CHAPTER 1. INTRODUCTION

1.1 Project Background

The population in Indonesia is increasing day by day. It is known that in 2021 Indonesia's population will increase by 1.22% compared to the previous year, in 2022 Indonesia's population will increase by 1.17%, and in 2023 Indonesia's population will increase by 1.13%. The consequence of population growth is an increase in living needs, especially food, so that the use of agricultural technology is very necessary to meet these food needs (*Badan Pusat Statistik*, 2023).

The agricultural sector itself in Indonesia is a source of agricultural wealth. 40% of Indonesia's population earns its livelihood in the agricultural sector. Indonesia's agricultural wealth is supported by Indonesia as an archipelagic country with 17,508 islands and a land area of 1,922,570 km². This makes it possible for Indonesia to become the largest agricultural country in the world. With Indonesia's position in the tropics, there are many types of plants that can live well (Ayun et al., 2020). Demand for horticultural commodities continues to increase, especially vegetables, in line with the needs and increasing population from day to day. Horticultural commodities are one of the providers of nutrition needed by the Indonesian population for activities such as vegetables. Of course, to balance the need for horticultural commodities, they must be maintained properly in order to increase the productivity of horticultural crops for daily needs (Barat, 2023).

The agricultural sector is very vulnerable to crop failure caused by climate change. According to research conducted by students from the Department of Geophysics and Meteorology, IPB University, one of the biggest factors in crop failure experienced by Indonesian farmers is uncertain climate change. Climate change is something that cannot be avoided due to global warming. Among the impacts that occur are an increase in extreme weather, changes in rain patterns, and an increase in temperature and sea water (Malau et al., 2023). Climate change causes horticultural farmers to experience many losses. Most Indonesian f5armers still use conventional planting

methods so that in current conditions farmers cannot predict the weather during the planting period so farmers have difficulty choosing suitable plants to plant according to the weather. Apart from that, climate change results in uncertain planting and harvest seasons, so it is not uncommon to experience crop failure. This problem is directly proportional to basic needs in Indonesia which are increasing because population growth continues to increase every day. One of the basic needs that is increasing here is vegetables. One of these vegetables is tomatoes (Wadu, 2023).

Tomato plants are plants that are popular with Indonesian people. Besides that, this plant has high economic value. According to research conducted by the Agribusiness Department, Faculty of Agriculture, Halu Oleo University, the large demand for tomatoes for daily needs and the uncertain climate result in crop failure, which is one of the causes of high price fluctuations on the market. Usually in the dry season tomatoes will be abundant and fill the market so the most expensive selling price is around 10,000/kg. but when the rainy season comes, farmers cannot meet the market so that the price of tomatoes experiences quite high fluctuations, as in research in Sorawolio village, Bau Bau sub-district, Indonesia (Nasran et al., 2023). One suitable method for planting cultivated plants for tomato plants is the planting method in a greenhouse. Greenhouse technology is an alternative solution for controlling microclimatic conditions in plants. A greenhouse is a building with a frame or shaped like bubbles, covered with clear or translucent material that can transmit light optimally for production and protect plants from climatic conditions that are detrimental to plant growth (Syadza & Permana, 2020).

To obtain optimal horticultural crop results, it is necessary to pay attention to factors in the plant growing environment such as solar radiation, temperature, soil, water, rainfall and nutrients in the area. In greenhouse maintenance, there are several things that are usually checked manually, including temperature, watering, light intensity, air and soil humidity, and soil pH levels, which are supporting factors for plant growth. The existence of an agricultural system with a controlled environment can improve quality and quantity (Tando, 2019). In general, farmers plant conventionally without any control and measurement according to plant needs, only relying on habitual factors. As in research conducted on 32 farmers in Musir Lor village, Indonesia. Almost all of the farmers in this area still use conventional planting methods. This is a problem for farmers because they have to continuously check

several parameters and control the environmental conditions of the green house manually, such as checking the watering of the plants so that they are in accordance with the plant's needs. In order for farmers' work to be more efficient and easier, technological support is needed (Maulana et al., 2023).

After farmers experience significant losses due to unpredictable weather, farmers will be greatly helped by the greenhouse planting method. To build a greenhouse and drive a farmer's roof requires quite a lot of electricity and energy. This is a problem for farmers. Therefore, the energy alternative that has been widely discussed this year is solar panel energy. Utilizing solar panel energy has an important role in meeting the electrical energy needs for a smart green house. The potential of sunlight energy as a source of solar panel energy is widely available in nature. Therefore, developing the potential of solar energy as an alternative renewable energy source and replacing paid electricity can greatly save costs for farmers who have experienced losses from crop failure.

Automation technology with Arduino Uno control is a use of technology that can control the system so that it can run automatically. Arduino Uno-based automation technology is one of the technological development products that can be used to help overcome these problems. Like creating technology that is sophisticated and useful for everyday life. Such as creating tools that can work automatically in monitoring and controlling (Tullah & Setyawan, 2019). With the added help of the Internet of Things or what is usually called IoT, you can utilize an internet connection which allows objects to be connected to each other. IoT itself is a network of devices that can be connected via the internet. IoT allows devices to exchange data with each other. These two things are used so that farmers can easily control watering and moving the roof automatically and can monitor anywhere and at any time. Carrying out effective roof watering and moving requires a method so that the control system can be achieved as planned (Sembiring et al., 2022).

Based on these problems, the research carried out was to create an automatic greenhouse control system that saves energy and electricity to help farmers with irrigation, lighting and can protect plants from rain. The plants used in the research were tomato plants. Parameters monitored include soil pH conditions, weather when it rains, air humidity, soil moisture, water level and light intensity in the greenhouse. The parameters of air temperature, air humidity, soil moisture are read by sensors from

the Arduino Uno implementation to produce values based on parameters that are suitable for watering and closing the roof when it rains according to plant needs. Weather parameters when it rains, air humidity, soil moisture are used to activate watering and if it rains the roof will close automatically. The research carried out uses an Android application to monitor and control plant growth in a greenhouse so that it can make it easier for farmers to control their plants even though they are quite far from the greenhouse. Therefore, the proposed research title is "Arduino Uno-Based Automation Of Watering And Lighting For Tomato Plants Using Solar Panels"

1.2 Problem Statement

Based on the explanation in the project background, this research aims to overcome obstacles in tomato farming in Indonesia. Indonesian farmers often face problems in growing tomatoes due to Indonesia's uncertain climate and most farmers in Indonesia still use conventional planting methods. This causes market demand to be difficult to fulfill because conventional planting methods follow the seasons. If it is rainy season, tomato farmers avoid planting tomatoes and prefer to plant other plants that can survive rainy weather.

Tomato farmers often face problems with unstable climatic conditions, this causes the growth of tomato plants to be disrupted. Tomato plants themselves like hot climates with watering that is not too frequent. If tomato plants are exposed to too much rain in a short time, the tomato roots do not have the ability to absorb water quickly. This causes the tomato plants to rot and causes the tomato plants to fail to harvest. This does not mean that tomato plants do not need watering. Tomatoes also need water in the growth process, but tomatoes also cannot receive too much water because the absorption capacity of tomato roots is not large. Therefore, the proposed solution is to use a greenhouse equipped with solar panels as an electricity source. In addition, the large electricity costs to run a greenhouse environment can be a burden for farmers. Because this system must be able to provide sufficient energy requirements to maintain the environmental conditions of the green house so that tomatoes can be maintained.

When it rains, if the tomato plants are in an open environment and not in a greenhouse or other roof protection, this can pose a risk of damage to the tomato plants and can reduce crop yields. However, if the tomato plants are always protected by a roof, this is also not good for the growth of the tomato plants because the tomato plants

lack sunlight. According to students from Gunadarma University, tomato plants require direct exposure to sunlight if it is not raining. But tomato plants also don't like hot sunlight, this can cause tomato plants to dry out (Nisa & Stefanie, 2023).

In ensuring that tomato plants get enough water or not, farmers have difficulty knowing this, especially when they have to take care of large areas of land or when farmers have other activities so they cannot always be in the garden. Manual watering of tomato plants is prone to errors, especially in measuring the correct water requirements and ideal watering times. This can have an impact on the quality and quantity of the harvest. To improve efficiency, health and plant growth, an automation solution is needed that is able to accurately regulate the watering of tomato plants.

Therefore, the proposed solution is to use a green house equipped with an automated system for watering tomato plants and a roof drive using an Arduino Uno and using solar panels as an electricity source. Thus, farmers can automatically control the detection and adjustment of watering tomato plants based on soil moisture, plant water needs, and optimal watering schedules, so that plants receive water precisely and automatically without manual intervention. Farmers can also ensure that plants get sufficient exposure to sunlight and are protected from rainy weather. And farmers can control the environmental conditions of crops at lower costs and are more environmentally friendly. So farmers can maximize their harvest.

1.3 Objectives of the Project

The project's objectives are outlined as follows:

1. To study and implementation Arduino-Uno Based Automation Of Watering And Lighting For Tomato Plants Using Solar Panels
2. To design a smart greenhouse as a place for cultivating plants using solar panels as an electricity source.
3. To create a function that enables automatic watering of plants whenever the plants need watering
4. To create a function that in a system for measuring the level of accuracy of the system for controlling watering, lighting, and protecting against rainy weather using parameters from rainy weather, air humidity, soil moisture with the implementation of an Arduino Uno.

1.4 Scope of the Project

The project scope encompasses the following areas:

- **Data Collection**: The tomato data collection that will be used for this project is taken from farmers in Indonesia, and the problems that have been explained in the project background are problems experienced by farmers in Indonesia. The type of tomato that will be used in this project is a vegetable tomato native to Indonesia with the Latin name Lycopersicon esculentum. This data collection requires data that involves the use of soil moisture sensors, weather/light sensors to measure environmental conditions and plant conditions. The data collected is in the form of soil moisture data for tomato plants to know when tomato plants need watering, data on sunlight intensity, room temperature and weather for roof sensors when it rains and when plants need sunlight. This allows the system to make decisions based on the data it receives.
- **Algorithm Selection and Development**: Evaluate the algorithm that will be used in an Arduino Uno-based system to automate watering tomato plants and activating plant roofs when it rains through extensive experiments and benchmarks. This project will probably require several different algorithms. For example, this project will require an algorithm for when and how much to water plants based on data from soil moisture. These algorithms are developed or adapted to suit the specific needs of tomato plants. Apart from that, this project also requires an algorithm to move the roof based on data from light, temperature or weather sensors. Because the roof needs to be opened or closed depending on weather conditions and if the plants need sunlight.
- **System Development**: Create mobile system based applications. To enable monitoring of greenhouses anytime and anywhere via an internet connection so that users can monitor and view plant data remotely. It is also important to ensure good integration between the components in this project. Such as adapting program code to the specific needs of the automation system, and considering energy efficiency and system maintenance possibilities to ensure smooth operation.
- **Performance Evaluation**: Test system accuracy, efficiency and robustness under various conditions. Performance evaluation in the Arduino Uno based tomato plant watering and roof driving automation project with solar panels involves several aspects that can be measured and evaluated :

1. Evaluate how well the solar panels produce the power necessary to support the system on a continuous basis.
2. Evaluate how quickly the system responds to changes in environmental conditions (such as soil moisture, temperature, and light).
3. Evaluate the accuracy and reliability of soil moisture sensors, weather sensors, and other sensors in detecting correct environmental conditions.
4. Check that the sensors provide consistent and accurate data
5. Review the reliability of automation controls (water pumps, roof drives) and how well the system complies with instructions provided from sensor data processing
6. Review how well the system operates over long periods of time, including capabilities under different environmental conditions (e.g., variable weather)
7. Evaluate whether the system has sufficient energy availability from solar panels, especially in situations of bad weather or minimal sunlight.
8. Review system durability when solar panels do not produce enough power.

Combine all of the above aspects to evaluate the overall performance of the automation system, including the system's reliability, efficiency, and ability to support tomato plant growth.

- **Ethical and privacy consideration :** In automation projects like this, there are ethical considerations such as ensuring that the system does not have a negative impact on the surrounding environment, for example the use of dangerous chemicals or inappropriate waste disposal, ensuring that the use of the automation system does not disturb the balance of the local ecosystem and the existence of flora and fauna in the surrounding area. And privacy that needs to be considered such as Ensure that data collected from sensors or stored in the system is not threatened with security, especially if the information is related to the home environment or personal information, Ensure that users of automation systems are given clear information about how the data is collected, used, and whether there is the potential for disclosure of information to other parties.

1.5 Significance of the project

Using solar panels as an energy source represents a shift to environmentally friendly renewable energy. By using solar panels, greenhouse owners can reduce the cost of electricity used for lighting, temperature control and irrigation systems. This

also helps in reducing dependence on fossil energy sources. So this project can prove efficiency in the use of resources, by using solar energy to run an automated watering system and roof drive for tomato plants. This could inspire the use of similar technology in other applications to switch to using solar panels as an energy source

With an automated watering system, this project helps in water conservation by watering plants only when needed, thereby helping farmers reduce water wastage. This also helps in maintaining tomato plants more efficiently. The automatic watering and roof drive system for tomato plants can increase the productivity of tomato plants and ensure optimal conditions for the growth of tomato plants, which in turn will really help farmers to increase agricultural yields.

This project represents an innovation in the use of microcontroller technology (Arduino Uno) and renewable energy (solar panels) for agricultural purposes, demonstrating the potential in using technology to increase efficiency in the agricultural sector. This automation system makes it easy for farmers or tomato plantation owners to manage irrigation and plant care automatically, thereby reducing the dependence of tomato farmers in Indonesia on intensive manual monitoring. So farmers can switch from conventional to modern planting methods

The application of renewable energy and more efficient water management helps farmers in their efforts to maintain the sustainability of the green house environment and contributes to more environmentally friendly agricultural practices. This project has an important impact in developing smarter and more sustainable agricultural technology, so that this project can show the role of technology in supporting more efficient agriculture and having a positive impact on the agricultural environment in Indonesia. Especially in horticultural crop farming namely tomatoes.

1.6 Assumption and Limitation

In the context of the “Arduino-Uno Based Automation Of Watering And Lighting For Tomato Plants Using Solar Panels” project, several key assumption and limitation are recognized, which frame the project’s scope and potential constraints:

1.6.1 Assumptions

In the Arduino Uno-based tomato plant watering and rooftop automation project with solar panels, there are several assumptions underlying the implementation of the project:

1. Sun availability: Solar panels will receive adequate sunlight exposure to produce the required power. But a lack of sunlight can affect the availability of power needed to run the automation system, thereby reducing the effectiveness of the system.
2. Predicted environmental conditions: Data from soil moisture sensors, weather sensors, and predicted light can provide an accurate picture of environmental conditions. However, if sensors provide inaccurate or compromised information, the automation system may not respond appropriately, affecting overall system performance.
3. Device and component reliability: Components such as the Arduino Uno, sensors, motors and solar panels will operate with high reliability. But there are bad things to fear, such as component failure that can cause disruption in the automation system, affecting its efficiency and effectiveness.
4. Water savings and plant performance: Automation systems will lead to water savings and improve tomato plant performance in anticipated ways. But If the system does not perform as expected, the anticipated results in water savings or improved plant performance will not be achieved.
5. Efficient energy use: Solar panels and battery systems will provide enough power to run the automation system. But the impact that will result if the power produced is not enough, the system may not run optimally or may even be disrupted.
6. Required maintenance measures: The system requires minimal maintenance and can operate autonomously after initial installation. But if routine maintenance or upkeep is required more frequently than anticipated, this can affect the efficiency and performance of the system.

1.6.2 Limitation

Due to its reliance on solar panels for energy, the performance of this system is greatly affected by the weather. When the weather is cloudy or rainy, the solar panels may not be able to generate enough energy to run the system. Although the solar panels work during the day, at night or in bad weather conditions, the system needs backup energy. If the energy storage capacity is lacking, the system will not run optimally. Components such as the Arduino Uno and solar panel need regular maintenance and replacement and are susceptible to damage from extreme weather.

The project may not be effectively implemented on a larger scale, such as in commercial fields or orchards, without significant infrastructure upgrades and investments. Although the Arduino Uno is powerful, it has limitations in processing capacity and the number of sensors or devices that can be connected and managed. The system may not be able to adapt to different types of crops or different environmental conditions without modifications to the software or hardware.