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KLIKTani: A Concept of a Smart Edible Garden using IOT for Indigenous Community in Malaysia

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ABSTRACT

Traditional gardening requires labor to control the environmental parameters. The manual intervention method requires high labor cost and it is less effective especially for busy people. This paper introduces the concept of a smart edible garden with the integration of the Internet of Things (IOT). IOT is a smart farming concept that is able to monitor the parameters thus, reducing the need for manual intervention. For controlling the environment in a smart edible garden, different sensors are proposed such as temperature, moisture, humidity, light dependent resistor (LDH) and pH. These sensors collect parameters from the environment to help in the decision making. Data will be sent to a cloud server and is accessed using IOT. IOT approach eliminates the need for constant manual monitoring. It uses a cloud server to store and perform data analytics to control connected devices. This concept provides cost-effective and optimal solutions to the farmers with minimal manual intervention. A solar powered IOT sensors will be an energy efficient option to smart gardening. With these sensors, the greenhouse state, plants and water consumption can be monitored via digital alerts from the system to the grower through a mobile apps and online web portal. Automatic irrigation is carried out in this intelligent system. An automated worm farm system is integrated to supply organic fertilizer for the garden. Worms can turn organic waste into fertilizer, so integrated worm farm can ensure a regular supply of organic fertilizer to the plants. A water system from a fish tank will add the advantage as the water source is very rich in nitrogen and other nutrients came from fish waste in pond water. This multi-function IOT garden is proposed for the indigenous community to give them the digital empowerment to adopt and use technology in their everyday life. This is a work in progress. Results have shown that 50% growth of kangkung plant is recorded in 7 days with IOT farming against traditional farming.

Key words: Internet of Things (IOT), Smart Farming, Arduino, Precision Agriculture

1. INTRODUCTION

In Malaysia, food security and farming sustainability are currently considered as the objectives of agro-food subsector development, as outlined in the National Agrofood Policy (NAP), 2011-2020. The national food agenda is aimed to provide the nation's growing demand of affordable and nutritional food and consistent supplies for resouce based industries. Currently, the farming community faces greater challenges resulted from changes in global economy and trade liberalization. However, in order to ensure food supplies are sufficient for local consumption and export markets, the national agricultural sector need to have new strategies to address the issues and challenges.

Unfortunately, it os found that the number of investment from prvate sectors in agriculture is lower and the interest among the younger people to work in this sector is dwindling. In addressing this challenges, the Ministry of Agriculture and and Agro-based Industry (MOA) Malaysia has introduced 5 strategies for 2019 – 2020 implementation [13]. Under Strategy 1, the ministry is attempting to improve the economy of farmers and fishermen by accelerating adoption of ICT and farming technologies through precision agriculture. Precision agriculture integrates information, communication and technologies for agriculture is a potential solution for the community [1, 2]. Hence, KLIKTani is very much in line with the aspiration of MOA in 2019 and 2020 to create agroprenues.

A preliminary investigation with the Department of Indigenous Development (JAKOA) and MOA that to date (2019), no IOT related project for agriculture and aquaculture has been implemented by any indigenous community in Malaysia. This project is highly recommended by both agencies as it is not only helping the B40 community to generate their own income but also empower them to use digital technologies in their daily activities. Precision farming with IOT allows the indigenous community to grow their own food with less human intervention as a new source of income. IOT makes this community relevant to Industrial Revolution 4.0 (IR 4.0) and can be a training platform to develop techpreneurs among the indigenous youths who are majority came from poor families.

The following problems with traditional farming by the local indigenous community have been observed:

1. **Traditional farming is usually exposed to wildlife attacks.**
   Paddy field, maize, coconut and tapioca farms are the most sought after crops by the elephants and monkeys. The depletion of forest resources had been forcing wild animals to look for food in farmlands. They not only eat but also destroy large amount of unripe fruits.

2. **Traditional farming is too laborious.**
   Farming is a complex system that requires endless days of laborious from seed sowing, watering, fertilizing to harvesting.

3. **Low production by non-skilled farmers.**
   Non-skilled farmers are not able to look after the condition of the farms. Crops and grains are destroyed by pests, insects and weeds.

4. **Soil salinization.**
   Dissolved salts in water supply is the main cause of soil salinization.

2. RELATED WORK

The IOT is a system of interconnected computing and engineering devices, objects, animals or people that are labeled with unique ID and the ability to transfer data over a network. It helps people and things to be connected anytime, anyplace, with anyone. Automation is another important application of IOT technologies. It helps to monitor and control the garden environment by using different types of sensors and actuators that control lights, temperature, and humidity, moisture, soil, pH. Smart phones, internet, televisions, sensors and actuators are connected to the internet where the devices are intelligently linked together which enables them a new form of communication. This happens amongst people and themselves with the help of IOT [3]. The significant development of IOTs over the last couple of years has supported the need of Industrial Revolution 4.0 (IR 4.0). The IOTs technology for smart homes provides intelligence, comfort and improved quality of life.

There have been few implementations on IOT gardens. Tomen is a plant monitoring and smart gardening using IOT in the Raspberry Pi platform. Tomen uses a cloud-based server and a mobile application that can run on both Android and iOS devices which controls the sensors and monitor the status of the plants. Tomen is able to detect the changes in the temperature, moisture, light and perform necessary actions on the plants by providing irrigation and illumination for the plants.

Tomen is a smart gardening system that monitors soil moisture content and light intensity and send the data to ThinkSpeak IOT cloud server [4]. With Tomen, plants are grown faster with less human intervention and ensure the naturally grown products to serve grower's dinner table efficiently and thus to support food security.

Postolache et al. [5] proposed "a water quality monitoring system via Wireless Sensor Network (WSN) as an IOT solution for water quality assessment through the measurement of conductivity, temperature, and turbidity." Water quality monitoring is essential for hydroponic IOT garden. Solar powered device is a renewable energy option to power IOT system from the solar cells [6, 7]. This is a popular trend in energy efficiency management that promotes sustainability using the self-powered devices. It uses harvesting technology from the sun to prolong the battery life span of the IOT system [8]. However, energy depletion is one of the main issues to be considered in IOT as discussed by Ain et. al,[9]; Chen et. al.[10] and Diedrichs et. al. [11].

IOT is a perfect solution for smart farming for both agriculture and aquaculture industries. Agri-IOT [14,15] is a semantic framework for smart agriculture which supports real time heterogeneous data processing. Agri-IOT is tested on large scale crop farming and produced reliable results that are used to facilitate farmers to make accurate decision. However, there is an issue in the implementation of IOT on large scale farming. Most existing IOT devices are installed in controlled environment to keep the sustainability and life span of the devices. Although many of these devices incurred a huge installation cost, the maintenance can be greatly reduced and the cost is much lower that hiring labors to manually managing the farm. Despite of huge investment for smart agriculture farming, Ruan et.al. [16] found that large scale farming is normally facing the risk of non tech savvy farmers who are not willing to adopt technology in their everyday life. Due to this, the author believe that proper training and maintenance fund must be provided by the right authorities.

In Malaysia, agriculture and aquaculture are considered as well developed sectors. Malaysia is one of the most world palm oil supplier. There is a significant need for IOT enabled farming in Malaysia. Small scale farming can be encouraged to improve rural economy and maintain food security. This include giving digital empowerment for the community living in the rural areas including the indigenous community.

3. METHODOLOGY

KLIKTani will be a new mobile application that controls an integrated edible garden system. The system connects a fish tank to provide nutritious water to the plants, a worm farm that reuse the organic waste from the kitchen supplies organic fertilizers for the soils and sensors-actuators management system that work automatically or with human intervention. Regular reports will be sent to KLIKTani for real time updates. It can be a personal apps or a shared app with the community if they are working on a similar garden. With KLIKTani a simple laborious job is made easy for everyone from just anywhere with a click away.

This research is targeting the indigenous community to empower them with the use of digital technology in agriculture. Figure 1 shows the proposed framework. A mobile application is developed as a portable platform to monitor the parameters of the garden and automate the watering process from the fish tank at anytime and anywhere. NodeMCU is used to connect different sensors which collect the parameters of soil and transmits the information to Firebase through inbuilt Wi-Fi to control the actuators. Solar panels are used to reduce cost to power the connected sensors and actuators. Rain harvesting and water recycling are considered in order to optimize resources. The whole system can be applied as community garden suitable for both indoor and outdoor either large-scale or small-scale farming which can also be a platform for technopreneurship capacity development.

The proposed framework is a multi-function concept of a smart gardening system which uses automatic water irrigation system from the fish tank. This provides natural fertilizer to the plants. Additionally, the research aims to educate the indigenous community on recycling the food scrap through the worm farming concept. A worm farm is a collection of worms in a special container fed with food scraps and some other organic wastes, in which the worm will turn them into natural fertilizers. A worm farm is ideal for those with small gardens balconies, school or office environment. Worm farming is a method of using worms to process organic food waste in order to produce a nutrient rich soil.

Worm farming usually uses composting worms such as tiger worms and red worms to eat the mixture of food scraps, garden waste including waste paper and cardboard to produce worm castings (composted material) and liquid fertiliser, known as worm tea or worm wiz [12]. The worm tea will be extracted automatically and use as organic fertilizer for the plants. The proposed design of the integrated worm farm is shown in Figure 2. The IOT sensors provide information on the light levels, pressure, humidity, and temperature. Data received from the sensors are used to control the actuators and notification will be sent to user through a mobile app.

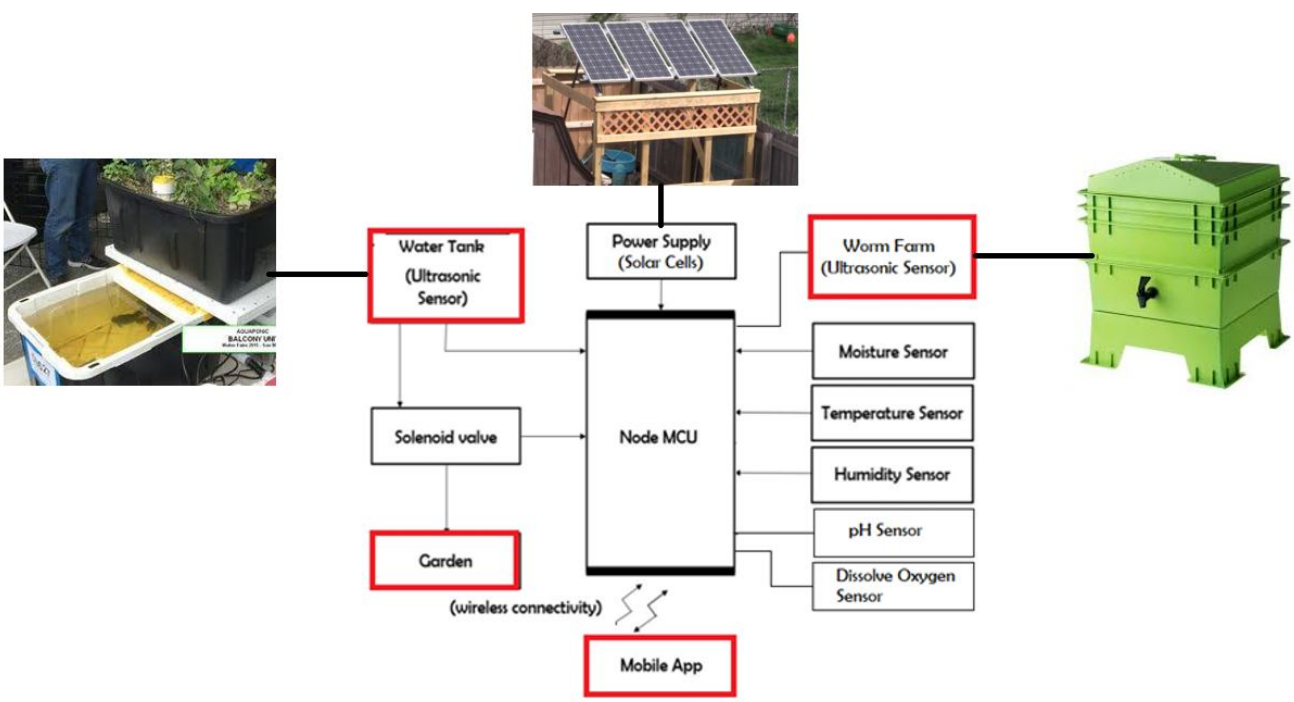

Figure 1: Smart Edible Garden with IOT Framework

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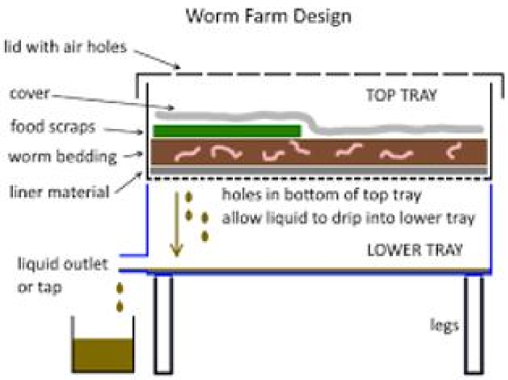

Figure 2: Worm Farm Architecture

This is a work in progress. At present, the prototype is consisting of Node MCU (ESP 32 model), a solenoid valve, a moisture sensor, a rain sensor, a plant bed with LECA Hydroton, an acrylic fish tank with motor filter as shown in Figure 3. A web based portal for data monitoring is built using the open source website for IOT known as AddFruit.IO. Kangkung plant is experimented on both KLIKTani system and traditional method. The results are observed for 7 days. The water in the fish tank will get dirty due to waste produced from the fish. The water is transported using a water pump into the soil bed through a rubber pipe. KLIKTani promotes water saving as it recycles the water from the fish tank and send the water bak into tank. The water level will raise until it reaches 80% (equivalent to 3000 analog value produced by the moisture sensor) threshold which will then trigger the solenoid valve to open and flush the water back into the fish tank. If the rain sensor detects a drop of water, it will control the solenoid valve to remain open and let the rain water flows to the fish tank through the plant bed. The sensing of data is refreshed every 5 minutes. For large scale farming, PH sensor will be used to monitor the PH level of the water in the fish tank and the Dissolved Oxygen (DO) sensor is to monitor the level of DO of the water. Once the values reach certain threshold, the system will trigger an aerator to reduce the amount of chemicals needed to treat a body of water by providing the oxygen that bacteria need to function. Aeration brings water and air in close contact in order to remove dissolved gases (such as carbon dioxide) and oxidizes dissolved metals such as iron, hydrogen sulfide, and volatile organic chemicals. Turbidity sensor works similarly as PH sensor and can be a cheaper option too.

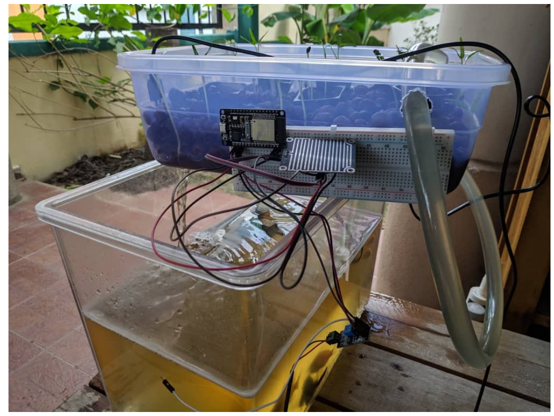

Figure 3: KLIKTani Prototype Version 1.0

4. RESULTS AND DISCUSSIONS

Kangkung has been planted conventionally and using KLIKTani method. The progress was observed for 7 days. It is found that kangkung planted with IOT monitoring system grew faster than the traditional method. This is due to the continuous watering system and the natural fertilizer provided by the fish in the fish tank. Whilst for the traditional farming, the kangkung is watered twice a day. Figure 4 - 6 below illustrates the growth rate of the kangkung from day 1 to day 3 with KLIKTani and Figure 7 shows the visible difference between KLIKTani and the traditional farming result.

Figure 4: Progression of Kangkung Development (Day 1)

Figure 5: Progression of Kangkung Development (Day 2)

Figure 6: Progression of Kangkung Development (Day 3)

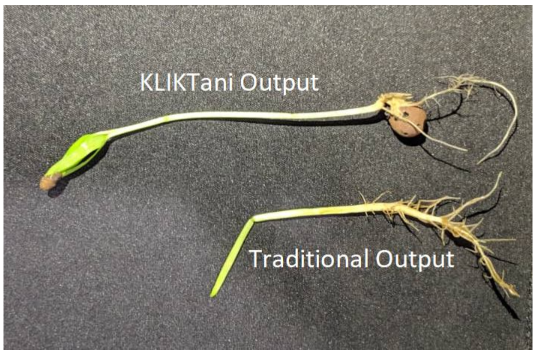

Figure 7: Different Growth Rate between IOT and Traditional Farming after 7 Days

The monitoring was done through a web portal developed using io.adafruit, an open source content management system for IOT as shown in figures below.

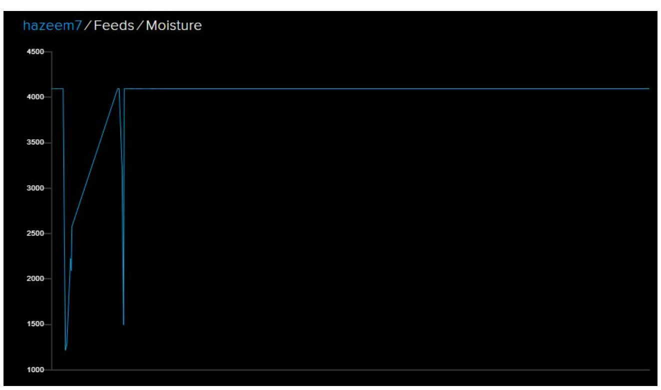

Figure 8: Graphical View of Moisture Sensor Monitoring

5. CONCLUSION

Smart gardening allows people to grow plants in smarter way called vertical gardening and will create carbon sink around us thus help to reduce the effect of global warming due to extensive carbon emission. In this project, the smart gardening using IOT is a new concept the researchers would like to propose to the indigenous community in order to grow their cultural competencies using technologies. The IOT sensors in a complete smart gardening system would provide information on the water level, pressure, humidity, temperature, etc. These sensors can control the actuators automatically such as to turn on lights, control a heater, turn on a fan, which all controlled through NodeMCU, a WiFi enabled controller. Mobile apps have grown quite powerful over the last few years and now they have started to influence the growth of the IOT. Mobile apps are the interface between the garden and the users (owners). The proposed concept offers a labour free approach to gardening using technology. Digital technology is now a significant part of our life and turn many everyday tasks easier.

Created at	Value	Location
2019/05/29 3:14:54pm	4095	
2019/05/29 3:14:53pm	4095	
2019/05/29 3:14:52pm	4095	
2019/05/29 3:14:51pm	4095	
2019/05/29 3:14:50pm	4095	
2019/05/29 3:14:49pm	4095	
2019/05/29 3:14:48pm	4095	
2019/05/29 3:14:47pm	4095	
2019/05/29 3:14:46pm	4095	
2019/05/29 3:14:45pm	4095	
2019/05/29 3:14:44pm	4095	
2019/05/29 3:14:43pm	4095	
2019/05/29 3:14:42pm	4095	
2019/05/29 3:14:41pm	4095	
2019/05/29 3:14:40pm	4095	
2019/05/29 3:14:39pm	4095	

Figure 9: Moisture Sensor Values (Analog)

There is a significant risk of the unavailability of Internet to support the implementation of IOT in the rural areas such as in the areas where most of the indigenous communities are living. In the case that Internet access is not available, LoRa technology can be used. LoRa (Long Range) is patented digital wireless data communication technology for IOT introduce in 2012 by Semtech. LoRa based signals can travel multiple miles. A LoRa hub is not expensive and could last for up to 10 years with a single battery. LoRa hub enables the monitoring process of remote devices that are difficult to access or has no common wireless connection or telco facilities. However, the limitation to this technology is the limited amount of bandwidth it offers. In order to have such a long range and extended battery life, the frequency of a LoRa transmission must be very low. The more data to be transferred at a time, the less distance and more battery will be used. In other countries, LoRa has been used widely.

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