Innovative Sprinklers for Horticulturists in the Mountainous Area

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Abstract. This paper presented the design for innovative sprinklers for mountainous area. Horticulturalists often faced difficulties in maintaining the land in the mountainous landscape and the chance of gaining more sustainable crops receded significantly. The study used an ethnographic approach to gained information from the horticulturalists. From the needs analysis, an innovative design for sprinklers in the mountainous area was created. The design included an automated system of sprinklers operated using mobile application. The design was implemented and evaluated. The study showed a successful implementation of the innovative design and good receptibility from the horticulturalists. It was concluded that an innovative design required to follow the needs of the users and the receptibility of the environment.

1 Introduction

Zero hunger is one of the goals in United Nation's Sustainable Development Goals (SDGs) and this goal focuses on ensuring sustainable food production systems. The production sustainability depends on the implementation of resilient agricultural practices, which focuses on increasing productivity and production (https://www.un.org/sustainabledevelopment/hunger/). It is believed that such agricultural practices could also help maintain ecosystems, resulting in guaranteed sustainability of food security.

Maintaining the ecosystem has been the concern of many countries. Countries with agricultural histories and cultures especially are struggling to realize this idealized ecosystem. This is because productions need to be economically sustainable and using the most efficient technology [1-3]. It has also been reported in various studies that such provision of produce would eventually be controlled by information technology [2, 5]. This means, the realization of SDG goal would take an integrated effort of productivity, technology, and information utilization.

The first aspect of the integration is the natural resources, which lays as the foundation for the ecosystem. A community ideally needs to nurture the natural potentials to contribute to the sustainability of food. Places with natural resources, such as geyser, for example, could take advantage in the geothermal energy sources to empower the greenhouses [5]. Other places such as mountainous areas would take advantage of the wind energy. Knowing the natural potential as fundamental resources is important for the realization of sustainable food production system.

The second aspect of the integration is technology. Using the most efficient and culturally sensitive technology is important for maintaining the process of food provision [2, 3]. Without the correct technology the use of certain method and knowledge would cease to happen because it is not naturally part of the community's culture and habits [4]. Previous research, for example, reported the failed effort of using certain farming tool simply because farmers do not see the increase of value in using the new tool [2-5]. In addition, farmers do not use the tool because the tool is difficult and rare to acquire. It is important to use and develop technology which is not entirely foreign to the farmers.

The third aspect important for maintain the sustainable ecosystem is the provision of information technology. Good and powerful management of information is important for famers to know the demand from the market for the produce. Farmers also need a system to manage the information and understand the supply chain. Eventually, good information system will enable farmers to have a sustainable production and business. The availability of produce, efficient and culturally informed technology, and the provision of information system guarantee the sustainable food production system (United Nations Development Goals). This is a model of food production system which would eventually maintain the ecosystem. This paper presents an example he implementation of such model by providing an innovative design for farmers. The innovation takes place in the form of water sprinklers for horticulturists in the mountainous areas.

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1.1 Objectives

The research was conducted to create a design for horticulturalists in the mountainous area. This aim was reached by answering two questions:

1. What considerations and issues from the horticulturalists were identified?
2. What innovation would be designed following the needs analysis from the horticulturalists in the mountainous area?

2 Literature review

Technology is defined as "…the collection of techniques, skills, methods and processes used in the production of goods or services or in the accomplishment of objectives, such as scientific investigation. Technology can be the knowledge of techniques, processes, and the like, or it can be embedded in machines which can be operated without detailed knowledge of their workings" [3]. From this definition the use of technology is expected to meet the objectives by way of refining techniques and processes. Technology needs to be sensitive to the identified needs and demands of the users. As a result, the results of technology should be tangible in terms of output and outcomes.

In agricultural technology, advancement has been identified by Alvin Tofler [3] using his classification of three waves in human civilization. Agricultural wave as the first wave focused on the growth of produce and supplies., resulting in the exploration and exploitation of tools and invention to maximize agricultural production. The second wave focused on the efficient use of resources for getting the most revenues and profit. The third and last wave in human civilization was deemed to be the electronic wave, which is identified with the maximum utilization of information and electronic applications in every aspect of human being. With this agricultural technology has reached its full potential by utilizing information technology and applications.

Applying information technology in agriculture resonates with industry 4.0 development. [1] industrial principles could be applied, [1] proposed four fundamental designs for the industrial era called industry 4.0. The most important foundation is interconnection, Interconnection focuses on the provision of interconnectivity between machine, device, sensors, and people forming what is called as Internet of Things (IoT). IoT enables machines and human (notable through artificial intelligence) to communicate seamlessly to create a sustainable process enabled by information technology. The result is technology which understands human, and which provide results as expected by humans every point in time. Utilization of information becomes vital in the creation of sustainable and more equitable economy [5]. Using these concepts, innovation in agricultural technology would be effective and sustainable.

3 Methods

The research was conducted in a qualitative manner. SMKS Kristen 1 Tomohon has several study programs, including electricity study program. In this study program, the aim is to maintain the electrical voltage system. Each year, the study program evaluates its curriculum and selects a school's flagship program to be reported to the government. The method for the flagship program included: (1) identifying the existing electrical voltage system and its respective parts, such as heating, motors, circuits, and generators and (2) make new installment of cable systems and circuit boards. For this study, the electrical system was focused on making new installment for automatic sprinklers.

Several steps were taken to install the new electricity system for automatic sprinklers, which were: (a) performing existing maintenance while (b) checking and finding problems in the old sprinklers' system, followed by (c) laying foundation for the new electrical system for the sprinklers, and (d) testing the newly installed system. In post-installment several security measures were also implemented, focusing on specialized knowledge in electricity hazards, cooling system, solid state electronic control, and safety procedures for users. The main feature in the innovative design for the sprinklers was the use of timer. The automatic water sprinklers system was controller using timed mechanism. This timer made the automatic water sprinkler system different from traditional sprinkler controlled manually by the people at Tomohon. This system uses a timer or time that can be set according to the wishes by the consumer.

4 Data collection

Data for the design of the sprinkler was collected using ethnographic approach in focus group discussion (FGD) activities. Need analysis was conducted to horticulturists at a town in Sulawesi, Indonesia. Representations of farmers or growers of vegetables and fruits in Tomohon, North of Sulawesi were invited by a vocational school to share their experiences and challenges in farming. The name of the vocational school conducting the focus group discussion (FGD) was SMKS Kristen 1 Tomohon (Private Christian Vocational School 1 Tomohon). Needs analysis conducted through FGD focused on two questions, which were: (1) What is required to sustain your farms, and (2) What would be needed to make your farms expand. In addition to the FGD, needs analysis was also conducted using secondary information from the government. Through the documents from Tomohon municipality, information on horticulturists' activities was collected. The information included the natural resources and socio-economic potentials available in each sub-district in Tomohon.

5 Results and discussion

The result from data collection shows results of macro, micro, and needs analysis. In conjunction to the implementation of technology, results for implementing automatic water pump system are also presented.

5.1 Macro and micro analysis on Tomohon, North Sulawesi

Macro analysis showed Tomohon as the City of Flowers. Tomohon was famous as a tourist area and especially North Sulawesi Provincial Area was famous for the coconut plantations and was dubbed the Waving Coconut Trees area. In addition, Tomohon city was a city in the highlands. Tomohon was surrounded by Mount Lokon, Mahawu mountain, and Masarang mountain. The city of Tomohon because of the fertility of the land so that many people's income came from horticulture, namely agriculture, plantations, and livestock.

At present, Tomohon is known as the City of Flowers. This was because there were many flower vendors in the city of Tomohon, the flowers sold are purely the result of plants from the people of Tomohon City. The beauty of these flowers can be enjoyed when entering Tomohon City from Manado. To develop the existing tourism potential, the infrastructure of public roads and roads leading to tourist attractions has largely been created by the government. Because it became an icon of the government flower city, the government visited groups of flower farmers who came from the community to assist the development of the florists in the area. Figure 1 shows the conventional watering techniques used by florists in this mountainous area.

Fig. 1. Facilities most expected by creative workers from three sub-sectors.

Micro analysis resulted in the fact that the city had a good school to realize the empowerment. SMK Kristen 1 Tomohon was granted by the government as a school and Center of Excellence (CoE), which focused on continuing the efforts to develop the expertise of electricity study areas for the surrounding environment and in a wider scope, namely in the city of Tomohon, North Sulawesi Province. SMKS Kristen 1 Tomohon Tomohon to provide the innovative measures to the development of horticulture at Tomohon. SMKS Kristen 1 Tomohon was located on Jln. Tomohon-Tondano, Matani I Kec.Tomohon Tengah Village, Tomohon City, North Sulawesi Province. Access to the school was easy both for private and public transportations, two-wheeled and four-wheeled vehicles. School area was safe, comfortable, and cool for the teaching and learning process.

The school's flagship program was the Electrical Installation Engineering or also known as the Electricity Engineering Expertise Program. The Electrical Expertise Program owned a teaching factory offering services and products from the students. Such services and products were done by students in collaboration with the teachers. However, the school did not have an outlet to sell the products yet. The presence of an outlet was important to train students to do business by selling the products and offering the services to the public directly.

5.2 Results from needs analysis from the horticulturalists

Tomohon is an agricultural city in North Sulawesi Province. The city is situated in a mountainous area surrounded by Mount Lokon, Mount Mahawu, and Mount Masarang, all active volcanoes. As a result, Tomohon is enjoying very fertile land, where crops from Tomohon are widely known in surrounding areas to have good qualities. Most people in Tomohon rely on agriculture for their main income, especially from horticultures. One of the notable produces from the city of Tomohon is the tropical flowers. There are many florists in the city of Tomohon and the flowers came solely from Tomohon. These florists also provide the needs to surrounding areas. This is because there are many festivals, including cultural and flower festivals happening in Tomohon and Manado. Figure 1 shows the typical greenhouse in Tomohon. Figure 2 shows the typical greenhouse in Tomohon.

Fig. 2. Greenhouse for horticulture in Tomohon.

The needs analysis showed the strengths of farming in Tomohon, which were: vegetables, ornamental plants, and herbs for traditional medicines. In addition, the municipality also is known for becoming (a) Minahasa traditional stage house production center, (b) one of important tourist destinations in North Sulawesi, (c) culinary tourism city, and (d) the largest geothermal energy provision in North Sulawesi.

Documents in municipality showed the development of the tourism and agriculture sectors in the past five years. The increase was expected to be sustained in steady increase, despite the COVID-19 pandemic, for it could provide leverage for economic improvement and community welfare. In specific, the agricultural sector

was expected to finally be developed to food sovereignty status. This was because several villages and sub districts, such as Tara-Tara, Woloan and Kayawu were major rice growers and considered as rice barns for Tomohon. Several villages such as Rurukan, Kumelembuai, and Kakaskasen became centers for horticultural and vegetable production. Tomohon was also popular for its flora and was dubbed the flower city of North Sulawesi.

The mayor of the city, Caroll JA Senduk stated that "This agricultural potential needs to be managed in an integrated manner so as not to harm farmers as well as become a food reserve area in Tomohon City and North Sulawesi," in one FGD session including representations from agricultural cooperatives and organizations in Tomohon.

Also, some problems occurring in the farming sector in Tomohon were detected during the FGD session. One of the problems was delays in providing for the request in busy times, such as main holidays and annual festivals. The delay in providing for demands for flowers, vegetables, and fruits were known to be caused by the traditional ways to cultivate vegetables, ornamental plants, and herbs. This was because farms were lacking in skilled human resources. Most farmers were in their middle-age and could not cope with the high demand from the market. Another problem was the lack of marketing skills amongst the farmers and horticulturists throughout the municipality. The farmers usually considered the surge of demands during holidays and cultural festivals as blessings from God the Almighty. People at Tomohon spent many hours during the week to prepare for services in churches. When asked whether there were anticipations for handling the surge of demands the following years, most of the farmers were adamant to make detailed preparations for increasing the crops. Less interest was also shown on the mentioning of marketing and promotion.

5.3 Automatic water pump system works system

From the FGD in needs analysis activities, it could be concluded that sustainable crop production could be improved using automatic sprinklers. Meanwhile, the water pump is controlled by a timer controlled by smartphone.

The system for automatic sprinkler using timer could be seen in Figure 3 below:

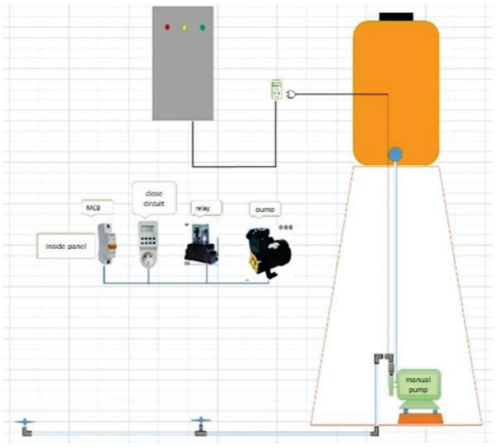

Fig. 3. Design for timer used in sprinklers installation.

5.4 Installation of smartphone controlled sprinkler system

The timer as the main feature in the automatic sprinklers use remote technology in smartphone. The controller system uses an application installed in the smartphone that can be downloaded for free, such as smart life applications. The integration of smartphone controller for timer and sprinklers could be seen in Figure 4.

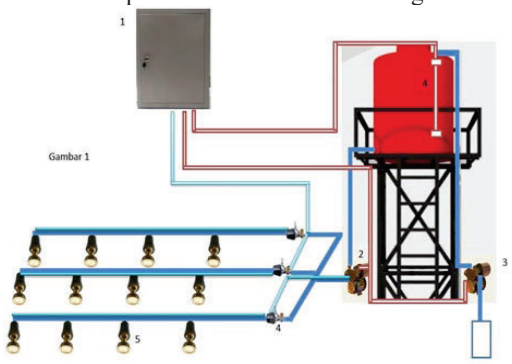

Fig. 4. Smartphone automated sprinklers installation.

The installation consisted of:
1. Electrical panel
2. Automatic pump for sprinklers
3. Automatic pump for filling in water into the tank
4. Valve Wifi Automaton
5. Sprinklers

Meanwhile, the smartphone system for the sprinkler is shown in Figure 5:

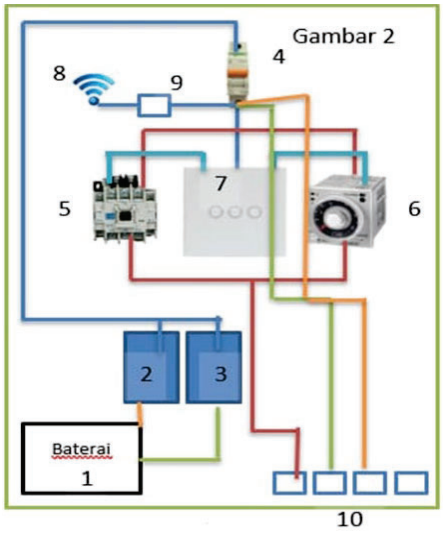

Fig. 5. Smartphone installation system for the automatic sprinklers.

The system requires (as indicated in Figure 5):
1. 12 Volts Battery
2. DC inferter to AC
3. 12 Volt Battery Charger
4. MCB 1 Phrase
5. Contactor
6. Timer
7. Wifi switch
8. GSM Modem
9. Outlet
10. Output Terminal

When installed, the controller would regulate the water tanks using water level detection system as shown in Figure 6. The controller in the water tank is seen in Figure 6:

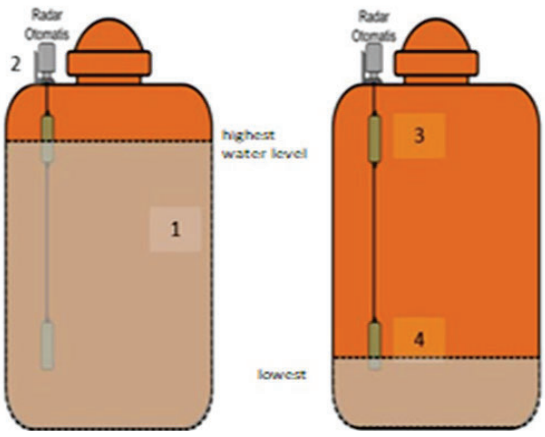

Fig. 6. Controller for the water tank.

The controller uses the equipment:
1. Water Tank
2. Automatic Radar
3. Full Water Detector on the tank
4. Less Water Detector inside the tank

When the installation was set up, the working system is explained in the following section.

5.5 Working system of smartphone controlled sprinkler system

The working system could be explained below:
1. Water from the well is pumped using a water pumping machine controlled by an automatic buoy system (radar) to the tank profile,
2. By the time the volume of water on the tank reaches the upper limit or water volume level, the pump will automatically stop working.
3. When the tank reaches the lower limit, the pump will automatically work.
4. From profile tanks, water is piped to the lands using water pumps.
5. The water pump will be controlled by an electrical circuit that has been assembled inside the electrical panel.
6. The water pump is controlled by a Wifi switch operated via a smartphone.
7. Using the smartphone, water pump is controlled by a timer in the application.
8. Farmers as users of the application could set up the time to start to sprinklers and the intervals for watering the plants or the planting areas.

5.6 Implementation and evaluation of the innovative sprinklers

The implementation of automatic sprinkler system was conducted on the first week of December 2021. The implementation took place in Tomohon, North Sulawesi. The implementation started by simulation inside the school area. Figure 7 below shows the simulated sprinkler.

Fig. 7. Simulated sprinklers in SMKS 1 Tomohon.

After one week of simulation the sprinkler worked well and installation in the field was conducted. The field belonged to the school, which was rented to horticulturalists. The sprinkler was installed as seen in Figure 8:

Fig. 8. One sprinkler station in the field.

The automated sprinkler's installation started with preparing the field and starting the planting. The steps conducted during the implementation were:

1. Preparing the field, including clearing the field from weeds and other killer plants
2. Covering the area with mulch (plastic sheets) to protect the plant, facilitate maintenance, and maintain moisture and fertilization effectiveness.
3. Installing a mulch hook to hold the plastic, making sure mulch stayed in the moat.
4. Hollowing out by filling the coals in a container. The coals are the result of burning coconut shells.
5. Placing the plants from the polybags to the field.
6. Watering for maintenance

Figure 9 below shows the implementation of the automated water sprinkler:

Fig. 9. Implementation started with preparing the field.

Automated sprinklers were used to maintain the plants and the soil The sprinkler system was adjusted based on the weather situation. When the weather was hot, the sprinklers were set to water the filed up to 3 times a week, mainly in the afternoon. When there were rains, the sprinklers were set to OFF mode or no watering schedule. Altogether there were six stations of sprinklers were installed.

Following the installation, evaluation was conducted. Horticulturalists reported that they faced no problems and difficulties in operating the system after few weeks of installation. The system also worked properly and no stalled or damaged could be detected from the installation. All sprinklers worked well as scheduled. In addition, the horticulturalists managing the field admitted that they needed to pay less electricity bills after the innovative automated sprinklers.

6 Conclusion

An automatic sprinkler was designed for farmers in the mountainous area of Tomohon, North Sulawesi. The innovative design was created following needs analysis involving farmers and stakeholders. It could be seen in the design that automated system makes use of the smartphone technology, which could be operated easily using application. It could be concluded that the automatic sprinkler system could reduce the manual workloads of farmers. The innovative design would also enable farmers to regulate their farms easily. The efficient technology and user-friendly design would encourage farmers to have steady and escalating productions. Such improvements would eventually create a sustainable system for food provision as one goal in sustainable development goals.

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