

# Chapter 1

## Introduction

In an era marked by rapid technological advancements, the integration of IoT and LoRa-based communication systems is revolutionizing shrimp farming by enabling real-time and energy-efficient water quality monitoring that enhances both productivity and sustainability.

### 1.1 Background

Shrimp farming is an aquaculture practice of cultivating shrimps in a controlled environment. It can be achieved in saltwater, brackish water, or freshwater. Traditionally, shrimps were considered a secondary product of fish farming; however, with their increasing economic potential, shrimp cultivation has become the primary focus [1]. Effective water quality management is essential because poor water quality adversely affects shrimp health, reduces farm productivity, and degrades coastal water quality [2]. Key parameters such as pH, dissolved oxygen, temperature, and salinity must be monitored periodically to ensure optimal growing conditions [3]. Traditional monitoring methods are labor intensive, time-consuming and often deliver delayed results. In this context, a LoRa-based IoT system offers an innovative solution by integrating low-power long-range wireless communication with solar energy to provide continuous real-time water quality data.

### 1.2 Problem Statement

The research addresses several critical challenges in shrimp farming:

1. **Inconsistent Data Collection:** Current methods do not offer continuous real-time monitoring of water quality parameters (pH, temperature, dissolved oxygen, ORP, and salinity), resulting in delayed detection and response.
2. **Data Transmission Reliability:** Limited documentation exists on the performance of LoRa technology under the high humidity and water exposure conditions typical of shrimp

farms.[4], [5]

3. Power Efficiency: A power-efficient design is necessary to minimize the dependency on solar panels and battery capacity.
4. Outdoor Deployment: The node requires a water-resistant and robust mechanical design for long-term survival in outdoor environments.

### 1.3 Thesis Objectives

The primary objective is to design, develop and evaluate a reliable and energy efficient LoRa-based IoT system for real-time monitoring of water quality in shrimp farming. Specific objectives include:

1. Creating a sensor node to collect water quality data (pH, temperature, dissolved oxygen, ORP, and salinity) at predetermined intervals.
2. Establishing a reliable data transmission method using LoRa technology with a range of up to 1 km. [4], [6]
3. Designing a system fully replenished through solar power.
4. Ensuring that the system is robust enough for outdoor deployment in shrimp farming environments.

### 1.4 Significance of Study

The significance of this study lies in its multifaceted contributions to the field of Mechatronics and sustainable aquaculture practices. By developing a LoRa-based IoT system for water quality monitoring in shrimp farming, this research introduces a novel integration of sensor technologies, renewable energy solutions, and advanced wireless communication protocols. This innovative system not only enhances real-time data collection and decision-making processes but also addresses the limitations of traditional, labor-intensive water quality monitoring methods. From a Mechatronics perspective, the study offers valuable insights into low-power system design, efficient energy management through solar integration, and the effective deployment of long-range communication technologies. These contributions have practical implications for improving the reliability and scalability of monitoring systems in harsh, outdoor environments, which is critical for maintaining optimal conditions in shrimp farming. In essence, the research paves the way for more sustainable and economically viable aquaculture operations, while also expanding the application potential of Mechatronic systems in various industrial and environmental contexts.

## 1.5 Scope and Limitations

### Scope:

- Focus on engineering aspects including mechanical design, electrical design, and the LoRa/LoRaWAN stack.
- Development of sensor node, renewable energy integration, and communication aspects.

### Limitations:

- Emphasis on abiotic water quality parameters, excluding biotic factors.
- Sensor calibration and accuracy are not the primary focus.

## 1.6 Thesis Structure

A brief overview of subsequent chapters is provided:

- Chapter 2: Literature Review
- Chapter 3: Methodology
- Chapter 4: Results and Discussion
- Chapter 5: Conclusions and Recommendations
- Additional sections include Glossary, References, Curriculum Vitae, and Appendices.