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Smart Irrigation System

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Smart Irrigation System, temperature, solar system, turbine system, energy usage

Abstract

Malaysia is located on the equator where the areas along this line experience a tropical climate characterized by high temperatures throughout the year and receiving the most sunlight year-round. The issue of excessive heat inside homes for residents in inland areas remains a persistent problem until now. This study aims to develop a water flow system that uses renewable energy sources that could reduce heat in the house due to solar radiation and at the same time includes a hydroponic plant cultivation system. To address these issues, it is necessary to identify the components necessary to create a system capable of performing various functions known as a Smart Irrigation System (SIS). The Smart Irrigation System can optimize water usage by cycling water flow from roofs to plants, directing it to water tanks, and then redistributing it back onto the roofs. For energy power solar panels are utilized to collect energy during the daytime, and the water passing through turbines generates kinetic energy, serving as a support for solar panels during the nighttime. In addition to lowering interior temperatures, water spilling onto roofs can stop plants from using too much water by maintaining a continuous water cycle. Consequently, this Smart Irrigation System was designed to help people who were having problems with heat, and it is important for future study on hydroponic systems, renewable energy sources, water use, and many other topics.

1. Introduction

Global warming refers specifically to an increase of the average surface temperature of the Earth. It is among the signs of "climate change," along with rising ocean temperatures, altered precipitation patterns, rising sea levels, desertification, and extreme meteorological phenomena. These alterations are distributed in a varied manner, with some places on Earth that are more affected than others, like the glaciers melting, permafrost thawing, and arctic amplification. Societal concern about climate change and global warming has grown since the initial alarm launched by the 1972 publication of “The Limits of Growth”. In 1988, the United Nations established the Intergovernmental Panel on Climate Change (IPCC), which promoted the growing awareness of the health of living beings that reproduce on Earth. (including humans, animals, plants, fungi, and bacteria) be impacted deeply [1].

Malaysians commonly experience the negative effects of global warming, which drives up home temperatures and worsens living circumstances. There are a few things that can be done to stop the increase in interior temperature that comes with global warming. There are several steps that can be taken to prevent the rise in indoor temperature brought on by global warming. Using the roof pond system is one of the actions that can be performed. Roof ponds are traditional systems to reduce solar gains through the roof based on increasing the thickness, thermal mass and insulation, as well as adding shading elements and reflective finishes. However, the use of roof ponds for cooling purposes has some advantages over traditional systems due to the high thermal capacity of the water, which can reduce temperature swings and peak temperature [2].

The Earth is predicted to reach a 4.8 C warmer by 2100, leading to a rise of 82 cm in sea level [3]. This is due to the increasing frequency of extreme weather events and the use of air conditioners that release Chlorofluorocarbon gas. This increase in temperature will also threaten water resources and the world's agricultural base [4]. To address this issue, a study aims to develop an environmentally friendly water flow system that reduces heat in homes due to solar radiation exposure. This system will use renewable energy sources and incorporate a hydroponic system that uses rainwater as plant water, reducing water resource wastage. The project aims to promote energy efficiency and reduce the need for air conditioning.

The general goal of this project is to investigate the creation of a smart irrigation system using mobile sensors that are powered by solar energy through a solar system based on the reality of hot weather and rising temperatures in Malaysia. The objective of this study to differentiate the temperature in the building when using this smart irrigation system and when not using it. The project involves creating a comprehensive plan for a smart irrigation system, encompassing the selection of suitable storage tanks, gutters, filtration components, and renewable energy sources. The findings from the effectiveness of the viability water flow functions.

2. Material and Methods

2.1 Material

The selection of a material is crucial for accurate estimates and meeting intended features. Polyvinyl Chloride (PVC) is a popular choice due to its strength, affordability, and lightweight design, making it suitable for various applications such as building frames, water drainage systems, and electrical conduits. Fig. 1 shows the step-by-step process for building and testing a smart irrigation system.

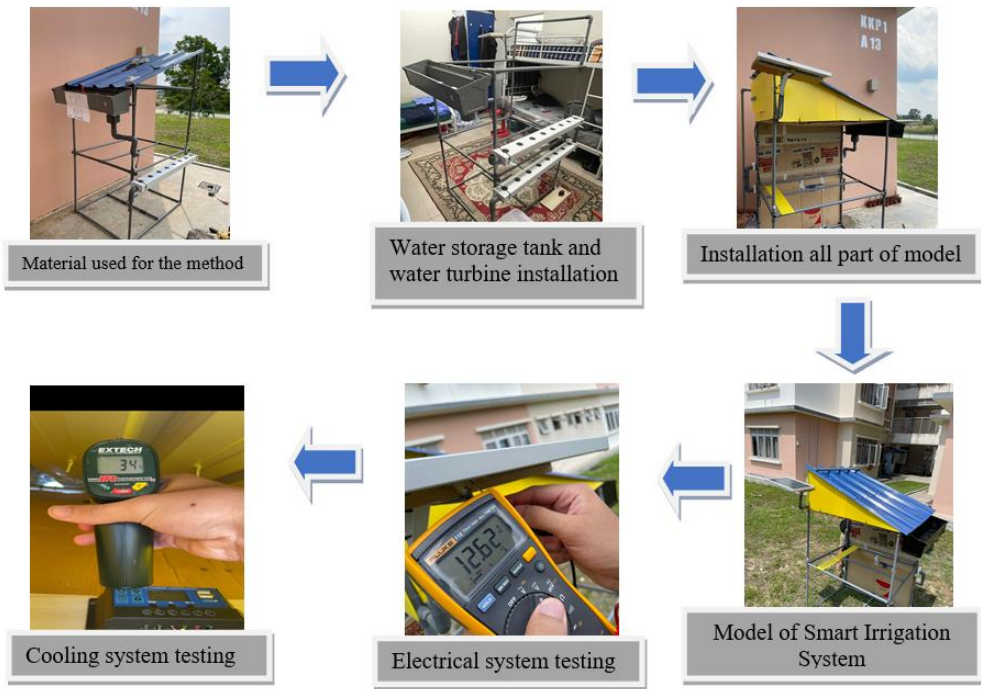

Fig. 1 *Process of produce the Smart Irrigation System model*

At the initial stage it started with the installation of the model frame with the materials that had been determined during the discussion to build the SIS, followed by the installation of the water storage tank and the water turbine. Next, all parts of the model are assembled to produce a complete SIS model. Finally, the process of testing the electrical system and testing the cooling system is carried out after the installation of the sis model is completed.

2.2 Methods

2.2.1 Process System

Fig. 2 collectively illustrates the layout and integration of renewable energy and hydroponic systems in Smart Irrigation System (SIS) from different angles.

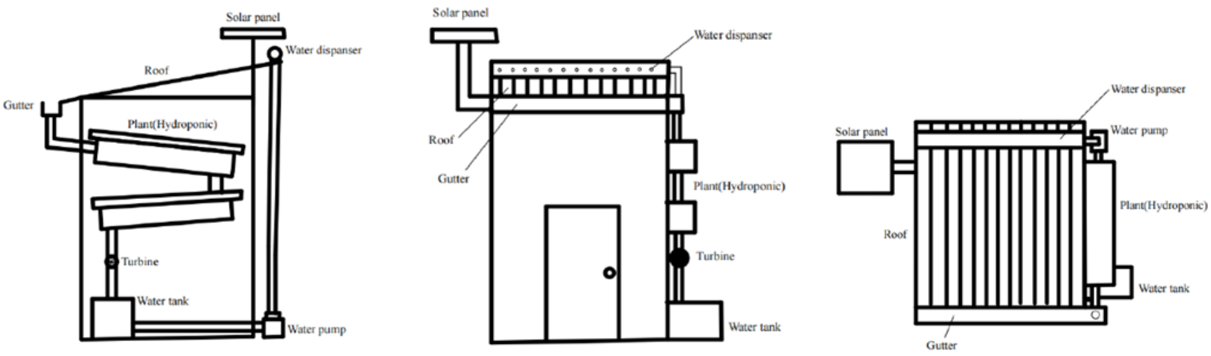

Figure 2(a) side view of SIS **Figure 2(b)** Front view of SIS **Figure 2(c)** top view of SIS

Fig. 2 *Design of the product Smart Irrigation System (SIS) based on different views*

A renewable energy option, the Smart Irrigation System (SIS) runs on rainwater collected from the roof. During the dry season, the extra water that was collected during the rainy season is used in a tank and allowed to evaporate into the surrounding atmosphere. Hydroponic cultivation is another feature of the technology that enables plants to use water sources that constantly flow at their roots. This system offers a sustainable way to irrigate plants and is totally free to run.

2.2.2 Turbine System

Electricity supply companies produce electricity using water, an easily accessible and inexpensive energy source. The turbine drives the water flow from irrigation lines, generating electricity that is classified as environmentally friendly. This system uses water flow as a booster for solar energy, which is used to charge solar panels. The turbine continues to run, allowing water to flow through the hydroponic system to plants and rolling systems, ensuring they receive water. This system is particularly useful during the night when solar energy cannot be charged.

2.2.3 Solar System

Solar photovoltaic (PV) systems, also known as solar panels, convert solar energy into electricity. Solar PV technology is predicted to supply over 25% of the world's electricity demands by 2050, making it the second most important generation source behind wind power [5]. It collects energy during the day, pumping water from a tank and transporting it to the building's roof. When solar panels are unable to generate energy at night, they utilize kinetic energy from a turbine system. Solar panels are ideal for inland regions with infrequent rainfall, but the Smart Irrigation System uses hydroelectric power for continuous operation.

2.2.4 Hydroponics System

Hydroponics is a technique for growing plants without soil using mineral nutrient solutions, particularly in urban or arid regions [6]. It has been shown to facilitate faster growth rates, reduce fertilizer use, and reduce land and water requirements by 75% and 90%, respectively, presenting a potential solution to global food scarcity. The type of hydroponic system is a hydroponic system with anaerobic supernatant (HPAD). The anaerobic supernatant from an on-site anaerobic digester that processed lettuce plant waste such as roots and inedible leaves was repurposed in this system. Weighed and combined, the waste lettuce was added to the AD reactor. The only nutrient solution for the HPAD was the supernatant that was collected from the reactor after it overflowed. Periodically, samples of mineralized sludge from the digester were taken to assess the effectiveness of digestion and the concentration of nutrients in the supernatant [7].

3. Result and Discussion

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3.1 Temperature Testing

The Smart Irrigation System (SIS) was tested under standard MS 1525:2007 to evaluate its effectiveness in maintaining optimal indoor temperatures [8]. Proper insulation, efficient ventilation systems, and smart heating or cooling solutions are crucial for achieving and maintaining these temperatures. The system's performance under varied environmental conditions ensures its suitability for practical application in homes, promoting comfort, well-being, productivity, and energy efficiency. The tests were conducted at three different times to obtain precise data.

Table 1 *Temperature test result on Smart Irrigation System (SIS)*

Method	Temperature, °C								
	Morning			Noon			Afternoon		
Not using SIS	35	36	35	64	62	61	48	44	46
Average	35.33			62.33			46		
Using SIS	28	26	29	34	33	31	33	29	32
Average	27.67			32.67			31.33		

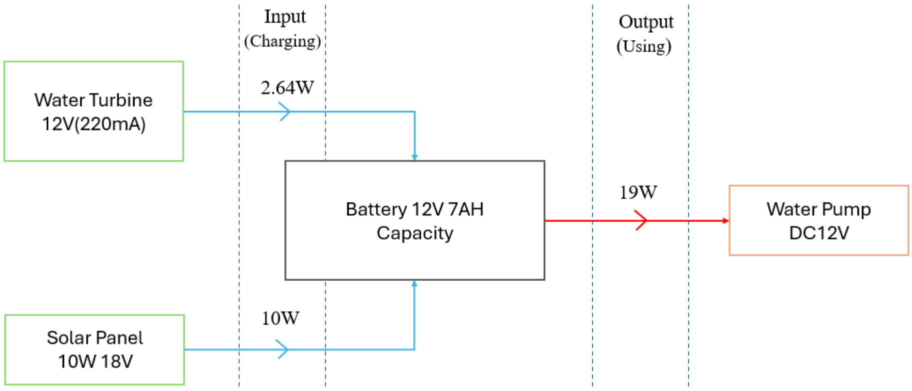
Based on Table 1, when the SIS was turned on and put to use, it consistently lowered the temperature to within the 23°C to 26°C suggested for room comfort by the MS 1525:2007 standard. Even though the results fell short of the ideal temperature range, they markedly increased household comfort. The test area's partial enclosure, which lets outside influences affect temperature readings, is the cause of the little variation. Improving installation circumstances will improve the system's capacity to maintain the appropriate temperature over time, underscoring its promise for a cozier interior atmosphere.

3.2 Energy Usage

The Smart Irrigation System (SIS) uses natural resources like solar energy and water movement to generate and store electricity. A water turbine and solar panel generate electricity from water falling from the roof and hydroponic system, which is then used by a water pump. The calculation below shows the electrical values generated, stored, and used for each related electric device. The Table 2 and Fig. 3 shows the input and output energy generated and used by various electrical devices to determine if the battery is experiencing overload or under load of power.

Table 2 *Table of the electrical energy values for each electric device*

Electrical devices	Function	Input	Output	Storing
Solar panel	Charging	10W	-	-
Water Turbine	Charging	2.64W	-	-
Battery	Storing		-	84W (watts per hour)
Water Pump	Using	-	19W	-



Summary of energy usage
Input: 2.64W + 10W < 19W: Output
Input :12.64W < 19W: Output

Values required:
Input: 2.64W + 10W + 6.36 < 19W: Output
Input: 19W =19W: Output

Fig.3 *Flowchart for the involved energy process*

Fig. 3 displays the calculations of energy consumption with specific input and output conditions. It presents two sets of conditions: one where the input power is less than the output threshold, and another where the input power is equal to the output threshold. The "Required values" section highlights the additional inputs required to achieve the specified conditions. The battery is experiencing under load due to insufficient input power, requiring at least 19W of power to prevent the water pump from depleting its electrical energy. Hydroponic farming uses nutrients-rich water solutions to grow crops without soil, using irrigation systems, lighting and plant media like onions. This efficient method reduces damage and disease but may have slower growth rates [9]. Fig. 4 (a) shows the temperature measurement when without using SIS and when using SIS in different period of the day

3.2.1 Lifespan of Plant

The Smart Irrigation System (SIS) is a water management system that combines advanced water management techniques. Fig. 4(b) shows the graph of the results of Scallion growth in 6 weeks. The graph above shows the lifespan of a Scallion in six weeks. In the first week, the leek seed shoots start to grow and are light green in colour. Then, in the third week, the leeks start to grow and begin to sprout in other parts. At the last observation, which is the sixth week, leeks become mature. The walls of leeks become thicker and darker in colour. Some of the leeks are growing more mature and some of the leaf bases are starting to turn yellow.

3.2.2 Scallion Growth Rate

Hydroponics, despite varying water usage based on the system, environmental conditions, and plant requirements, generally outperforms traditional farming methods in water efficiency. The graph in Fig. 4 (c) describes the number of leeks that are still alive with the water flow rate for 2 hours. In the second week after planting, the shallots were healthy and fresh, and the number of plants planted was 13 shallots. Next, in the fourth week, some scallions grow to maturity while a small number of scallions grow at a slow rate but no plants wilt or die. In the sixth week it was found that some of the tips of the leeks started to turn yellow and wither. This is due to the mature growth rate of scallions has reached its maximum level and its lifespan is decreasing. In addition, the increased temperature and watering method are also among the factors that cause disruption to the growth of scallions.

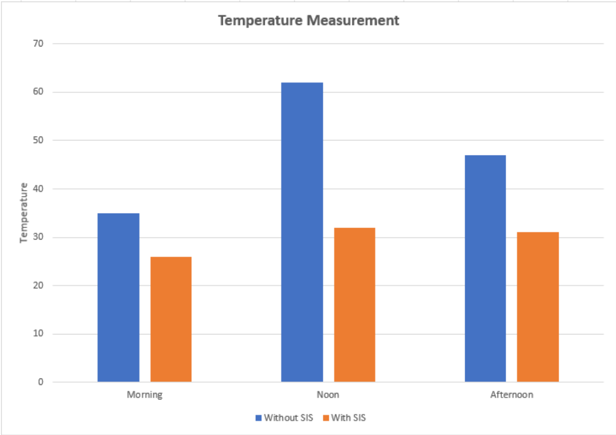


Fig. 4(a) *Temperature Measurement*

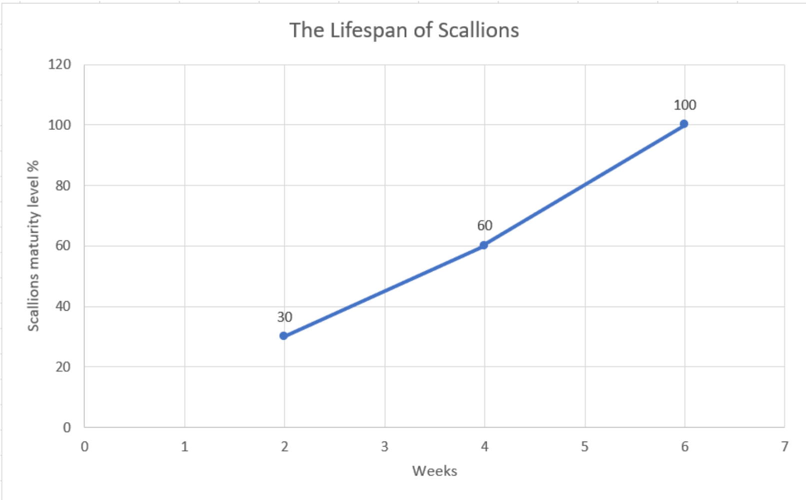


Fig. 4(b) *The lifespan of plants*

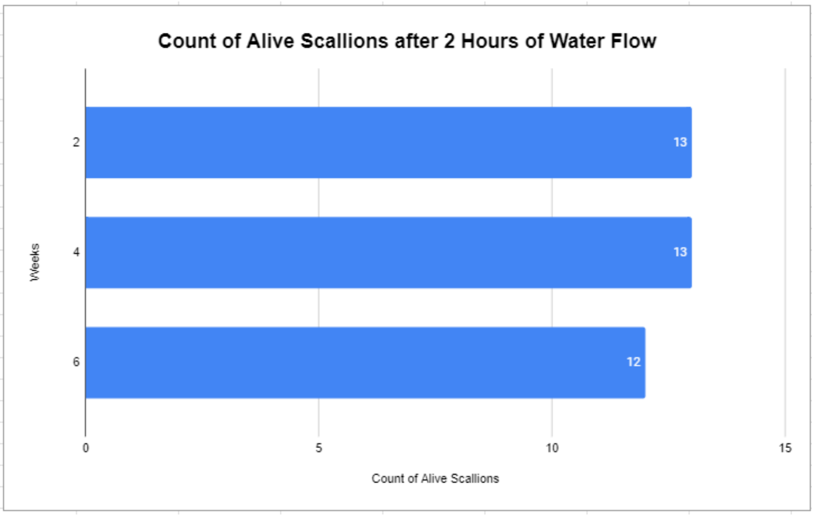


Fig. 4(c) *Count of Alive Scallions after 2 Hours of Water Flow*

4. Conclusion

In conclusion, the Smart Irrigation System (SIS) has proven to be effective in achieving multiple objectives. It efficiently manages water distribution by automatically providing plants with consistent hydration, ensuring optimal health and productivity. This automated process not only reduces manual labor but also minimizes water wastage, contributing to sustainable agricultural practices. Moreover, by incorporating renewable energy sources like solar panels and water turbines, the SIS reduces reliance on conventional electricity grids. This dual-energy approach not only cuts down operational costs but also promotes environmental sustainability by lowering carbon footprints. In terms of residential applications, the SIS enhances indoor comfort by utilizing water flow over rooftops for cooling purposes. This method efficiently absorbs heat, thereby reducing the need for energy-intensive air conditioning systems and lowering electricity bills. Despite its operational efficiency, achieving the exact comfort temperature range as outlined in standards such as MS 1525:2007 remains a primary goal. Continuous enhancements, including optimizing installation conditions and ensuring full enclosure of testing areas, are essential for maximizing the SIS's performance potential. Overall, the Smart Irrigation System (SIS) stands as a promising innovation that integrates advanced water management techniques with renewable energy solutions to improve agricultural productivity, promote energy efficiency, and enhance residential comfort sustainably.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Mohammad Hakimi Zainal Abidin, Muhammad Akmal Hariz Yasrizal, Nur Alieya Natasha Mahadzir, Khairi Supar;* ***data collection:*** *Mohammad Hakimi Zainal Abidin, Muhammad Akmal Hariz Yasrizal, Nur Alieya Natasha Mahadzir, Khairi Supar;* ***analysis and interpretation of results:*** *Mohammad Hakimi Zainal Abidin, Muhammad Akmal Hariz Yasrizal, Nur Alieya Natasha Mahadzir, Khairi Supar;* ***draft manuscript preparation:*** *Mohammad Hakimi Zainal Abidin, Muhammad Akmal Hariz Yasrizal, Nur Alieya Natasha Mahadzir, Khairi Supar. All authors reviewed the results and approved the final version of the manuscript.*

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