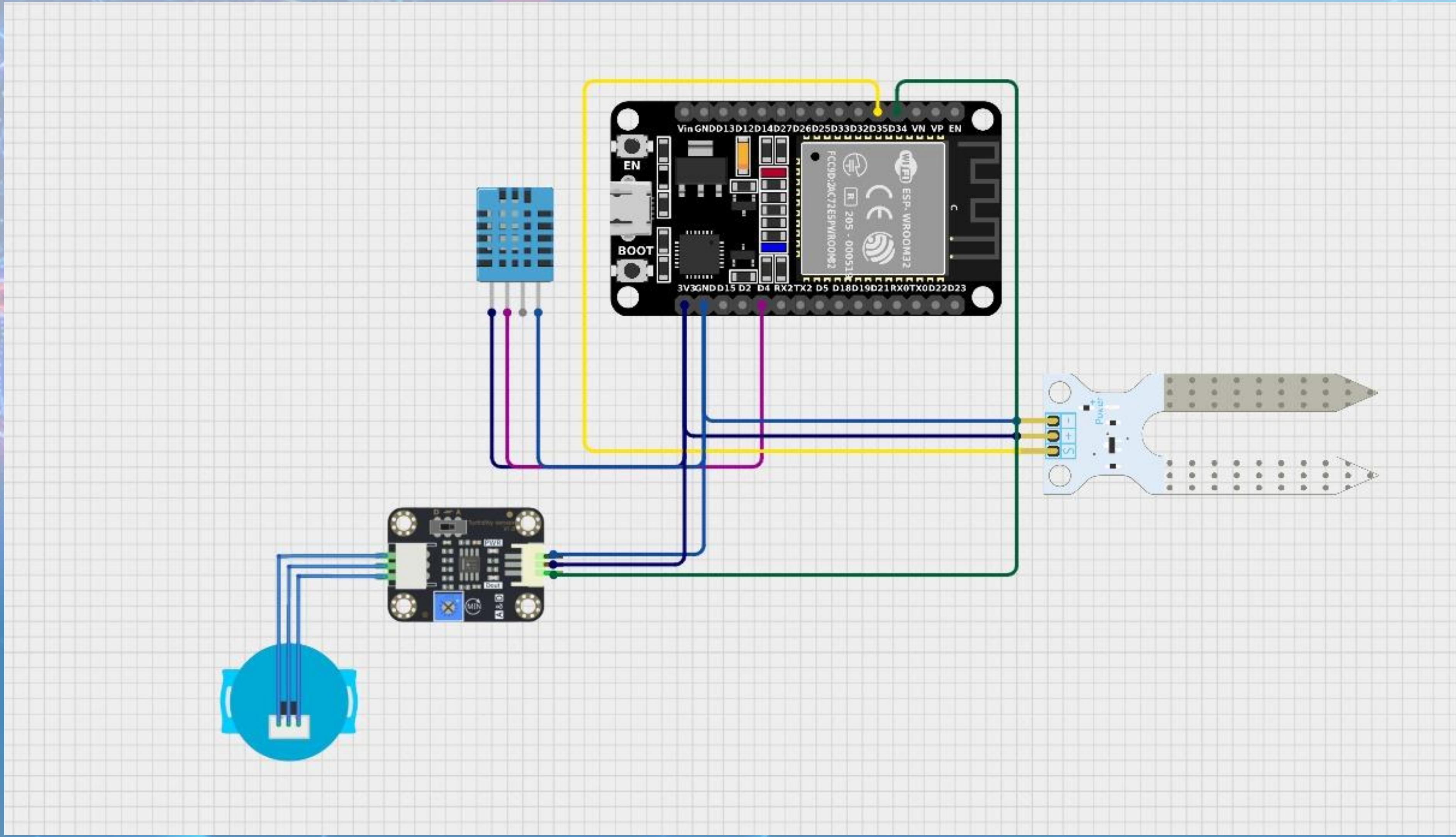
- **Hardware:** ESP32 microcontroller, DHT11, Turbidity Sensor, Soil Moisture Sensor.
- **Software & Tools:** Thingspeak, Jupiter Notebook, Wokwi Simulator

System Design

- Block Diagram



Circuit Design



CODE SNIPPET

DATASET

SYNTETHIC DATA GENERATED:

created_at	entry_id	Temperature	Humidity	Soil Moisture	Turbity percentage
01-06-2025 00:00	1	26.1	60.4	3691	54
01-06-2025 00:01	2	25	61.8	3620	57
01-06-2025 00:02	3	24.8	62.6	3815	58
01-06-2025 00:04	4	25.5	61.9	3837	54
01-06-2025 00:05	5	26.3	61.3	3606	59
01-06-2025 00:07	6	26.8	61.2	3779	56
01-06-2025 00:08	7	26.1	61.5	3901	57
01-06-2025 00:10	8	25.4	62.2	3797	56
01-06-2025 00:11	9	25.8	59	3770	56
01-06-2025 00:12	10	25.1	59.1	3935	53
01-06-2025 00:14	11	25.6	62.5	3851	57
01-06-2025 00:15	12	25.5	60.7	3738	57
01-06-2025 00:17	13	25.9	61.7	3863	55
01-06-2025 00:18	14	25.8	61.7	3784	56
01-06-2025 00:20	15	25	60.7	3825	56
01-06-2025 00:21	16	25.7	61.8	3771	58
01-06-2025 00:22	17	26	60.2	3690	54

Up to 7000 values

DATA RECEIVED FROM SENSORS:

created_at	entry_id	Temperature	Humidity	Soil Moisture	Turbity percentage
2025-06-09 07:57:17 UTC	59	25.7	61.3	3722	55
2025-06-09 07:57:40 UTC	60	25.7	61.5	3728	55
2025-06-09 07:58:03 UTC	61	25.7	61.4	3827	56
2025-06-09 07:58:27 UTC	62	25.7	61.9	3814	56
2025-06-09 07:58:50 UTC	63	25.7	61.9	3802	56
2025-06-09 07:59:13 UTC	64	25.7	61.9	3760	56
2025-06-09 07:59:38 UTC	65	25.7	61.8	3776	56
2025-06-09 08:00:00 UTC	66	25.7	61.9	3770	56
2025-06-09 08:00:24 UTC	67	25.7	62.1	3764	56
2025-06-09 08:00:48 UTC	68	25.7	62.1	3765	56
2025-06-09 08:01:11 UTC	69	25.7	62.1	3760	56
2025-06-09 08:01:34 UTC	70	25.7	62.1	3763	56
2025-06-09 08:01:58 UTC	71	25.7	62	3758	56
2025-06-09 08:02:21 UTC	72	25.7	61.9	3904	56
2025-06-09 08:02:45 UTC	73	25.7	62.5	4042	56
2025-06-09 08:03:11 UTC	74	25.7	62.7	4095	56
2025-06-09 08:03:34 UTC	75	25.7	62.6	4095	56

DATASET

	A	B	C	D	E	F	G	H	I
1	Station	Date	NITRATE(PPM)	PH	AMMONIA(mg/l)	TEMP	DO	TURBIDITY	MANGANESE(mg/l)
2	station1	01-02-2022 8.00	18.3	5.7	0	17.69	11.6	86.1	0.71
3	station1	01-02-2022 8.20	3.6	5.1	0	19.42	10.5	71.8	0.62
4	station1	01-02-2022 8.40	13.1	5.5	0	18.6	10.3	75.9	0.73
5	station1	01-02-2022 9.00	18.1	5.2	0.1	19.1	9.4	70.3	0.64
6	station1	01-02-2022 9.20	10.8	5.2	0.1	18.57	8.8	66.9	0.68
7	station1	01-02-2022 9.40	1.8	5	0	16.48	7.3	13	0.67
8	station1	01-02-2022 10.00	22	5.3	0	14.33	11.5	47.2	0.63
9	station1	01-02-2022 10.20	17.7	5.9	0	15.89	9.6	18	0.7
10	station1	01-02-2022 10.40	10.7	5.8	0.1	14.95	10.9	63.7	0.64
11	station1	01-02-2022 11.00	1.4	5	0.1	18.17	6	41.2	0.68
12	station1	01-02-2022 11.20	8.4	5.4	0	15.3	9.5	36	0.64
13	station1	01-02-2022 11.40	11.4	5.4	0	19.93	7.6	12.6	0.61
14	station1	01-02-2022 12.00	20.5	5	0	14.36	6.8	11.7	0.6
15	station1	01-02-2022 12.20	12.5	5.8	0.1	14.74	6.1	82	0.72
16	station1	01-02-2022 12.40	5	6	0	15.93	7.9	42.3	0.72
17	station1	01-02-2022 13.00	25	5	0.1	18.94	6.8	51.9	0.66
18	station1	01-02-2022 13.20	27.5	5.6	0.1	18.23	12	9.7	0.71
19	station1	01-02-2022 13.40	0.9	5.5	0	19.15	10.3	66.8	0.68
20	station1	01-02-2022 14.00	29.1	5.3	0.1	18.65	8.8	46.5	0.64
21	station1	01-02-2022 14.20	3.9	5.4	0	17.66	6.7	35.8	0.72
22	station1	01-02-2022 14.40	15.3	5	0	18.98	11.2	76.9	0.64
23	station1	01-02-2022 15.00	17.9	5.4	0	19.46	11.2	85.5	0.71
24	station1	01-02-2022 15.20	12.3	5.7	0	16.44	6.1	61.5	0.74
25	station1	01-02-2022 15.40	29.7	5.8	0.1	14.14	9.3	84.3	0.71
26	station1	01-02-2022 16.00	8.1	5.2	0	15.53	7.2	86.4	0.75
27	station1	01-02-2022 16.20	3.9	5.3	0	15.87	11.5	9.3	0.69
28	station1	01-02-2022 16.40	1	5.5	0.1	19.06	6.5	35.4	0.7
29	station1	01-02-2022 17.00	23.6	5.1	0.1	15.03	7	82.6	0.66
30	station1	01-02-2022 17.20	29.9	5.7	0.1	19.64	6.6	70.4	0.65

Implementation Details

1. Problem Analysis
Identified water quality as critical for fish survival.
Key parameters: Temperature, Humidity, Turbidity, Soil Moisture.

2. Hardware Selection
Sensors: DHT11, Turbidity Sensor, Soil Moisture Sensor
Microcontroller: ESP32
Platform: ThingSpeak (IoT Cloud Dashboard)

3. System Architecture
ESP32 reads sensor data → connects to Wi-Fi → sends data to ThingSpeak.
Data is visualized in real-time using cloud graphs.

4. Hardware Integration
Wired ESP32 with sensors.
Verified functionality using Serial Monitor.

5. Coding & Data Processing
Developed code to:
- Read and map sensor data
- Connect to Wi-Fi
- Transmit data to ThingSpeak via HTTP

6. Cloud & Dashboard Setup
Created ThingSpeak channel with 4 data fields.
Configured graphs for real-time monitoring.

7. Testing & Calibration
Tested sensors under different conditions (wet/dry, clean/dirty).
Calibrated readings for accuracy.

8. Visualization & Alerts
Visual dashboards show trends.
(Optional) Alerts via buzzer/SMS/app for critical conditions.

9. Documentation & Review
Recorded all design, code, and testing notes.
Reflected on what worked and areas to improve.

10. Modular Design & Maintenance
Broke system into micro-modules: sensor reading, Wi-Fi handler, HTTP sender, etc.
Ensured ease of debugging and upgrades.

Results & Observations

Performance of the embedded system

Metric	Value / Status
Sensor Read Interval	Every 20 seconds
Data Upload Time	~1–2 seconds per transmission
Wi-Fi Connectivity	Stable with retry logic
Power Efficiency	Moderate (can be improved with deep sleep)
Data Accuracy	High (after sensor calibration)
System Uptime	24/7 monitoring with minimal crashes
ThingSpeak Latency	Low (~1-3 sec delay in visualization)

Advantages & Limitations

Key benefits of your solution

Benefit Area	Description
Real-time Monitoring	Constant tracking of temperature, humidity, turbidity, and soil moisture.
IoT Cloud Integration	ThingSpeak dashboard enables remote visualization and historical analysis.
Automation & Alerts	Reduces human labor by automating data logging and enabling alerts.
Scalability	Modular design allows for adding more sensors (e.g., DO sensor, pH sensor).
Improved Fish Health	Early detection of poor conditions helps prevent fish death and disease.
Low Cost	Utilizes affordable components (ESP32, basic sensors).
Educational Value	Ideal for learning IoT, embedded systems, and environmental monitoring.
Extensible Design	Can integrate ML for predictive analysis and mobile notifications.

Advantages & Limitations

Constraints and Limitations

Constraint Area	Description
Sensor Limitations	DHT11 is low-resolution; DO sensor unavailable in current build.
Accuracy and Calibration	Requires sensor calibration; turbidity and soil sensors can drift.
Power Dependency	Requires stable power; no battery or UPS backup yet.
Connectivity Required	Needs continuous Wi-Fi for ThingSpeak updates.
No Auto-Control	Currently only monitors, doesn't take corrective action (e.g., water purge).
Limited Alerting System	No SMS/mobile app alerts in current version—future feature.
Environmental Noise	Sensor readings may be affected by tank bubbles, vibrations, or placement.

Future Scope

Future Enhancements

- Add Dissolved Oxygen Sensor
- Mobile App Interface
- Predictive Alerts with Machine Learning
- Solar/UPS Backup for reliability

Conclusion

- Summary of learnings
- Key achievements

Thank you