### ****Project Plan: Smart IoT System for Algae Cultivation – Enhanced with Computer Vision and Intelligent Control****

### Team Members:

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### 1. ****Introduction****

We are proud to present our project titled **“Smart IoT System for Algae Cultivation – A Blue Carbon and Sustainable Green Economy Solution.”**

Our goal is to build a **smart and autonomous algae cultivation system** using IoT, AI, and **computer vision**. In this extended version, we integrate a **camera** to analyze **algae density** and use this data to intelligently control **CO₂ pumps, lighting, and fan systems** for optimal energy efficiency and productivity.

### 2. ****Phase 1: Research and Planning (Week 1–2)****

####  **Research:**

* Studied the environmental needs of algae species: **Spirulina, Chlorella, and Nannochloropsis**.
* Identified critical parameters: **light, pH, temperature, CO₂, dissolved oxygen (DO), turbidity, and algae density**.

#### **Hardware Components:**

* **ESP32** for real-time sensor data collection.
* **Raspberry Pi** as the IoT gateway, image processing unit, and data logger.
* **Camera (USB or Pi Camera)** for monitoring algae growth and density via image analysis.
* **Sensors**: pH, temperature, DO, CO₂, light intensity, turbidity.
* **Actuators**: water/CO₂ pumps, fans, LED lighting system.
* **OLED display** for local data visualization.
* **Relays** for automated device switching based on data.

####  **System Architecture:**

* Sensor and camera data are transmitted over **MQTT** protocol.
* Visual data processed with **OpenCV or AI models**.
* Control logic incorporates both sensor and camera data for decision-making.

### 3. ****Phase 2: System Setup and Configuration (Week 2–4)****

#### **ESP32 Programming**:

* Developed with Arduino IDE or PlatformIO.
* Reads data from all sensors, displays values on OLED, and sends via MQTT.

#### **Raspberry Pi Setup:**

* OS: Raspberry Pi OS (Lite or Desktop).
* Installed:
	+ **Node-RED** for data flow and UI dashboard.
	+ **Mosquitto MQTT Broker** for messaging.
	+ **InfluxDB or MySQL** for data logging.
	+ **Python + OpenCV** for real-time image capture and **algae density estimation** using image segmentation or pixel analysis.

####  **Automation Logic:**

* System intelligently controls injection, lighting intensity, and fan speed **based on both sensor data and algae density from camera**.
* Integrated with **Telegram or Zalo** for live alerts and system status updates.

### 4. ****Phase 3: Visualization and Control (Week 3–4)****

* Built a responsive dashboard with **Node-RED** showing all real-time sensor values and system states.
* Implemented manual and auto-control toggles for pumps, lighting, and fan.
* Integrated **Grafana with InfluxDB** for advanced time-series visualization.
* Displayed **camera feed** and live algae density indicators on the dashboard.

### 5. ****Phase 4: AI Optimization (Week 4–6)****

* Collected long-term environmental and visual data.
* Developed an API for feeding data into machine learning models.
* Applied **AI models** (e.g., linear regression, decision trees, CNNs) to:
	+ Predict optimal conditions.
	+ Automatically adjust CO₂ levels and lighting based on **growth stage and density**.
	+ Optimize energy usage while maximizing algae yield.

### 6. ****Phase 5: Finalization and Expansion (Post Week 6)****

* Plan to integrate **solar energy** as a power source.
* Migrate system infrastructure to the **cloud (AWS/GCP/Azure IoT)** for remote monitoring and control.
* Design a **carbon credit model** based on the amount of CO₂ absorbed by algae.
* Expand to **large-scale, fully automated algae farming systems** for industrial application.

### 7. ****Conclusion****

Our smart algae cultivation system aims to:

* Provide real-time monitoring and automation for optimal algae growth.
* Analyze both sensor and camera data to enable intelligent decisions.
* Apply AI to **minimize energy usage**, **enhance productivity**, and **support environmental goals**.

We believe this project not only contributes to **sustainable agriculture**, but also supports **global carbon reduction efforts** and the development of a **green economy**.

**Thank you for your attention!**