

CHAPTER I

INTRODUCTION

1.1. Background of Study

Aquascape is the art of arranging an aquatic ecosystem within an aquarium, with the main focus on aesthetics and the balance of the water ecosystem, particularly aquatic plants [1]. In practice, aquascaping not only focuses on visual aesthetics but also on maintaining ecosystem balance so that fish and plants can survive and thrive properly. This balance is achieved through proper water quality management, thereby creating a harmonious and aesthetically pleasing environment.

To maintain the balance of the aquascape ecosystem, several water quality parameters must be controlled, such as temperature and turbidity levels [2]. In addition, other parameters such as light intensity must also be considered. Imbalances in these parameters can affect the growth of aquatic plants and disrupt ecosystem stability. Unstable temperatures can cause stress to both plants and fish, while high turbidity levels can block light and inhibit photosynthesis. Light intensity is also crucial, as insufficient exposure can hinder the photosynthesis process in plants.

Previous studies have shown that Mamdani Fuzzy Logic has great potential in controlling water quality in aquascapes, particularly for parameters such as pH and water temperature. The applied method involves the development of a fuzzy logic model using MATLAB software, with inputs in the form of pH and temperature data. The system is designed to maintain the water pH within the range of 6–8 and the water temperature between 22°C and 25°C, which are ideal conditions for an aquascape ecosystem. The results show that the system is able to identify ecosystem balance with outputs categorized as "*Tidak Seimbang*," "*Cukup Seimbang*," and "*Seimbang*". Although there are slight differences between manual calculations and MATLAB results, the system has proven to be effective in maintaining water quality and minimizing the risk of damage to the aquascape ecosystem. [3]

In addition, other studies have also been conducted, in which the results of the implementation of IoT in controlling pH and water turbidity in aquascapes indicate that the system is capable of maintaining water conditions within an ideal range for aquascape ecosystems. The data obtained from these sensors are processed in real-time and transmitted to the MQTT platform for monitoring via web browsers or smartphones. The implemented system is also capable of automatically controlling actuators such as cooling fans and water pumps based on sensor data, thereby ensuring that water conditions remain optimal without manual intervention [2].

The Type-2 Fuzzy Logic method offers a more adaptive approach in controlling water quality. Type-2 Fuzzy Logic is capable of handling uncertainty and variability in water parameters more effectively compared to the Type-1 Fuzzy Logic method. Type-2 Fuzzy Logic has the advantage of handling uncertain data by utilizing a range of values, thereby making it more effective in various applications that require accurate decision-making [4]. Type-2 Fuzzy Logic consists of four important processes that are carried out sequentially, namely fuzzification, inference, type-reduction, and defuzzification[5]. With its flexibility, this method enables the control system to be more responsive to changes in parameters that cannot be predicted with certainty.

Therefore, after further analysis, the author decided to develop a control and monitoring system for light intensity, temperature, and water turbidity in aquascapes based on IoT (Internet of Things) using the Type-2 Fuzzy Logic method and utilizing the ESP32 microcontroller as an innovation. The main objective of this system is to control light intensity, temperature, and turbidity in the aquascape system, so that aquascape plants can grow optimally, thereby improving the efficiency of maintenance in an autonomous manner.

This system is capable of automatically controlling the on/off state of devices, for example by commanding relays to operate actuators required to maintain optimal water quality. In addition, it is able to monitor light intensity, temperature, and water turbidity conditions; if the water is detected to be outside the desired range, the system will promptly provide notifications to the user through the Blynk

platform. This is intended to facilitate time efficiency for users, as well as to obtain results in a more real-time manner.

1.2. Problem Formulation

Based on the description presented in the background section, there are several key problems that need to be identified and addressed in this research in order to achieve the established objectives:

1. How to design an IoT-based system using Type-2 Fuzzy Logic to monitor and control environmental parameters in aquascapes?
2. How can an IoT-based system using Type-2 Fuzzy Logic maintain the stability of key aquascape parameters (such as water temperature, light intensity, and turbidity) to meet the requirements of the aquascape ecosystem?
3. How does the performance of an IoT-based system using Type-2 Fuzzy Logic in creating stable water conditions to support the balance of the aquascape ecosystem?
4. How can a microcontroller- and IoT-based system be designed to perform remote and real-time monitoring and control of aquascape environmental conditions?

1.3. Research Objectives

Based on the problems formulated in this research, the objectives of developing an IoT-based water quality control system using the Type-2 Fuzzy Logic method are as follows:

1. To design an IoT-based system using Type-2 Fuzzy Logic to monitor and control indoor aquascape environmental parameters.
2. To implement an IoT-based system using Type-2 Fuzzy Logic to maintain the stability of key aquascape parameters (including water temperature, light intensity, and water turbidity) in accordance with the requirements of the aquascape ecosystem.

3. To evaluate the performance of the system in creating stable aquatic environmental conditions in order to support the balance and health of the aquascape ecosystem.
4. To develop a microcontroller and IoT based system that allows monitoring and controlling aquascape environmental conditions remotely and in real-time.

1.4. Scope and Limitation

Based on what has been explained in the problem formulation, the scope of the study defined by the author to support the accuracy of the research is as follows:

1. The application is limited to controlling and monitoring water parameters required for aquascape plant maintenance in real-time.
2. The medium used for remote control and monitoring utilizes Internet of Things (IoT) technology.
3. The ESP32 microcontroller is used as a device to control the sensors and actuators in the system.
4. The Type-2 Fuzzy Logic input variables used in this study are light intensity, turbidity level, and water temperature.
5. The testing is conducted using an aquarium with dimensions of 40*30*30cm, and the plants utilized in this study are categorized as low-tech aquascape plants.

1.5. Significance of Study

The significance of this study is to improve efficiency and accuracy in aquascape management. This is achieved through the implementation of an Internet of Things (IoT)-based system capable of automatically monitoring and controlling environmental parameters.

In addition, the system is capable of maintaining the stability of key aquascape parameters in a measurable manner, with water temperature maintained within the range of 28–30°C and light intensity ranging from 13–16 W, as well as providing notifications when the water turbidity level reaches 50 NTU. This contributes to improving the success of plant and organism growth.

The implementation of this system is capable of improving operational efficiency by reducing the need for manual intervention, as all monitoring and control processes are carried out automatically and in an integrated manner.

Furthermore, the significance of this study provides a foundation for the development of more modern and measurable aquascape management systems, enabling implementation at various scales with a high level of reliability. The resulting system can serve as a practical solution to support the automation of water environmental control and to enhance the overall quality of aquascape management. In addition, the findings of this study can be used as a reference for the development of similar systems with improvements in terms of accuracy, response speed, and technological integration, thereby providing added value for the advancement of IoT-based control systems in the future.