UNIVERSITI TEKNIKAL MALAYSIA MELAKA

# FACULTY OF ELECTRONICS & COMPUTER TECHNOLOGY AND ENGINEERING

# DEVELOPMENT OF SMART AQUAPONIC SYSTEM WITH IoT FOR URBAN AGRICULTURE APPLICATION

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**Bachelor of Electronics Engineering Technology (Telecommunications) with Honours**

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# DEVELOPMENT OF SMART AQUAPONIC SYSTEM WITH IoT FOR URBAN AGRICULTURE APPLICATION

**MUHAMAD FAHMAN BIN MOHAMED SHAH FATHIL**

**A project report submitted**
**in partial fulfillment of the requirements for the degree of**
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**FACULTY OF ELECTRONICS & COMPUTER TECHNOLOGY AND ENGINEERING**



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# DEDICATION

Dedicated to my beloved father, Mohamed Shah Fathil Bin Ahmed

my precious mother, Faridah Binti Alang Ismail

my supervisor Ts. Fakhrullah Bin Idris

my teammates for giving me advise and moral support

Thank You So Much

# ABSTRACT

Urban agriculture helps to address growing demand for sustainable food in densely populated areas. Aquaponics, a farming system that mixes aquaculture and hydroponics, could help cities produce food efficiently and sustainably. Aquaponic systems require close monitoring of many environmental factors and fast intervention. These challenges can be overcome by construct an IoT-integrated Smart Aquaponic System. IoT sensors and actuators will monitor water, moisture, and pH levels in the aquaponic system in real time. This data will be wirelessly sent to a control unit for analysis and decision-making. Machine learning algorithms will analyse data to improve system performance. The device then activates pumps and aerators to optimise fish and plant development. A smartphone interface will allow farmers or urban gardeners to remotely monitor and control the aquaponic system. This interface will display real-time system status, environmental data, and yield progress to let users make informed decisions and respond quickly. This Smart Aquaponic System with IoT integration aims to revolutionise urban agriculture by optimising crop yields, resource utilisation, and labour. Automating and optimising aquaponic systems in urban areas promotes self-sufficiency and reduces the environmental impact of conventional farming.

# *ABSTRAK*

Pertanian bandar membantu menangani permintaan yang semakin meningkat untuk makanan mampan di kawasan berpenduduk padat. Akuaponik, sistem pertanian yang mencampurkan akuakultur dan hidroponik, boleh membantu bandar menghasilkan makanan dengan cekap dan mampan. Sistem akuaponik memerlukan pemantauan rapi terhadap banyak faktor persekitaran dan campur tangan pantas. Untuk mengatasi kesukaran ini, projek ini akan membina Sistem Akuaponik Pintar bersepadu IoT. Penderia dan penggerak IoT akan memantau tahap air, kelembapan dan pH dalam sistem akuaponik dalam masa nyata. Data ini akan dihantar secara wayarles ke unit kawalan untuk analisis dan membuat keputusan. Algoritma pembelajaran mesin akan menganalisis data untuk meningkatkan prestasi sistem. Peranti itu kemudian mengaktifkan pam dan pengudara untuk mengoptimumkan pembangunan ikan dan tumbuhan. Antara muka telefon pintar akan membolehkan petani atau tukang kebun bandar memantau dan mengawal sistem akuaponik dari jauh. Antara muka ini akan memaparkan status sistem masa nyata, data persekitaran dan hasil kemajuan untuk membolehkan pengguna membuat keputusan termaklum dan bertindak balas dengan cepat. Sistem Akuaponik Pintar dengan penyepaduan IoT ini bertujuan untuk merevolusikan pertanian bandar dengan mengoptimumkan hasil tanaman, penggunaan sumber dan tenaga kerja. Mengautomasikan dan mengoptimumkan sistem akuaponik di kawasan bandar menggalakkan sara diri dan mengurangkan kesan alam sekitar pertanian konvensional.

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TABLE OF CONTENTS

## LIST OF TABLES

## LIST OF FIGURES

## LIST OF ABBREVIATIONS

| | | |
|---|---|---|
| $V$ | - | Voltage |
| cm | - | centimeter |

## LIST OF APPENDICES

# CHAPTER 1

# INTRODUCTION

## 1.1 Background

Aquaponics is a sustainable way to farm that blends fish farming (aquaculture) and hydroponics (growing plants in water) in a way that benefits both. It is a new way to grow food that aims to make the best use of resources and have less of an effect on the environment.

Aquaponics has been used in different ways for hundreds of years, but its modern growth can be traced back to the 1970s and 1980s, when scientists and hobbyists began experimenting with putting together systems for growing fish and plants.The connection between fish and plants is mutually beneficial, because fish waste gives plants the nutrients they need to grow, and plants filter the water, making it clean and healthy for the fish.

An aquaponic system is made up of a fish tank where fish are raised and one or more grow beds where plants are grown. Nitrifying bacteria take the ammonia-rich waste from the fish and turn it into nitrites and then nitrates. The roots of the plants in the grow bed take in the nitrates, which are good for the plants and help them grow. The nutrients are taken up by the plants, which cleans the water. The water is then sent back to the fish tank.

One of the best things about aquaponics is that it makes good use of resources. Since water is recycled and used again and again, the system uses less water than standard soil-based farming. Also, there is less need for artificial fertilisers because the nutrients plants need to grow come from the fish waste. Aquaponics also gets rid of the need for poisons because the closed system makes it less likely that pests and diseases will spread. Also, aquaponics can grow fish as well as a wide range of vegetables, herbs, and fruits in a small space. This makes it a good option for urban and peri-urban areas. It can be used on many different levels, from small systems in homes to big commercial operations.

Aquaponics research includes things like fish biology, plant physiology, water quality management, system design and engineering, nutrient cycling, and figuring out how to get the most out of production factors. Researchers and people who use aquaponic systems are always looking for ways to make them more efficient, productive, and profitable. They are also looking into how to use new technologies and different species.

Aquaponics shows promise to grow food that is sustainable and good for the environment. It could help solve problems like a lack of space and water and the need for more resilient and resource-efficient farming methods. Aquaponic systems are becoming more popular and used all over the world because they can provide fresh, locally grown food all year long, regardless of temperature or location.

## 1.2 Food Security issue that related to aquaponic

The growing number of people and the lack of space and other resources have made it very hard for agricultural producers to keep up with the growing demand for food. To deal with this problem, key sources like fertilizers and other chemicals are used too much, which is bad for the environment[1]. Combining aquaculture (fish farming) and hydroponics (growing plants in water), aquaponics offers a potential solution by establishing a closed-loop system in which fish waste provides nutrients for plant growth and plants purify the water for the fish. However, widespread adoption of aquaponic systems is hindered by high setup and maintenance costs, limited access to technology and resources in developing regions, and the need for specialized training and knowledge. Taking on these challenges and encouraging the widespread adoption of aquaponics can contribute to sustainable food production, water conservation, and climate change resilience.

## 1.3 Problem Statement

The number of people in the world has been growing regularly, and most of them now live in cities. Technology has changed at a speed that is hard to keep up with, and business has become more connected and global. As part of this new economy, however, many countries have not seen steady growth. As a whole, the world economy is not growing as much as was thought. Conflict and unrest have grown and become harder to solve, which has caused more people to move. Climate change and more extreme weather are changing agricultural productivity, food production, and natural resources. This has effects on food systems and rural ways of life, such as a drop in the number of farmers[2]. The development of a smart aquaponic system with Internet of Things for urban agriculture applications addresses the challenges of achieving sustainable and efficient food production in urban environments. Due to rapid urbanization and a lack of available land, conventional farming methods are unable to satisfy the rising demand for fresh produce. Aquaponics, a sustainable farming method that incorporates aquaculture and hydroponics, will be integrated with IoT technologies to create an innovative and automated system.

Using IoT sensors and actuators, the intelligent aquaponic system is able to monitor and control essential parameters such as ph level sensor, ultrasonic sensor and soil moisture sensor. This collection and analysis of real-time data enables enhanced resource management, plant growth, and fish health. In addition, IoT connectivity enables remote monitoring and control, allowing urban farmers to easily administer their aquaponic systems. This intelligent aquaponic system has the potential to revolutionize urban agriculture by providing a sustainable and efficient method of producing fresh, healthy food in confined spaces while reducing the environmental imprint.

### 1.4 Project Objective

This subject also helped us apply theoretical and technical knowledge throughout our study session at University Technical Malaysia Melaka (UTeM). "Smart Aquaponic" has its own objectives. Each objective can be seen to carry a particular interest. Objectives that can be summarized is:

a) Design an effective method for the planting and breeding of aquatic plants for urban agriculture.

b) Create new aquaponic system combined with latest electronic equipment.

c) Find better parameter to analyze feedback from potential users and customers who may procure the system.



### 1.5 Scope of Project

The development of smart aquaponic systems with IoT (Internet of Things) for applications in urban agriculture is an emerging field of study that integrates aquaponics, advanced technology, and sustainable urban farming. This study seeks to harness the power of IoT to improve the efficiency, productivity, and sustainability of this system.

Firstly , this research focus on the  agriculture and aquaculture. In order to fulfill the rising demand for food production, the study of agriculture and aquaculture includes the scientific investigation, evaluation, and application of concepts and methods connected to plant and animal farming.

Secondly , the area of study includes investigating how the aquaponic system interacts with the urban setting. This entails taking into account the spatial constraints of metropolitan locations and investigating cutting-edge ideas that can be applied in constrained areas like rooftops, balconies, or inside settings. The smart aquaponic system will be sustainable in urban environments by addressing the energy needs of the system and looking at energy-efficient solutions.

Thirdly , determining suitable fish and plant species for an aquaponic system involves careful consideration of their compatibility, nutritional requirements, growth rates, and environmental tolerances. The selection of fish species should prioritize those that can thrive in a closed recirculating system, exhibit efficient nutrient conversion, and have a market value or personal preference. Likewise, plant selection should focus on species that can effectively utilize the nutrients provided by fish waste, have rapid growth rates, and are compatible with the water conditions created by the aquaponic system. The aim is to establish a symbiotic relationship where the fish provide essential nutrients for plant growth, while the plants filter and purify the water for the fish, resulting in a sustainable and productive aquaponic systems.



Lastly, in order to build a smart aquaponic system with IoT for urban agriculture applications, a survey for hardware and software components is crucial. The hardware survey entails identifying the necessary IoT devices, including sensors for monitoring water quality, pH levels and fish health, as well as actuators for controlling water flow and environmental conditions. Additionally, the survey should consider energy-efficient components, connectivity options, and scalability to suit the specific needs of urban agriculture. In terms of software, the survey involves exploring data analytics platforms, cloud-based solutions, and communication protocols to collect, analyze, and visualize the data obtained from the IoT devices. The software should enable real-time monitoring, data-driven decision-making, and remote access for efficient system management. Conducting a comprehensive survey for both hardware and software ensures the selection of appropriate technologies that align with the goals of developing a smart aquaponic system with IoT for urban agriculture application

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Introduction

This can be the body section of the whole content shows an overview of the theory, the critical point of current knowledge, and the finding of previous researchers. Although, this to form the justification for future research within the area. In this section, it consists of current and relevant references. This is important because it determines whether the system is working properly and can solve the problem.

## 2.2 Agriculture and Aquaculture

Agriculture is the practice of cultivating crops, rearing animals, and engaging in other activities associated with the production of food, fiber, and other commodities. It dates back thousands of years and is one of the earliest and most fundamental human activities. Agriculture played a crucial role in the development of human civilization, allowing communities to consolidate in a single location, form societies, and construct advanced civilizations. Agriculture's primary purpose is to produce sustenance to sustain human populations. It also includes the production of basic materials for industries such as textiles, pharmaceuticals, and biofuels. Agriculture requires a variety of techniques, knowledge, and abilities, such as soil cultivation, irrigation, planting, breeding, and insect control. Time by time has past we can see this will be the main threat for the plant and animal population.

In China, Agriculture has destroyed natural vegetation and fragmented landscapes, threatening biodiversity. Agricultural expansion can indirectly harm surrounding natural ecosystems. However, the indirect effects of agricultural growth on natural habitats and their responses to landscape fragmentation are unknown. From 2000 through 2020, land use/cover and habitat quality were examined in Lishui, China. An agricultural expansion scenario was constructed to separate direct and indirect effects of agricultural growth on natural ecosystems. Regression analysis and geographical detection methods examined the direct/indirect effects of the four landscape fragmentation processes (area, edge, shape, and isolation). Agricultural growth caused 376.04 km2 of forest loss. Agricultural expansion destroyed natural habitats by 6.08%, 43.84% directly and 56.16% indirectly. Agricultural expansion indirectly affected 14,209.06 km2 of natural ecosystems, 32 times the direct impact (449.51 km2)[3]. Linear/nonlinear landscape fragmentation processes affected natural habitats. Landscape fragmentation interactions showed duality and nonlinear amplification. Area and edge changes had the most direct effects, whereas agricultural land type and forest isolation had indirect consequences. Agricultural expansion and landscape fragmentation were driven by the agricultural land system balance policy. Sustainable agricultural landscape management reduces biodiversity loss from agricultural expansion. This research advances agricultural landscape design and biodiversity conservation.



Other than that, Large-scale expansion of oil palm (*Elaeis guineensis)* monocultures throughout Southeast Asia is resulting in ecosystems with homogenous habitats and limited species diversity. However, the habitat heterogeneity of oil palm smallholdings is greater than that of large-scale plantations. Insufficient field research on primate species, particularly macaques in oil palm plantations, has been conducted to date. The group size of long-tailed macaques (*Macaca fascicularis*) is examined in four habitat types: unlogged forest, logged forest, large-scale oil palm plantations, and smallholdings. In 2015 and 2016, field censuses were conducted to ascertain the population size of *M. fascicularis* in large-scale oil palm plantations and smallholdings.[4] These data from oil palm plantations were compared to surveys undertaken on a logged lowland forest reserve and an earlier study conducted in a non-logged lowland forest. The group size of *M. fascicularis* was found to be smaller in large-scale plantations compared to smallholdings, logged forest, and unlogged forest. The chi-square test revealed an association between the age class (juvenile or adult) of *M. fascicularis* and agricultural systems. The conclusion of the paper is that the expansion of large-scale oil palm monocultures should be restricted due to their negative effects on biodiversity, including common species such as *M. fascicularis*.

Traditional agriculture is always depending on the land. It has been proved by the study in the Global South. Global South or as known as G20 generally seen as home to Brazil, India, Pakistan, Indonesia and China, which, along with Nigeria and Mexico, are the largest Southern states in terms of land area and population. Urbanisation in the Global South makes it possible for country people living near towns to make a better living, but this does not happen naturally. Literature shows that as towns grow, they use the land around them more intensively and start making more high-value goods. But competition for land around towns that are growing can make people in those areas more economically vulnerable, especially if they don't own land or have weak rights to rent it. Urban growth can also hurt the environment in ways like destroying marshes and cutting down trees.[5] There aren't many studies in the current literature that look at the effects of rising towns on food security, fairness, and the environmental effects on food systems in rural areas.

People have been trying to mould the natural world to better fit their needs and preferences ever since the beginning of time. The damage to the environment, which started around the time of the industrial revolution, was ignored for a significant amount of time. The traditional viewpoint of evolution was that nature solved this issue by cleansing itself at regular intervals. In contrast to what many people believe, it is abundantly obvious that the pollution that humans generate in the natural world does not, in fact, disappear on its own. Agriculture, the "innocent" and most prevalent technique of providing food, also has a significant influence on the environment. This impact may be negative or positive. In industrial agriculture, the use of harmful chemicals like pesticides, herbicides, and fertilisers poses a significant threat to the natural environment.[6] The purpose of this study is to investigate the tension that exists between the environmental degradation that is caused by agriculture and the effects that this degradation has on agriculture.

The shift in climatic circumstances, which occurs naturally over time, presents the greatest opportunity for human development. The findings of this study suggest that the current climate crisis may contribute to a global scarcity of food. Aquaculture is an important part of the solution to the problem of a lack of food across the world. It is expected that by the year 2028, the proportion of fish produced for human consumption that originates from aquaculture would have increased to 58%, up from the current average of 52% for the years (2016–2018).[7]The most significant negative impact that conventional aquaculture systems have is their influence on the water quality and their contribution to secondary contamination, which in turn causes severe harm to aquatic resources.



The adoption of high-density, large-scale monocrop agriculture has had a substantial effect on the utilisation of agricultural land worldwide. This conventional farming method frequently necessitates immense tracts of land devoted to a single crop, resulting in deforestation, habitat loss, and soil degradation. In addition, the extensive use of chemical inputs and water resources exacerbates environmental stress. However, aquaponics offers a promising solution for reducing the agricultural footprint on the land. By employing vertical farming techniques, aquaponics enables high-density cultivation on a reduced amount of land. The integration of fish and plants in a closed-loop system maximises resource efficiency and permits the concurrent cultivation of multiple commodities. This efficient land use, coupled with the environmentally benign and sustainable nature of aquaponics, provides a viable alternative to large-scale monocrop agriculture, thereby reducing the pressures on agricultural land and contributing to a more sustainable and resilient food production system.

## 2.3 Development of Aquaponic System and Design

In today's technological era, the use of electronic tools is increasingly being pursued to meet the needs of the people as well as the needs of the industry. This is evident in several successful projects.

Aquaponics framework is a cooperative combination of aquaculture and hydroponics that promotes soil-less plant growth by utilising the vastly improved effluent of fish or other oceanic organisms, which contains all the nutrient required for optimal plant growth in an enclosed space. Aquaponics is viewed as a standout amongst the best cultivating systems due to the utilisation of one live biological system to profit another common environment to achieve a brilliant and sustainable cycle in natural cultivating with two income surges, fish, and vegetables.[8] This framework makes it conceivable to cultivate in a way that is ecologically sound because it accelerates plant development by a factor of several compared to conventional methods, eliminates the use of pesticides and fertilisers, and reduces water usage by 90 percent compared to conventional methods.



In other side, this aquaponic system also has create because of the food security issue in the world. The researcher from our neighbouring country which is Singapore mention that this issue is exacerbated by growing world population and climate change, which inevitably leads to an increased demand for food. Aquaponics on a large scale has demonstrated efficient production of edible fish and vegetation in recent years.[9] This paper explores the design and development of an aquaponics system for the home, with the belief that if every household in a country can produce its own fish and vegetation, the country's overall food demand will decrease. Even though, if the user busy working they also can handle it because of the development of this system make user can monitor all the data anywhere.

In the meantime, the country of India also uses the method of aquaponics, which brings together the practises of aquaculture and hydroponics. It is possible that this could be used to solve the issues that are caused by conventional farming. Whereas hydroponics is concerned with the growth of soilless plants through the provision of necessary nutrients, aquaculture is concerned with the growth of fish. Aquaculture is also known as pisciculture. The use of aquaponics technology will allow to produce organic food for the nation. Because it reuses water, this approach takes up less room and offers the user with naturally occurring nutrition.[10]

Agriculture utilises the most water, accounting for nearly 70 percent of total consumption.[11] Aquaponics is the most effective approach for reducing water consumption. Aquaculture and hydroponics are combined to produce aquaponics. Aquaponics involves the continuous cycling of water between the fish vessel and the plant bed. This research aimed to develop a prototype that utilises IoT technologies to monitor and control the aquaponic system.



As the world's population continues to expand, a few factors, including climate change, the degradation of soil, and a shortage of water, continue to influence agricultural production.[12] Because of these challenges, it is difficult to access water sources for activities such as watering plants and rearing fish, which has a negative impact on the ability to provide adequate supplies of food. The latter problem may have a remedy in the form of aquaponics farming. This research proposes an aquaponics system that can reduce water usage by utilising circulation and the ammonia that is produced by fish to produce nitrites and nitrates that can be used by plants that are grown in aquarium tanks.

The practise of aquaponics has been shown to be effective all over the world in reducing the amount of water that is wasted and raising the overall quality of the plants grown. Aquaponics is a viable solution for environmentally responsible and efficient food production since it utilises natural methods, minimises the use of chemical inputs, and creates sustainable farming systems. Aquaponics has the potential to contribute to a more sustainable and resilient future while also bringing about a revolution in agricultural practises as its use continues to spread. The table 2 show the comparison table between the project:

| PROBLEM | METHOD | REFERENCE |
| --- | --- | --- |
| Usage of pesticides, fertilizer and a lot of water use for one purpose only. | Make a system that can act naturally so it's an reduce usage of pesticides and fertilizer and can save water up 90% as in traditional cultivating by recycle it. | [8] |
| Growing of world population and climate change cause the food security issue in over the worlds. | Exploits the design and development of an aquaponics system for home environment so that every home can have their own fish and plant | [9] |
| High dependency rate on land, chemical fertilizers, pesticides and high water resources. | Develop design to replace tradisional farming which can produce natural food and reduce wastage | [10] |
| Agriculture makes for over 70% of all water usage, making it the most water-intensive industry. | Replacing the agricultural system with aquaponics that recycles water from the fish tank to the plants | [11] |
| The increase in the earth's population and several reasons such as climate variation, soil degradation and water scarcity impact agricultural activities | Replace it with aquaponic system which is can saves water through circulation and utilization of ammonia released by fish to produce minerals such as nitrites and nitrates for plants in an aquarium tank. | [12] |

Table 2 comparison of application of aquaponic system

## 2.4 Fish Selection for Aquaponic

Fish are an essential component of aquaponic systems, where they not only play an important part in supplying nutrients for the development of plants but also benefit from the system's ability to filter and purify the water that they swim in. In aquaponics, the ammonia in fish waste is used as a natural fertilizer for the plants that are being grown. Ammonia is converted into nitrates, which are then taken up as nutrients by plants by microorganisms that are beneficial to the environment. The fish, in turn, reap the benefits of the plants' ability to filter and clean the water, which contributes to the maintenance of a robust and stable environment. A healthy aquaponic system cannot be kept in good working order without careful fish management, careful monitoring of the system's water parameters, and appropriate fish selection.

First, koi carp as a subject for their study in an aquaponic system because they are a popular ornamental fish species that is commonly kept in ponds and aquariums, making them an attractive choice for aquaculture.[13] Koi carp are also known for their hardiness and adaptability to different water conditions, which makes them suitable for use in aquaponic systems that may experience fluctuations in water quality. Additionally, koi carp are omnivorous and can feed on a variety of foods, making them suitable for use in aquaponic systems that rely on nutrient recycling. They are also aesthetically pleasing due to their colorful patterns and can grow up to 3 feet in length, making them a popular choice among hobbyists who want to create visually appealing aquaponic systems. They put the fish in 3 types of tanks with different densities. They observe the fish for 15 days to observe the growth. Table 2.1 show fish growth parameters of koi carp in different treatment:

| Parameter | T1 | T2 | T3 | C1 |
|---|---|---|---|---|
| Weight (g) | | | | |
| *Initial* | $5.61 \pm 0.01^{a}$ | $5.59 \pm 0.03^{a}$ | $5.55 \pm 0.03^{a}$ | $5.61 \pm 0.03^{a}$ |
| *final* | $12.53 \pm 0.20^{d}$ | $9.92 \pm 0.20^{b}$ | $8.40 \pm 0.06^{a}$ | $11.26 \pm 0.13^{c}$ |
| Length (cm) | | | | |
| *Initial* | $7.50 \pm 0.06^{a}$ | $7.43 \pm 0.07^{a}$ | $7.40 \pm 0.11^{a}$ | $7.46 \pm 0.08^{a}$ |
| *final* | $10.79 \pm 0.24^{d}$ | $9.07 \pm 0.09^{b}$ | $8.08 \pm 0.05^{a}$ | $9.89 \pm 0.03^{c}$ |
| Feed Conversion Ratio(FCR) | $2.64 \pm 0.05^{a}$ | $4.00 \pm 0.13^{c}$ | $5.68 \pm 0.15^{d}$ | $3.21 \pm 0.06^{b}$ |
| Feed Efficiency Ratio(FER) | $0.38 \pm 0.01^{d}$ | $0.25 \pm 0.01^{b}$ | $0.18 \pm 0.01^{a}$ | $0.31 \pm 0.01^{c}$ |
| Protein Efficiency Ratio(PER) | $1.08 \pm 0.02^{d}$ | $0.71 \pm 0.02^{b}$ | $0.50 \pm 0.01^{a}$ | $0.89 \pm 0.01^{c}$ |
| Specific Growth Rate (SGR) (% day$^{-1}$) | $1.33 \pm 0.03^{d}$ | $0.95 \pm 0.03^{b}$ | $0.694 \pm 0.01^{a}$ | $1.16 \pm 0.02^{c}$ |
| Survival percentage | $100 \pm 0.00^{a}$ | $100 \pm 0.00^{a}$ | $100 \pm 0.00^{a}$ | $100 \pm 0.00^{a}$ |

Table 2.1 Fish growth parameters of koi carp in different treatments.[13]

In Nepal they also choose koi carp as the fish species for their studies about aquaponic system. Behind the reason why they choose the koi carp is because koi carp are known to be hardy and able to adapt to a variety of environments.[14] So, this fish is very suitable for aquaponic because of the ability of itself that can live in water where the quality changes. Koi carp are also a popular fish for decoration, which could make them a good choice for aquaponics production. Koi carp can eat both plant and animal food. This means that they can be fed the same food as the plants in the hydroponic system. This can help to lower the cost of food and improve the way nutrients move through the system. Last but not least, koi fish are easy to breed in captivity, so they can be grown right where they are used in aquaponics systems. This can help cut down on transportation costs and make sure the system has a steady flow of fish.

In the meantime, Suárez-Cáceres et al. 2021 select for the red hybrid tilapia *(Oerochromis niloticus x Oerochromis mossambicus)* because of its rapid development rate, which is essential for sustaining a substantial amount of plant biomass. In addition, it has been discovered that the red hybrid tilapia is a resilient and adaptive fish species that is able to endure a broad spectrum of environmental conditions, such as shifts in temperature and variations in the quality of the water. [15]As a result, they are suited for use in aquaponic systems that could potentially undergo changes in these parameters. Because of its delicious taste as well as its high nutritional content, red hybrid tilapia is becoming an increasingly popular option for use in food production.

Meanwhile in Brazil, white shrimp has been chosen in aquaponic system. The biomass that shrimp make can be broken down by bugs into forms that plants can use as food.[16] This makes it so that both the shrimp and the plants benefit. The plants clear and clean the water for the shrimp, and they use the shrimp's waste as fertilizer. This can cut down on the need for a lot of water and fertilizers, which makes aquaponics a better choice for the earth than standard methods. In aquaculture, shrimp are also a popular and economically significant species, particularly in Brazil, where the study was conducted. By integrating shrimp production with plant production, the authors intended to create a more sustainable and efficient system that could provide producers with economic benefits. Table 2.2 show Shrimp *(L. vannamei)* performance in a control without aquaponic system and aquaponic system:

| Parameter | Control | Experimental |
|---|---|---|
| Final average weight (g)±SD(min-max) | 12.9±4.1(7.7-18.3) | 11.5±2.9(8.0-14.3) |
| Weekly weight gain ($g.weekly^{-1}$) | 1.5 | 1.3 |
| Final biomass ($g.m^{-3}$) | 3103.2 | 2866.7 |
| Survival rate (%) | 91.7 | 95.0 |
| Feed conversion factor | 1.4 | 1.5 |
| Biomass gain (g) | 158.1 | 142.6 |

Table 2.2 Shrimp *(L. vannamei)* performance in a control without aquaponic system and aquaponic system for 56 days with 254 shrimps $m^3$.[16]

Nile Tilapia *(Oreochromis niloticus)* is also one of the species that is suitable in the aquaponic system. In this study this species has been choose based on its economic viability, adaptability to different environmental conditions, fast growth rate, and consumer appeal. First off, Nile Tilapia is an economically sensible option for aquaponics systems since it is a fish that is often farmed in Egypt and has a strong market demand.[17] Second, because hydroponic plant culture is incorporated into aquaponic systems, where water quality might change, Nile Tilapia is recognised for its tolerance to various environmental circumstances and its capacity to resist low water quality. Additionally, under ideal circumstances, Nile Tilapia may develop quickly and reach market size in about six months. This makes them a desirable alternative for commercial aquaponics systems since, in comparison to other fish species, they can be collected quite fast. Consumers also enjoy the Nile Tilapia's mild flavour and robust texture, which further increases its market appeal. Table 2.3 show the frowth performance parameter of tilapia in aquaponic system :

| PARAMETERS | INITIAL WEIGHT (G) | FINAL WEIGHT (G) | WEIGHT GAIN(G) | GROWTH RATE (G PER DAY) | FOOD CONVERSI | FEED EFFICIENCY RATIO (%) | SURVIVAL RATE (%) |
|---|---|---|---|---|---|---|---|
| Values | 18 ±0.8 | 136 ±4.6 | 118 ±4.0 | 1.1 ±0.03 | 1.2 ±0.0 | 80.2±2.7 | 90 |

2.3 Growth performance parameters of tilapia (O.niloticus)reared in the aquaponic system.

In conclusion, the success of an aquaponic system depends on choosing the right kind of fish. When selecting fish species, factors like water temperature, climate, and intended results should be taken into account. Due to their flexibility, quick development, and high nutritional output, tilapia, trout, catfish, and perch are frequently utilised in aquaponics. These fish are essential to the ecology because they supply the nutrients required for plant development and keep the ecosystem in balance. They may also be collected for human consumption, giving the aquaponic system a useful new food supply. To make sure the selected fish species are suitable for the particular aquaponic environment and achieve the system's objectives, careful attention and study should be made.

## 2.5 Plant for aquaponic

In an aquaponic system, plants are very important because they use the waste from the fish to grow and do well without dirt. This link between plants and fish makes for a way to farm that is both sustainable and effective. Because they can grow well in nutrient-rich water, leafy greens, herbs, and some flowering plants are often chosen for aquaponic systems. Aquaponics works well for leafy greens like lettuce and kale, as well as herbs like basil and mint, which have short roots and grow quickly. Some plants that bear fruit, like tomatoes and cucumbers, can also be grown in aquaponic systems, but they need more care and control. Using the power of aquaponics, these plants grow well in a setting based on water and provide a steady supply of fresh, healthy food.

In Nuwansi et al. 2021 , Gotukola *(Centella asiatica)* or as known as "pegaga" in Malaysia as a plant for their aquaponic system for several reasons. First of all, Gotukola is a flower that is used in traditional medicine to treat a wide range of illnesses.[13] It has been shown to have many different kinds of benefits, such as anti-inflammatory, antioxidant, and neuroprotective. So, having Gotukola in an aquaponic system is a good way to keep getting this useful herb. Second, Gotukola grows quickly and does well in both wet and dry environments. It can be grown in small pots or in hydroponic systems because its roots aren't very deep. Because of this, it is a great choice for aquaponic systems with limited room. Third, Gotukola is known to be good at removing heavy metals and organic molecules from water, which are two types of pollution. Because of this, it can be used in phytoremediation, which is the process of using plants to clean water of harmful substances. Table 2.4 show growth parameter of gutoloka chlorophyll content in different treatment :

| Parameter | Treatment | | | |
|---|---|---|---|---|
| | T1 | T2 | T3 | C2 |
| Leaf width (cm) | 4.26 ± 0.12[a] | 4.66 ± 0.12[a] | 5.53 ± 0.22[b] | 4.33 ± 0.09[a] |
| Number of leaves | 263.33 ± 8.81[a] | 381.00 ± 5.85[b] | 495.00 ± 7.63[c] | 391.66 ± 4.43[b] |
| Number of plantlets | 85.33 ± 2.72[a] | 104.33 ± 5.72[ab] | 126.33 ± 5.36[b] | 99.00 ± 6.08[a] |
| Number of runners | 41.33 ± 1.20[a] | 48.67 ± 4.48[b] | 82.00 ± 3.21[c] | 52.00 ± 1.53[b] |
| Length of runners (cm) | 694.36 ± 9.51[a] | 852.06 ± 30.31[ab] | 976.52 ± 35.10[c] | 845.36 ± 10.44[ab] |
| Final yield (g) | 116.13 ± 9.02[a] | 177.30 ± 11.59[bc] | 203.76 ± 11.03[c] | 152.50 ± 10.74[ab] |
| Chlorophyll a (mg $g^{-1}$) | 0.69 ± 0.01[a] | 0.71 ± 0.01[ab] | 0.73 ± 0.01[b] | 0.69 ± 0.01[ab] |
| Chlorophyll b (mg $g^{-1}$) | 0.54 ± 0.03[a] | 0.61 ± 0.02[ab] | 0.64 ± 0.01[b] | 0.61 ± 0.01[ab] |
| Carotenoids (mg $g^{-1}$) | 0.23 ± 0.01[a] | 0.25 ± 0.01[ab] | 0.27 ± 0.00[b] | 0.26 ± 0.01[ab] |

Table 2.4 Growth parameter of gotukola chlorophyll content in different treatment[13].

Other than that , water celery also has been used in aquaponic system. Water celery is a plant species that thrives naturally in streams or damp soil, it is ideally suited for cultivation in hydroponic or aquaponic environments.[14] Additionally, it has been demonstrated to have a high potential of nutrient uptake, which is essential for the upkeep of water quality in aquaponics systems. In conclusion, water celery is a practical option for this study since it is simple to harvest and control in hydroponic systems. This makes it an interesting crop to investigate. As a result of all of these variables, water celery is an excellent species of plant to use when researching the processes by which nitrogen is transformed in constructed aquaponics systems including koi carp.

In Sepanyol , a polyculture of fruits , vegetable and herbs has been choosen as plant for aquaponic system. Not only because it is suitable with the hydroponic production its also come with objective which is to provide a family with a diversity of products that enabled achieving a nutritionally healthy diet.[15] Both their suitability to hydroponic cultivation and their nutritional value played a role in the selection process for the species that would be used in the polyculture. Cucumbers are low in calories and high in water content, peppers are rich in vitamin C and antioxidants, basil has anti-inflammatory properties, onions are high in antioxidants and have anti-inflammatory effects, stevia is a natural sweetener with no calories or carbohydrates, and pumpkin is high in fibre and vitamin C. For example, tomatoes (Raf and Roma) are rich in vitamins A and C; watermelon is a good source of vitamin C and potassium; eggplant is high in fibre and antioxidants. So , by choosing these species for the polyculture system based on their nutritional value and their ability to grow well in hydroponic systems, the goal was to give the family a wide range of fruits, veggies, and herbs that would help them eat a healthy diet.

In one of the experiment in brazil, 3 types of halophyte plant species has been choose for aquaponics system. Salicornia virginicus, Salicornia neei, and Batis maritima. Plants known as halophytes are evolved to thrive in salty conditions, making them ideal for use in aquaponics systems where the water may contain significant amounts of salt. The Brazilian coast is home to the halophyte Batis maritima. It has been demonstrated that it might be helpful in phytoremediation, the practice of utilizing plants to remove toxins from soil or water. Batis maritima may be able to assist with the removal of extra nutrients from the water and the improvement of water quality in the setting of aquaponics.[16] Both the halophytes Salicornia neei and Salicornia virginicus are frequently utilized in aquaponics systems. They have been demonstrated to be efficient in removing extra nitrogen from the water, which can aid in improving water quality and lowering the possibility of dangerous algal blooms. These plants may also be harvested for their biomass, which can be utilized as a source of biofuel or as animal feed.

The choice of lettuce (Lactuca sativa) as the study's plant species was influenced by a number of reasons. A common leafy green vegetable with a considerable market demand worldwide is lettuce. Its quick growth rate makes it a desirable option for aquaponics systems that demand quick plant growth.[17] Furthermore, lettuce is renowned for being nutrient-rich due to the presence of important minerals, vitamins C and A, fibre, folate, and phytonutrients. Its attractiveness as a healthy dietary component is also enhanced by the fact that it is low in calories and cholesterol-free. Furthermore, lettuce has shown effective nutrient uptake in aquaponic systems, which makes it a good choice for this investigation. The adoption of this plant species is further supported by the compatibility of lettuce with Nile Tilapia in terms of their similar water quality needs, such as slightly acidic pH values (6.0–7.0). In conclusion, the market need, quick growth, nutritional density, compatibility with Nile Tilapia, and effectiveness in nutrient uptake inside aquaponic systems are all reasons why lettuce was chosen for this study.

In conclusion, the selection of plants for aquaponic systems should take into account the size of the system, the resources that are available, consumer demand, and personal preferences. Due to their quick growth, excellent nutritional absorption, and market demand, leafy greens including lettuce, kale, and spinach are preferred options. Herbs with a high market value, such basil, mint, and cilantro, also grow well in aquaponic systems. Additionally, in bigger aquaponic installations, fruiting plants like tomatoes, peppers, and cucumbers may be cultivated effectively. In order to ensure a successful and fruitful culture cycle, the choice of plants should ultimately be adapted to the particular objectives and conditions of the aquaponics system. Table 2.5 show the comparison table for fish and plant in aquaponic system.

| Method | Types of animals | Types of plant | Parameter | Reference |
| --- | --- | --- | --- | --- |
| Fish has been in 3 different treatment and water from the tank has been use to feed plant in 15 days. | Koi carp *(Cyprinus carpio)* | Asiatic Pennywort or Pegaga *(Centella asiatica)* | - Weight of fish.<br>- Lenght of fish.<br>- Leaf width .<br>- Number of leaf. | [13] |
| Floating raft hydroponic and aquaculture. | Koi carp *(Cyprinus carpio)* | Water celery *(Oenanthe javanica)* | - Temperature in fish tank and H-bed.<br>- pH in fish tank and H-bed.<br>- Dis-solved oxygen (DO). | [14] |
| Micro – scale aquaponic system in Brazil. | Red hybrid tilapia *(Oreochromis niloticus)* | Many types of plant such as :<br>-Watermelon *(Citrullus lanatus)*<br>-Stevia *(Rebaudiana Bertoni)*<br>- Lettuce *(Lactuca sativa)* | -Growth of tilapia<br>- total production of plant. | [15] |
| Shrimp culture ponds and Nutrient Film Technique(NFT)<br>. | White Shrimp *(Litopenaeus vannamei)* | -Saltwort *(Batis maritima)*<br>-Amaranthaceae *(Sarcocornia neei)*<br>- Seashore Dropseed *(Sporobolus virginicus)* | - Final mass of shrimp.<br>- Number of shrimp survive<br>- Height of plant<br>- Water quality | [16] |
| Aquaculture and raft system plant. | Tilapia *(Oreochromis niloticus)* | Lettuce *(Lactuca sativa L.)* | - Water quality<br>-Biochemical parameters<br>- Growth performance | [17] |

Table 2.5 Comparison Table of Fish and Plant in Aquaponic System

## 2.6 Equipment and intelligence control system.

In recent years, there has been a rise in the use of an environmentally friendly and technologically advanced technique that cultivates plants and fish in a symbiotic setting. It is becoming more vital to make use of cutting-edge technology and sophisticated control systems in aquaponic setups to achieve the highest possible levels of both production and efficiency. These technologies play a significant part in monitoring and preserving the ideal circumstances for both plants and fish, therefore assuring the health of both groups of organisms and improving the efficiency of the system. In this introductory section, we will discuss the many types of equipment and sophisticated control systems that are used in aquaponics, focusing on the merits of these systems as well as their potential to revolutionize the way we approach environmentally responsible agriculture.

The IoT-based monitoring and control system for Aquaponics helps improve the efficiency and sustainability of farming by allowing users to monitor and control various devices.[18] This study shows how the Internet of Things (IoT) can be used to make a system for tracking and controlling the surroundings in aquaponics. Users can check on and handle the function of devices, such as 3 water pumps, 3 air pumps, pH sensor, dissolved oxygen (DO) sensor, temperature sensor, humidity sensor, exhaust fan, and misting, through an app on their smartphones. There are two ways to watch and handle these devices: automatically and by hand. For 3 pumps and 3 air pumps, the user can set the pump time between water pumps and between air pumps when the system is in automatic mode. In manual control mode, a smartphone app lets the user manage water pumps and air pumps with the touch of a button. Monitor pH and DO, and let the user set the pH threshold and the DO threshold so that an alarm goes off when pH or DO goes over the threshold. Monitor the temperature and humidity in the membrane house and let you set the temperature threshold and humidity threshold to control the exhaust fan and misting, respectively, when the temperature or humidity exceeds the threshold. This method was tried out at Dong Thap Aqua, an aquaponics farm. The results show that this system works well and has a lot of potential, which is very good for aquaponics. It also helps improve the economy of output and the long-term growth of green agriculture. Figure 2 is a system design of this project[18]:

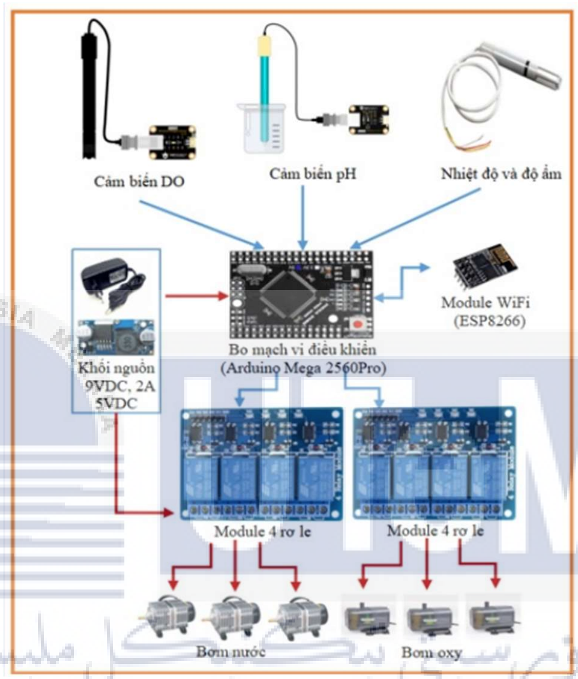



Figure 2 System diagram[18]



Finding a suitable water source for growing plants and raising fish seems challenging. Additionally, due to shrinking farmland, it is crucial to use water and land-saving technology in combination with a diversity of vegetables to create the highest output.[19] Aquaponics is a sustainable agriculture method that combines hydroponics and aquaculture in a symbiotic setting. To make sure the plants get the nutrients they need, and the water can be adequately filtered by the planting medium, this water system should run on the medium frequently. This study developed a smart aquaponics system that integrated an internet-based mobile application to control and monitor the amount of acidity, water level, water temperature, and fish nutrition. A sensor was installed in this system to collect data, which was then sent to an Ubuntu IoT Cloud server that could be accessed in real time over an internet connection. As a result, the quality and flow of the water were well conserved. Results revealed that 92.35% of pH sensors, 99.94% of temperature sensors, and 97.91% of ultrasonic sensors had successful measurements. The monitoring system operated as planned, and the water pool's appropriate for aquaponics fluctuated in temperature from 20 to 300C and pH from 7 to 75. Figure 2.1 is a system design for this project[19]:

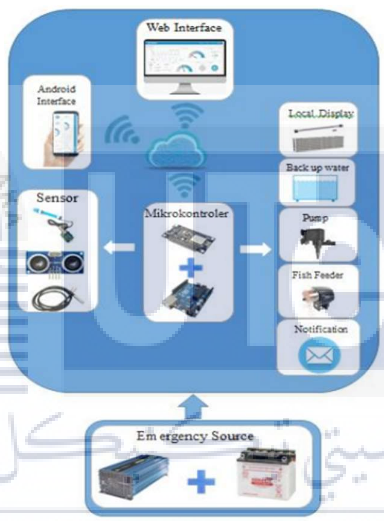





Figure 2.1 system design[19]

Future more, this study come with objective to optimum the usage of water in agricultural activities, aquaponic is the solution to it. Not just reducing water, it is also one of the brilliant ways to recycle water for other benefits such as for plants. In this study prove that this system can reduce than 90% of water.[8] This study also includes numerous features, including temperature detection and control using a heat source and cooling fan, pH detection in water using a pH sensor, and a syphon for cleansing and re-coursing water. The proposed project begins by identifying the parameters of water using various sensors.

Then, using a PIC 16F877A microcontroller, the data will be compared to an ideal range of the parameters, and if the parameters are below or above the ideal range, the corresponding tasks will be performed. The Internet of Things (IoT) is an innovation that transcends any barrier between the physical and digital worlds. Using IoT, the webserver in this aquaponics monitoring system continuously displays parameter and data estimations. Figure 2.2 is the block diagram for this system[8]:

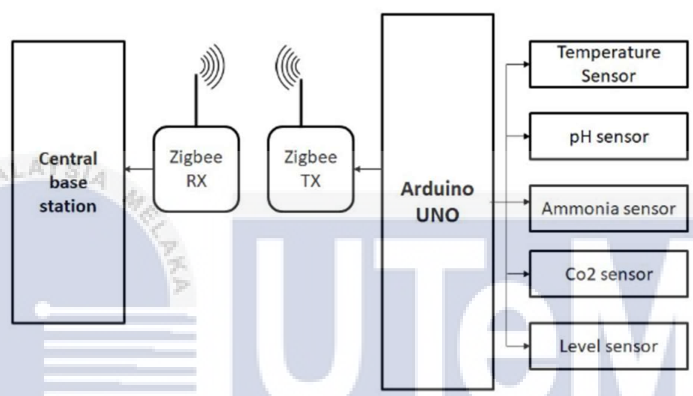



Figure 2.2 System Block Diagram[8]



Meanwhile , in India this method used to overcome the problem of conventional farming which is take up less space and provides the user with natural sustenance because it recycles water. [10]They used an Arduino to control an autonomous fish feeder with a servo motor and a timer. It will provide fish nourishment every 12 hours. By using a real-time clock, this system can be able to programme at any time. Utilising the Internet of Things and sensors for pH, temperature, and humidity, as well as water flow and water temperature, aquaponics can be managed and controlled automatically. Operating sensors on microcontrollers such as Node MCU and Arduino UNO, with monitoring results easily accessible via the Bevy wise application. This technique is applicable for both indoor and outdoor systems. Figure 2.3 shown the block diagram of this project[10]:

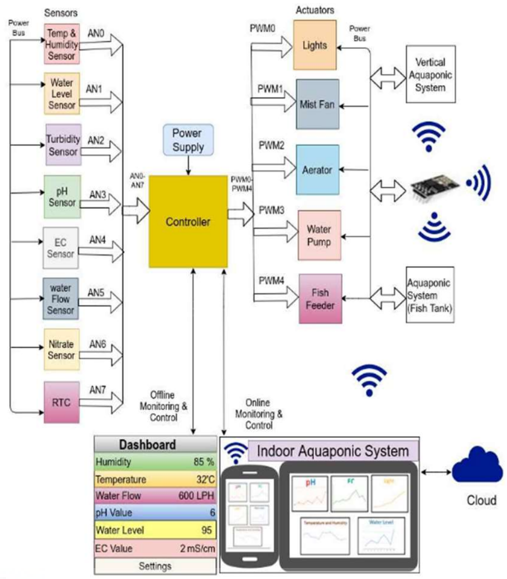



Figure 2.3 Block diagram[10]

The aquaponics system suggested in this research conserves water by using circulation and ammonia generated by fish to make nitrites and nitrates for plants in aquarium tanks.[12] The system monitors and regulates water quality using sensors, actuators, and microcontrollers. The actuators are used to correct the anomalies the sensor identified. The sensors are used to collect data, which is then communicated with the help of a Wi-Fi module to an IoT cloud platform called Thing speak. The outcomes of the experiment demonstrate that the quality and water circulation were well-maintained. These are discussed in this work using linear regression analysis and R-squared plots, which demonstrated a substantial correlation between the number of days and the height of the plants and the weights of the fish. The system boosts aquaponics productivity while reducing water waste. Figure 2.4 is an example of system block diagram[12]:

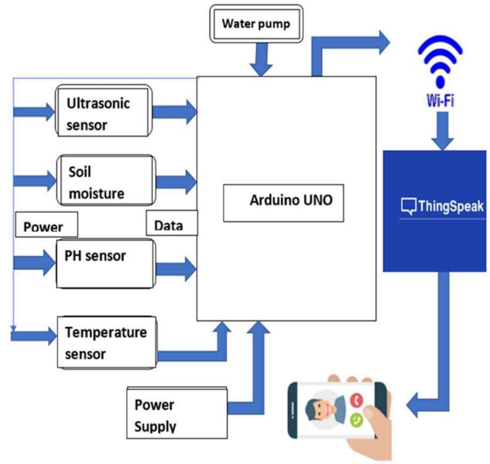



Figure 2.4 System's Block Diagram[12]

In Taiwan, Internet of Things (IoT) technology was implemented in science and technology agriculture, and the IoT-based Aquaponics System (IAS) was constructed. The study confirmed the viability of precision technology agriculture and compared the pros and cons of the conventional greenhouse sowing system and IAS. In this study, the Intelligent Voice Control System (IVCS) of the Internet of Things was also proposed as a solution to the problem of farmers lacking the ability to use information interfaces. IVCS can effectively replace the conventionally inconvenient operation interface.[20] Therefore, IVCS can provide partners interested in the development of science and technology agriculture with a reduced barrier to entry for science and technology and inspire the development of more diverse applications that effectively enhance the production efficiency of agriculture, fishery, and planting. The integration of IAS and IVCS is shown in Figure 2.5 :

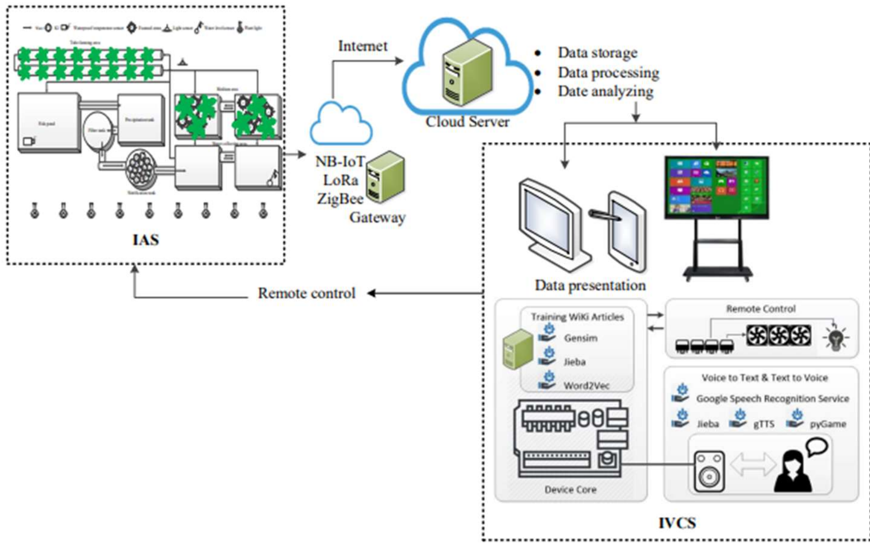



Figure 2.5 The integration of IAS and IVCS. [20]

In this study, a smart automation aquaponic monitoring system is proposed to help to stabilize environmental sustainability, especially in urban habitation, while lowering labor and operating expenses, as well as options for meeting food demand[21]. Users can utilize smartphone applications to maintain and watch over the system. HC-SR04 measures water level, FC-28 maintains soil moisture, and DHT11 records temperature and humidity. To process the data, the sensors are integrated with an ESP8266 microprocessor based on We Mos D1 Wi-Fi. The gathered data is saved in the cloud and accessible through the Blynk application, which serves as an actuator and lets users manage the associated parameters. The application aids in keeping track of the fish tank's humidity, temperature, and water level as well as controlling the actuator for fish feeding. Additionally, the system notifies the user of any actions taken, such as feeding fish, watering plants, or detecting an anomalous temperature in the area. Regression modelling was used to evaluate the system's performance. The outcome shows healthy growth for both plants and fish over the course of the monitoring period, indicating the success of the suggested approach. Figure 2.6 show the system architecture:

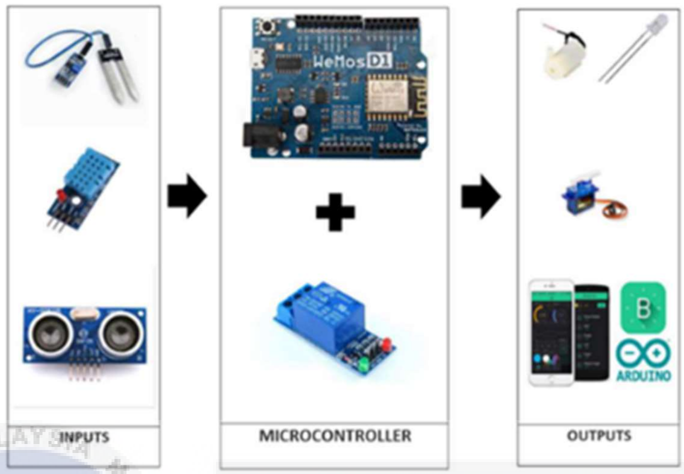



Figure 2.6 System architecture[21]

In conclusion, aquaponics provides a revolutionary method of sustainable and effective food production through the combination of cutting-edge machinery and sophisticated control systems. Operators may closely monitor and optimize key factors including water quality, temperature, nutrient levels, and oxygenation by combining sensors, monitoring devices, and automated control systems. This not only guarantees the best circumstances for fish health and plant growth, but also reduces resource waste and increases output. Real-time data analysis and decision-making are made possible by intelligent control systems, allowing for prompt modifications and interventions to preserve system balance and avert potential problems. In the end, aquaponics' equipment and intelligent control systems pave the way for a more precise, dependable, and environmentally friendly approach to agriculture, addressing the expanding demand for sustainable food production in a world with less resources. Table 2.6 shows the comparison between the implemented aquaponic projects discussed in this subtopic.

| Project title | Hardware | Result | Reference |
|---|---|---|---|
| Design of a monitoring and control system for Aquaponics based on Iot Technology. | - Arduino Mega 2560 pro<br>- Module WiFi<br>- pH sensor<br>- Dissolved oxygen (DO) sensor<br>- Temperature sensor<br>- Humidity sensor | User can control all water pump and monitor all the sensor that has been plug in in the aquaponic system. User also can set alarm on the limit of pH and DO. | [18] |
| Smart aquaponic system based Internet of Things (IoT). | - Arduino Uno<br>- Module WiFi<br>- pH sensor<br>- Ultrasonic sensor | Sensor installed to retrieve data, which was then transmitted to Ubuntu IoT Cloud server that could be accessed in real time through the internet network. Thus, the quality and water circulation were well preserved. | [19] |
| IoT controlled Aquaponic System. | - PIC 16F877A<br>- LM35 sensor<br>- LDR sensor<br>- Ammonia Sensor<br>- Co2 sensor | The structure and usage of aquaponics framework utilizing IoT which was the point and target of this task was effectively actualized. Information are sorted out, framework is easy to use, the information control and observing are done by means of Internet of Things (IoT). | [8] |
| IoT-Based Smart Aquaponics System Using Arduino Uno. | - Arduino uno<br>- Ultrasonic sensor<br>- Soil mositure sensor<br>- pH sensor<br>- Temperature sensor<br>- WiFi module ESP8266-01 | This system can save water through circulation and utilization of ammonia released by fish to produce minerals such as nitrites and nitrates for plants in an aquarium tank. The system uses sensors, actuators, and microcontrollers to monitor and control water quality. The sensors are used to collect data and the data are transmitted with the aid of a Wi-Fi module to an IoT cloud platform called Thingspeak and actuators are applied to resolve the abnormalities detected by the sensor. | [12] |

Table 2.6 Comparison table of aquaponic system

# CHAPTER 3

# METHODOLOGY

## 3.1 Introduction

Chapter 3 discusses the procedures utilized to construct this system using the ESP 8266 as its primary component. The project's flowcharts, the software and hardware that are used, how the process works, and how to develop and implement the project are all going to be covered in detail.

## 3.2 Methodology

This thesis presents how this project is carried out with the main component used which is ESP 8266. The essence of the approach used in this project focuses on the concept of Aquaponic system with IoT. The approach used in this project focuses on the concept of an aquaponic system for urban agriculture. The approach chosen is based on quantitative type, which aims to develop design of aquaponic systems that can take data and analyze the fish and plant growth. The design method is important for experimental purposes where the project achieves its objectives or not. Next, figure 3 and figure 3.1 shows the flow chart and block diagram project of this thesis.

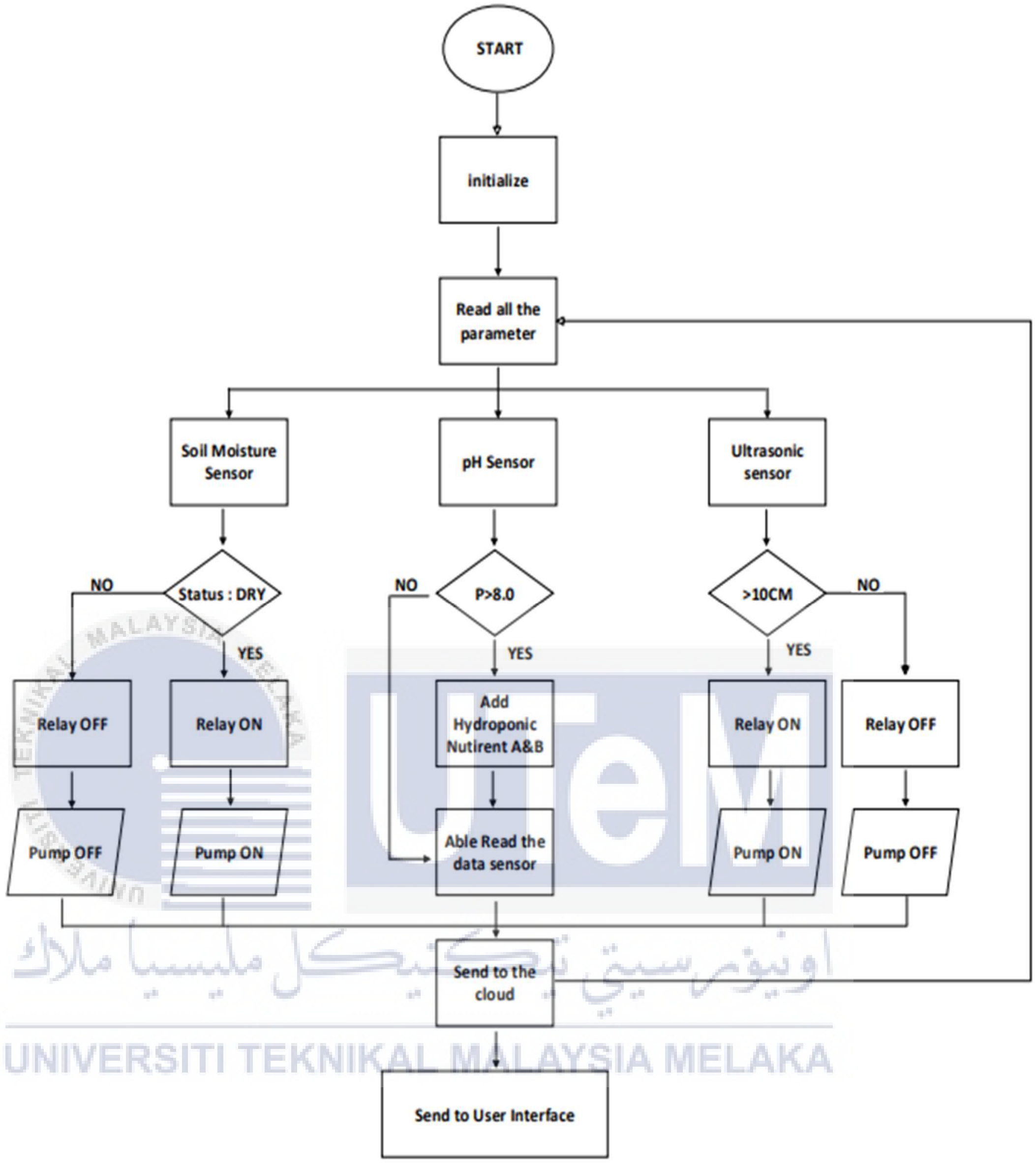



Figure 3 Flow Chart

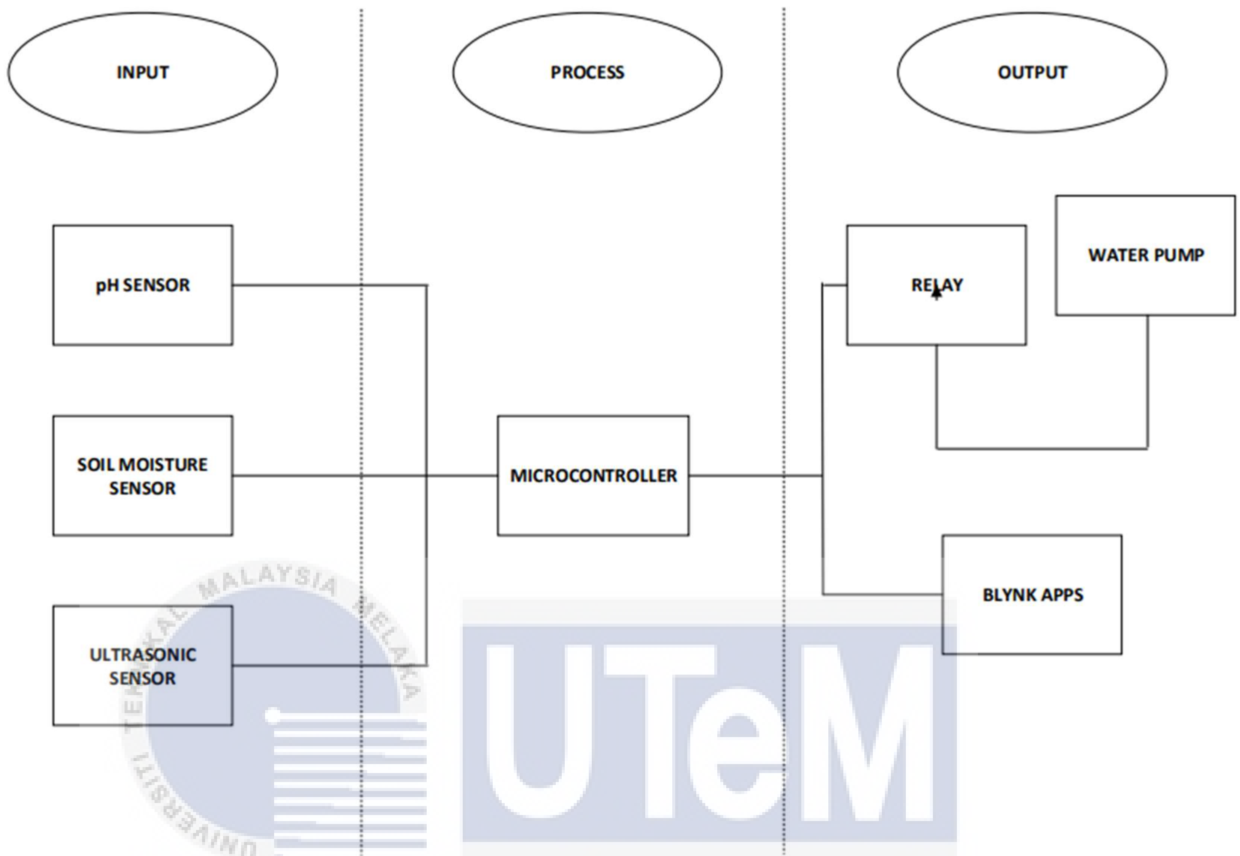



Figure 3.1 Block Diagram

Refer to the figure 3, a flow chart is a picture that shows the order in which people or things move or act in a complicated system or activity. With a flow chart, it's easy to see how a system works. The explanation about flow chart of figure 3 is basiclly the operation happen mainly in the fish tank. When the soil moisture sensor detect the area in the plant tray in dry condition it will triggered the water pump to pump the water that contains the biomass that produced by animal and pump it to the plant tray. The water will recycle back to the main tank. After that , ultrasonic sensor acts as a sensor for the water level in the tank. The process of running water to the plant may cause a reduction in the water in the main tank. With the presence of this sensor can ensure that the water level is at a good level. The pH sensor detect the pH value in the water send it to the user interface. It is very important to make sure that the the pH value in a good level or normal level because if not it will effect the ecosystem in the tank. This process will always be repeated as long as the system is full functional.

## 3.3 Experiment setup

Experimental setup for this project will be presented in this subtopic. Before creating a project, designing is very necessary to understand the concept for the project and also what hardware will be used that suits the project. Among the main hardware for this project are Arduino Uno, ultrasonic sensor, soil moisture sensor, pH sensor and water pump. With all the combination of main hardware with other hardware the preparation to make this project will run smoothly. Circuito.io has been use to make circuit design. Figure 3.2 show the circuit design of the project.

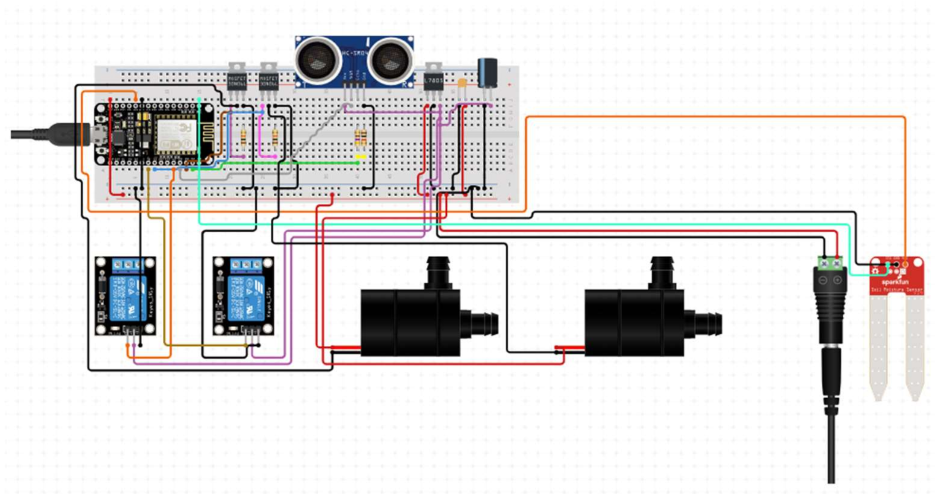


Figure 3.2  Circuit design of the project

## 3.4 Hardware and software



Figure 3.3  ESP8266

The ESP8266 is a flexible and small microcontroller with Wi-Fi functionality created for Internet of Things (IoT) applications. It is perfect for embedded systems and Internet of Things (IoT) projects since it combines a potent 32-bit Tensilica CPU, flash memory, and Wi-Fi connection onto a single chip. The ESP8266 provides developers with an economical and effective way to link their products to wireless networks thanks to its low power consumption and tiny form factor. It enables seamless data transmission and control by supporting several communication protocols, including TCP/IP, UDP, and MQTT. The ESP8266 is extremely flexible and can be programmed using well-known development environments, allowing developers to design creative and interconnected solutions for a variety of applications.

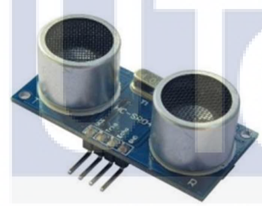


Figure 3.4 Ultrasonic Sensor



When installed in an area with water, the ultrasonic sensor measures the water level and, depending on the application being used, can communicate information to the user. When an ultrasonic sensor detects water on a tank, the user may determine how much water is there at that level. If a water tank were used as an example, the user could be informed when the tank was full that there was still water in it, as well as when the water level was low.

Figure 3.5 pH Sensor

One of the most crucial pieces of equipment for evaluating water is a pH sensor. This kind of sensor can measure the levels of acidity and alkalinity in water and other liquids. When used properly, PH sensors can ensure both the processes that occur within wastewater and the safety and quality of a product. Typically, a number from 0 to 14 is used to represent the pH scale in its conventional form. A substance is referred to as neutral when its pH is seven. A substance is more alkaline if its pH value is greater than seven, while it is more acidic if its pH value is lower than seven.



Figure 3.6 12V DC R385

The 12V DC R385 water pump is a lightweight and effective tool made to pump water in a variety of settings. It can easily be powered by a battery or any other 12V DC power source because of its low voltage demand of 12 volts, making it adaptable and portable. For applications including irrigation, aquarium circulation, water cooling systems, and more, the R385 pump is renowned for its dependable performance and high flow rate. Due to its compact design and light weight, it is simple to integrate into already-existing systems or install in confined locations. The R385 water pump is a great option for both residential and commercial applications needing a dependable and energy-efficient water pumping solution because of its tough design and brushless motor, which offers a long lifespan and silent operation.

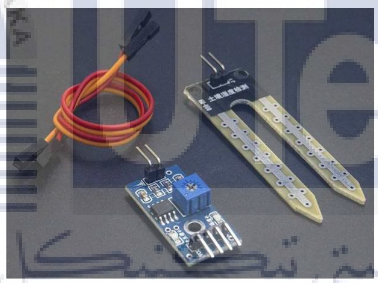


Figure 3.7 Soil Moisture Sensor

A soil moisture sensor detects the soil's moisture content to gather important data regarding the soil's water availability. Two metal probes are normally used, which are put into the soil to contact it. The sensor measures the electrical resistance between the probes because soil conductivity is affected by soil moisture. The sensor can assess the soil's moisture content and tell whether it is dry, moist, or saturated by evaluating the resistance. This knowledge is essential for effective irrigation techniques since it enables farmers, gardeners, and researchers to choose the right time and amount of water to apply to plants to maximize water efficiency and avoid either overwatering or underwatering. In agricultural and horticultural applications, soil moisture sensors are essential for improved resource management and supporting strong plant growth.



Figure 3.8 Arduino Software

The programming language Arduino is frequently used to build websites and applications, automate processes, and conduct data analysis. As a general-purpose programming language, Arduino software can be used to create a variety of applications and is not specifically designed to solve any one issue. It has evolved into one of the most popular programming languages in use today due to its adaptability and beginner-friendliness.

Figure 3.9 Blynk application

Using the widgets from the Blynk toolkit, this framework makes it simple for Arduino programmers to create GUI elements. Blynk widgets can be used to make buttons, menus, data fields, and much more in an Arduino application. Once constructed, these graphical components can be connected to or interact with features, functionality, methods, data, and even other widgets.

## 3.5 Design project prototype

Design project prototype is a description of a project where the flow of the system is shown in more detail. With the prototype design of this project, it is easier to understand. Figure 3.5.1 is the design of the project which is included the hardware that will be used :

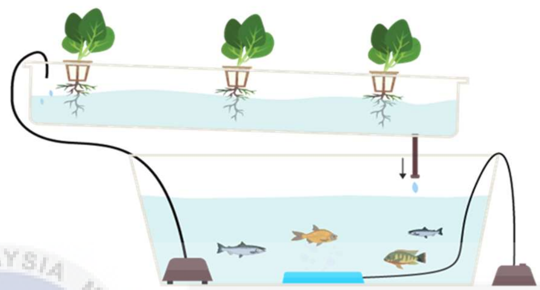


Figure 3.10 Project Prototype Design

By referring to the figure above, this project will use freshwater prawn (*Macrobrachium rosenbergii*) as water species and types of plant that use in this system is Asiatic Pennywort or Pegaga (*Centella asiatica*). The water from the aquarium will be pumped out, flowed to the plant, and then filtered using a layer inside the plant container before it is all flowed back into the aquarium. This function is implemented by the moisture level sensor. When this sensor detects that the condition of the plant container is dry, it will trigger a relay to turn on the water pump and pump out water from the aquarium. The fish tank has been equipped with a pH sensor and an ultrasonic sensor. The pH sensor acts as a tool to monitor the level of alkali and acid in water and send it to the user interface. So, the user can always know the pH level in the aquarium. Meanwhile, ultrasonics also play a role in ensuring that the water in the aquarium is at the specified level. A certain parameter has been set in the sensor so that when the distance between the water and the sensor is less than the set parameter, it will trigger the water pump to pump in water to top up the water in the aquarium.

### 3.6 Limitation of proposed methodology

Each system or project designed must have the limitation of proposed methodology. Limitation of proposed methodology is a design feature or methodology that affects a system or project to be designed. One of the limitations of this project is that the hardware is prohibitively expensive. Expensive costs are one of the constraints that necessitate sufficient funds or financial resources prior to the design of a project. If one of the hardware components is not purchased, the project will be impacted. Although the project is complete, half of the IoT-based hardware, such as ESP 6822, requires stable internet connectivity so that the data sent to users can be correctly viewed. In addition, running out of stock is a limitation of this methodology because it prolongs the duration of the project. As the designer has established a deadline for the completion of the project, the out-of-stock hardware will delay the completion of the project. The pH sensor reading is inaccurate, which can affect the alkalinity and acidity levels of water. Therefore, if the pH sensor is inaccurate, it is not good for the animals and plant in the system. As a result, this system still has limitations, as some monitoring equipment does not receive accurate data. Lastly, the level of durability of the water pump which cannot operate for a long time because it can cause the water pump to heat up and then be damaged.

### 3.7 Summary

In conclusion, chapter 3 covers the methodology, which comprises the project flow chart, in addition to the software and hardware that were utilized for the goal of generating this project. In the same vein, the outcomes of all these debates concerning methodologies make it easier to comprehend how the procedure is carried out, in addition to how to effectively plan and carry out initiatives.

# CHAPTER 4

# RESULTS AND DISCUSSIONS

## 4.1 Introduction

The project's findings and analyses are presented in this chapter. After the hardware had been presented, the results and analysis needed to be made, as explained in chapter 3 regarding the technique of how the project was generated. The required outcomes are obtained using the data's results, which follow its programming. Therefore, the results are crucial in order to determine whether the outcomes will be the same once the project is finished.

## 4.2 Results and Analysis

After all designs and prototypes have been created as stated in chapter 3, results and analysis will be presented in this chapter. To obtain an exact and correct study free of errors that could cast doubt on this product, the data collected needs to be collected with greater care. Data and analysis will be presented following the explanation of the prototype. The design is shown in Picture 4 below, and all of the hardware and components have been connected in accordance with the project's requirements. The sort of sensor, motor, and filter utilized in the prototype are depicted in the image below. The prototype image is then displayed, followed by an explanation of how this project functions.



Figure 4 Project prototype design.

Figure 4.1 is the design proposed in chapter 3. Thus, all the hardware and components proposed in the methodology have been completed on the prototype. The picture will show the labels for the components and hardware used.

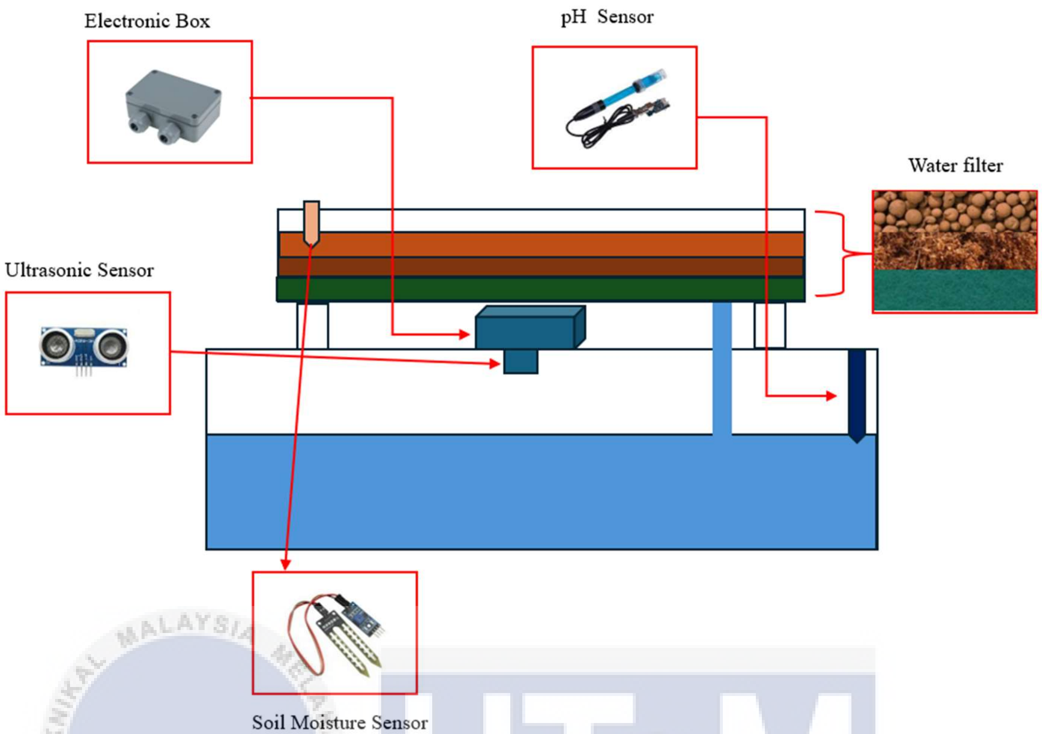



Figure 4.1 The proposed design is complete with component and hardware.

For this system, when the water is full, the ultrasonic sensor will send data to ESP8266 to be processed before being sent to the user through the Blynk application. It is also the same procedure that happens at pH level sensor. ESP8266 will process the data from the sensor which is pH value in the water then it will send to user through Blynk application. The internet connection needs to be connected first between the user's esp32 and icloud so that the data can sent continuously.

For water pump condition, in this system have 2 water pump with 2 different task. First water is for pump the water from aquarium to the plant. Its happen when the soil moisture sensor detect the soiless media in plant tray in dry condition. The sensor has been set with certain value to declare either the plant need to be watered and or not. In this system, when the value of moisture is above 500 it will automatically on the water pump to pump water. The water pump will stop pump when the value is below 500. Meanwhile , second water pump is for topup water in the aquarium. In this case ultrasonic sensor has been set with a value which is when the value is less than 10cm new water will be pump in into the aquarium. If else the water pump turn off or stop pump in the water. In this case both of the water pump has been connected with relay which is act as switch in this circuit.

Other than that, pH sensor also very important in this system. The function of this sensor is to make sure the pH value is in the good conditon. The value of pH level will appear in the user interface through blynk application. When the value is 7 it means the water in a good quality it safe for plant and animals. If the value is below or above 7 the water can be not good quality. In this case it is very important because if the quality of water not good it will effect the plant and animals.



The three analyses that will be presented are as follows: an analysis of the project's condition , an analysis of the durability of freshwater lobster, and an analysis of plant growth.

### 4.3 Analysis for the project condition

There are 3 conditions below where the results shown are the output for this project included with the output in blynk. So the user can know the status of this project whether it is in good condition or not and whether the system is running well even if the user is not in the area.

**Table 4 Moisture Condition for plant**

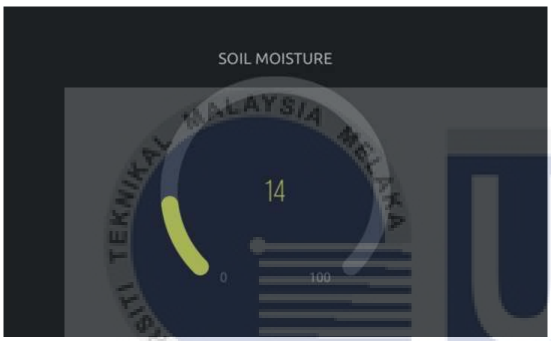
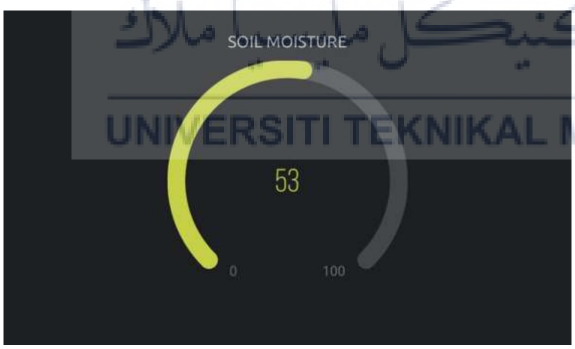
| Data | Result |
|---|---|
|   | Moisture Level:<30<br>Water Pump: on |
|   | Moisture Level:>30<br>Water Pump: off |

**Table 4.1 Water level in tank**

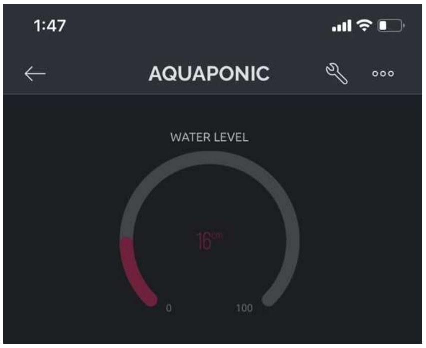
| Data | Result |
|---|---|
|   | Water Level: 16 cm<br>Water Pump: on |
|   | Water Level: 16 cm<br>Water Pump: off |

**Table 4.2 pH value in tank**

| Data | Result |
|---|---|
|   | pH Value: 7<br>Description : natural and safe |

## 4.4 Analysis for freshwater lobster durability

The examination of the durability of freshwater lobsters provides important insights regarding the health and adaptability of these marine animals in certain settings. Freshwater lobsters are essential to aquaponic systems and ecosystems, and they are frequently important parts of aquaculture systems. The goal of this investigation is to thoroughly investigate the variables that affect freshwater lobster durability, taking into account elements like water quality, temperature, habitat circumstances, and disease susceptibility. Comprehending the resilience of freshwater lobsters is essential for maximizing their farming, guaranteeing sustainable aquaculture methods, and promoting the general well-being and steadiness of aquatic environments. Table 4.3 show the data that has been collected in 2 weeks.

Table 4.3 Data for freshwater lobster

| Time stamp | pH value | Lobster activity | Health status | Description |
|---|---|---|---|---|
| 2023-12-30 07:30 AM<br>2023-12-30 10:30 PM | 7.1 | Resting<br>Active | Healthy | Water condition clear |
| 2024-01-03 07:30 AM<br>2024-01-03 10:30 PM | 6.9 | Resting<br>Active | Healthy | Water condition clear |
| 2024-01-06 07:30 AM<br>2024-01-06 10:30 PM | 7.6<br>7.1 | Not active<br>Active | Healthy | Change water in tank |
| 2024-12-06 07:30 AM<br>2024-01-06 10:30 PM | 7 | Resting<br>Active | Healthy | Water condition clear |
| 2024-01-09 07:30 AM<br>2024-01-09 10:30 PM | 7 | Resting<br>Active | Healthy | Water condition clear |
| 2024-01-12 07:30 AM<br>2024-01-12 10:30 PM | 7 | Resting<br>Active | Healthy | Change water in tank |



## 4.5 Analysis for plant growth

An important investigation into the dynamic interactions between aquatic creatures, plants, and their shared environment is the study of plant development in aquaponic systems. Aquaponics is a sustainable and integrated farming method that integrates hydroponics and aquaculture to promote a mutually beneficial relationship between fish and plants. The goal of this investigation is to look into the many environmental elements, moisture levels, and growth and development of plants in such a system. This study intends to offer insights into optimising plant growth, improving nutrient cycle efficiency, and eventually promoting a sustainable and productive agricultural model by analysing the complex relationships inside the aquaponic ecosystem. Analysing plant development in an aquaponic setting has important ramifications for developing resource-efficient farming techniques and adding to the conversation about cutting-edge, environmentally responsible food production methods. Table 4.4 show the data has been observe by plant.

Table 4.4 Data for Asian Pennywort (pegaga)

| Time stamp | Moisture level (%) | Plant height (cm) | Health status | Description |
|---|---|---|---|---|
| 2023-12-30 07:30 AM<br>2023-12-30 10:30 PM | 51<br>48 | 2 | Healthy | - |
| 2024-01-03 07:30 AM<br>2024-01-03 10:30 PM | 61<br>50 | 3.5 | Healthy | Some of the plant has been eat by snail |
| 2024-01-06 07:30 AM<br>2024-01-06 01:30 PM | 49<br>29 | 5.2 | Not healthy | Put the planter under direct sun |
| 2024-12-06 07:30 AM<br>2024-01-06 10:30 PM | 50<br>31 | 7.0 | Stable | - |
| 2024-01-09 07:30 AM<br>2024-01-09 10:30 PM | 65<br>55 | 10.5 | Stable | Some leaf have brown dot |
| 2024-01-12 07:30 AM<br>2024-01-12 01:30 PM | 56<br>28 | 12.5 | Healthy | - |

## 4.6 Summary

In conclusion, this chapter discusses the obtained analysis and results. Referring to chapter 3's discussion of methodology, all the components discussed there have been implemented in chapter 4. Because of the successful installation of the project prototype, it was successfully designed in accordance with the chapter 3 requirements. In addition to the correct installation of the circuit, the success of the analysis and the obtained results also depend on not neglecting this factor. Therefore, there are three categories of analysis-related decisions which are the growth performance of plant and animals, moisture condition and pH value. The conclusion of the analysis is that the system will operate successfully.

# CHAPTER 5

# CONCLUSION AND RECOMMENDATIONS

## 5.1 Conclusion

In conclusion, this research aims to recreate the new era of aquaponic system , as highlighted in Chapters 1, 2 and 3. Based on the findings of Chapters 3, 4, and 5, this chapter explained conclusions. Following the sequence of the three study objectives described in section 1.3 of Chapter 1, the conclusion is based around a discussion of the key research objectives. The conclusion chapter also discusses the research findings' recommendations, their addition to knowledge in this field, and the study's shortcomings. This chapter concludes with research recommendations. The incorporation of Internet of Things technology, moisture sensor, pH sensor, and ultrasonic sensor into the aquaponic system has been demonstrated to be a revolutionary method for the cultivation of crops in a manner that is both environmentally responsible and precisely managed. A full awareness of the aquaponic environment has been made possible as a result of the real-time data capture that is supplied by the Internet of Things infrastructure. This, in conjunction with the insightful analyses that are carried out by the moisture and pH sensors, has enabled this. The contribution that the ultrasonic sensor makes to the monitoring of the water level improves the effectiveness of the system even further. The combination of these technologies makes it possible to initiate quick responses to changes in the parameters of the water, thereby ensuring that the circumstances are ideal for both the fish and the plant components. The capability of remotely monitoring, analysing, and controlling the aquaponic system not only helps to maximise the utilisation of available resources, but it also makes a contribution to the overall health and productivity of the ecosystem. The combination of these technologies holds a great deal of potential for the subsequent advancement of precision agriculture, the promotion of environmentally responsible practices, and, ultimately, the redefinition of the landscape of urban farming.

Several recommendations for optimal performance have emerged as a result of the full study of the aquaponic system that was integrated with data from the Internet of Things (IoT), moisture sensor, pH sensor, and ultrasonic sensor respectively. Through the utilisation of Internet of Things technology, the implementation of a real-time monitoring system enables continuous evaluation and control of vital parameters. The integration of moisture and pH sensors enables exact tracking of soil conditions, which in turn ensures that circumstances are appropriate for plant growth in terms of both moisture levels and pH balance. The ultrasonic sensor is extremely useful for accurate water level monitoring, which helps to prevent potential problems like as overflows or insufficient water supply. Consider implementing automation features that are triggered by sensor data in order to improve the efficiency of the system. Some examples of these features include automatic modifications to nutrient dosage or water circulation. In addition, the incorporation of a user-friendly interface for remote monitoring and control guarantees accessibility and makes the operation of the system simpler. It is advised that sensors undergo routine maintenance and calibration in order to ensure that the data they produce is accurate and dependable. The implementation of these principles, in general, helps to cultivate a robust and sustainable aquaponic system, which maximises food yield while simultaneously minimising the amount of resources used and the potential dangers involved.

## REFERENCES


[1] F. Shah and W. Wu, "Soil and Crop Management Strategies to Ensure Higher Crop Productivity within Sustainable Environments," *Sustainability*, vol. 11, no. 5, p. 1485, Mar. 2019, doi: 10.3390/su11051485.

[2] Food and Agriculture Organization of the United Nations., International Fund for Agricultural Development, UNICEF, World Food Programme, and World Health Organization, *The state of food security and nutrition in the world : safeguarding against economic slowdowns and downturns.*

[3] S. Ma, L. J. Wang, J. Jiang, and Y. G. Zhao, "Direct and indirect effects of agricultural expansion and landscape fragmentation processes on natural habitats," *Agric Ecosyst Environ*, vol. 353, Sep. 2023, doi: 10.1016/j.agee.2023.108555.

[4] S. L. Tee, A. Solihhin, S. A. Juffiry, T. Rinalfi Putra, A. M. Lechner, and B. Azhar, "The effect of oil palm agricultural expansion on group size of long-tailed macaques (Macaca fascicularis) in Peninsular Malaysia," *Mammalian Biology*, vol. 94, pp. 48–53, Jan. 2019, doi: 10.1016/J.MAMBIO.2018.12.006.

[5] S. van Berkum, "How Urban Growth in the Global South Affects Agricultural Dynamics and Food Systems Outcomes in Rural Areas: A Review and Research Agenda," *Sustainability (Switzerland)*, vol. 15, no. 3, Feb. 2023, doi: 10.3390/su15032591.

[6] E. Candan Demirkol, "Impacts of modern agriculture on environment and sustainable agriculture," *JOURNAL OF LIFE ECONOMICS*, vol. 9, no. 3, pp. 171–182, Aug. 2022, doi: 10.15637/jlecon.9.3.05.

[7] A. P. Tom, J. S. Jayakumar, M. Biju, J. Somarajan, and M. A. Ibrahim, "Aquaculture wastewater treatment technologies and their sustainability: A review," *Energy Nexus*, vol. 4, p. 100022, Dec. 2021, doi: 10.1016/j.nexus.2021.100022.

[8] Sri Eshwar College of Engineering and Institute of Electrical and Electronics Engineers, *2020 6th International Conference on Advanced Computing and Communication Systems (ICACCS).*

[9] R. Mahkeswaran and A. K. Ng, "Smart and Sustainable Home Aquaponics System with Feature-Rich Internet of Things Mobile Application," in *2020 6th International Conference on Control, Automation and Robotics, ICCAR 2020*, Institute of Electrical and Electronics Engineers Inc., Apr. 2020, pp. 607–611. doi: 10.1109/ICCAR49639.2020.9108041.

[10] K. R. Rao *et al.*, "Design and Implementation of an Automated Aquaponics System using Internet of Things," 2021.

[11] M. S. Chandana, C. Sridevi, R. A. Chowdary, and D. Likhitha, "Automated Aquaponics Farming using Internet of Things (IoT)," in *Proceedings of the 2023 2nd International Conference on Electronics and Renewable Systems, ICEARS 2023*, Institute of Electrical and Electronics Engineers Inc., 2023, pp. 643–647. doi: 10.1109/ICEARS56392.2023.10085340.

[12] M. P. Ntulo, P. A. Owolawi, T. Mapayi, V. Malele, G. Aiyetoro, and J. S. Ojo, "IoT-Based smart aquaponics system using arduino uno," in *International Conference on Electrical, Computer, Communications and Mechatronics Engineering, ICECCME 2021*, Institute of Electrical and Electronics Engineers Inc., Oct. 2021. doi: 10.1109/ICECCME52200.2021.9590982.

[13] K. K. T. Nuwansi, A. K. Verma, M. H. Chandrakant, G. P. W. A. Prabhath, and R. M. Peter, "Optimization of stocking density of koi carp (Cyprinus carpio var. koi)

with gotukola (Centella asiatica) in an aquaponic system using phytoremediated aquaculture wastewater,” *Aquaculture*, vol. 532, Feb. 2021, doi: 10.1016/j.aquaculture.2020.735993.

[14] S. R. Paudel, “Nitrogen transformation in engineered aquaponics with water celery (Oenanthe javanica) and koi carp (Cyprinus carpio): Effects of plant to fish biomass ratio,” *Aquaculture*, vol. 520, Apr. 2020, doi: 10.1016/j.aquaculture.2020.734971.

[15] G. P. Suárez-Cáceres, J. Lobillo-Eguíbar, V. M. Fernández-Cabanás, F. J. Quevedo-Ruiz, and L. Pérez-Urrestarazu, “Polyculture production of vegetables and red hybrid tilapia for self-consumption by means of micro-scale aquaponic systems,” *Aquac Eng*, vol. 95, Nov. 2021, doi: 10.1016/j.aquaeng.2021.102181.

[16] R. M. F. Schardong, M. F. Moro, and O. H. Bonilla, “Aquaponic System with White Shrimp Litopenaeus vannamei Rearing and Production of the Plants Batis maritima, Sarcocornia neei and Sporobolus virginicus,” *Brazilian Archives of Biology and Technology*, vol. 63, 2020, doi: 10.1590/1678-4324-2020190118.

[17] H. Soliman, A. Osman, M. Abbass, and A. Badrey, “Paired Production of the Nile Tilapia (Oreochromis niloticus) and Lettuce (Lactuca sativa) within an Aquaponics System in Sohag Governorate,” *Sohag Journal of Sciences*, vol. 8, no. 1, pp. 35–40, Jan. 2023, doi: 10.21608/sjsci.2022.165767.1037.

[18] N. C. Nguyen, K. P. H. Nguyen, Q. H. Nguyen, H. Van Nguyen, and H. T. Ho, “Design of a monitoring and control system for Aquaponics based on Iot technology,” *Science and Technology Development Journal - Natural Sciences*, vol. 4, no. 4, p. First, Nov. 2020, doi: 10.32508/stdjns.v4i4.951.

[19] Haryanto, M. Ulum, A. F. Ibadillah, R. Alfita, K. Aji, and R. Rizkyandi, “Smart aquaponic system based Internet of Things (IoT),” in *Journal of Physics: Conference Series*, Institute of Physics Publishing, May 2019. doi: 10.1088/1742-6596/1211/1/012047.

[20] S. C. Wang, W. L. Lin, and C. H. Hsieh, “To improve the production of agricultural using IoT-based aquaponics system,” *International Journal of Applied Science and Engineering*, vol. 17, no. 2, pp. 207–222, May 2020, doi: 10.6703/IJASE.202005_17(2).207.

[21] M. Saef, T. Abdullah, and L. Mazalan, “INTERNATIONAL JOURNAL ON INFORMATICS VISUALIZATION journal homepage : www.joiv.org/index.php/joiv INTERNATIONAL JOURNAL ON INFORMATICS VISUALIZATION Smart Automation Aquaponics Monitoring System.” [Online]. Available: www.joiv.org/index.php/joiv

## APPENDICES

| WEEKS | W1 | W2 | W3 | W4 | W5 | W6 | W7 | W8 | W9 | W10 | W11 | W12 | W13 | W14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Activities | | | | | | | | | | | | | | |
| PSM 2 Briefing | | | | | | | | | | | | | | |
| Discussion with SV | | | | | | | | | | | | | | |
| Ultrasonic Sensor test with blynk | | | | | | | | | | | | | | |
| Soil moisture sensor test with bynk | | | | | | | | | | | | | | |
| Combine all coding and test | | | | | | | | | | | | | | |
| Troublesho oting | | | | | | | | | | | | | | |
| Assemble all and run a demo | | | | | | | | | | | | | | |
| PSM 2 Report Submission | | | | | | | | | | | | | | |
| PSM 2 Presentation | | | | | | | | | | | | | | |

**Appendices A : Gantt Chart**