LOTUS GUARDIAN:AN AUTONOMOUS LOTUS FARMING SYSTEM

Prof. Komalakumari[1], Mr. Akash Gowda M S[2], Mr. Koushik S[3], Mr. Mohammed Ismail[4], Mr. Vinay Kumar M K [5]

[1]Professor, [2]Student, [3]Student, [4]Student, Student[5]
[1]Department of Electronics and Communication Engineering,
[1]VIDYA VIKAS INSTITUTE OF ENGINEERING AND TECHNOLOGY MYSURU-570028, KARNATAKA

ABSTRACT

The cultivation of lotus plants, while culturally and economically significant in many regions, faces challenges such as fluctuating water levels, pest infestations, labor-intensive maintenance, and inefficient monitoring practices. This project introduces ***Lotus Guardian: An Autonomous Lotus Farming System****, a smart agricultural solution designed to automate and optimize lotus farming through the integration of IoT, robotics, and environmental sensing technologies. The system comprises a floating autonomous robot equipped with water quality sensors, a camera module for plant health monitoring, and an automated irrigation and nutrient management unit. Controlled by a microcontroller and powered by solar energy, the Lotus Guardian continuously monitors key parameters such as water temperature, pH levels, turbidity, and humidity. It employs AI-based image processing to detect early signs of disease or pest attacks and notifies farmers through a mobile application interface. By automating routine tasks such as fertilization, weed detection, and real-time environmental monitoring, the system significantly reduces labor requirements and improves crop yield. Experimental implementation in a controlled lotus pond environment demonstrated improved water management, early disease detection, and consistent plant growth.*

Keyword: Smart farming, IoT monitoring Autonomous robot, Water quality sensing, Lotus cultivation

---

1. INTRODUCTION

Agriculture remains a vital part of the global economy and food production system, and with rising food demands and changing climate conditions, it faces mounting pressure to become more efficient, intelligent, and sustainable. Among the various branches of agriculture, aquatic farming—particularly the cultivation of lotus— poses unique challenges. Lotus, known for its cultural, medicinal, and ornamental value, is widely cultivated across Asia, especially in regions like India, China, and Japan. Despite its popularity and economic significance, lotus farming still relies heavily on traditional methods that are labour-intensive and inefficient. Lotus cultivation requires precise control over environmental variables such as water depth, temperature, turbidity, and nutrient availability. Inconsistencies in these parameters can significantly affect plant growth, flowering cycles, and overall yield. Furthermore, sudden changes in water quality, weather conditions, or pest infestations often go unnoticed until visible damage occurs, by which time it is often too late to take corrective action.

The agricultural sector is undergoing a digital revolution, with smart farming methods being adopted to monitor and manage resources in real-time. This evolution, commonly known as Precision Agriculture, emphasizes data-driven decision-making. In this context, Internet of Things (IoT) technology has emerged as a powerful enabler of smart farming. By embedding sensors and microcontrollers in farming environments, IoT systems can collect, transmit, and act upon data automatically. The Lotus Guardian project emerges from the idea of applying IoT principles to a traditionally manual domain lotus farming.

1.1 LITERATURE SURVEY

The integration of Internet of Things (IoT) technology in agriculture has brought significant transformation in how farming operations are carried out. While extensive research and implementation have been done in the domain of smart agriculture for soil- based farming, aquatic farming, and more specifically, lotus cultivation, remain underexplored in terms of automation and IoT applications. This literature review explores various studies and technological advancements that have laid the groundwork for the development of an automated lotus farming system.

Table 1 : Review of Related Work

Sl No.	Title	Author`s name	Method	Merits
1.	Autonomous River Depth Mapping for Tourist Safety	Bugatha Ram vara Prasad	Impact of fast charging on grid	Reduce the fuel consumption
2.	IoT-Based River Monitoring Robot for Drowning Prevention 2020	Sanghoon, C, Yong hae	Design of bidirectional battery charger of electric vehicle,	Simple and more practicle ways.
3.	Smart Surface Robot for River Depth Detection. 2019	M Singh	Feasibility study on bipolar pads for effient wireless power chargers.	Sola power for keeping the charging system going.
4.	GPS-Enabled River Monitoring Robot for Tourist Areas 2019	Suh, Y H and Chang K	Simulation and experimental analysis of solar charging station for IOT	No need to stop for charging.

2. SYSTEM ARCHITECTURE

Hardware Overview:

Hardware Required:

The system is built on a river boat platform designed for automated lotus flower collection. It utilizes a combination of wireless communication, motor control, and mechanical harvesting components. An Arduino microcontroller serves as the brain of the system, receiving commands from a smartphone application via a Bluetooth module. The boat is powered by a rechargeable battery and driven by DC motors connected to a motor driver, enabling smooth navigation across the pond. A flexible net mechanism mounted on the boat assists in harvesting lotus flowers as the boat moves, and can be lifted or lowered using a motor or servo for efficient collection. The chassis of the boat is designed to be waterproof, sturdy, and capable of supporting all electronic and mechanical components. Overall, the system offers a semi-autonomous lotus harvesting solution that reduces manual effort and improves efficiency in aquatic farming environments**.**

Software and Control Logic:

The system utilizes the Arduino IDE to program the microcontroller, which acts as the central control unit for the lotus harvesting boat. Through the IDE, code is written and uploaded to manage the boat’s movements, operate the motors, and control the net mechanism based on commands received wirelessly. To enable seamless user interaction and remote control, a Bluetooth-enabled mobile application is used. This app either custom-developed or an existing Bluetooth controller tool — allows the operator to command the boat using an intuitive interface. With functions such as forward/backward navigation, left/right steering, and activation of the harvesting net, the app provides real-time control and enhances operational efficiency in lotus farming.

The Lotus Harvesting Boat system is composed of several interconnected components that work together to automate the lotus harvesting process. The system architecture is designed to integrate robotics, IoT, and Bluetooth control to provide an efficient, safe, and eco-friendly solution. Below is a breakdown of the system's architecture:

1. Components of the System Architecture:

a. **Bluetooth-Controlled Boat Bluetooth Module**: The boat is equipped with a Bluetooth module (such as the HC-05 or HC-06) that allows remote communication between the boat and a mobile application.

- **Microcontroller**: A microcontroller (like Arduino or Raspberry Pi) is responsible for controlling the boat's movements and the harvesting mechanism based on commands received via Bluetooth.

- **Motorized Propulsion System**: The propulsion system consists of motors that drive the boat in all directions (forward, backward, left, right). This system is connected to the microcontroller to execute the navigation commands.

- **Power Supply**: The boat is powered by a battery (rechargeable, preferably solar-powered) to ensure sustainable operation on water.

b. **Automated Harvesting Mechanism o Harvesting Net**: The boat is equipped with a durable net designed to capture lotus flowers. The net is attached to the boat and is deployed automatically as the boat moves across the water.

- **Sensors**: Proximity sensors or ultrasonic sensors can be used to detect obstacles and ensure that the boat navigates through the lotus field without damaging the plants.

- **Collection Area**: The lotus flowers collected by the net are stored in a designated collection area on the boat until they are manually removed. The app communicates with the boat via Bluetooth, allowing users to steer the boat and control the net remotely.

c. **Mobile Application o Control Interface**: A mobile application is developed to control the boat's navigation and harvesting process. The app communicates with the boat via Bluetooth, allowing users to steer the boat and control the net remotely. o User Dashboard: The app includes a user-friendly interface that displays battery status, boat location (via GPS), and other critical information.

- **Safety Features**: The app includes safety features like low battery warnings, operational status alerts, and emergency stop functions to ensure smooth operation. The app communicates with the boat via Bluetooth, allowing users to steer the boat and control the net remotely

d. **Environmental Sustainability Features o Compact and Lightweight Design**: The boat is designed to be light and small enough to minimize disruption to the water body and the ecosystem.

- **Eco-Friendly Materials**: The materials used to construct the boat and net are eco-friendly to ensure that the system does not harm the aquatic environment. A microcontroller (like Arduino or Raspberry Pi) is responsible for controlling the boat's movements and the harvesting mechanism based on commands received via Bluetooth. The app includes safety features like low battery warnings, operational status alerts, and emergency stop functions to ensure smooth operation.

3. PROPOSED METHODOLOGY

The methodology adopted for the development of the Lotus Guardian system is structured to achieve an efficient, autonomous, and scalable solution for lotus farming. The process is divided into multiple stages, each focused on integrating appropriate hardware, software, and communication technologies to address the core requirements of aquatic agricultural monitoring and automation.

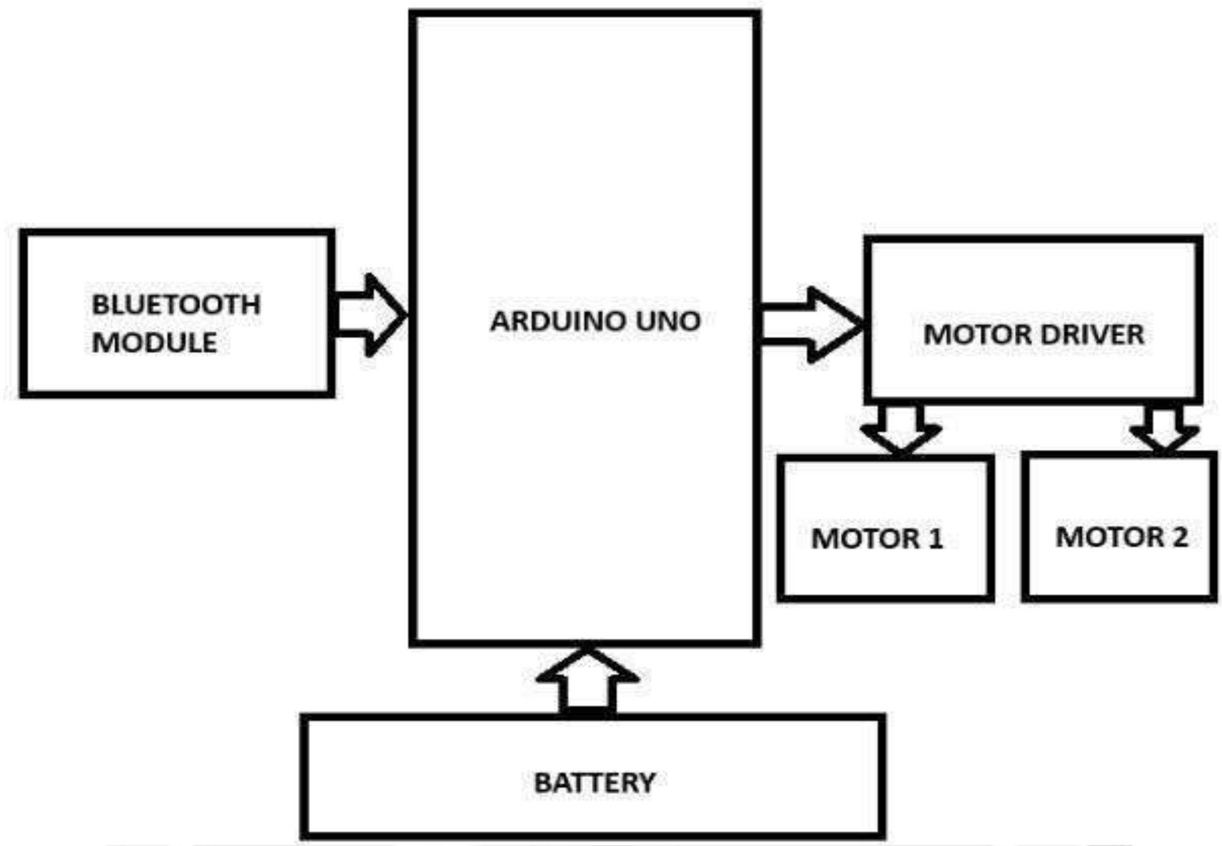


Fig 3.1 Block diagram of Proposed Architecture

3.1 Working Principle

The working principle of the Lotus Harvesting Boat is based on automation and remote control via Bluetooth communication. Below is a detailed explanation of the system's working process:

1. System Initialization

- The operator powers on the Bluetooth-Controlled Boat, ensuring that the Bluetooth module is activated and ready for communication.
- The boat's microcontroller (Arduino/Raspberry Pi) initializes the movement controls, the harvesting mechanism, and the sensor systems.

2. Bluetooth Connection

- The operator opens the mobile application designed for controlling the boat.
- The app pairs with the boat's Bluetooth module, establishing a connection for real- time control.
- Once connected, the app's user interface displays options for steering the boat, controlling the harvesting net, and monitoring the battery status.

3. Navigation and Movement

- Using the mobile app, the operator controls the movement of the boat via directional commands: forward, backward, left, and right.

- The app sends commands to the microcontroller, which translates the signals into motor controls to move the boat accordingly.

- The motorized propulsion system drives the boat through the lotus-covered water body, enabling precise navigation for efficient harvesting.

4. Automated Harvesting Process

- As the boat moves, the harvesting net is automatically deployed and positioned to capture lotus flowers along the boat's path.

- The net is attached to the boat's structure and is designed to ensure that flowers are gently captured without causing damage to the plant.

- The boat moves in a pre-defined path, with the net continuously sweeping through the water to collect lotus flowers.

5. Data and Control Feedback

- The boat's environmental sensors (e.g., proximity, ultrasonic sensors) continuously scan the surroundings for obstacles and adjust the boat's trajectory to avoid collisions.

- The mobile application provides feedback on the boat's battery status, GPS location, and real-time operational status.

- The operator can receive alerts for low battery, abnormal water conditions, or any issues related to the harvesting process.

- If required, the operator can take manual control to adjust the boat's position or stop the harvesting process.

6. Collection and Completion

- The lotus flowers collected by the net are stored in the collection area on the boat.

- Once the boat completes a specific area of the pond, the operator can either:

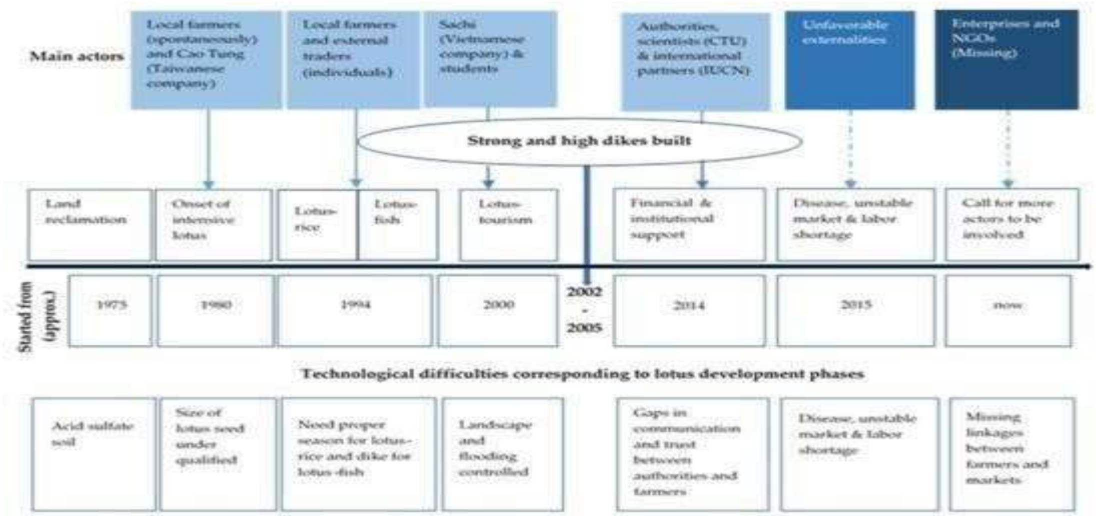
    - Continue the operation.

    - Return the boat to shore for unloading the collected lotus flowers.

7. End of Operation

- After harvesting is completed, the operator navigates the boat back to the starting point or to a docking station using the mobile app.

- The system is powered off, and the Bluetooth module disconnects, ensuring the boat is ready for the next operation.



4. RESULT AND DISCUSSION

4.1 Result Analysis

The Lotus Guardian system was developed and tested under controlled conditions to evaluate its performance, reliability, and effectiveness in monitoring aquatic environments specifically tailored for lotus cultivation. The results obtained during the experimental phase reflect the system's potential in transforming traditional lotus farming into a smart, data-driven practice.

1. Sensor Accuracy and Reliability

Each environmental parameter was measured using dedicated sensors and compared against manually measured benchmarks:

- **pH Sensor:** Displayed consistent readings within ±0.2 accuracy, proving reliable for identifying imbalances in water acidity.
- **Water Temperature Sensor (DS18B20):** Delivered highly accurate readings with minimal deviation (< ±0.5°C), ensuring accurate thermal monitoring.
- **Water Level Sensor (Ultrasonic):** Effectively tracked fluctuations in water level with a high degree of sensitivity and minimal error.
- **Turbidity Sensor:** Accurately detected water cloudiness, useful for early detection of contaminants and algae blooms.

2. Real-Time Monitoring and Alert System

Data was successfully transmitted from the sensor modules to the IoT cloud platform using Wi-Fi and Bluetooth communication. Real-time data updates and visualizations were consistently received on the mobile application, demonstrating reliable connectivity and low latency. Alert notifications were triggered accurately whenever sensor values crossed predefined thresholds, allowing timely intervention.

3. Mobile Application Functionality

The Android app developed via Android Studio provided an intuitive user interface for monitoring all sensor parameters. Users could visualize historical trends through graphs, receive immediate alerts, and trigger manual controls for actuators such as pumps. Feedback from test users indicated the app was easy to navigate and effectively extended system control remotely.

4. Energy Efficiency

The inclusion of the TP4056 charging module and support for solar panel integration ensured uninterrupted power supply during the testing period. The system operated continuously for over 48 hours on battery power alone, validating its suitability for offgrid deployment.

5. Automation and Actuator Response

Automated actions, such as turning on water pumps based on sensor input, were triggered without delay. The servo motors and actuators responded effectively, maintaining optimal water levels and conditions. This confirmed the system's potential to reduce manual labor and increase productivity.

6. Scalability and Environmental Adaptability
The modular design of the system allowed for easy replication in different pond setups. The hardware and software were tested under slightly varying environmental conditions, and the system demonstrated stable performance with minor recalibrations.

7. Cost and Practical Viability
Compared to traditional monitoring tools and commercial precision agriculture systems, the Lotus Guardian offers a significantly more affordable alternative. All components were sourced with budget constraints in mind, and the system was assembled with minimal technical resources, making it highly practical for rural farming communities.

4.2 Discussion

The development and testing of the Lotus Guardian system demonstrate how Internet of Things (IoT) technologies can be successfully adapted for aquatic agriculture, particularly for crops like lotus that require continuous and precise environmental monitoring. The system bridges the technological gap between traditional manual practices and modern precision farming by offering real-time, autonomous monitoring and control capabilities. One of the key discussion points revolves around the **reliability and precision of sensor data**. During the implementation phase, the sensors used (pH, temperature, turbidity, and water level) performed within expected accuracy ranges. This confirms that cost-effective sensors, when properly calibrated, can serve practical purposes even in critical applications such as farming. However, regular maintenance and calibration are necessary to ensure long-term reliability, especially in outdoor aquatic environments where sensor fouling can occur due to algae or sediment buildup.
Another important aspect is the system's **autonomous response mechanism**. The automation of actions like water level adjustment or contaminant alerts reduces the need for constant human supervision, which is particularly beneficial for farmers with large ponds or those located in remote regions. The ability to send real-time alerts through the mobile app further empowers farmers to take immediate corrective measures, minimizing potential crop loss. In terms of **usability**, feedback from prototype testing showed that the Android-based mobile interface was intuitive and user-friendly. This is crucial for rural adoption, where technological familiarity may vary. By focusing on a clean and accessible design, the system becomes more inclusive and encourages broader adoption across different levels of technical literacy. The project also raises interesting implications for **sustainability and energy efficiency**.
The use of solar-powered energy modules and low-power components like the ESP8266 ensures that the system can operate in off- grid conditions, promoting environmental sustainability while maintaining continuous operation. This is a major advantage in remote farming areas with unreliable electricity. Despite its strengths, the system does have certain **limitations**. Environmental factors like heavy rainfall or water pollution could potentially impact sensor performance or damage hardware if proper housing is not provided. Additionally, while the system works well for monitoring, further enhancements—such as machine learning for predictive analysis or integration with automated nutrient dosing—could make it even more powerful and autonomous. From a broader perspective, the Lotus Guardian illustrates how technology can be customized to serve niche agricultural sectors that are often overlooked. It encourages innovation in sustainable farming and highlights the need to extend smart agriculture technologies beyond soil-based systems to aquatic environments.

5. CONCLUSION AND FUTURE WORK

The *Lotus Guardian* project presents a significant advancement in the automation of aquatic agriculture, specifically tailored to the unique requirements of lotus farming. By integrating modern technologies such as IoT, automation, and environmental sensing, the system enables precise monitoring and control of critical parameters like water level, temperature, humidity, and nutrient balance. This not only reduces manual labor but also ensures optimal growing conditions, improving crop yield and resource efficiency.
The autonomous operation of the system allows for continuous observation and timely intervention, making lotus cultivation more resilient to environmental fluctuations and human error. With features such as automated irrigation, remote data access, and alert mechanisms, the *Lotus Guardian* offers a smart and scalable solution for sustainable lotus farming. In addition to boosting productivity, it supports eco-friendly agricultural practices by minimizing water and fertilizer wastage.
In conclusion, the *Lotus Guardian* demonstrates how automation and smart farming technologies can transform traditional farming practices. It provides a foundation for future developments in precision agriculture, especially in aquatic crop cultivation, and holds promise for broader applications in improving food security and environmental sustainability. The **Lotus Harvesting Boat** represents a significant leap forward in the modernization of lotus farming and aquatic agriculture. By combining Bluetooth-controlled automation with an efficient harvesting mechanism, the system offers a safer, more efficient, and environmentally friendly solution to the traditional manual methods of lotus collection. The boat not only reduces the physical labor required but also minimizes the risks

associated with working in aquatic environments, making it a valuable tool for both small and large-scale farmers.
This innovative system improves productivity, enhances the quality of the harvest by minimizing damage to the delicate lotus flowers, and offers a cost-effective solution for the growing demands of lotus farming. Additionally, its environmental considerations ensure that the aquatic ecosystem remains undisturbed, making the system sustainable in the long term.

5.1 Future Work

.

1. Integration with Autonomous Navigation:
Future advancements could include autonomous navigation systems using GPS and sensors for obstacle detection, allowing the boat to operate without manual control, further increasing efficiency and reducing human intervention.

2. Improved Harvesting Mechanism:
The development of more advanced, adaptable harvesting nets or robotic arms could enhance the boat's capability to collect lotus flowers of varying sizes and growth stages, increasing versatility and reducing damage.

3. Solar-Powered Operation:
Incorporating solar panels could make the boat energy-efficient and environmentally friendly, allowing it to operate for longer periods without relying on external power sources, especially in remote or off-grid areas.

4. Real-Time Data Analytics:
The integration of sensors for water quality monitoring, plant health, and environmental conditions could provide real-time data on the water body’s status. This would help optimize harvesting operations and offer valuable insights for farmers.

5. IoT and Cloud Connectivity:
Future iterations could include cloud connectivity for remote monitoring and control, enabling farmers to track and manage multiple boats from a centralized platform. This would allow for better fleet management and data collection across large farms.

6. Robust AI Integration:
AI could be utilized to analyze harvesting patterns, predict the best times for harvesting, and adjust the boat’s path for maximum efficiency. Machine learning could help in understanding the growth cycle of lotus flowers and improve harvesting strategies.

7. Enhanced Navigation in Challenging Environments:
Future developments could include better navigation capabilities, such as the ability to operate in shallower waters or dense aquatic vegetation, making the boat more adaptable to diverse aquatic environments

8. Integration with Smart Farming Systems:
The boat could become part of a broader smart farming system, connected to other devices such as drones for aerial monitoring, soil moisture sensors, and automated irrigation systems, making the entire farming process more streamlined and efficient.

9. Global Adoption in Aquatic Ecosystem Management:
Beyond commercial farming, the technology could be adapted for use in managing invasive aquatic species, environmental cleanup, or even maintaining water bodies in urban areas, expanding its applicability on a global scale.

REFERENCES

[1] N. Patel, A. Mehta, and R. Joshi, “Smart irrigation system using IoT,” International Journal of Computer Applications, vol. 182, no. 45, pp. 25–29, 2019.
[2] Y. Zhao, L. Chen, and H. Sun, “IoT-based smart aquaculture system for real-time monitoring,” IEEE Internet of Things Journal, vol. 7, no. 6, pp. 5403–5410, 2020.
[3] Indian Council of Agricultural Research, “Agronomic practices for improved lotus (Nelumbo nucifera) cultivation,” Indian Journal of Agricultural Sciences, vol. 88, no. 10, pp. 1598–1603, 2018. [4] P. Sharma and A. Rajput, “Development of an automated greenhouse using Arduino and IoT,” International Journal of Engineering Research & Technology, vol. 10, no. 2, pp. 105–110, 2021.
[5] S. Karthik, R. Bansal, and T. Roy, “Comparative study on sensor deployment in agricultural and aquatic environments,” Sensors and Transducers, vol. 254, no. 7, pp. 112–118, 2021.
[6] J. Gubbi, R. Buyya, S. Marusic, and M. Palaniswami, “Internet of Things (IoT): A vision, architectural

elements, and future directions," Future Generation Computer Systems, vol. 29, no. 7, pp. 1645–1660, Sep. 2013.
[7] P. Phunchongharn, E. Hossain, and D. In Kim, Resource allocation for device-todevice communications underlaying LTE-advanced networks," IEEE Wireless Commun., vol. 20, no. 4, pp. 91– 100, Aug. 2013.
[8] T. Peng, Q. Lu, H. Wang, S. Xu, and W. Wang, "Interference avoidance mechanisms in the hybrid cellular and device-to-device systems," in Proc. IEEE 20th Int. Symp.
Pers., Indoor Mobile Radio Commun., 2009, pp. 617–621.
[9] I. Akyildiz, F. Su, W. Sankarasubramaniam, and Y. E. Cayirci, "Wireless sensor networks: A survey," Comput. Netw. (Elsevier) J., vol. 38, no. 4, pp. 393–422, Mar. 2002.
[10] J. Apcar, "Routing in the Internet of Things/M2M Networks," presented at the Ciscolive365, Melbourne, VIC, Australia, 2013, BRKSPG-1661.