PERCEPTIONS OF MAINTENANCE MANAGEMENT FOR AQUAPONIC SYSTEM

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DECLARATION

I hereby declare that this project report is based on my original work except for citations and quotations which have been duly acknowledged. I also declare that it has not been previously and concurrently submitted for any other degree or award at UTAR or other institutions.

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APPROVAL FOR SUBMISSION

I certify that this project report entitled "**PERCEPTIONS OF MAINTENANCE MANAGEMENT FOR AQUAPONIC SYSTEM**" was prepared by **NG JUN JIE** has met the required standard for submission in partial fulfilment of the requirements for the award of Bachelor of Science (Hons) Construction Managemnt at Universiti Tunku Abdul Rahman.

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Specially dedicated to

my family, friends and supervisor

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ABSTRACT

In recent years, Malaysia with rapid urban development, raising of population, land scarcity, implementation of Goods and Services Tax (GST) and expensive of labour and pesticides raise serious concerns about the food security. The growth of cities is already challenging the local food supply system. Urban farming is one of the strategies to combat food insecurity. However, in Malaysia, the awareness of urban farming is still low and the concept of aquaponic system is not a widespread concept. The aims of this research is to study the interest and willingness of potential user with agriculture background for practicing a sustainable maintenance for urban farming. The objectives of this research are (i) to identify the perception of potential user in practice the maintenance management for an aquaponic system and (ii) to analyse the barriers and the potential related with aquaponic system. Through intensive literature review, it provided a better understanding on the detail of different type of maintenance and the issues regarding to maintenance management for aquaponic system. This research also helps to shorten the learning curve in the process of learning the operation and maintenance for the aquaponic and also increase the confidence of people for the aquaponic system. The data used for this research is collected through survey questionnaire and interview with Agriculture Science lecturers in UTAR. A total of 56 sets of survey questionnaire are handover to the respondents and successful received 34 sets. All the collected data were analysed through using the descriptive statistic method and relative mathematical formula. The result indicates the total amount of action needs for the maintenance of aquaponic system is high which required 265

actions. Based on the result, the use of technology is able to reduce the burden of maintenance. Requirement of high intellect in aquaponic, high amount of maintenance, and requirement of critical skill are the three main barriers for the implementation of aquaponic system. Conversely, the potential of an aquaponic system are it can be a basic system for further improvement and can used for business purpose. In future study, the integration of building design with aquaponic system can be studied to increase the motivation of people to practice an aquaponic system.

Keywords: Urban farming, aquaponic system, maintenance management, potential user perception, water quality parameters.

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Nowadays, Malaysia has become a country with rapid urban development and the raising of the population. According to Department Statistics of Malaysia (2016), the population size of Malaysia has increased annually from 30.7 million in 2014 to 31.2 million in 2015 and then it will be increased to 31.7 million in 2016. Therefore, food supply has become the critical path to ensure the food security along with the growth of city and population, especially in the cities area. This is because, in the cities area, there is lack of agriculture activities that able to produce sufficient food for self-sufficiency.

According to Deputy Agriculture and Agro-based Industry Minister, Datuk Tajudin Abdul Rahman, Malaysia each year has imported around RM3.22 billion worth of vegetables and fruits from other countries to fulfil the local market demand even though home grown supplies are at a self-sufficient level (Carvalho, 2015). Land scarcity, Goods and Services Tax (GST), expensive labour and pesticides are reasons that contributed to this situation (A. Ruban, 2016). Therefore, in order to make the cities become more sustainable, the introduction of urban farming can be one of the strategies to solve the food insecurity problem (Prain & Dubbeling, 2011). As a case

study, in Singapore, the urban farming is successful contributed almost 25% of its food supply (Rabu & Mohd, 2015).

Unfortunately, in Malaysia, the awareness of urban farming is still low compared with other nations such as Taiwan and Singapore (Jahil, 2017). This is because the scarcity of land and water, agriculture waste, the use of chemical residues and pollutants which are not environmental friendly became the constraints for the urban farming (Rabu & Mohd, 2015) .

Urban farming is defined as the growing, cultivating, processing and distributing of a diversity of agriculture products, using largely human, space, and water, within a city or metropolis to generate revenue (Lanarc-Golder, 2013; Hoornweg & Munro-Faure, 2008). In the urban area, the urban farming is essential to ensure the food security and job security for the urban residents. The operation of large scale of urban farming can create the job opportunity for the resident because it involves many processes from the initial until the final which are growing, harvesting, processing, packaging, distributing, and marketing. Through these processes, the final agriculture products will be the solution to food insecurity in cities.

Furthermore, urban farming can also be used as an education tool for ecological study to increase the awareness of people about the local food system. The farmers in the urban area can share their knowledge and experience with the community residents. Other than that, the government or any organization can organize some events regarding the urban farming such as festivals, harvest dinners, growing demonstrations, and educational programs to simulate the motivation of people to understand about the urban farming and local food system (Lanarc-Golder, 2013).

An aquaponic system is one of the type of urban farming which is created through integrated the hydroponic (water-based planting) and aquaculture (fish cultivation) system into one new system (Backyard Aquaponics, 2011). The aquaponic system has the features of this two systems which are soilless, able to rear fish and

plant vegetable. Besides that, this system has a new special feature which is it is self-proving nutrient to the plants. The fishes in the fish tank produced waste in the ammonia form and then converted to the nitrate by nitrifying bacteria for plant to uptake. At the same time, when the high ammonia water is pass through the grow bed, the roots of the plant will help to clean up the water for the fish (Backyard Aquaponics, 2011). This process is known as nitrogen cycle.

However, the aquaponic system still required regular maintenance to ensure its operation. The water quality maintenance is the critical factor for the whole system. This is because all the living things in this system like the fishes, bacteria and plants need water to survive and grow. Therefore, the water quality parameters like pH level, temperature, dissolved oxygen and ammonia, nitrites, and nitrates level must be will maintain (Somerville et al., 2014). Other than that, there still have many factors need required the maintenance such as nutrient, algae, diseases and inserts. Thus, the selection of maintenance method must be based on the duration spend, effectiveness and tools and equipment involved.

1.2 Problem Statement

An urban farming is undeveloped in Malaysia, especially the knowledge of its maintenance (Jahil, 2017). According to a Malaysia aquaponic enthusiast, Mohd Affnan Sharifuddin Ramli, the concept of aquaponic is popular in western countries, however, it is not a widespread concept in Malaysia (Hannah Rafee, 2015). This situation leads to people lack of understanding about the operation of an aquaponic system and its maintenance. However, for an aquaponic system, the maintenance is necessary to prevent minor problem become a grave problem in the future. Thus, the poor maintenance management can lead to the failure of the whole aquaponic system. Along with the increasing of failure cases, the confidence of people to start up the

system was reduced. Then, this become a barrier in the effort to promote the aquaponic to public.

1.3 Aim and Objective

Aim

The aim of this research is study the interest and willingness of potential user with agriculture background for practicing a sustainable maintenance for urban farming.

Objective

In order to accomplish the aim, the below objective must be carry out:

1. To identify the perception of potential user in practice the maintenance management for an aquaponic system.

2. To analyse the barriers and potential related with aquaponic system and urban farming.

1.4 Significant Study

In this research study, the identification of effectiveness maintenance method is contributing to solving the poor maintenance study problem. This research can help to shorten the learning curve in the process of learning the operation and maintenance the aquaponic system for a person. The identification of the different type of maintenance can help a person clearly understand the detail of the maintenance involved. This can make them have the knowledge about the maintenance manual for an aquaponic system such as the procedure and effectiveness for the different type of maintenance. As the knowledge and data about aquaponic maintenance being increase and complete, the confidence of people toward the successful of aquaponic also increase. They become more confidence and knowledgeable to operate the aquaponic system and handle the maintenance. This situation can promote the effectiveness of aquaponic system to other citizen and then create a green culture in Malaysia.

1.5 Scope of Study

This research is focused on the study of the small-scale aquaponic system in Malaysia, which is studying the aquaponic that placed in the building and the various maintenance related to architectural utilities such as water, space, wind movement, lighting system, and fertilizer sources. Besides that, the perception of a group of lecturer and student and their interest and willingness to operate and maintain will also be studied. The targeted group of lecturer and student is the lecturer and students who teach/study the Agriculture Science in Universiti Tunku Abdul Rahman (UTAR). The reason for chooses them as the target respondent is due to they are the potential user in the future and they have the relevant knowledge in this firm and also aware of the aquaponic system. Thus, they can provide a reliable data for this research.

Throughout this research, the primary data will be collected through the interview and qualitative survey questionnaire method. In the survey questionnaire, various questions regarding the maintenance issues will be asked. However, for the secondary data, it will be collected through online resources such as the article, journal, data analysis, and e-book.

1.6 Limitation

The limitation found in this research is there is the availability of experts and practitioner in this field. In Malaysia, the operator of the aquaponic system is no much as foreign countries such as America and Australia. This situation lead to the difficulty to obtain the detailed information about the maintenance management of aquaponic system.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter discussed the maintenance required for the aquaponic system to make sure it able to last longer and operate without any problem. Besides that, the factors that lead to maintenance problem and what the maintenance should be applied to prevent and avoid the problem also will discuss in this chapter. Other than that, the important of periodical maintenance also will be discussed.

2.2 Relationship of Urban Farming with Built Environment

Urban farming has a close relationship to the architectural design because it can contribute to the reduction of carbon footprint in the city. Carbon footprint is a serious issue to the environment because it is the total amount of carbon dioxide and greenhouse gasses emission that directly or indirectly caused by an individual or organization (Spencer & Clarke, 2010). The sustainability of local food system can help to limit the transportation of food through directly distribute the agriculture

product to the local market and catering industries (Lanarc-Golder, 2013). This will reduce the frequency of food transportation from another region or foreign country and then direct reduce the carbon dioxide emitted by the vehicle. In the other hand, plant is absorb the carbon dioxide and natural sunlight during the day to carry out photosynthesis. During the process, the plant will produce the oxygen to the environment.

Furthermore, the urban farming can also help to regulate urban temperature and improve the microclimate. The vegetables are competent to increase the surrounding humidity through transpiration process. Along with the increasing of humidity, the ambient temperature will be reduced. Other than that, the vegetables have the ability to improve the air quality through capture dust and gasses from the polluted air and produce more pleasant odors to the environment (Deelstra & Girardet, 2000).

According to the Deputy Agriculture and Agro-Based Industry Minister, Nogeh Gumbek (2016), the daily food waste in Malaysia is around 15,000 tons, including 3,000 tons that are still fit for consumption and should not be discarded. However, the food waste is a potential fertilizer that can use in urban farming after converted into compost. Compost is defined as the organic fertilizer that produced from the food waste at a lower cost (Inckel et al., 2005). The used of food waste as raw material for the urban farming can help to reduce total amount of food waste and decrease the travel distance and frequency for disposed of food waste (Lanarc-Golder, 2013).

Besides that, the developing of urban farming will encourage the use of rainwater harvesting system. The integrated of rainwater harvesting system with urban farming was contributed to water conservation and reduced the risk of flooding in the city (Hoornweg & Munro-Faure, 2008). Basically, the rainwater can be collected from the rooftop, land surface and roof catchment, used as water resource for the urban

farming (Macomber, 2010). This system can optimizing the water management systems in the city.

2.3 Aquaponic System

An aquaponic system is one type of the urban farming that has the characteristics of aquaculture and hydroponic system (Backyard Aquaponics, 2011). This system combines these two systems to create a new system which enables the production of fishes and crops can achieve in one system. The aquaponic system is consists of three main essential components which are fish, nitrifying bacteria, and plant (Pattillo, 2017).

Generally, the small-scale aquaponic system is popular among the people due to the size of the aquaponic system is fixed to their housing area. The vacant area of the backyard, garden or roof are the places people who like to choose due to this area are exposure to the weather (Somerville et al., 2014).

In a practical aquaponic system, the water is pumped up by a water pump from the fish tank to the grow bed (Tezel, 2009). These water pumped from the fish tank have already contained the ammonia which is act as the nutrient for the plant. Ammonia is the waste that produced by the fish in the ammonia form. After that, the water is flowing through the grow media, past the roots of the plants before draining back into the fish tank. During the water cycling process, the nitrifying bacteria that live in the grow bed and water will convert the ammonia waste first to nitrite and then nitrate which the plant can uptake (Backyard Aquaponics, 2011). This conversion is in term of “nitrogen cycle”. At the same time, the root of the plant will clean up the polluted water when it passes through (Mullins et al., 2010).

Grow bed that filled with growing media such as hydroponic substrate, hydro ton lean clay, 100% natural clay, expanded clay rock and others are the common methods in aquaponic to provide a growing environment for the plant (Somerville et al., 2014). The selection of growing media depends on its size, the pH level contained in the media, size of grow bed, type of vegetable and so on.

In an aquaponic system, the fish is playing an important role in the nitrogen cycle. This is because the fish is act as a preliminary producer to produce waste as fertilizer for the plant to consume. Therefore, any accident to the fish can cause whole the system down and failure. Basically, fish is easier to suffer stress when there has any change in their living environment (Adams et al., 2002). Therefore, the result of environment change can lead to acute or chronic mortality (Higginbotham & Sink, 2013). The consequences of fish become stressors are their scale and tail rotted, having ulcers, bulging eyes, lack of growing, low immunity and high rate of mortality (Francis-Floyd, 2002). All of this situation can be prevented through conduct water quality maintenance.

Tilapia is one species of fish which is popular and suitable grow in an aquaponic system. This is because the Tilapia fish has the strong ability to adapt to the environment, easy to breed and fast growing (Popma & Masser, 1999). Of course, another type of fish still can adapt to this system like catch fish, silver perch, koi, and so on (Martan, 2008). However, the breed and selection of fish must obey the local rule and regulations.

The plant select for the aquaponic can be seedling or seeds. They could be sprinkle over the grow media or buried into the grow media (Backyard Aquaponics, 2011). Besides that, the plant for aquaponic has two main categories which are leafy green vegetables and fruiting vegetables (Somerville et al., 2014). The operator can base on their preference to select the plant but they must have certain knowledge about the way to plant.

2.4 Water Quality Maintenance

Water quality maintenance is important to ensure all the living thing can be survived. The water quality maintenance is included pH level control, algae control, temperature control, ammonia, nitrite and nitrate control, and dissolved oxygen.

2.4.1 PH Level Control

According to Søren Peter Lauritz Sørensen, pH is defined as a measure of acid or basic solution is on a scale ranging from 0 to 14, with 7.0 being neutral. The value of pH that above 7.0 is considered as alkaline while the value is below 7.0 is considered as acidic (Kohlmann, 2003).

In an aquaponic system, the pH level must be manipulated to prevent it too high or too low. The standard pH level range for the aquaponic system is between 6-7, which is suitable for the fish and plant. The pH is important in controls the chemical equilibrium of several toxic fish metabolites such as unionized ammonia and carbon dioxide. Other than that, it also will affect the bacteria reproduction ability, ability of plants nutrient intake and the health of fish and plant (Tucker & D'Abramo, 2008). For instance, a pH value of 7.5 can lead to nutrient deficiencies of iron, calcium, potassium, phosphorus, and manganese (Somerville et al., 2014). Besides that, the low pH value may result in the unbalanced nitrogen cycle in this system. The low pH value will make the bacteria decrease the conversion of ammonia to nitrate. After that, the level of ammonia will begin increase.

Normally, if the pH level is higher than the required level, it can be lower through adding some acid into the water. However, the acid is only used when the water condition is very basic and hard because the excess of acid may cause the living

things in the aquaponic system died. This situation is occurred due to they don't have any notification of the pH change at the initial. The continual acid added will make the pH level suddenly drop drastically (Somerville et al., 2014). Thus, to avoid the risk is to add the acid into the resupply water in a separate tank. After that, the treated water just add into the aquaponic system. The common type of acid to be used is the muriatic, phosphoric, and nitric acid (Bernstein & Lennard, 2017). On the contrary, the critic or concentrated acid are prohibited from applying in this system. The critic acid is antimicrobial, while the concentrated acid is dangerous to the system and operator.

For the low pH case, this problem can be solved by increase the pH level with buffers or bases. Calcium carbonate (CaCO3) and potassium carbonate (K2CO3) are the common and safety choice to increase the bases. They are powerful in increase the carbonate hardness (KH) and the pH level (Somerville et al., 2014). The common types of calcium carbonate are crushed eggshells, finely crushed seashells, coarse limestone grit and crushed chalk (Backyard Aquaponics, 2011). In a good practice, the selected material is put in a porous bag and then suspended in a tank. Besides that, the pH level will be test and monitor over a few week period. When the desired pH is achieve then the bag need to remove.

2.4.2 Algae Control

In the biological view, algae are defined as plants or plantlike organisms that lack the true roots, stems or leaves and is often found in water or high moisture places and exposure to sunlight (Carlsson & Clayton, 2007). In a food chain, the algae act as food for most of the marine species. However, in an aquaponic system, the algae is a serious problem because algae can cause the pH level swings in this system when they are dying and decaying into ammonia.

Besides that, the algae also consume the nutrient contained in water which is prepared for the plants. Subsequently, this will cause the plant lack of nutrient and may die. As plants or plantlike organisms, algae also can produce the oxygen through photosynthesis process during the day. However, it also can dramatically reduce the oxygen through respiration during the night and then cause the fish died (Brunson et al., 1994). The other problem that can caused by algae is impeded the water circulation. This is because the growth of brown filamentous algae can block the drains and filters which may lead to water circulation problem (Somerville et al., 2014).

The best and simple way to prevent the algae grow is to block off the contact with natural sunlight (Somerville et al., 2014). This is because the exposure of sunlight can fasten the produce of algae over a short period. Other than that, regular weekly water changing also can help to prevent the algae grow because it can lower the nutrient in the water. The percentage of water exchange is between 5-10% to keep the nitrate low (Emily Cassidy, 2009).

2.4.3 Temperature control

Water temperature is one of the essential water quality parameter for the aquaponic system because it has an effect on dissolve oxygen. The high water temperature can caused less dissolve oxygen, more ammonia, and restrict the absorption of calcium in plants. In an aquaponic system, the optimum water temperature in aquaponic system is around 18-30 ℃ (Somerville et al., 2014).

Generally, most of the fish are poikilothermic which means they are cold blood and their internal body temperature is fully dependent on the surrounding water temperature. In order to solve the high-temperature problem, the simplest way is to use

the heat-tolerant fish such as tilapia. This is because the tilapia fish can survive in the warm water condition, so it is suitable to use in Malaysia (Goddek et al., 2015).

The fish tank can be totally cover by an insulation board to minimize the radiation process. However, they must ensure that the oxygen supply for the fish does not be affected by the insulation board. Furthermore, the insulation board must have the characteristic of low R-factor of insulation such as blue board (Mullins et al., 2010).

2.4.4 Ammonia, Nitrite and Nitrate Control

In an aquaponic system, the ammonia has comes from the waste that produced by the fish through their gills. After this, the nitrifying bacteria will convert it to the nitrate for plant consume (Backyard Aquaponics, 2011). However, the surplus of ammonia level does not mean good for the system. This is because the ammonia actually is toxic to the fish and then if the level of ammonia exceeds the standard level it will be the disaster to the fish for surviving. On the other hand, the lower level of ammonia also is a problem for the plant to grow. With the growth of the plant, the required nitrates will also increase. Thus, the shortage of ammonia will affect the growth of the plant. Besides that, the lower level of ammonia over a long period will make the fish stress and increase the probability of diseases (Virginia, 1997).

Therefore, the ammonia level must be controlled to ensure the safety of the fish. In order to do that, the measurement of ammonia level must be conduct weekly through using ammonia's test kit (Klinger-Bowen et al., 2011). When the ammonia level turns high, it can be lower by changing the water. Water change is the fastest and safety method for reducing the ammonia level. The percentage of water need to remove is between 10-15% and replace by treated water. After that, continue to change the water over the next 2-3 days until the ammonia level become balance (Matt, 2014).

Besides that, the ammonia level also can be controlled by avoiding overfeed. This is because the uneaten fish food can produce the ammonia which increase the ammonia level in fish tank (Backyard Aquaponics, 2011).

Nitrites are similar with the ammonia which also are toxic to the fish. The unsuitable level of nitrates will cause the same consequence as the high level of ammonia which are make the fish stress and increase the probability of diseases (Virginia, 1997). Although nitrates are far less toxic compared to nitrites and ammonia, it also has the negative impact on plants. This is because the excessive of nitrates will cause the plants abnormal growth. Furthermore, the hazardous accumulation of nitrates in leaves have the risk of danger human health (Virginia, 1997).

For the nitrite and nitrate, if they are too high, water exchange also is the solution. The water exchange can dilute the concentration of nitrite and nitrate. Other than that, adding cheap pool salt or water softener salt can help to control the nitrite and nitrate level. The suitable ratio of salt to water is 1 kg of salt per 1000 liter of water (Bernstein, 2011).

2.4.5 Dissolved Oxygen

As a knowledge of general, oxygen is vital for all the living thing to survive. In the aquaponic system, the amount of dissolved oxygen is crucial for fishes to survive. This is because the supplement of dissolved oxygen may insufficient to fulfill the demand of the fish, plant and bacteria due to there is high fish density in the fish tank. Other than that, with the growth of the fish and plans, the dissolved oxygen required for the fish and plant will increase. Thus, the initial oxygen level is insufficient to meet the current oxygen requirement (Somerville et al., 2014).

The sufficient dissolved oxygen can be achieved through used the water pump to create water movement or used aerators to create air bubbles (Backyard Aquaponics, 2011). Water movement is essential to create the water circulation in the aquaponic system with the purpose of flow the water throughout the system. This is because the cease of water circulation will lead to the reduction of dissolved oxygen and accumulation of wastes in the fish tank (Somerville et al., 2014). The accumulation of unconsumed fish food in the fish tank can reduce the concentration of dissolved oxygen (Viet Linh, 2014). Therefore, the water pump is important to ensure the amount of dissolved oxygen. The common method used to move the water are used submersible impeller water pump, airlift and human power.

The aerator is also known as air pump which used a driven motor to operate the air pipes and air stone to inject fresh air into the water. Generally, the air stone is lied in the bottom of the tank to produce the air bubbles which used for increased the dissolved oxygen level in the water (Somerville et al., 2014).

2.5 Other Maintenances Required for Aquaponic System

This topic is briefly discussed about the maintenance which are not related with water quality such as light energy, wind protection, fertilizer source, pest management, and disease management.

2.5.1 Light Energy

Photosynthesis is an energy transfer reaction of the green plant which using the light to synthesize the carbohydrate from the carbon dioxide and water as an energy source.

These carbohydrates are used as energy by the plant to grow and develop it structure. According to the (Oebker & Call, 2008), most of the vegetables required 6-8 hours of the full sun of exposure throughout a day. The insufficient of sunlight may slow down the growth rate of the plant.

However, some of the plants still need tolerate partial shade to avoid high intensive of sunlight. For instance, the light sensitive like lettuce, salad greens and cabbages cannot tolerate with high intensive sunlight because they will become bitter and unpalatable. The shade structure is a good option to provide the plant a shady area to avoid the excessive sunlight (Love et al., 2015).

Basically, the sun is traveled from east to west throughout a day. Thus, the location of the system can be placed based on the sun pathway and the type of plant. For the plant that is light preference, the system can be placed in the sunny area that fully exposure to the sunlight like backyard or garden. In the case of the aquaponic is located within the building, try to place it near to the window which can as an access to receive the sunlight (Somerville et al., 2014).

Artificial light also is one of the solution for the limitation of sunlight. The artificial light can be used as replacement lighting, supplemental lighting and photoperiod lighting. The replacement lighting is means the artificial light can fully replace the solar radiation for indoor growth rooms and growth chambers. If the artificial light used as supplemental lighting, it can used to supplement periods of low natural light. Photoperiod lighting is mean used to regulate flowering of plants sensitive to day length (Argus, 2010). The artificial light can be categories into three main type which are incandescent, fluorescent, and discharge.

2.5.2 Wind Protection

Sometimes, the wind can be a disaster for the plant especially the strong wind. This is because the high velocity of wind speed has the potential to uproot the vegetable or destroy part of their body (Derzaph & Hamilton, 2013). Therefore, the aquaponic operator must take the precaution to minimize the influence of the wind to their plant.

The simplest way to protect the plant from the wind is placed the aquaponic system in a shelter such as inside of building or greenhouse. The structure of the shelter can act as a wall against the wind so the wind will not blow in. However, if the aquaponic system is located at outdoor area, try to find a place which already has a living windbreak. The living windbreak is referred to the trees or shrubs that designed and establish to reduce the velocity of the wind (Hanley, 1984).

Furthermore, the structural wind barriers also effective to protect the plant against wind when the windbreak are not available. The structural wind barriers are a fence of board, baled straw or steel slats. They can provide the wind protection as the windbreak but the protection area are smaller than windbreak due to the height of fence cannot cover larger area. However, this method is need too much space and can immediately provide the protection upon the construction. Generally, the structural wind barrier can reduce the open wind velocities by 40% to 60% (Hanley, 1984).

2.5.3 Fertilizer Sources

Fertilizer is the natural material that provided the nutrients for the plant to facilitate the growth rate and prevent the plant deficiencies (Food And Agriculture Organization, 2000). For the aquaponic system, there have several common plant deficiencies due to insufficient nutrient such as potassium, phosphorus, magnesium, calcium and iron

deficiencies. These nutrient deficiencies can be solved by using the fertilizer. However, not all the type of fertilizer is suitable for aquaponic system especially the synthetic fertilizers. This is because the synthetic fertilizers is harsh to the aquaponic and can break the ecosystem (Somerville et al., 2014).

The most suitable fertilizer for the aquaponic system is the compost tea, which is the compost made by the decomposed organic matter, including food waste in the liquid form (Dearborn, 2011). Conventionally, this compost can be done easily at home with high quality. The procedure to make a compost tea is adding the food wastes into the compost bin and place it over six months to let the aerobic bacteria, fungi, and other organisms decomposed the organic matter into simple nutrients for plants to consume. Humus is the final product and it is free from pathogens and is full of nutrients (Somerville et al., 2014).

After the compost is produced, it can convert to the compost tea. The process of compost tea has tied the compost within a mesh bag, weighted with some stones (Inckel et al., 2005). After that, suspended the bag in a bucket with 20 liters of water. Then, an air pump that connected with an air stone will place underneath the mesh bag to create the bubble to agitate the content. Lastly, left the mixture over few days with the constant aeration and the final product is the compost tea. The ratio of compost tea to water is 1:10 (Allahyari et al., 2015).

Other than the fish food, fish also consumed the phytoplankton and zooplankton as they indirect food resources. Phytoplankton is a microscopic green plant that thrive in the water. However, the zooplankton is a very small animal that lives in the water such as copepods and rotifers (Inckel et al., 2005). Therefore, the amount of phytoplankton can be increased through added the organic compost for them to thrive. After that, the zooplankton will consume them and then eaten by the fish. Thus, the final result is the quality of the fish increased due to adequate intake of nutrients.

2.5.4 Pest Management

For the plant, pests are their natural enemies such as caterpillars, fruit flies, snails and others. This is because the pests like to eat the plant whatever what species of the plant are and at what growth stage even though hasn't matured. Any part of the plant can be eaten by the insects like fruit, leaf, stem, and root. This is a trouble for the owner to ensure their harvest (Dufour, 2001).

Pests control can be achieved through applied the physical net or spray the repellent on plant thoroughly. The physical anti-pest net is effective in control the amount of pest because it prevents the pest come into the area of planting. Besides that, the anti-pest net is resistant to the ultraviolet ray means that it can last longer even exposure to the sunlight. The wearing of the anti-pest net is also accurate to confirm 100% mesh density and it is lightweight (Simon et al., 2014). However, the net must be installed prior to the pest appearance due to it just exclude the pest does not eradicate them (Somerville et al., 2014).

Trapping also is one of the common methods to eradicate the pest. The common sticky traps used to control the pest which is yellow and blue sticky trap. The yellow sticky trap has the function of trap whiteflies and micro-Lepidoptera while for blue sticky trap, it can trap the adult stages of thrips. Generally, the sticky trap is positioned above the canopy of plants with a hanger to maximize it effectively. However, this stick trap is less effective in outdoor because the new pest can easily come in the protected environment (Somerville et al., 2014).

The repellent is referred to the essential of plant or herb used as a natural drug to control the inserts (Pattanayak & Dhal, 2015). The natural smell of some plants or herbs like citronella or citrus is effective in expelling pests. Thus, in an aquaponic system, the plant-based repellent is the best choice used to expel the pest with no other effect on plants and fishes. Normally, the citronella or citrus is used in this system due to them able to control broad spectrum of pests. The method of application of citronella

and citrus is dissolved them in water and then spread on the plant thoroughly (Somerville et al., 2014). The number of spread just once a day.

2.5.5 Disease Management

Disease is referred to any physiological or structural abnormality that interferes with growth rate, development, appearance or function of an organism (Long & Specialist, 2016). In fact, the aquaponic system is unlike the hydroponic system that able to manage under sterile conditions due to it is comprised of complex microscopic ecosystem. Inside the aquaponic system, there can found the presence of fish, plant, bacteria, and other microorganisms. The complex microscopic ecosystem caused the plant and fish more easily infected by the disease caused by pathogen. However, a practical disease management can prevent the influence of disease and minimize the loss.

2.5.5.1 Plant Disease Management

There have two type of plant disease which are abiotic and biotic disease. The abiotic disease is normally caused by the non-living things such as ambient temperature, moisture, nutrition, toxicity and so on. However, the biotic disease is caused by the living organism like fungi, harmful bacteria, viruses and others (Small, 2011). The common plant diseases are septoria leaf spot, late blight, fire blight, powdery mildew, cedar - apple rust and others. Thus, the plant disease management must be carry out to prevent the disease.

Monitoring is the best way to discover the symptom of plant diseases at the earlier stage. The regular inspection of the aquaponic system can help in preventing the outbreak of diseases. This is because any of the infected branches, leaf, or the

whole plant can be removed from the grow bed if any symptom of the disease is found before they spread throughout the entire plant (Leonberger et al., 2016).

The nutrition of the plant is very important because insufficient nutrient of plant will make them become more vulnerable. Some of the nutrients are effective in preventing the fungal disease such as nitrogen, calcium, potassium, silicon, and phosphorus (Somerville et al., 2014). Thus, the sufficient nutrient for the plant is important to increase their immune system against the diseases.

Environment control is the most effective solution to prevent the abiotic and biotic disease. Through control the temperature and humidity, the germination of fungal spores will be avoided due to the prohibition of growing environment. Other than that, the high density of plantation also will increase the risk of disease. Thus, the planting area must very designed carefully to allow the ventilation and reduce the humidity (Small, 2011).

2.5.5.2 Fish Diseases Management

Fish is easier suffered stress and very sensitive with the water condition. The water is act as living environment to the fish, thus, any change of water condition has the direct effect to the fish such as fast change of water temperature and pH. Therefore, any poor condition of water will reduced the immune system of the fish to against the diseases (Somerville et al., 2014). Other than that, overstock of fish in aquaponic system will also cause them stressed and easier suffered damaged due to fight with each other. This is because, when the fish is become stressed they will lose their appetite and then the consequence is the ability of immune system turn down.

Similar with the plant diseases, the fish diseases also can classified into two categories which are abiotic diseases and biotic diseases. For the reason that contribute to fish stressed has already explained in the subtopic 2.3 and the solution is explained in subtopic 2.4. From the previous part, the important of environment control to protect the fish from stress have been showed.

Daily monitoring is the best way in the fish diseases management. Any infected fish can be discovered at the first time and then the prevention method can be quickly carried out. In the aquaponic system, the infected fish will be insulated with other fish to control the spreading of diseases in the fish tank. This allows the infected fish received the treatment in another tank (Somerville et al., 2014).

2.6 Daily Maintenance

The daily maintenance included the scheduled feeding, check temperature, check pump and plumbing, and check for the pest.

2.6.1 Feed Fish

The most basic task of daily maintenance is feed the fish with appropriate fish food. In order to ensure the amount of fish food does not too much or less, the standard daily feed rate can apply. According to a research, for the leafy green vegetables, 40–50 grams of feed per square meter per day is sufficient. However, for the fruiting vegetables, they need to have 50–80 grams of feed per square meter per day (Somerville et al., 2014). The reason for the high feed rate ratio for fruiting vegetables is because they need a huge amount of nutrient to produce flowers and fruits.

2.6.2 Check Temperature

The regular daily temperature checking can ensure the water temperature is always at the ideal range which is between 18 and 30℃ (Backyard Aquaponics, 2011). Thermometer is a reliable measurement tool used to measure the temperature. The record of data of water temperature can help the operator develop the strategy to maintain the desired temperature.

2.6.3 Check Pump and Plumbing

The pumps and plumbing must check daily because any breakdown of them will affect whole the aquaponic system. The function of pumps is used to create the pressure to push the water flow upward and then flow through the system. Thus, if the pumps lost their function and do not immediately take any action, it can cause all the plant died due to lack of water. Besides that, the plumbing also needs to check regularly because they are acting as a channel for water to flow through. Any damaged of pipes will make the water leakage and then lead to water scarcity problem for the plant. Other than that, if there have any block of the plumbing, the obstruction must be (Somerville et al., 2014).

2.6.4 Check for the Pest

The existence of pest in the aquaponic system must be taken serious action because it may destroy all the plant. The pest control is required day to day inspection of the aquaponic system. Once the pest is discovered, the preventive action must quickly carry out to prevent the scale of suffered increase (Somerville et al., 2014).

2.7 Weekly Maintenance

The weekly maintenance is included the inspection of ammonia, nitrite, and nitrate level, check pH, and add water.

2.7.1 Check ammonia, nitrite, and nitrate level

The ammonia, nitrite, and nitrate are interrelated, thus any change of one will affect the others. The ammonia level in the aquaponic system can be used as an indicator to show the overall health of the system. Therefore, the weekly check of ammonia through using water test kit can help to maintain the required level before them out of control (Bernstein, 2011).

2.7.2 Check PH

The suitable pH level is important to the fish, plant, and bacteria to survive. The change of pH in the water can affect the internal pH of fish and plant. This situation may cause them stressed and then died. The early identification of change is the key to success pH control (Somerville et al., 2014).

2.7.3 Add Water

Under the hot weather, the water in the aquaponic system was evaporated quickly. Thus, weekly water adding is required to compensate the water evaporated. This is to ensure the water is always sufficient to the plant and fish. Before adding the water to the system, the water must be dechlorinated first to remove the harmful chemical contain to the fish (Bernstein, 2011).

2.8 Monthly Maintenance

The monthly maintenance is included clean out pump and plumbing and measure the condition of the fish.

2.8.1 Clean Out Pump and Plumbing

It is important to clean the pump and plumbing of the aquaponic system once a month. The pipe will be apart to clean the inlet area and the filter also is cleaned. This can help to prevent any algae grow and remove the odor emitted from fish solid waste (Bernstein, 2011).

2.8.2 Measure the Weight and Length of Fish

The weight and length of the fish can reflect the health of the fish and the water condition. This is because when the fish is under stress and suffered the disease, the weight and length of the fish will lose to a healthy fish. Form this, the condition of the water and fish will be known and this enable to operator immediately take action to prevent the situation become worst. The measure of fish just need once a month and only measure some sample of fish (Somerville et al., 2014).

2.9 Overall Review

Total Action of Maintenance x Frequency = Severity Index

Frequency: 1= once; 2= intermittence; 3= regular

Table 2.1: Action of Maintenance for the Fish (Somerville et al., 2014)

Maintenance Required for Fishes	Action of Maintenance	Total Action	Frequency	Severity Index
	Perform water test 1. Prepare the water test kit. 2. Carefully open the pH packet and take out strip. 3. Immerse the regent pads into sample and remove immediately. 4. Analyse the result	4	3	12

PH level	**Lowering pH with acid** 1. Prepare suitable acid like phosphoric acid 2. Add the acid in a separate water reservoir 3. Then, add the treated water to the system	3	2	6
	Increasing pH with buffers and bases 1. Prepare the suitable bases like crush seashell, eggshells and so on. 2. Put them in a porous bag suspended in the fish tank. 3. Regularly testing pH over the next few weeks to monitor the increase in pH. 4. Remove the bag after reached desired pH level.	4	2	8
				26
Prevent algae grow	**Algae Prevention** 1. Prepare shade cloth, tarps, woven palm fronds or plastic lids. 2. Used it to cover fish tanks and bio filters to cut off the contact with the sunlight.	2	1	2
Temperature control	**Daily checking** 1. Use a thermometer to check the water temperature.	1	3	3
	Weather Prevention 1. Prepare a thermal insulation board. 2. Place the insulation board upon the fish tank.	2	1	2
				5

Ammonia, nitrate and nitrite control	**<u>Weekly Water Test</u>** 1. Prepare the water test kit. 2. Carefully open the packet and take out strip. 3. Immerse the regent pads into sample and remove after 2 second. 4. Analyse the result.	4	3	12
	<u>Ammonia control</u> 1. When the ammonia level is too high, remove 10-15% of the water. 2. Replace by treated water. 3. Keeps change the water over the next 2-3 days. 4. Check the ammonia level.	4	2	8
	<u>Nitrate and nitrite control</u> 1. Conduct water test weekly to check the level of ammonia by using water test kit. 2. When the level is too high, remove 10-15% of the water. 3. Replace by treated water. 4. Keep change the water over the next 2-3 days. 5. Adding aquarium or water softener salt with the ration 1:1000 (1kg salt: 1000 liter water) 6. Check the nitrate and nitrite level.	6	2	12
				32

Dissolve oxygen	**Increasing the dissolve oxygen with air pump** 1. Prepare the air pump and air stone with the consideration of fish tank design. 2. Select a suitable location for air pump. 3. Connect the airline tubing to the air pump. 4. Connect the airline tubing to the air stone. 5. Turn on the air pump and check the bubble condition.	5	1	5
Scheduled feeding	**Feeding** 1. Selected suitable type of the fish food with the consideration of the fish's size. 2. Feed the fish with suitable amount of fish feed pallet to avoid uneaten pallet. 3. Store the fish feed pallet in a dark, dry, cool and secure conditions.	3	3	9
Clean pump and plumbing	**Clean the pump and plumbing system** 1. Dismantle the pump and plumbing from the system with care. 2. Wash them and remove the particles and algae. 3. Install back to the correct position.	3	3	9

Fish disease management	**Daily Observation** 1. Daily visual observation to discover any unhealthy fish.	1	3	3
	Fish disease management 1. Any unhealthy fish needs to remove to another tank for receive treatment. 2. Carry out the preliminary treatment through adding the salt to the fish tank. 3. After that, add the suitable fish medicine into the fish tank. 4. Observe the condition of the fish in following week. 5. When the fish was recovered, put it back to the fish tank.	5	2	10
				13
Adding water	**Adding water** 1. The water of the system need adding weekly to ensure the amount of water is sufficient. 2. Before the water are add, it must be dechlorinated first in another tank in order to remove harmful particle. 3. After the treated water are add to the aquaponic system, a suitable amount of salt can be added.	3	3	9

Measure weight and length of fish	**Check the fish growth rate** 1. Catch a number of sample fishes by using fish net. 2. Place the fish in the weighing machine to record it weight. 3. Use a measurement tape to measure the length of fish. 4. Record all the data obtained. 5. Measure them each month to identify their growth rate.	5	3	15
Scheduled harvest	**Harvest the fish** 1. When the fish are mature, harvest them by using fish net to avoid over density. 2. Measure the weight of the fish. 3. Frozen them for later consume or distribution. 4. A new batch of fish are add to the fish tank to ensure the nutrient for the fish is sufficient.	4	2	8
Total				**133**

Table 2.2: Action of Maintenance for the Plant (Somerville et al., 2014)

Maintenance Required for Plant	Action of Maintenance	Total Action	Frequency	Severity Index
PH level	**Perform water test** 1. Prepare the water test kit. 2. Carefully open the pH packet and take out strip. 3. Immerse the regent pads into sample and remove immediately. 4. Analyse the result	4	3	12
	Lowering pH with acid 1. Prepare suitable acid like phosphoric acid 2. Add the acid in a separate water reservoir 3. Then, add the treated water to the system	3	2	6
	Increasing pH with buffers and bases 1. Prepare the suitable bases like crush seashell, eggshells and so on. 2. Put them in a porous bag suspended in the fish tank. 3. Regularly testing pH over the next few weeks to monitor the increase in pH. 4. Remove the bag after reached desired pH level.	4	2	8
				26

Prevent algae grow	**Algae Prevention** 1. Prepare shade cloth, tarps, woven palm fronds or plastic lids. 2. Used it to cover fish tanks and bio filters to cut off the contact with the sunlight.	2	1	2
Temperature control	**Net structure house** 1. Preparation of the site 2. Drill a hole to place the embedment fittings down the pipes. 3. Pour cement in the holes and let harden. 4. Erect the structure of the net house. 5. Select the suitable size of shade cloth. 6. Cutting the shade cloth. 7. Staple the shade cloth into place. 8. Carefully trim the edges of the excess shade cloth.	8	1	8

Ammonia, nitrate and nitrite control	**<u>Weekly Water Test</u>** 1. Prepare the water test kit. 2. Carefully open the packet and take out strip. 3. Immerse the regent pads into sample and remove after 2 second. 4. Analyse the result.	4	3	12
	<u>Ammonia control</u> 1. When the ammonia level is too high, remove 10-15% of the water. 2. Replace by treated water. 3. Keeps change the water over the next 2-3 days. 4. Check the ammonia level.	4	2	8
	<u>Nitrate and nitrite control</u> 1. Conduct water test weekly to check the level of ammonia by using water test kit. 2. When the level is too high, remove 10-15% of the water. 3. Replace by treated water. 4. Keep change the water over the next 2-3 days. 5. Adding aquarium or water softener salt with the ration 1:1000 (1kg salt: 1000 liter water) 6. Check the nitrate and nitrite level.	6	2	12
				32

Dissolve oxygen	**Increasing the dissolve oxygen with air pump** 1. Prepare the air pump and air stone with the consideration of fish tank design. 2. Select a suitable location for air pump. 3. Connect the airline tubing to the air pump. 4. Connect the airline tubing to the air stone. 5. Turn on the air pump and check the bubble condition.	5	1	5
Light energy	**Provide sufficient energy with UV light** 1. Select the suitable type of lighting system based on the amount of light needed. 2. Select a suitable place which can maximise the area. 3. Install the UV lighting system. 4. Test whether it can function or not. 5. Set the time of turn on the UV light.	5	1	5
Wind pressure protection	1. Preparation of the site 2. Drill a hole to place the embedment fittings down the pipes. 3. Pour cement in the holes and let harden. 4. Erect the structure of the net house. 5. Select the suitable size of shade cloth. 6. Cutting the shade cloth. 7. Staple the shade cloth into place. 8. Carefully trim the edges of the excess shade cloth.	8	1	8

Provide nutrient	**<u>Method to make an organic plant fertilizer</u>** 1. Collected suitable food waste like natural product. 2. Add the food waste to a compost unit with proper layering 3. Wait for four to six month for the break down process. 4. During the process, water may be added if the compost is too dry. 5. After the compost are completed, tied the compost within with in a mesh beg and then weighted with some stones. 6. Then the bag is suspended in a bucket of water (20 litres). 7. Position an air stone underneath the mesh bag so that the bubbles agitate the contents. 8. The mixture is left for several days with constant aeration. 9. After 2-3 days, use a fine cloth to strain the compost tea and then diluted 1:10 with water. 10. Then add the suitable amount of compost tea to the aquaponic system.	10	2	20

Pest Management	1. Preparation of the site 2. Drill a hole to place the embedment fittings down the pipes. 3. Pour cement in the holes and let harden. 4. Erect the structure of the net house. 5. Select the suitable size of shade cloth. 6. Cutting the shade cloth. 7. Staple the shade cloth into place. 8. Carefully trim the edges of the excess shade cloth.	8	1	8
Plant disease management	**Disease Prevention** 1. Regular inspection is needed to enable early treatment for infected plant. 2. Provide sufficient nutrient for the plant. 3. Make sure the environment for the plant is appropriate. 4. Identify the type of plant disease. 5. Any infected plant must be treated by suitable method that does not harm the fish.	5	2	10
Scheduled harvest	**Harvest the plant** 1. Harvest the plant when there are mature. 2. Make sure all the root system is removed. 3. Place harvested plant in a clean bag. 4. Wash and chill the crops to maintain its freshness.	4	2	8
Total				**132**

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

In this chapter, the overview of the research methods conducted will be explained. The research method is used as a tool to help the researcher to obtain the desired information and data in order to achieve the aim and objective. There have many types of research methods can be used but all of them can be classified into two main categories which are qualitative and quantitative. In addition, the collected data also can be classified into two main categories which are primary data and secondary data. This chapter will discuss all the research method that used to collect the information and data throughout the research.

3.2 Quantitative and Qualitative Research

Quantitative research is focused on the collection of numerical data from the target population to produce a statistically reliable data that able used to describe and explain the specific phenomena. Basically, the mathematical models are commonly used by

the researcher to analyze to collected data such as Statistical Package for the Social Science (SPSS) software (Williams, 2007). Besides that, the quantitative research also can use to analyse the general trend of the target population. In this research, the quantitative research will be used as methodology of data collection.

Qualitative research is a type of scientific research that focused on the explanations of social phenomenon. This type of research is concerned the words rather than number, as data analysis. Normally, the qualitative research is dealing with the question of why and how (Degu & Yigzaw, 2006). There have three common research methods that can be used by researcher to collect data which are observation, interview and focus group. However, all of these methods are time consuming compared with the quantitative research (Hancock, 1998).

3.3 Data Collection

A suitable and reliable data is important in a research as a proof to other people. Thus, the selection of data must be very carefully to select. Throughout this research, the primary and secondary data have been collected as a proof and support information to the research.

3.3.1 Primary Data

The primary data is the data that directly collected by a researcher for a specific research project. On the other hand, these data is unpublished or complied by any individual or organization in a forum of accessible to the public. There have several

types of method can be used to collect primary data which is survey questionnaire, interview, experiment and observational method (Hox & Boeije, 2005).

3.3.2 Secondary Data

Secondary data is referred to the data that have been collected for the purpose other than the problem at hand readily available from other sources. Normally, the secondary data can be used to (1) identify the problem statement, (2) develop a solution to the problem, (3) obtain relevant data, (4) interpret the result of primary data, and (5) create a suitable research design (Church, 2002). The secondary data can be obtained through published data like journal article, book, website information, e-book, newspaper and so on.

3.4 Sampling Design

Sample method is the selection of a relevant population as the representative of the study area and then collect data and information from them (Latham, 2007). The sampling design is regarding how the researcher select the population, why he selects that population, where is the population have, and how he collects information from them. In here, the target respondents and sampling location will be discussed.

3.4.1 Target Respondents and Location

The target respondents for this research is the lecturer and student of Agriculture Science in University Tunku Abdul Rahman (UTAR). The reason for choosing them as the target respondent is because they are the person who has the certain knowledge in agriculture and urban farming issues and may become the potential user of aquaponic system in the future. Thus, they can be the potential respondents to provide reliable response to this research.

3.5 Survey Questionnaire

In this research, the survey questionnaire was be selected as the method to collect the primary data. Survey questionnaire is defined as a series of question regarding the research topic that has been list down in a paper and then required the target respondents to answer it (Hox & Boeije, 2005). This method is effective in the collect larger amount of data because it can send to many respondents and collect back within a short period.

Besides that, the Likert scale and ranking scale method are applied as the answering method for the respondents. The Likert scale is referred to psychometric response scale that used to obtain the degree of agreement of the respondent to a statement (Bertram, 2007). For the ranking scale method, the respondents are required to fill in their answer based on the list of choices provided (MacDonald & Headlam, 1999). Other than that, the feedback of the respondents also will be conducted to obtain their perspective on the maintenance issues of the aquaponic system.

3.5.1 The Purpose of Application on Survey Questionnaire

The reason for choosing survey questionnaire as the research method is due to this method is effective in obtain large amount of data within a short period. This is because the survey questionnaire can send to many people at the same time and the time spent for answer the questionnaire is short. Conveniently, the survey questionnaire also can send through the e-mail which is not incurred any cost and is collect back quickly.

3.5.2 Questionnaire Design

In the survey questionnaire, there have included many types of question regarding the maintenance issues. There will have 3 section in the survey questionnaire which are Section A, Section B, and Section C. In Section A, the questions regarding the personal profile will be asked such as knowledge level, experience, period of practice and so on. However, for the Section B and Section C, the question will be more focused on the aquaponic maintenance issues such as the purpose of maintenance, maintenance criteria for the fish and plant. Other than that, the instruction of each section will be given to guide the respondents answer in correct method. The question will be answered in the form of Likert Scale and ranking and rating. The format of Likert Scale is the number 1 to 5 are respectively represent strongly disagree, disagree, neither, agree and strongly agree then the respondents choose the number based on their opinion.

3.6 Data Analysis

Data analysis is an important part throughout this research due to it will be discussed and explained the phenomenon. After all of the survey questionnaires has been gathered, the data analysis will be conducted in Chapter 4. In this research, the data will be analyzed through using the Statistical Package for the Social Science (SPSS) software. Generally, the SPSS is a Window statistical software that used by the researcher to manipulate, analyze, and present the data (Landau & Everitt, 2004). The benefits of using SPSS is it can work with a large amount of data due to there do not have any limit for the data size.

Other than the SPSS, the descriptive analysis also will be used in this research with the purpose to analyze the data. The descriptive analysis is used to transfer the raw data into a form that easier the data to summarize, described, presented and interpreted the data. For instance, the data collected from the survey questionnaire can be transfer into the form of tables, charts, and graphs. Besides that, it helps the researcher to simply the data from a large amount of survey questionnaire into a simpler summary (Jaggi, 2003). There have two common methods of descriptive statistic which are numerical and graphical. The numerical approach is used to measure the statistics such as mean average, the exhibition of percentage and standard deviation. However, the graphical approach is used to present the data in the patterns such as graph and chart. Through this, the data will be easily understood by the other peoples.

In addition, there have some mathematical formulas have been used to analyse the collected data which are:

1. Rating mean x Priority mean = Score
2. Total Action of Maintenance x Frequency = Severity Index

Frequency: 1= once, 2= intermittence, 3= regular

3.7 Interview

Interview is a two-way communication between the researcher and respondent and is focused on specific issues. In this method, the researcher often asks the question regarding his research to the interviewee while the interviewee is providing their perspective and opinion to the question asked (Kajornboon, 2005). Through an effective interview, the researcher is able to collect the detailed information from the interviewee. This is because, during the interview period, the researcher has the chance to probe the interviewee why they behave in this way (Driscoll, 2011). However, the limitation of interview is it just focus on small scale study and is time-consuming (Alshenqeeti, 2014).

In this research, there have an interview with two Agriculture Science lecturers in UTAR to discuss their perspective on the topic about maintenance of aquaponic system and the barrier and potential of aquaponic system in Malaysia.

CHAPTER 4

DATA ANALYSIS

4.1 Survey Questionnaire

4.1.1 Introduction

In this chapter, the statistical data that collected through the survey questionnaires are presented and discussed. The target respondent for this research is the lecturer and students of Agriculture Science in University Tunku Abdul Rahman (UTAR) due to they may be the potential user of aquaponic system in the future.

The total amount of time used to design this survey questionnaire is up to 2 weeks and used 3 weeks to collect back the survey questionnaire. This survey questionnaire is consist of two parts which are:

- Section A: Respondent's information
- Section B: Intention for maintenance management in aquaponic, maintenance criteria for the fished and plants.

A total of 56 survey questionnaire have been distributed to the Agriculture Science student through personal handover, but only successful received 34 set of survey questionnaire. Besides that, a number of 4 set survey questionnaire have been received from the lecturers.

4.1.2 Section A

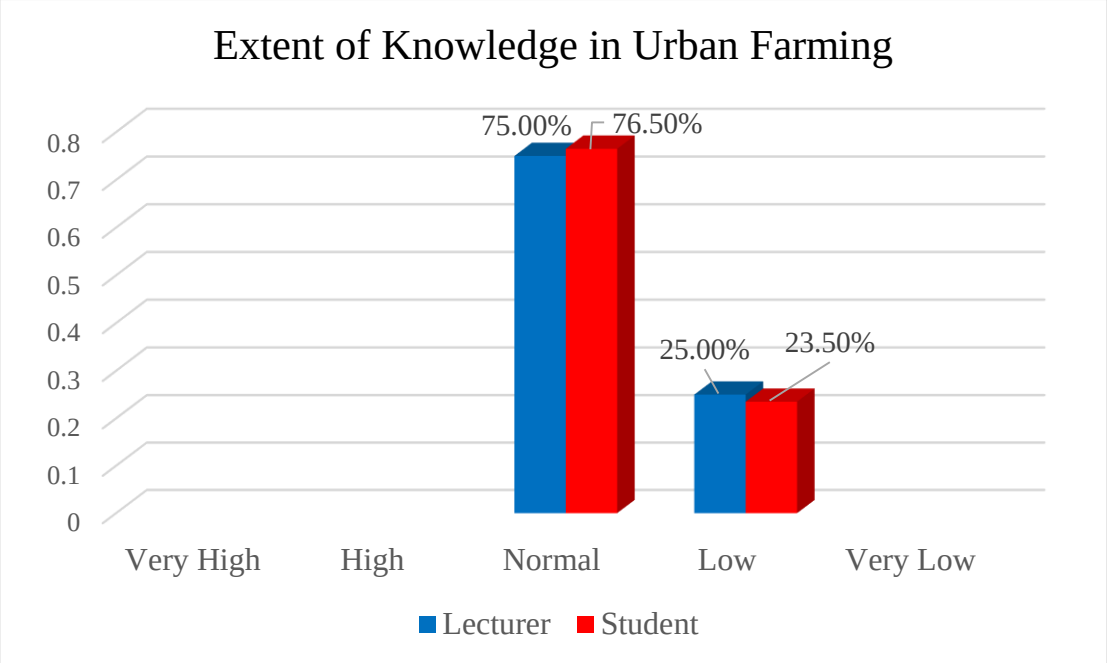

Figure 4.1: Extent of Knowledge in Urban Farming

In order to identify the extent of knowledge regarding to urban farming, the respondents were asked to rate their level of knowledge on this subject matter. Through the result, majority of the students perceived that their extent of knowledge in urban farming is normal with the percentage of 76.5%. Besides that, only 23.5% students perceived that their extent of knowledge is low. This result is similar with the lecturer which have 75% of the lecturers perceived that their extent of knowledge is normal and only 25% lecturer rated that she has low knowledge in urban farming. None of the lecturers and students think that they are at the level of high and very high. Therefore,

based on this result, it can deduced that majority of the respondents have the moderate knowledge regarding to urban farming but they still considered that there have an improvement space for them about the urban farming.

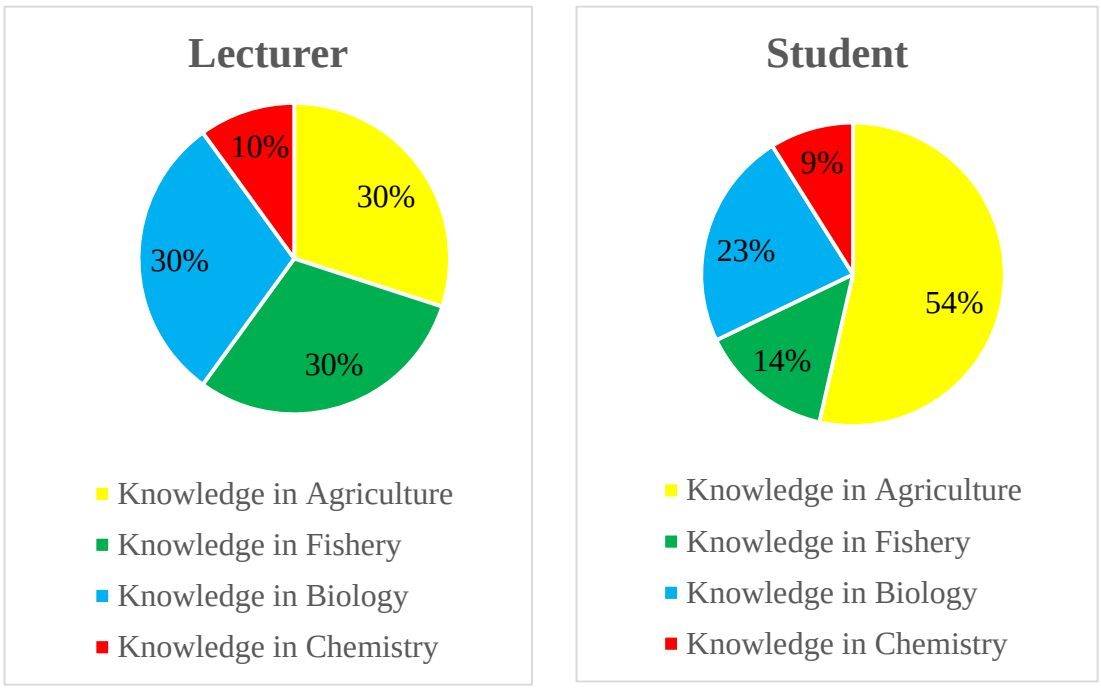

Figure 4.2: Type of Respondent Knowledge

In order to future examine the knowledge of respondents, the respondents were asked to select the type of relevant knowledge in agriculture, fishery, biology, and chemistry. From the figure 4.2, most of the students with percentage of 54% perceived that they have the knowledge in agriculture and followed by knowledge in biology which consists of 23%. 14% of the students perceived that they have the knowledge in fishery. However, they are low percentage in chemistry which only have 9%. This result is same with the lecturer because only 10% of the lecturers considered that they have the knowledge in chemistry. For the lecturers, the relevant knowledge they have are more balance than the students. This is because, 30% of the lecturers have the knowledge in agriculture, fishery and biology. Based on this result, it can deduced that both of the lecturers and students have poor knowledge level in chemistry aspect. This may cause them lack of confidence for the aspect regarding water chemical.

The different between the knowledge of the lecturers and students can be explained by education level and experience. Generally, the lecturers have the higher education level than the students. This is because most of they have completed their master program even though Doctor of Philosophy (PhD) before they become a lecturer. Thus, they were exposure to more information and practical. The accumulation of knowledge make them more knowledgeable than the student. In addition, some of the lecturers have the experience in the agriculture or aquaculture firm. These experiences enable them more understand the actual practice of those system. During the process, they will learned something that is out of the book. On the contrary, most of the students just have the theoretical knowledge or some have 3 months intern experience. Those factors were limited the students' knowledge level.

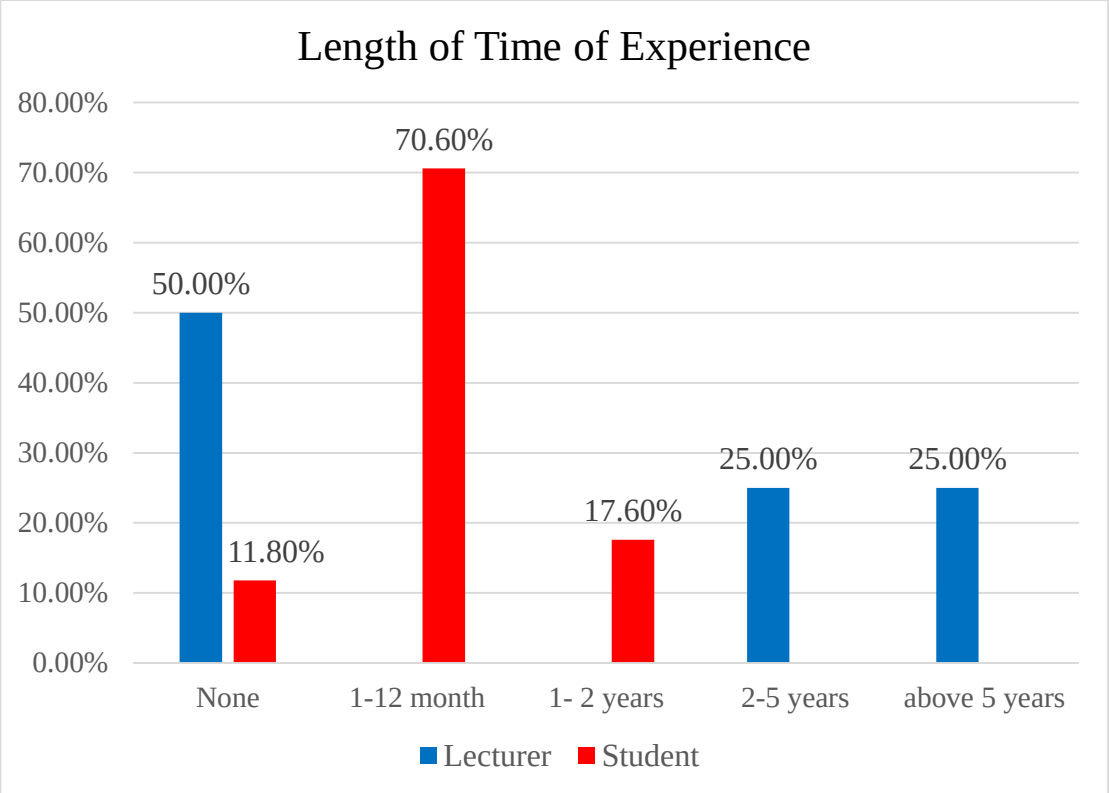

Figure 4.3: Length of Time of Experience

Experience is important for a person to develop his knowledge and perception for an issues. Thus, the length of time of experience in aquaponic, aquaculture, hydroponic or agriculture of the respondents was asked is to obtain the reliable data. As refers to

the Figure 4.3, only 50% of the lecturer have the experience above 2 years, one is between 2-5 years and another is above 5 years. However, another two lecturers considered that they don't have the real experience in practicing the aquaponic, aquaculture, hydroponic or agriculture system.

Besides that, 76% of the students perceived that they have 1-12 months experience in practice the aquaponic, aquaculture, hydroponic or agriculture system. It can deduced that those experiences are gained during their internship program but they may overconfidence about their experience level. In addition, 17.6% of the students considered them have 1-2 year experience and only 11.8% of them perceived that they don't have any experience is practice those system.

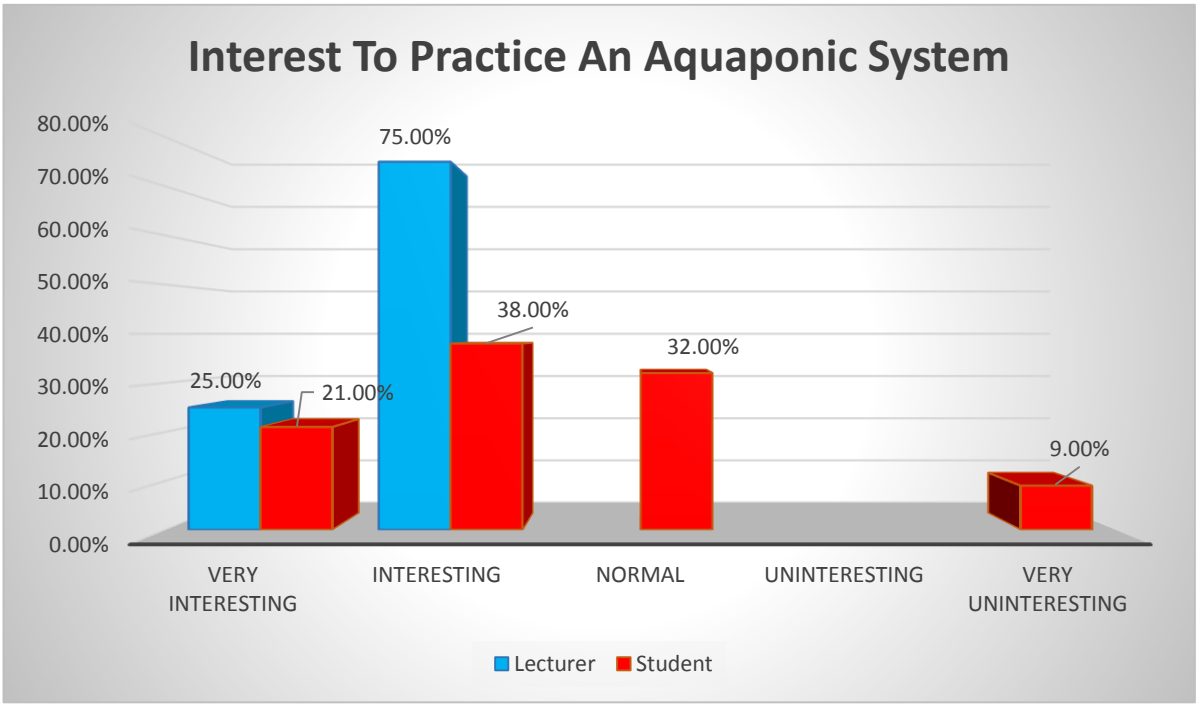

Figure 4.4: Interest of Respondent to Practice an Aquaponic System

As referred to Figure 4.4, all the lecturers have the interest to practice an aquaponic system. Besides that, out of 34 of the total students, 59% of them are interesting to practice the aquaponic system and 32 % of them considered they have normal interest to startup an aquaponic system. Only a percentage of 9% of the student perceived that

they don't have the interest to practice the system. However, it does not affected their perception in the maintenance management for the aquaponic system. In the view of the result, it shows that majority of the respondents are willing and interesting to practice an aquaponic system in the future.

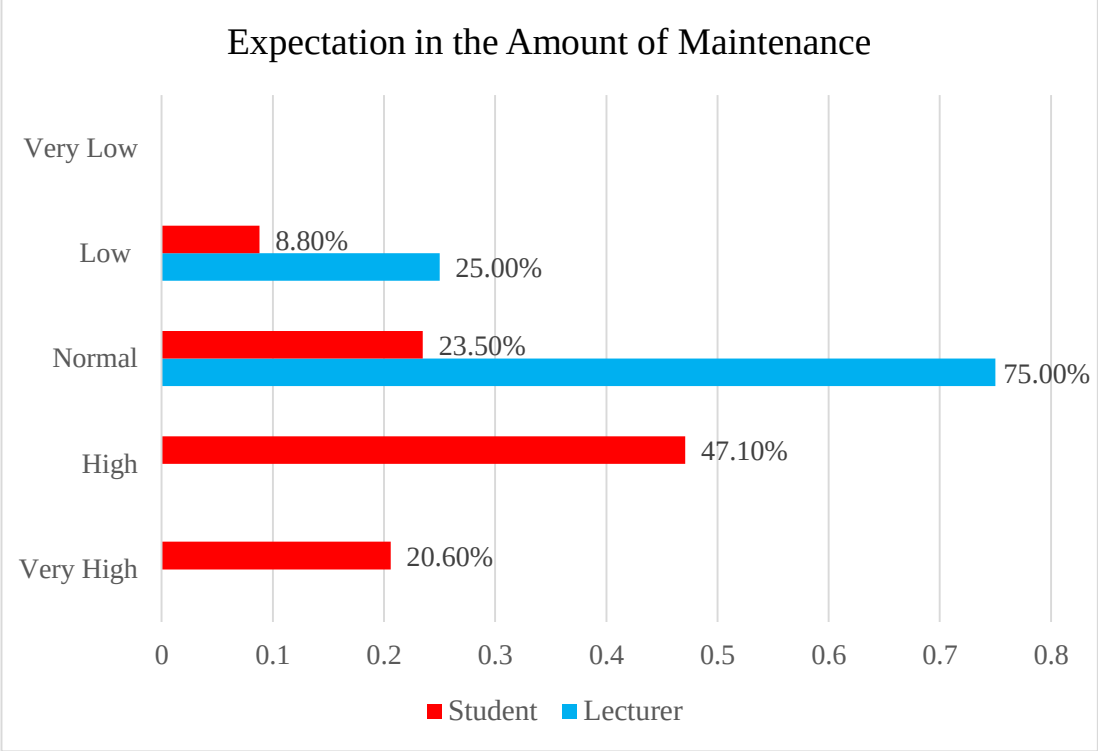

Figure 4.5: Expectation in the Amount of Maintenance for Aquaponic System

According to Figure 4.5, the expectation in the amount of maintenance for an aquaponic system between lecturers and students are great different. This is because 75% of the lecturers considered that the amount of maintenance required is normal and only 25% of the lecturer considered it is low. However, 47.1% of the students perceived that the maintenance required is high and 9% of the students considered that an aquaponic system is required very high amount of maintenance. Only a number of 8 students with the percentage 23.5% perceived the amount of maintenance needed is normal. 8.8% of students perceived that their expectation in the amount of maintenance for the aquaponic system is low. Based on this, it can be deduced that majority of the

respondents expected that the actual amount of maintenance for aquaponic system is high.

4.1.2.1 Summary Review

- Majority of the respondents have the normal knowledge level in urban farming.
- Compare with student, the knowledge of lecturers is more balance than students. However, both of them have poor knowledge level in the chemistry aspect.
- Most of the students perceived that they have internship experience but this may cause them over confidence for their experience level due to they just explore to limited practical.
- Majority of the respondents have the interest to practice an aquaponic system in the future.
- The expectation in the amount of maintenance by students is high but the lecturers just considered as normal.

4.1.3 Section B

4.1.3.1 Intention for Maintenance Management in Aquaponic System

Rating mean x Priority mean = Score

This formula has been used to find out the ranking for the selected criteria in Table 4.1 and 4.2. The score is represented the level of important of intention in maintenance management for aquaponic system. Thus, the higher the number of score, the more important of the criteria.

Table 4.1: Intention for Maintenance Management in Aquaponic System (Lecturer)

Intention	Rating mean	Priority mean	Score	Ranking
Prevent the mortality of living organisms	3.97	5.03	19.97	1
Ensure workability	4.17	4.35	18.14	2
Maximise harvest	3.79	4.41	16.71	3
Eliminate any potential factors	3.74	3.59	13.43	4
Durability	3.71	3.47	12.87	5
Prevent monetary losses	3.62	3.41	12.34	6
Stability of Ecological Cycle	3.76	2.59	9.74	7

Table 4.2: Intention for Maintenance Management in Aquaponic System (Student)

Intention	Rating mean	Priority mean	Score	Ranking
Stability of Ecological Cycle	4	5.5	22	1
Workability	4	5.25	21	2
Prevent the mortality of living organisms	4.25	4.75	20.19	3
Maximise harvest	3.75	4	15	4
Prevent monetary losses	4.5	3	13.5	5
Eliminate any potential factors	3.75	2.75	10.31	6
Durability	3.25	2.75	8.94	7

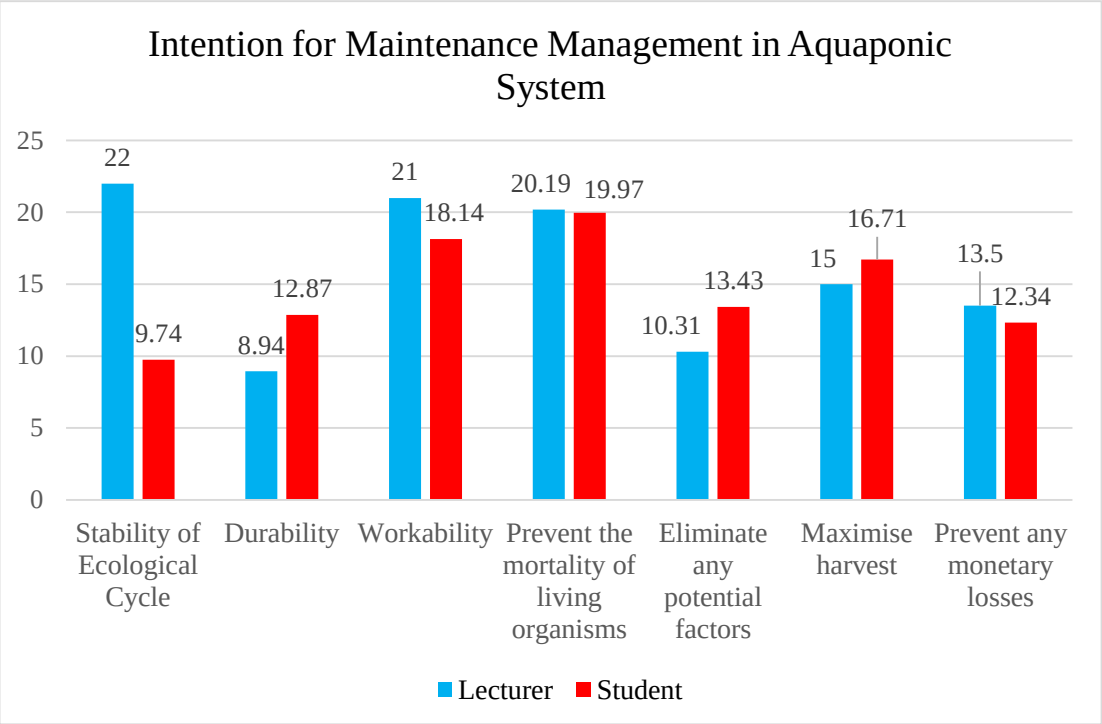

Figure 4.6: Intention for Maintenance Management in Aquaponic System

Refers to the Table 4.1, the lecturers were ranked the stability of ecological cycle within the aquaponic system as their first intention to carry out the maintenance management. They perceived that with the stability of ecological cycle, the following intentions like ensure workability, prevent the mortality of livings organisms, maximize harvest and prevent monetary loss can be achieved. However, they ranked the durability of the system as their last intention. It can be deduced that the durability of aquaponic system is not so important for the user to consider.

In the view of students, they were ranked the prevention of mortality of livings organisms, ensure workability, maximize harvest and eliminate the potential factors as their preferential intention to conduct the maintenance management. Based on this result, it can be deduced that the students does not focus on the ecological process within the aquaponic system since they ranked the stability of ecological cycle as their last intention. They may not be able to self-maintenance when they conduct an aquaponic system due to they did not understand the actual process of the aquaponic system.

4.1.3.2 Maintenance Criteria for Fish

This topic is discussed about ranking for the maintenance criteria for the fish by lecturers and students. The detail of information have been showed in Appendix A, B and C.

Table 4.3: Maintenance Criteria for Fish

Ranking	Lecturer	Student
1	Ammonia, nitrate and nitrite control	PH level
2	PH level	Ammonia, nitrate and nitrite control
3	Dissolve oxygen	Dissolve oxygen
4	Temperature control	Scheduled feeding
5	Prevent algae grow	Prevent algae grow
6	Scheduled feeding	Temperature control
7	Adding water	Fish disease management
8	Fish disease management	Adding water
9	Clean pump and plumbing	Clean pump and plumbing
10	Scheduled harvest	Scheduled harvest
11	Measure weight and length of fish	Measure weight and length of fish

Table 4.4: Automotive System for Fish's Maintenance

Maintenance Criteria	Total Action	Automotive System Action Need
pH level	26	14
Temperature control	5	0
Scheduled feeding	9	1
Adding water	9	1

From the Table 4.3, majority of the lecturers were ranked the ammonia, nitrate and nitrate as the most important maintenance criteria for fish. This shows that they are alerted about the impact of the ammonia, nitrate and nitrate. According to literature review, the excessive of ammonia, nitrate and nitrate can be the toxic for the fish. Besides that, the following ranked criteria are pH level, dissolve oxygen, temperature control and algae control. Based on this ranking, it can be deduced that majority of the lecturers are pay attention on the water quality parameters since the water is the essential living environment for the fish. Therefore, an extreme care must be taken in order to maintain the desired water condition for the fish. Refer to Appendix A, the total action for the top 5 ranked maintenance criteria by lecturers is 70. However, from the view of lecturer, the 70 actions needed in maintenance management for fish is considered normal.

In the view of students, their first ranked fall on the pH level and then followed by ammonia, nitrate and nitrate, dissolve oxygen, scheduled feeding and algae control. In addition, the total amount of actions needed for the top 5 ranked maintenance criteria is 74 actions (Appendix B) which is similar with the lecturers but most of them considered it is high. Furthermore, both of the lecturers and students were ranked the measure the weight and length of fish as least important maintenance criteria for fish. They perceived that condition of fish through visual observation.

The different perception of the lecturers and students regarding the amount of maintenance action need for maintenance management may result from knowledge level. Based on this, it can perceived that lecturers know how a set up and the use of advanced technology can help to reduce the maintenance required. In fact, the technology is actually can reduce the amount of maintenance action needed as showed in the Table 4.4. For instance, the actions needs for pH can be reduced from 26 to 14 actions when the technology is used.

4.1.3.3 Maintenance Criteria for Plant

This topic is discussed the ranking for the maintenance criteria for plants by lecturers and students. The detail of information was showed in Appendix I.

Table 4.5: Maintenance Criteria for Plants

Ranking	Lecturer	Student
1	Light energy	Light energy
2	Prevent algae grow	PH level
3	PH level	Prevent algae grow
4	Wind pressure protection	Temperature control
5	Plant disease management	Pest Management
6	Dissolve oxygen	Ammonia, nitrate and nitrite control
7	Temperature control	Dissolve oxygen
8	Pest Management	Provide nutrient
9	Ammonia, nitrate and nitrite control	Plant disease management
10	Provide nutrient	Wind pressure protection
11	Scheduled harvest	Scheduled harvest

Table 4.6: Automotive System for Plant's Maintenance

Maintenance Criteria	Total Action	Automotive System Action Need
pH level	26	14

As referred to Appendix D, the total action of the severity index for the top five maintenance criteria by lecturer is 51 actions. On the other hand, the total action of severity index by students for top five maintenance criteria is 49 (Appendix E). There is not great different between expectation between lecturer and student.

Both of the lecturers and students were ranked the light energy for plant is the most important maintenance criteria to maintain the growth rate of plant. Other than that, both of them also agreed that pH level and algae control are important. Based on this, it can be deduced that the nutrient is very important to the plant due to the out range of pH level and exist of algae can caused the plants lack of nutrient.

However, the wind pressure protection were ranked as fourth important to the plant while the students only ranked it as eighth important. This means majority of the students are not aware about the damage of the wind pressure to the plant. Although Malaysia are free from disaster, but sometime still have strong wind that has the possibility to destroy the crops. Furthermore, the lecturers were ranked the plant disease control as fifth important since it is difficult to use chemical medicine to treat the plant within the aquaponic system. This is because, most of the chemicals are toxic to the fish.

4.1.3.4 Summary Review

- Majority of the students did not understand the nitrogen process of the aquaponic system since they ranked the stability of ecological cycle as their last intention to carry out the maintenance management.

- The students have the basic understanding in the maintenance criteria needs for the aquaponic system.

- The use of technology is capable to reduce the burden of maintenance but the technology used for the plant is less than the fish.

4.2 Interview

4.2.1 Introduction

Throughout the data collection process, an interview sessions have been conducted with two interviewees that come from different background. The aim of the interview is to obtain the information regarding the aquaponic issues in Malaysia. Both of the interviewees have better knowledge in agriculture and aquaculture aspect. Therefore, the result of the interview are supportive and reliable. The interview session is conducted through face to face interview. Interview questions are well prepared in advance before carried out the personal interview. The background of the interviewees are briefly described in Table 4.1.

Table 4.7: Interviewee's Background

Name	Profession & Experience	Company Name	Education Qualification
Ms. Silvara Junus	➢ Lecturer of Agriculture and Food Science ➢ 2 year experience in aquaculture research company	UTAR	➢ Master of Science (Agricultural Engineering) ➢ Bachelor of Science (Hons) (Biosystems Engineering)
Dr. Ooi Ai Lin	➢ Assistant Professor of Agriculture and Food Science	UTAR	➢ Doctor of Philosophy (Ecology) ➢ Master of Technology (Environmental Management) ➢ Bachelor of Science with Education (Hons) (Biology & Chemistry)

4.2.2 Interview Content

1. **What is your opinion about the potential of aquaponic system in the future especially in Malaysia?**
Potential for commercial purpose
With the increasing of awareness about the healthy, more people will try to plant for themselves.

One of the interviewees recommended that the aquaponic system has the potential for commercial purpose but the user needs to make a study first before they start. Another interviewee said that now the people are more concerned about their healthy, thus, they will practice this system to produce chemical free foods for their own consumption.

2. **What is the suitable location for an aquaponic system?**
For small scale aquaponic system, indoor area is suitable.
For large scale, place it at outdoor more suitable

The interviewee recommended that if the space is limited, then the small scale aquaponic system can placed at indoor areas with the installation of UV light. However, for the large scale system, place it at outdoor area more suitable due to have the contact with the natural environment.

3. **What is the suitable location for an aquaponic system within an existing building?**
Flat roof
Car park
Orientation need to be considered

The interviewees suggested that roof top is more suitable for aquaponic system due to it have a large area that exposure to the natural sunlight but need to take care about the rainwater which may affect the water quality. However, for the car park, the aquaponic system may need a UV light if the orientation is not ideal.

4. Are the aquaponic system is required high maintenance compare to the traditional system?
Depend on it set up

Both of the interviewees agreed that a good set up of aquaponic system can lower the burden of maintenance.

5. Which part of the ecological cycle is most critical? Fish/Bacteria/Plant?
Fish
All since they are interdependent

For the critical part of the ecological cycle, one of the interviewees said that fish are important to the aquaponic system since it provide the nutrient to the plant. However, another interviewee said that all are important since they are interdependent.

6. What is the common problem to the aquaponic system?
Pant cannot growing well
Poor water quality

The interviewees recommended that the plant cannot growing well and poor water quality are the common problems to the aquaponic system.

7. Do you know the common method to reduce/manage the fish mortality rate?
Regularly change water
Appropriate feeding the fish
Control the fish density
Ensure the active of water filter
Provide sufficient oxygen
Fish disease management

Both of the interviewees are agreed that the common method to reduce the fish mortality rate is regularly change water, appropriate feed the fish, control the fish density, ensure the active of water filter, provide sufficient oxygen and fish disease management.

8. When the fish is sick, how you settle this problem? Abandon or give treatment?
Give them treatment but is in another tank

For this question, both of the interviewees said that the fish must receive treatment at another fish tank due to some chemical can be the toxic for other fish.

9. How do you determine the fishes are infected by disease? Visual observation? Water sample test?
Daily visual observation
Water sample test

They suggested that daily visual observation must be carried out to check the fish condition and the water sample test is conducted when there is a needed to identify the bacteria that presented in the aquaponic system.

10. Do you suggest any addition of technology to help in monitoring the system?
Remote sensor
Auto-feeding system
Rainwater harvesting system
Solar panel

They proposed that the remote sensor and auto feeding system can be applied to the aquaponic system to reduce the burden of maintenance. Other than that, they also suggest that the rainwater harvesting system and solar panel can be attached to the system in order to reduce the operational cost.

11. Are there have some species of fish and plant can lower the burden of maintenance?
Tilapia
Leaf green plant

The recommended least maintenance fish is the Tilapia while for plant is the leaf green plant.

12. What are the considerations for the fish tank design and how the fish design is important to aquaponic system?
Stocking density
Ease of tank & feces cleaning
Recirculating of water
Cutting operational cost

They defined that a good fish tank design must considered the stocking density, ease of tank & feces cleaning, and recirculating of water. Therefore, it is able to help to cut the operation cost.

13. How long do you think the system is consider durable?
At least 2 years

They considered that a good set up of aquaponic system must able to last at least two years.

14. What type of aquaponic system is low burden in maintenance? NTF system (Nutrient Film Technique)? Deep water culture or raft system?
Median system
Nutrient Film Technique

The recommended low burden maintenance of aquaponic system are the median system and nutrient film technique.

15. Will the aquaponic system (for hobby purpose) give user satisfaction since the user plant and rear fish until they consume the final product?
Yes

They answered yes. They further explained that the final product of aquaponic system can give people satisfaction in achievement and the user also enjoy the process.

4.2.3 Conclusion for Interview

In conclusion, aquaponic system is suitable for indoor only as a hobby where economy of scale is not important. However, if the need of economy of scale, it must be scaled up and larger space is required thus it did not work in existing building.

Besides that, flat roof or car park will be more suitable for aquaponic system to be placed in existing building. However there must have the consideration for the orientation of the aquaponic system to ensure the amount of received sunlight is sufficient. Balcony also can used for the aquaponic system but it is depend on its location. This is because if the aquaponic system is placed in the balcony which at a high level of condominium, it will have the problem of wind pressure. The strong wind may blow down the components of the system.

In an aquaponic system, the plant has the higher value than the fish since the amount of the fish is limited by the size of fish tank. However the fish is required more attention than the plant due to the fish is sensitive to their living environment. Any changing of their living condition will cause them suffered stress and then may lead to high rate of mortality. Thus, the user needs to more focus on the part of the fish.

Furthermore, the aquaponic system is high demand in maintenance. The total amount of action required for the maintenance of aquaponic system is 238. Therefore, the interviewees proposed some advanced technology which can reduced the burden of maintenance such as remote sensor and auto feeding system. Besides that, the used of rainwater harvest system and solar panel can help to reduce the operational cost. However, the implementation of those devices may increase the initial cost if apply in small scale aquaponic system, unless scaled up to farm, then the cost maybe reduced.

In the view of interviewees, they said that the practiced of aquaponic system can give the user satisfaction since the user set up the system, operate it, conduct the maintenance until they harvest the final products and consume it. This will give them a satisfaction of achievement and as a motivation to them carefully take care for the aquaponic system.

CHAPTER 5

RECOMMENDATION

5.1 Introduction

In this chapter, a summary of the overall analysis in Chapter 4 based on the research objectives will be described. The research objectives are to identify the user perception in practice the maintenance management of auqaponic system and to analyse the barriers and potential related with auqaponic system and urban farming. Besides that, the recommendation to future research will be proposed in this chapter.

5.2 Conclusion for Overall Result

5.2.1 Lecturer and student perception in maintenance management of aquaponic system

- The total actions of maintenances required for an aquaponic system is high which required 265 actions. This showed that the expectation of the student about the amount of maintenance is correct since majority of them expected the amount of maintenances is high.

- However, the burden of maintenance can be reduced through the use of technology which is able to reduce 17% of the maintenance action needs.

- A good set up of the system with a proper design also can lower down the burden of maintenance.

- Majority of the respondents ranked that durability of the aquaponic system is not important. It can deduced that the users are more prefer a flexible system like a module system rather than rigid and specific system due to the module system is easy to replace the broken components.

5.2.2 Barriers and potential related with aquaponic system and urban farming

- The barriers for the implementation of aquaponic system are the user must have some basic knowledge in order to avoid high mortality rate, high amount of maintenance, and critical skills are required for aquaponic system.

- The recommendations for the barriers are the operation and maintenance manual is useful for the beginner in order to increase their basic knowledge in aquaponic system. Other than that, the integration of good design and technology is effectively to lower the amount of maintenance required. The input of aquapopnic expert is also can guide the user to practice the aquaponic system.

- The potential of an aquaponic system is it can be used as a basic system for further improvement. For example, one of the interviewees suggested that people can plant the vegetation on the soil but use the fish tank water to irrigate, then, it will more workability.
- In addition, since more and more people are concerned about their health, the production of chemical free product will become popular. This situation is

actually created a business opportunity for the aquaponic user to earn profit. Besides that, a small scale aquaponic system has the potential to increase the confidence of the user to practice an economy scale system in the future since it provide a learning platform to the user.

5.2.3 Recommendations for Small-scale Aquaponic Guideline

- The orientation of the aquaponic system can place at north-south area so the aquaponic system can face to east and west (sun path way). This ensure the amount of received sunlight is sufficient for plant.

- If the aquaponic system is decided to place at balcony, a glass façade with sliding door is needed to prevent the strong wind against the system.

- However, for the balcony or rooftop aquaponic system, the user must consults an architect or civil engineer to see whether the strength of the roof can support the weight of the system and the effect of vibration to the building.

- Other than that, there must have some safety barrier for the rooftop aquaponic due to the flat roof is exposure to more wind pressure like place some concrete block under the legs of the system.

- For the rainwater harvesting system, a rainwater down pipe is not sufficient, there still required a vertical tank for collecting rainwater and then treat the rainwater before flow to the aquaponic system due to rainwater contains some harmful particle.

- Although solar panel is able to reduce the electrical cost but there must have a battery for any emergency situation that caused the electrical suddenly break off.

Figure 5.1: Small-scale aquaponic system

- For the size of a balcony aquaponinc likes Figure 5.1, a 4 feet moving area is required to ensure the safety of the user from falling down.

5.3 Recommendation for Future Research

- In order to expand the implications of aquaponic system in Malaysia, further research is required as there are some areas need to be improved. It is required to further study the method to lower down the burden of maintenance in order to attract people to practice this system.

- Furthermore, it is recommended to study the mathematical formula for the difficulties of maintenance required for an aquaponic system. This is because the difficulties of the maintenance have the relationship with the size of the aquaponic system. The larger the size of aquaponic system, the more difficulties to carry out the maintenance action.

- Besides that, a further research is needed to study the relationship between the technology used for lower down the burden of maintenance and the cost needed. This can helps the people to determine whether worth to use those advanced technology or not.

- Last but not least, it is recommended to study further on the integration of building design with aquaponic system. This is to study how the architect design the building with the consideration of urban farming issues and how he integrate an aquaponic system to become one part of the building like use as a shadow device for the building.

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APPENDICES

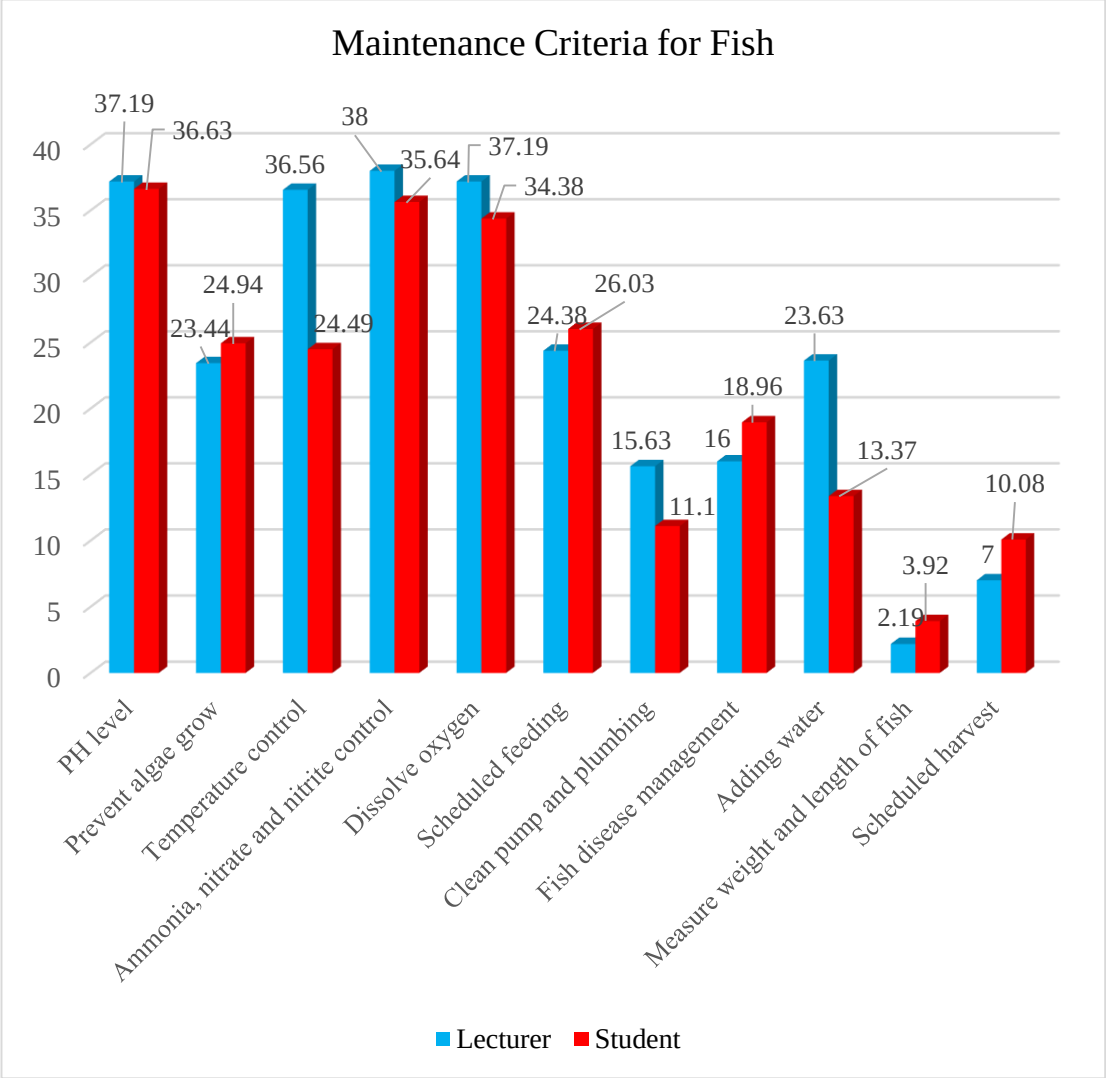
APPENDIX A: Table for Maintenance Criteria for Fish (Lecturer)

Maintenance Criteria	Rating average	Priority average	Score	Rank	Severity Index	Accumulation of action	Auto System Action Needed
Ammonia, nitrate and nitrite control	4	9.5	38	1	32	32	
PH level	4.25	8.75	37.19	2	26	58	14
Dissolve oxygen	4.25	8.75	37.19	3	5	63	
Temperature control	3.75	9.75	36.56	4	5	68	0
Prevent algae grow	3.75	6.25	23.44	5	2	70	
Scheduled feeding	3.75	6.5	24.38	6	9	79	1
Adding water	3.5	6.75	23.63	7	9	88	1
Fish disease management	4	4	16	8	13	101	
Clean pump and plumbing	2.5	6.25	15.63	9	9	110	
Scheduled harvest	3.5	2	7	10	8	118	
Measure weight and length of fish	1.75	1.25	2.19	11	15	133	

APPENDIX B: Table for Maintenance Criteria for Fish (Student)

Maintenance Criteria	Rating average	Priority average	Score	Rank	Severity Index	Accumulation	Auto System Action Need
PH level	4.25	8.62	36.63	1	26	26	14
Ammonia, nitrate and nitrite control	4	8.91	35.64	2	32	58	
Dissolve oxygen	4.25	8.09	34.38	3	5	63	
Scheduled feeding	3.75	6.94	26.03	4	9	72	1
Prevent algae grow	3.75	6.65	24.94	5	2	74	
Temperature control	3.75	6.53	24.49	6	5	79	0
Fish disease management	4	4.74	18.96	7	13	92	
Adding water	3.5	3.82	13.37	8	9	101	1
Clean pump and plumbing	2.5	4.44	11.1	9	9	110	
Scheduled harvest	3.5	2.88	10.08	10	8	118	
Measure weight and length of fish	1.75	2.24	3.92	11	15	133	

APPENDIX C: Ranking of Maintenance Criteria for Fish



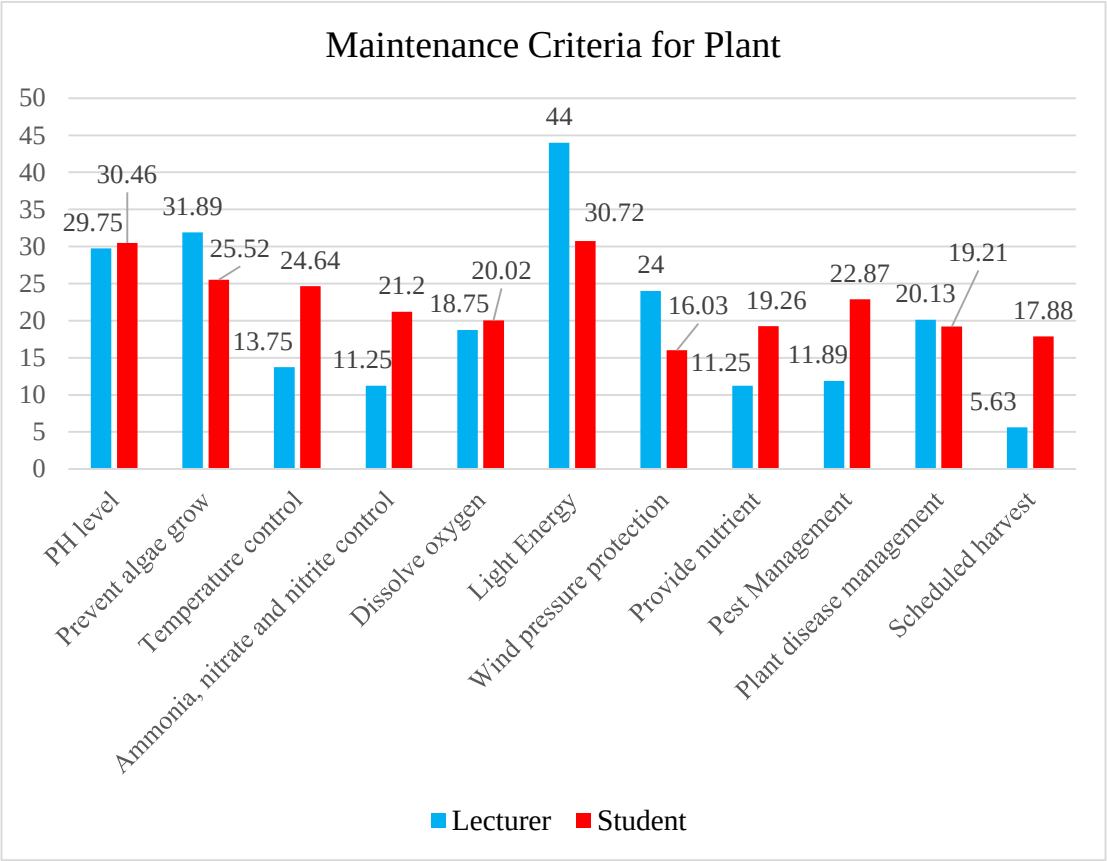
APPENDIX D: Table for Maintenance Criteria for Plants (Lecturer)

Maintenance Criteria	Rating average	Priority average	Score	Rank	Severity Index	Accumulation of Index	Auto System
Light energy	4	11	44	1	5	5	
Prevent algae grow	3.75	8.5	31.89	2	2	7	
PH level	3.5	8.5	29.75	3	26	33	14
Wind pressure protection	4	6	24	4	8	41	
Plant disease management	3.5	5.75	20.13	5	10	51	
Dissolve oxygen	3	6.25	18.75	6	5	56	
Temperature control	2.75	5	`13.75	7	8	64	
Pest Management	2.5	4.75	11.89	8	8	72	
Ammonia, nitrate and nitrite control	2.5	4.5	11.25	9	32	104	
Provide nutrient	2.5	4.5	11.25	10	20	124	
Scheduled harvest	2.5	2.25	5.63	11	8	132	

APPENDIX E: Table for Maintenance Criteria for Plants (Student)

Maintenance Criteria	Rating average	Priority average	Score	Rank	Severity Index	Accumulation of Index	Auto System
Light energy	4	7.68	30.72	1	5	5	
PH level	3.91	7.79	30.46	2	26	31	14
Prevent algae grow	3.82	6.68	25.52	3	2	33	
Temperature control	3.88	6.35	24.64	4	8	41	
Pest Management	3.91	5.85	22.87	5	8	49	
Ammonia, nitrate and nitrite control	3.68	5.76	21.20	6	32	81	
Dissolve oxygen	3.68	5.44	20.02	7	5	86	
Provide nutrient	3.62	5.32	19.26	8	20	106	
Plant disease management	3.82	5.03	19.21	9	10	116	
Wind pressure protection	3.47	4.62	16.03	10	8	124	
Scheduled harvest	3.62	4.94	17.88	11	8	132	

APPENDIX F: Ranking of Maintenance Criteria for Plant



APPENDIX G: Survey Questionnaire

SURVEY ON USER MOTIVATION IN MAINTENANCE MANAGEMENT OF AQUAPONIC SYSTEM

Student Name & ID : NG JUN JIE 14AGB04374

Course : Construction Management

Faculty : FEGT

University **:** UTAR

Section A: Respondent's Information

Please provide information about yourself through completing the following question. You can tick more than one box where appropriate.

1) What is the extent of your knowledge in urban farming?

□ Very high □ High □ Normal □ Low □ Very low

2) Type of relevant knowledge you have:

□ Agriculture □ Fishery □ Biology □ Chemistry □ Other

3) Did you have the experience in practicing an agriculture / hydroponic / aquaculture/ aquaponic system?

□ Yes □ No

4) What is the length of time of your experience in practicing those systems?

□ None □ 1 -12 months □ 1 – 2 years □ 2- 5 years □ above 5 years

5) Do you have the interest to practice an aquaponic system?

□ Very interesting □ Interesting □ Normal □ Uninteresting □ Very Uninteresting

6) What is your expectation in the amount of maintenance for an aquaponic system?

□ Very high □ High □ Normal □ Low □ Very low

Section B: Survey Question

Please place a tick on the appropriate column to represent how much you agree to the motivation for maintenance management in aquaponic system. **Rating:** Where 5= Extremely agree; 4= Strongly agree; 3= Agree; 2= Strongly disagree and 1= Extremely disagree. **Ranking:** most important = 7 to less important=1

	Intention for Maintenance Management in Aquaponic	5	4	3	2	1		**Ranking**
1	To ensure the **stability of ecological cycle** within aquaponic							
2	To enable the **durability** of aquaponic system							
3	To ensure the **workability** of aquaponic system in order to achieve 100% efficiency							
4	To **prevent the mortality** of living organisms within the aquaponic system							
5	To **eliminate any potential factors** that may leads to failure like algae and disease							
6	To **maximise the harvest** of aquaponic system							
7	To **prevent any monetary losses** which may arise from the failure of the system							

Please place a tick on the appropriate column to represent how much you agree to the maintenance criteria for aquaponic system **Rating:** 5= Extremely important; 4= Strongly important; 3= important; 2= Strongly unimportant and 1= Extremely unimportant. **Ranking:** most important = 11 to less important = 1.

	Maintenance Criteria for Fishes in Aquaponic System	5	4	3	2	1		**Ranking**
1	Control the PH level to achieve the desired pH level for the fish							
2	Prevent algae grow due to it may compete with the fish for the oxygen at night							
3	Temperature control to maintain the desired water temperature							
4	Control ammonia, nitrite and nitrate level to prevent excessive toxic for the fish							
5	Provide sufficient dissolve oxygen for fish to survive							
6	Scheduled feeding to ensure there have sufficient food for fish							
7	Pump and plumbing cleaning to maintain the prevent algae grow and remove solid waste produced by fish							
8	Fish diseases management to protect the fish from abiotic and biotic diseases							
9	Replace water weekly							
10	Measure the weight and length of fish							
11	Scheduled harvest to avoid too much fish in the fish tank							

	Maintenance Criteria for Plants in Aquaponic System	5	4	3	2	1		**Ranking**
1	Control the PH level to achieve the desired pH level for the plant							
2	Prevent algae grow due to it may compete with the plant for the nutrient							
3	Temperature control to maintain the desired water temperature							
4	Control ammonia, nitrite and nitrate level to prevent excessive							
5	Provide sufficient dissolve oxygen for plant to grow							
6	Provide the sufficient natural sunlight for the plant to grow							
7	Protect the plant from the wind pressure							
8	Provide sufficient nutrient for the plant through adding the fertilize							
9	Pest management to protect the plant from the harmful insect							
10	Plant diseases management to protect the plant from abiotic and biotic diseases							
11	Scheduled harvest to avoid too much plant							