IOT - CONTROLLED SEAWEED MONITORING SYSTEM

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ABSTRACT: *This study presents a comprehensive developmental approach encompassing both hardware and software components designed for the monitoring of seaweed aquaculture in Cantilan, Surigao del Sur. Over a meticulous six-month observation period, we scrutinized data derived from four pivotal charts illustrating variations in temperature, water salinity, dissolved oxygen levels, and pH Levels. Integrating innovative technologies in aquaculture monitoring aims to enhance our understanding of the dynamic environmental factors influencing seaweed cultivation in the waters of Cantilan. The findings contribute valuable insights for sustainable aquaculture practices and underscore the importance of technological innovation in optimizing seaweed production systems.*

This comprehensive understanding of seasonal variations enables strategic planning for seaweed cultivation, addressing potential diseases, and optimizing growth conditions. The project's focus on leveraging technology and environmental applications positions it at the forefront of innovative research with tangible implications for sustainable aquaculture practices. The study also recognizes seaweed farming problems. On a scale of 10, we analyzed the infestation rates for different issues: Ice-ice had an average score of 2.25, fish attacks averaged 1.8, and green-haired algae had an average rate of 1.5. Continuous monitoring is critical, particularly as issues intensify approaching the monsoon season. The findings contribute not only to local economic progress but also offer valuable insights for coastal regions worldwide engaged in seaweed farming.

Keywords: Seaweed Monitoring, IoT (Internet of Things), Aquaculture, Seaweed Farming

INTRODUCTION

The Philippines is the world's third largest producer of seaweeds, following Indonesia and China [3]. The country had been identified as having 1,065 species of seaweeds but what was in mass production is the Eucheuma and Kappaphycus. Furthermore, seaweed production in the country increased by 0.25 per cent during the first quarter of 2018 [8]. In 2022, seaweed production reached 1.5 million metric tons, and BARMM is the top producer owning more than half of the country's total production. The projected estimates approximately 1.2 million people are involved in and benefit from seaweed farming, which provides job opportunities and elevates the socioeconomic status of coastal communities across the country [9]. However, statistics show that the Eastern, Western, and Central Visayas regions produced fewer seaweeds. The Eastern Visayas Region's poor performance was primarily due to seaweed farms in Leyte being affected by ice-ice disease since December 2017. It was also stated that the prevalence of ice-ice disease in seaweed farms in Antique is the primary cause of the decline in seaweed production in the Western Visayas region [8].

The most common disease of the Eucheuma and Kappaphycus seaweeds is ice-ice disease. It is caused by unfavorable environmental conditions such as high or low salinity, high or low temperature, lack of nutrients, and other factors [1]. Furthermore, the cultivation ground is close to freshwater sources, which reduces the salinity of the seawater or the occurrence of high-water temperature and high light intensity which are conditions that can also trigger a bacterium that causes ice-ice disease in seaweeds.

As a result, farmers in the Philippines employ a variety of coping strategies to minimize the risk of ice-ice disease [2]. These include manual ice-ice disease removal, floating monoline, and fertilizer applications. However, these strategies are only used to minimize the risk; as a result, a highly effective management strategy is necessary to have full prevention [5]. One of the concerns that researchers will investigate is farmers' inability to control seaweed growth due to the uncontrolled nature of the open sea. Farmers' current cultivation method does not aid in the prevention of ice-ice disease. Thus, an IoT-controlled monitoring system for seaweeds has been proposed to solve the current problem. Environmental parameters such as temperature, salinity, and pH level influence the occurrence of ice-ice disease. These parameters were being monitored because they are uncontrollable in the seaweed's natural environment.

The Food and Agriculture Organization (FAO) projects that global food production must increase by **60% by 2050** to feed a population expected to reach 9 billion adequately. This challenge was compounded by the need for food security, which was threatened when people lacked access to sufficient, safe, and nutritious food. As the global population grows the demand for agricultural products rises, and there are significant market opportunities for supply, processing as well as in storage sectors. The sea offers a year-round food source, with fish and seaweed being vital components, especially since **60% of the world's population lives near coastlines**. While seafood production has traditionally been slow and low-paying, advancements in aquaculture are addressing these challenges [11]. Innovative methods are increasingly essential to meet the demands of changing demographics and consumer preferences, emphasizing that food security remains a top priority worldwide [6]. Additionally, integrating seaweed cultivation into energy production systems presents opportunities for economic development in coastal communities, aligning with broader goals of renewable energy and sustainable resource management [7].

Materials and Methods

The research materials and techniques, including block diagram design, hardware and software functionality, and standards, are included in this section. Using a developmental method, the researchers will design hardware and software and oversee their deployment and testing. The IoT-controlled seaweed monitoring system was composed of sensors. The Arduino board was used to program the sensors and gather data. The servo activates depending on the change in the value on depth parameters on the web server. Additionally, the seaweed farm can now be monitored conveniently and quickly with the help of an IoT application.

Block Diagram

The block diagram for the entire system is illustrated in Figure 1.

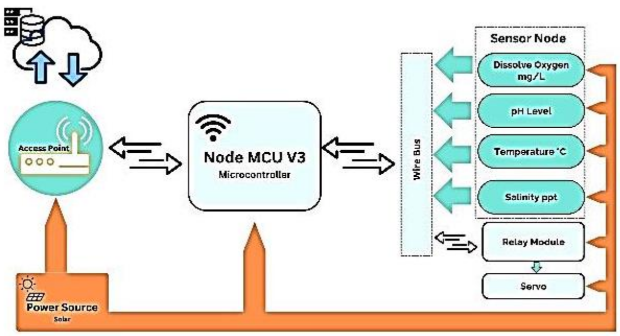

Figure 1. Block Diagram of the Proposed Project

The standard values set in the Node MCU V3 serve as the reference input. These are the optimal parameters for healthy seaweed growth that will result from the standard. The Node MCU acts as the main controller, equipped with attached sensors and a relay that allows remote access and control. The servo was attached to the relay circuit which awaits the trigger from the microcontroller. The servo allows the change in crop depth. The components were powered by a solar setup with the precise configuration of a voltage controller that distributes exact voltage to the different component's requirements. The sensors will serve as the system's feedback mechanism, with each sensor detecting changes in the environment and transmitting them to the Node MCU microcontroller, with version 3 it has a built-in Esp8266 WIFI module allowing direct communication to the designated Access Point. The gathered data is then constantly transmitted to the cloud at certain intervals by the Node MCU to the cloud server, and within the process allows also the checking of the reference input and compares it to the ideal parameters. The code determines whether the values meet the condition. If this occurs, the flow continues to repeat in a loop condition until the identified values exceed the predefined input parameters.

Hardware Design

The technologies that support seaweeds' healthy growth were the primary components that emphasize the hardware design. Every electrical part will be positioned within a circuit box. The circuit box is filled with the following parts:

1. ***Node MCU v3***

   The Node MCU V3 is the microcontroller with an integrated WIFI module ESP8266. The standard values of the parameters are defined within its code.

2. ***Sensors (DO, pH, Temperature)***

   The sensors attached to the microcontroller and left hanging in the seawater will collect data every second. The sensors will collect data from their surroundings and transmit it to the IOT application.

3. ***Voltage Regulator***

   The regulator used consists of a potentiometer that can be adjusted as to the right voltage and current needed for the project.

4. ***Solar Panel***

   The project uses one 50W solar panel cell capable of charging a 12V solar battery.

5. ***Charge Controller***

   A component that regulates the charging and distribution of the solar setup. It's where the battery and voltage regulator were interconnected to allow controlled management of power distribution.

6. ***12V Battery***

   Serve as storage and power source of the project.

Software Design

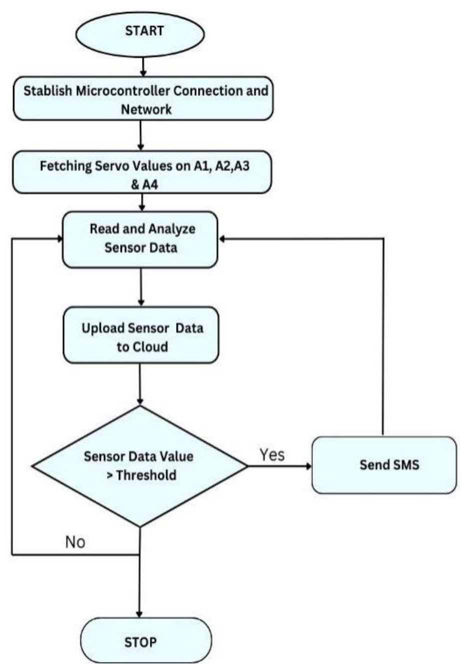

Figure 2. Flowchart of the Project

The Internet of Things application for seaweeds in understanding the environmental impact of different water parameters and weather conditions particularly in Cantilan Surigao del Sur. Served as one of the monitoring and controlling mechanisms of the system. The current temperature, DO, salinity, and pH level will be displayed by the application.

The IoT application has five (5) buttons on the main page: the sensors, controller, location map, about, and exit buttons. The app offers a window to the sensor data and control as well as project locations.

Standards

The optimum seaweed farming technique and suitable setup are identified in the ASEAN/SF/88/Manual No. 3 standard, which will serve as the foundation for this design.

The best seaweed system is developed using the standard to calculate the standard parameters. The standards for salinity (27–35 ppt) and temperature (25–30 °C) are what is considered ideal for the growth of seaweed [10]. Standard saltwater has a pH of 7-9, according to the ISO 18191:2015 standard, which is used as the threshold value of the project. The values are then predefined and integrated into the microcontroller command to execute a process as soon as sensors detect values go above or below the defined threshold.

Final Design

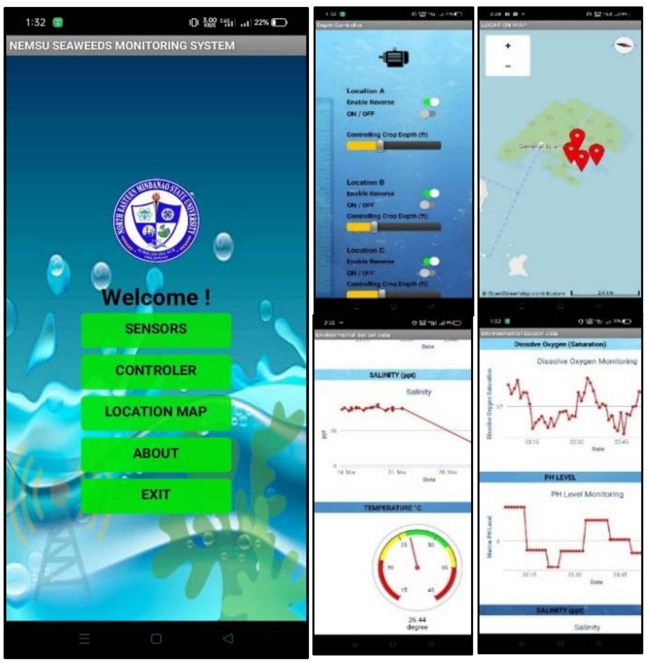

Figure 3. Seaweeds Mobile Application

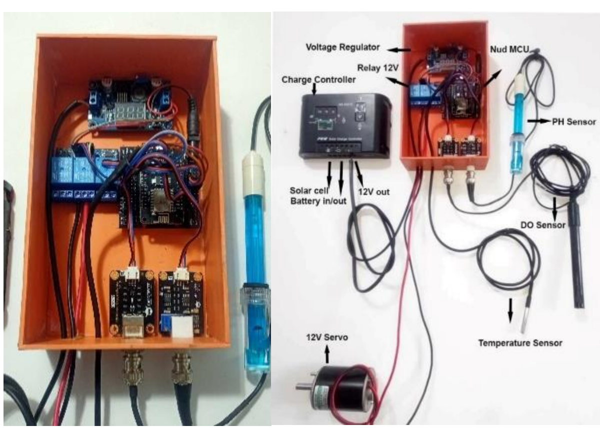

Figure 4. Seaweeds Hardware Component

RESULTS AND DISCUSSION

A. Sensor detection results Temperature, Dissolve Oxygen, Salinity, and pH

The first chart, depicting average temperature readings across four locations, reveals a noteworthy downward trend towards the end, indicating a significant temperature change. With a top pick of 29.8°C and lowest of 26°C across locations. This observation aligns with real internet data sourced from regional weather databases, confirming that the project site in Cantilan, Surigao del Sur, experienced a shift consistent with the onset of the monsoon season. Despite the proximity to the Pacific Ocean, the deviation from standard readings can be attributed to the influence of monsoon seasons on currents and wind patterns.

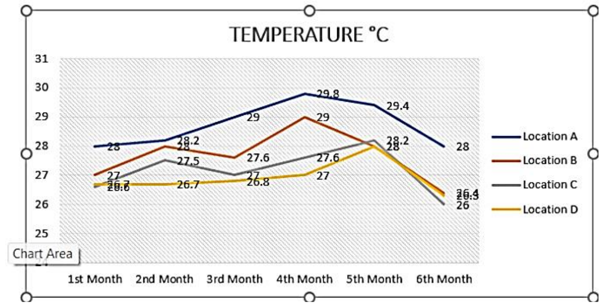

Figure 5. Average Temperature

The second chart, focusing on water salinity measured in particles per million (PPT), reinforces the impact of seasonal changes. A pronounced downward slope is evident, reaching from 35.1 to a minimum of 32 PPT. This substantial alteration in salt concentration underscores the dynamic nature of the oceanic environment, directly affected by monsoons. The project's strategic location near the Pacific Ocean positions it at the intersection of varied water masses during this period, contributing to the observed fluctuations.

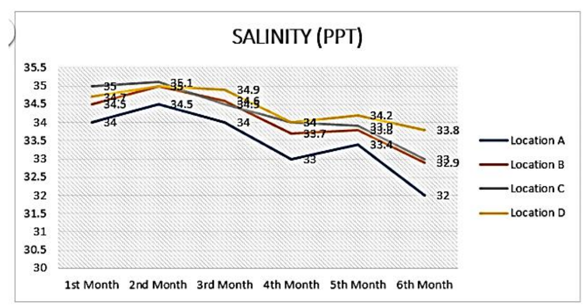

Figure 6. Average Salinity

Moving on to the third chart, which illustrates average dissolved oxygen levels, a contrasting pattern emerges. An upward slope culminates in a peak saturation level of 97.2. This intriguing phenomenon can be linked to the interplay of monsoon-driven currents, fostering optimal conditions for oxygen dissolution. The symbiotic relationship between seaweed cultivation and oxygen levels is crucial, and the data suggests an opportune time for such activities during the monsoon season.

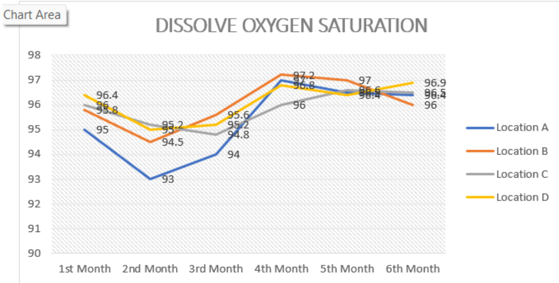

Figure 7. Average DO Saturation

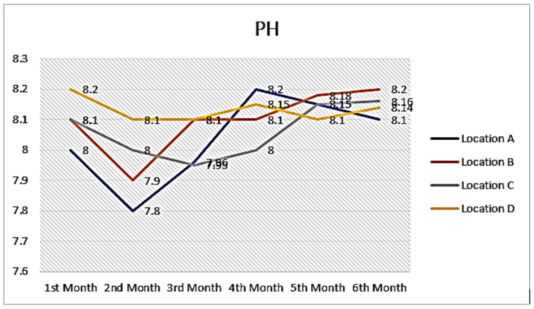

Figure 8. Average pH Level

The fourth chart detailing pH levels exhibits a nuanced fluctuation with a small upward slope, reflecting the intricate interplay of environmental factors. The highest was 8.2 and the lowest was 7.8 across locations. Monsoon seasons influence the pH of the seawater, impacting the feasibility of seaweed cultivation. This comprehensive understanding of the seasonal variations in temperature, salinity, dissolved oxygen, and pH enables strategic planning for seaweed cultivation, helping to mitigate potential diseases and optimize growth conditions. The project's focus on leveraging technology and environmental applications positions it at the forefront of innovative research with tangible implications for sustainable aquaculture practices.

A. Seaweeds Analysis

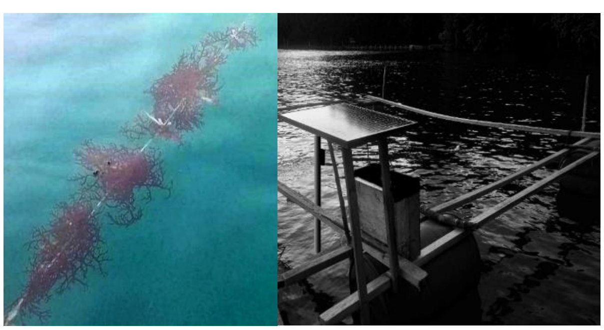

Figure 9. Seaweed Crop

Seaweed farming has been one of the contributors to the economic progress in some coastal countries in the world [4]. Its potential in the Pacific regions has been tested by some municipalities with calm coastal areas. This study explores its potential in the waters of Cantilan Surigao del Sur specifically in General Island areas. The target duration of the observation was six months with a seaweed variety known as Eucheuma and a brown species. The technology monitoring system developed helps understand some environmental factors that influenced the progress of the crop. During the duration, we were able to recognize seaweed farming problems from a macro perspective.

Ice-ice *Fish Attack* *Green Hair Algae*

The images above show the problem foreseen by the researcher as the project progresses. The problems occurred in the different locations identified. Its occurrence depends on the environmental parameters that influence water conditions in the area of the crop. Figure 10 plots the occurrence of these problems throughout the entire farming duration.

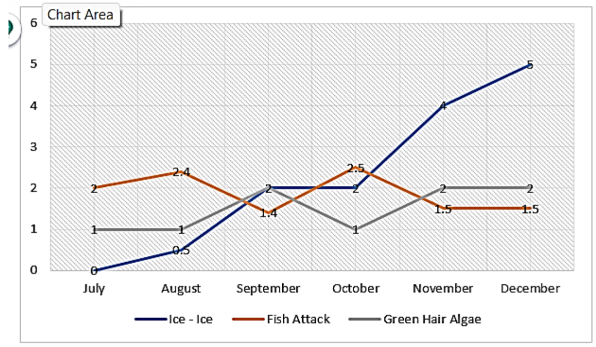

Figure 10. Seaweeds problem occurrence

The chart illustrates the average scale of the identified problem for the overall farming cycle. Ice-ice conveys an upper slope gaining a mean of 2.25 on a scale of 10 showing an increase of severity as the month approaches monsoon season. This further justifies that the ice–ice possibility increases as the water salinity drops as shown in Figure 7. Fish attack problem is imminent throughout the farming cycle which gains an average rate of 1.8 meaning, this could be minimized if the farmer conducts daily monitoring of the farm. The monitoring process creates distractions that could lessen the time for fish to eat the seaweed. The green hair algae problem shows a continuous presence throughout the farming cycle which gains an average rate of 1.5. Its existence was triggered by the right water conditions and exposure to sunlight.

CONCLUSION

The developed technology provides data for a comprehensive analysis of environmental factors in Cantilan, Surigao del Sur, conducted over a six-month observation period, and provides valuable insights for optimizing seaweed cultivation. The first chart, depicting temperature trends, indicates a significant shift aligned with the onset of the monsoon season. This deviation is crucial for understanding the dynamic nature of the region's climate, impacted by oceanic currents and wind patterns. In understanding water salinity issues, it emphasizes the influence of seasonal changes. The substantial alteration in salt concentration, from 35.1 to 32 PPT, underscores the project's strategic location near the Pacific Ocean, where it intersects varied water masses during the monsoon season.

Dissolved oxygen levels, illustrated in the third chart, show an upward trend, reaching a peak saturation level of 97.2. This phenomenon, attributed to monsoon-driven currents, creates optimal conditions for oxygen dissolution, highlighting a favorable period for seaweed cultivation. The nuanced fluctuation in pH levels, as depicted in the fourth chart, reflects the intricate interplay of environmental factors during monsoon seasons. This understanding enables strategic planning for seaweed cultivation, mitigating potential diseases, and optimizing growth conditions. In addressing specific challenges identified during the observation, such as Ice-ice, fish attack, and green hair algae problems, continuous monitoring is a critical strategy. The severity of issues increases as the monsoon season approaches, emphasizing the importance of proactive measures. The technological monitoring system developed proves instrumental in recognizing macro farming problems, providing an opportunity for timely intervention and optimization.

This study positions the project at the forefront of innovative research, leveraging technology and environmental applications for sustainable aquaculture practices. The findings contribute not only to the local economic progress in Cantilan but also offer valuable insights for coastal regions worldwide engaging in seaweed farming. The project focuses on real-time monitoring and strategic planning to understand the potential of seaweed aquaculture in Cantilan. It is best studied over the long term, as this allows for consideration of more factors, species, and data. The analysis of sensor detection and farming data shows that the best time to operate seaweed farming is from May to August. This will streamline the farming steps and methods for successful seaweed farming. The weather patterns and shifting can be a substantial contributing factor in understanding the changes in environmental parameters.

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