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Smart Farming: Integrated Solar Water Pumping Irrigation System in Thailand

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Abstract: The solar water pump is a system that uses electrical energy from the sun's light source. This technology has begun to be developed and applied to various aspects, one of which is the agricultural and plantation irrigation system in the concept of smart farming. The application of SWPS, which is user-friendly, easy to monitor and control, easy and inexpensive to maintain, and provides many benefits, makes this technology widely applied in the agricultural and plantation sectors, one of which is Thailand. This study aims to determine the application and usefulness of SWPS in agricultural and plantation irrigation, which is integrated into the smart farming concept. The method used in this research is descriptive qualitative. Collecting data is done through direct observation of SWPS users, while the analysis is carried out descriptively. Thailand uses SWPS in agricultural and plantation irrigation systems to support food security as part of implementing smart farming. SWPS has proven to be effective and efficient in providing water for irrigation. This technology is easy to operate and maintain and is inexpensive to maintain. The application of SWPS is also very much cheaper when compared to the use of diesel to drive pumps in agriculture or plantations, where the need is relatively high. Applying SWPS irrigation systems benefits farmers in terms of increasing the productivity of agricultural products, increasing income, increasing the efficiency of agricultural processes, and improving product quality.

Keywords: solar water pump system (SWPS), agriculture and plantation, smart farming, irrigation system.

1. Introduction

Agriculture is one of the crucial sectors in building food security that requires technical support to maximize its results. The support of various technologies is applied by many countries in every agricultural process, such as in the process of irrigation, seeding, fertilization to harvesting. One of the countries that use technology in agriculture is Thailand. Geographically, Thailand is a mountainous highland, central plains, and highlands with the main river Chao Praya and its tributaries forming an agricultural economy. This geographical condition is Thailand's advantage in being an agrarian country. The government in Thailand pays special attention to the irrigation system utilizing solar power, which is a solution to many areas in Thailand that are still short of electricity[1)]. Farmers in remote areas have implemented solar power as a source of irrigation water pumps. Thailand has the potential to take advantage of this unlimited energy considering that the average daily radiation per year is 18.0 MJ/m2-day[1)]. The solar-powered irrigation system is one of the Ministry of Energy's programs under the Alternative Energy Development Plan (AEDP) 2015-2036[2)]. With the widespread use of solar water pump systems in remote areas, monitoring systems for assistance systems are essential so that troubleshooting can be done remotely with the help of expert technicians and local operators. The concept offered by Thailand is an irrigation system with integrated monitoring and automatic running that can support smart farming.

Smart farms are agricultural developments that highlight the use of information and communication technologies in all cycles of agricultural management. [3]. Smart farming is fully equipped with the role of machine learning as insight seeking and decision making from the results of the deep learning data. Smart farming is equipped with IoT (Internet of Everything)-based sensors placed on agricultural land, making it easier for us to collect data. Smart farming should be hands-free so that farming practices are more precise and under control. An important component of this farm management approach is the use of information technology and tools such as GPS, robotics, drones, and autonomous vehicles[4,5] control system is developed to improve effectiveness, efficiency, and accuracy. Monitoring and action instructions through wireless communication that allows being carried out through gadgets.

Based on data from a solar water pump company (SWPS) widely used in Thailand, from 2010 to 2019, 63 installations were for irrigation, while the others were for clean water, communities, and swimming pools[6]. The application of irrigation utilizing solar power in Asia is more comprehensive than in Thailand, Bangladesh, Pakistan, India, Sri Lanka, and Indonesia have also started implementing the same system. In Indonesia, 147 regions apply for various installation purposes, one of which is for irrigation[7]. Most of the installations are government procurement programs in areas yet to be covered by electricity and far from water sources[8]. Using SWPS as a system in smart farming provides innovations in using renewable energy to assist agricultural irrigation systems. The benefits obtained are an increase in the productivity of agricultural products and help the government realize national food self-sufficiency[9].

Water pumps using solar power only require solar energy for operation. SWPS will keep working no matter if it is cloudy or rainy. It only affects the resulting energy discharge.

Another advantage of using an SWPS system is no need separate operator is required to operate the pump as the system is self-contained[10], easy to install and maintain[11]. A solar pump does not require a diesel supply, and does not emit gas that is clean and environmentally friendly. The SWPS system can reduce CO^2 emissions over a 25-year lifespan[13]. In addition to operational and environmental aspects, SWPS is also economically beneficial. It was shown through a positive NPV (Net Present Value), an IRR (Internal Rate of Return) value of 30% when compared to the purchase price of a tank truck, 34% when compared to the purchase price of jerry cans. Net Benefit-Cost Ratio (Net B/C) is more significant than one, indicating that the SWPS system is profitable from an economic point of view[12]. Meanwhile, The purpose of this study is to determine the application and benefit of SWPS in smart farming on agricultural irrigation systems in Thailand, also comparing smart farming and conventional farming.

2. Literature Review

2.1 Smart Farming Concept

Limited natural resources, costs, and agricultural productivity are becoming increasingly unavoidable problems. This challenge in the agricultural world becomes an opportunity for innovation along with the rapid development of technology so that the concept of smart farming is created that utilizes IoT technology. The primary domain of using IoT in agriculture is to increase resource efficiency so that productivity optimization is obtained, known as precision farming. IoT in precision farming is used in various monitoring applications such as weather conditions, soil fertility, disease or plant health, pesticide distribution, and irrigation[14]. Through the data that has been collected related to land and environmental conditions, it can be predicted the right time and location for planting and harvesting so that optimal yields are obtained. IoT supports system operations with continuous performance logging for integrated and remote analytics, prediction, and forecasting of future activities[15].

AI analyzes field sensors' values for temperature, humidity, light intensity, wind speed, pH, air pressure, and more to increase field output and reduce the risk of failure[16–20]. For example, irrigation will automatically activate when low soil moisture is detected. Artificial intelligence has many benefits, such as greater efficiency, reduced environmental impact, and fewer workplace injuries[21]. Reducing the risk generated by precision farming is to prevent routine activities on plants that pay attention to field conditions and improve management effectively. For example, minimizing pesticide wastage for effective weed, pest, and disease control and ensuring that crops receive adequate nutrients leads to highly effective green farming. Specifically, precision farming is a management strategy that uses information technology to improve agricultural quality and production[22]. Those may develop either sustainable agriculture or income for communities[23].

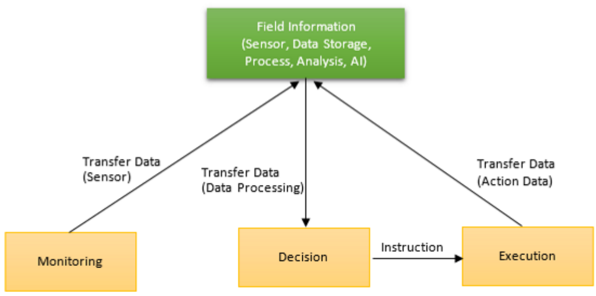


Fig1. General operation concept[17].

The concept of smart farming, as shown in Figure 1, consists of 3 main things: monitoring, decision, and execution. At the same time, the smart farming platform is based on three leading platforms: science, innovation, and space technology. Space technology is vital in mapping soil quality, water flow and supply, and sharing agricultural information. A large amount of geospatial data from various sources collected with groundwater and satellite aerial sensors and monitoring equipment is analyzed and used for smart agriculture and crop protection. Science and Innovation Various innovations, such as drones in agriculture are used for precise genetic manipulation of plant epigenetic Big Data and the Internet of Things[24].

Smart farming uses technological resources that assist in various stages of the production process, such as plantation monitoring, soil management, irrigation, pest control, and shipment tracking. These resources include, among others, temperature, luminosity, humidity, pressure, soil chemical concentrations, unmanned flying equipment, video cameras, agricultural information management systems, global positioning systems (GPS), and communication networks[25]. Fertilizers and pesticides are important for better agricultural and food production. This situation is much easier if you use automated systems such as smart farming concept[26]. Smart farming is expected to optimize food production by using more nutrients in the soil while reducing the number of pesticides and water used in irrigation.

2.2 Solar Water Pumping System (SWPS)

Solar water pumps are water pumps that are powered by the sun's energy to pump water. Physically the operation and installation of this water pump are similar to the conventional water pump. The only difference is the solar panel which integrates the water pump system as a source of electricity to operate the water pump. Solar water pumps are based on photovoltaic (PV) technology that converts sunlight into electricity to pump water. The PV panel is connected to a controller to convert the electrical energy supplied by the PV panel into mechanical energy for the water pump motor. PV monitoring helps maintain SWPS efficiency[27), 15]. The pump converts the mechanical rotation into hydraulic energy to draw water.

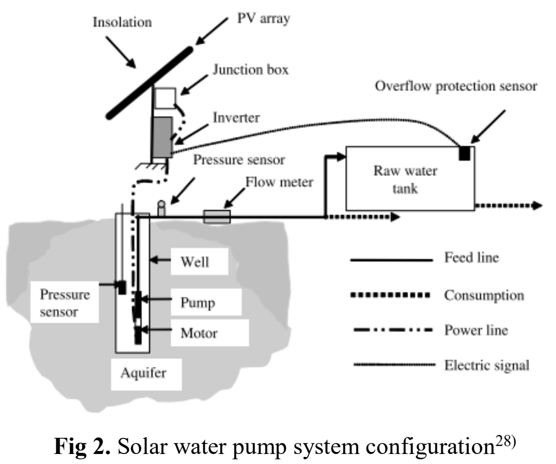


Fig 2. Solar water pump system configuration[28]

Based on figure 2, the capacity of a solar water pump system to pump water has three main function variables, pressure, flow, and power[29]. Solar water pump systems are widely applied for various purposes, including household purposes, irrigation, ponds, swimming pools, and others. The photovoltaic-powered irrigation system has been adopted in many places[30]. Photovoltaic (PV) power for irrigation has a competitive price compared to traditional energy sources for small-scale water pumping needs. As fossil fuel costs continue to rise and large-scale photovoltaic production reduces the cost of photovoltaic cells, the future will become more economical [31]. Embedding IoT into solar water pump systems will make it operators easily to maintain and monitor the system[15]. It may relate to smart farming systems. PV-powered water pumping systems have become attractive for livestock and agricultural applications in remote locations with limited access to conventional electricity.

Designing IoT-based solar energy systems for smart irrigation is essential for smart farming systems facing water and electricity shortages. The controller can read the field's soil moisture and temperature sensors and send the appropriate activation command signals to start the irrigation pumps. The controller also monitors the water level, which is important, so the pump motor does not burn out due to the water level in the well[32]. The use of IoT with voltage and current sensors from solar energy sources increases the potential efficiency and effectiveness of the smart farming system as an alternative and environmentally friendly source of electricity[33].

3. Research Methods

This research is a qualitative descriptive study. The research approach used is a qualitative socio-critical exploration approach. This approach aims to interpret the phenomenon of activities and information submitted by respondents. This approach also makes it possible to generalize the information obtained to assist researchers in understanding general aspects of a community or group in sociocultural life[34]. Primary data collection is done through exploratory techniques, as in Table 1. The observation method is a method of collecting data with a strong methodological character for observing, recording, and obtaining information about the research being carried out[35]. Field surveys and interviews made observations with SWPS users in Thailand.

Table 1. Primary data collection observation

Method	Goals	Implementation
Survey and observation	Knowing the condition of the solar water pump system directly. The survey was conducted at two irrigation installations in	• Identify the performance of the installation and components used in the solar water pump system. • Observing the process of

Method	Goals	Implementation
	Thailand, namely Nong Noch Garden in Pattaya and one installation in Buriram	operating the solar water pump system.
Interview	Exploring the information and perceptions from developers, installers, and the community	• Ask about community involvement in system planning and maintenance. • Ask about the participation of the government, developers, and the community in the program.

4. Result and Discussion

Indonesia and Thailand are close to the equator, so they have abundant sunshine throughout the year. Both are also known to be agricultural countries with food security as one of their priority programs. Of course, to achieve this program, government support is needed in terms of agricultural infrastructure and knowledge of farmers. The Thai government, through the Department of Alternative Energy Development and Efficiency (DEDE), the Ministry of Energy funded the manufacture of solar water pumps used for irrigation systems. The government funds from the manufacturing process to installation maintenance. The government also works with universities to review and evaluate the system's performance. With the government supporting these farmers, the community forms a community to maintain the existing system[36]. With the use of SWPS, Thailand has saved energy use of 1,680 USD per year at a fuel price of 0.85 USD[37].

This study made field observations at two pilot installations in Thailand, Pattaya, and Buriram. The installation in Pattaya is at Nong Noch Garden, which is privately owned, while the government owns the other installations. In general, the main components of a solar water pump system consist of photovoltaic, submersible pumps, water storage, as well as necessary accessories such as surge protection, level sensors, and so on. It is recommended that the SWPS installation is not equipped with a battery because the battery has a high maintenance cost in addition to safety and efficiency factors. Storage is recommended not in the form of a source of energy in the form of storing water. This is also stated in IEC 62253-2011 concerning photovoltaic pumping systems – design qualification and performance measurements[38, 39]. This standard can be used as a guide and procedure in installing the SWPS system so that problems in SWPS can be minimized[7].

3.1 Nong Nooch Garden

Tourism development requires a supply of energy and water as the basic needs of tourists[40]. Tourism development requires a supply of energy and water as the basic needs of tourists. Especially in the Nong Nooch tropical garden, which is located quite remotely and widely, requires large amounts of water to irrigate all the existing plants. To meet water demand, the previous system required two diesel pumps installed on a rainfed lake located 1.6 km from the park site. The diesel and water pumps are installed floating in the middle of the lake to adjust the water level, which varies depending on the season. Due to environmental reasons and diesel that once leaked and polluted the lake,]decided to use environmentally friendly energy, namely PV, to supply water at Nong Nooch Garden. Installation was done in November 2018.

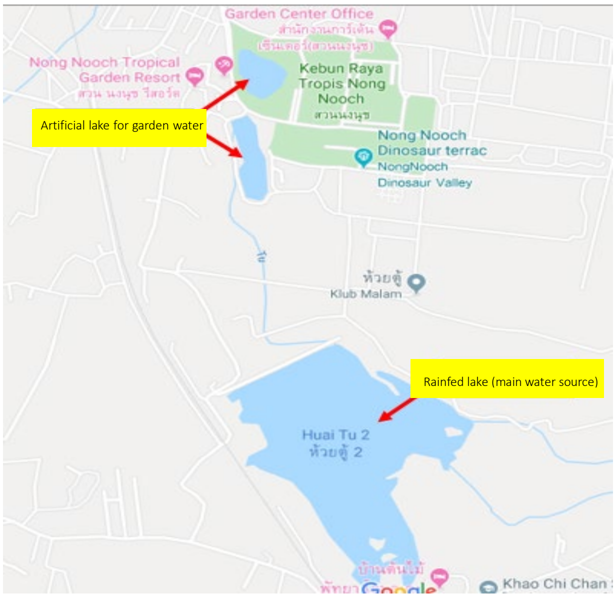
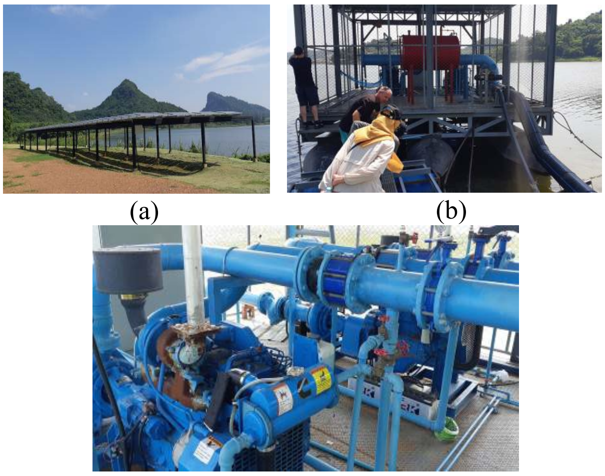


Fig 3. Description of Nong Nooch Garden location and water source

Based on figure 3, the installation is located in the tourist area of Pattaya with coordinates 12° North; 100° East has a water requirement of 1,400 m^3 per day for an area of 2,400 ha. The submersible pump is installed under a floating platform in a 10 inch pipe to cool the motor with bypass water sourced from the lake. The total dynamic head (TDH), which is the difference in height between the water source and water storage, is 37 meters. The accessory components are surge protection, level sensor, and Liquid Pressure Sensor. This is a hybrid installation combined with diesel as a backup power source when the SWPS is not operating. However, since the creation of the system in 2016, SWPS has not experienced significant problems. The design shows that the required panel output is 53.2 kW using the PSk2-40 C-SJ 120-3 pump. The system is built similarly to the design, and installation of the pump is carried out on a floating chart using the pipes provided by the previous system (figure 4 and figure 5).



(a) (b)

(c)

Fig 4. (a) Photovoltaic (power source); (b) Submersible pump floating pump chart; (c) Previous diesel engine installation

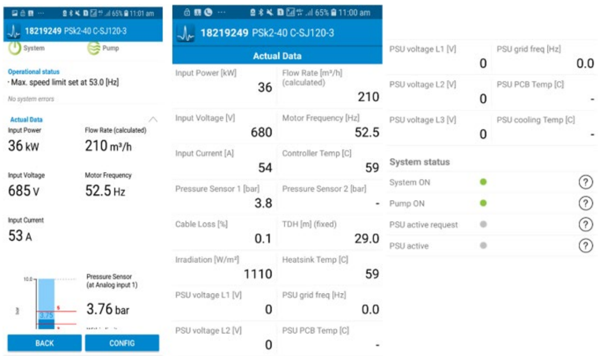


Fig 5. Actual data using Compass as a monitoring system on November 5, 2019

To calculate the system's efficiency is to know the Hydraulic Power (Ph) and the incoming Power (Pin). The equation (Ph) and Pin are contained in equations (1.1) and (1.2). The values of Vin and Iin are obtained through real data collected in the monitoring system registered on the device through a gadget synchronizing the controller's identity. Based on field data, it found that the value of the differential head (h), which is the TDH is 37 meters. The measurement of the pump efficiency value is obtained by following equation (1.3).

$$P_h = \frac{q \times \rho \times g \times h}{3{,}6 \times 10^6} \qquad (1.1)$$

$$P_{in} = V_{in} \times I_{in} \qquad (1.2)$$

$$\eta = \frac{P_h}{P_{in}} x 100\% \qquad (1.3)$$

Nomenclature:

P_h = hydraulic power (kW)
q = flow capacity (m3/h)
ρ = density of fluid (kg/m3) =1000 kg/m3 for water
g = gravity (9,81 m/s2)
h = differential head (m)
Pin = Input Power (kW)
Vin = Input voltage (V)
Iin = Input Current (A)
%η = Total efficiency

Following the equations in (1.1), (1.2), and (1.3), the results of the calculation of the efficiency of the Nong Nooch Garden installation pump are as follows:

$$P_h = \frac{210\left(\frac{m^3}{h}\right) \times 1000\left(\frac{kg}{m^3}\right) \times 9.81\left(\frac{m}{s^2}\right) \times 37(m)}{3{,}6 \times 10^6}$$

$$= 21{,}17kW$$

$$P_{in} = 685(v) \times 53(A) = 36{,}3kW$$

$$\eta = \frac{21{,}17kW}{36{,}3kW} \times 100\% = 58{,}3\%$$

The efficiency of the SWPS pump is affected by the height difference, PV quality, type of pump, and system life. Some works of literature say that the efficiency of centrifugal and helical pumps has different values. In the helical rotor pump, the efficiency is said to be good at a value of 48%-60%, while the efficiency of the centrifugal pump is at a value of 35-65% [39)]. The solar power system's output at the time of data collection is very satisfactory with an average discharge of 210 m3 per day or 117% of the desired target rate. The installed system has a very good efficiency of 58%. The efficiency value is useful for monitoring the annual decrease in efficiency so that it can be planned for preventive maintenance such as pump replacement or system power addition.

Given the vast irrigation area and different water needs, the irrigation system is supported by good and scheduled water management. Scheduled irrigation is proven to reduce operating costs and water usage[41,42)]. Monitor the water supply in real time and remotely. Damage to irrigation components and water availability can be detected through SWPS performance indicators in the monitoring system so that mitigation can be carried out earlier and on target[41)].

3.2 Multi Farming in Buriram

Most of the SWPS installations in Thailand are for irrigation. This installation uses irrigation for irrigation, fisheries, and drinking water. The government initiated this multi-farming concept and provided agricultural land and plantations to farmers with irrigation water flowing using SWPS. This installation was built in 2017 with a description of the location in the lowlands. The controller's location is under the PV module, about 30 meters from the water source. The height of the water storage is about 5 m above the surface of the water source. Storage consists of main storage, which accommodates 1,000 liters which are then distributed to storage with a smaller capacity at several points of rice fields. This storage division serves to stabilize the availability of water. Installed is a PS2-1800 8-7 pump unit with a 3000 Wp solar generator and an AC power pack to run the pump at night or in cloudy weather. The installation specification is the daily water requirement of 10 m^3/day for a land area of 3.2 hectares (ha). The total dynamic head (TDH), which is the difference in height between the water source and water storage is 25 meters. The water source is a well of about 7 meters with a depth of 40 meters. The investment cost required for this installation is 14,000 USD.

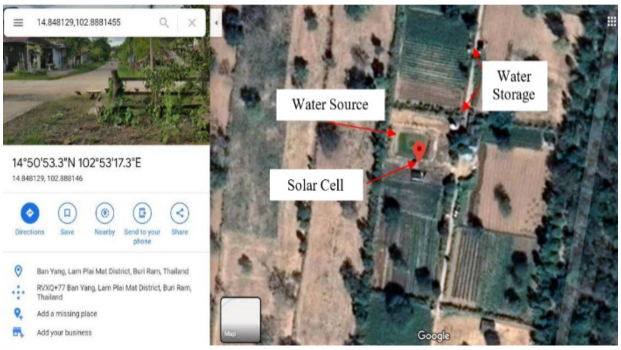


Fig 6. Description of the installation location in Buriram

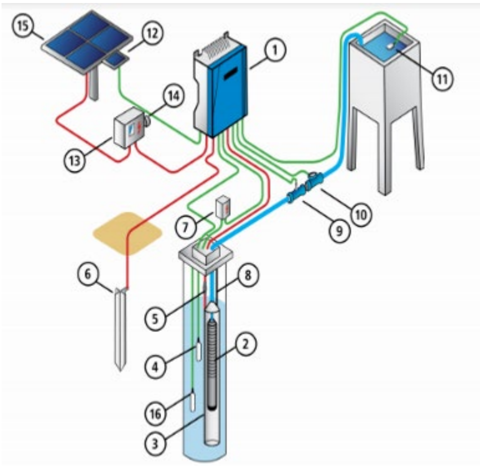
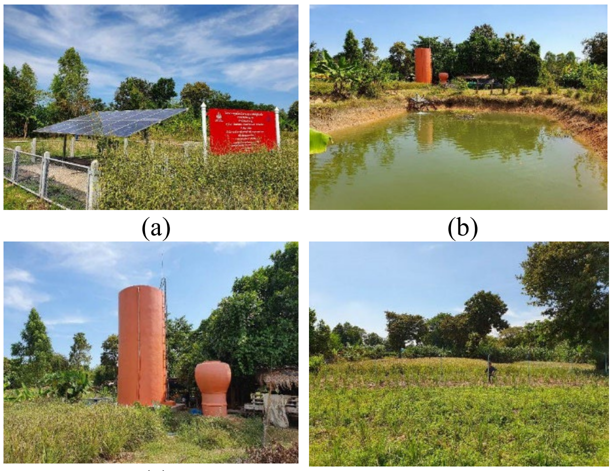


Fig 7. Multi farming in Buriram, Thailand layout system

The layout of the multi farming system in Buriram is presented in Figure 7, where there are five main components, namely the PV module (15), controller (1), submersible pump (2), grounding rod (6), and water storage (11). Each installation may have a different system, but five main components exist. Some of the accessories used in this installation are the sun switch (12), water level sensor (4), surge protector (7 and 14), water meter (9), and pressure sensor (10). Grounding and surge protectors are needed in areas with frequent lightning intensity (figure 6 and figure 7).

The type of pump used is a centrifugal pump. In contrast to the pump used in Nong Nooch Garden, a centrifugal pump is used because this irrigation maximizes water flow with a manageable TDH. The SWPS installation is not as complex as in Nong Nooch due to the different load of water requirements. The system layout in the Buriram installation is simpler because it does not plan the use of other power sources and requires a small power source.



(a) (b) (c) (d)

Fig 8. Buriram installation description (a) PV installation; (b) fish pond, (c) Main water storage and one of distribution storage, (d) One of farm

Figure 8 shows that irrigation uses flood and spray types at this site. The flood type is used for plants that require a lot of water, such as rice, while the spray type is used for plants that don't need water, such as lemongrass or peanuts. This combination of irrigation types is included in modern agriculture[43] and can be done remotely. Different types of irrigation are also included in water use management.

Table 2. Actual data of Buriram installation on November 5, 2019

Name of Data	Value	Name of Data	Value
Input Power	1.5 kW	Flow Rate	9.7 m^3/h
Input Voltage	125 V	Irradiation	1030 W/m^3
Input Current	12.0	Motor Speed	2930 rpm
Motor Current	12.3	Controller Temp	45 ^0C
Cable Loss	4.6 %	TDH	25 m

Following the equations in (1.1), (1.2), and (1.3) and the actual data in Table 2, the results of the calculation of the efficiency of the pump installation in Buriram are obtained as follows:

$$P_h = \frac{9{,}7\left(\frac{m^3}{h}\right) \times 1000\left(\frac{kg}{m^3}\right) \times 9.81\left(\frac{m}{s^2}\right) \times 25(m)}{3{,}6 \times 10^6}$$

$$= 0.661 kW$$

$$P_{in} = 125(v) \times 12{,}4(A) = 1{,}55 kW$$

$$\eta = \frac{0{,}661 kW}{1{,}55 kW} \times 100\% = 42{,}6\%$$

The pump efficiency calculation is 42.6%, indicating that the pump still performs well. The lower efficiency value compared to the system at Nong Nooch Garden is possible due to routine and periodic maintenance, such as private management. Farmers at the Buriram site also create a community to take care of the installation even though the government routinely monitors and maintains the system[36].

SWPS installations in Thailand and Indonesia are similar in systems and installations. The installations of these two countries use the main components, namely PV, controllers, and pumps with dimensions and capacities tailored to the needs, without using batteries as energy storage facilities. The most distinguishing thing is related to the purpose of using SWPS. In Indonesia, most use SWPS to fulfill one of the basic human needs, namely water for consumption[7]. Meanwhile, in Thailand, most SWPS are used as facilitators of the agricultural and plantation systems to improve the country's food security ratio. The implementation of SWPS in Indonesia is mostly implemented in remote areas with remote access to water sources and no electricity coverage[8]. At the same time, in Thailand it is applied in agricultural areas, plantations, and even tourist areas. Indonesia is an agrarian country with a large agricultural area that produces a variety of agricultural products[44], so the application of SWPS will provide benefits to increase agricultural production.

3.3 Internet of Things (IoT) on smart farming

In general, IoT technology can be interpreted as all types of devices consisting of chips, sensors, and instruments connected via data networks, both to other IoT devices and to other computing devices, such as servers, computers, or mobile devices like cell phones[45]. This IoT device usually functions to collect data, which is then sent to a server or cloud service for further analysis. Sometimes, some or all of this data can also be processed locally to speed up the process when IoT devices require faster data processing results[26]. When applied in the agricultural sector, IoT technology can be used to monitor the condition of agricultural land in real time. This monitoring uses, among other things, ground sensors, weather, UAV technology, or drones[32].

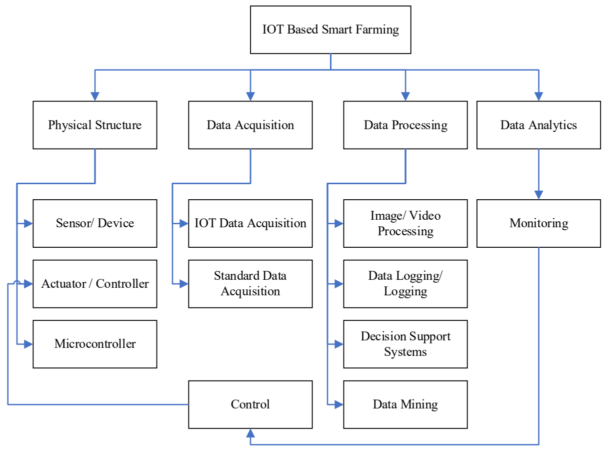


Fig 9. IoT Based on Smart Farming

Table 3. IoT architecture on smart farming

Area	Description
Application	Plantation monitoring, disease control, irrigation
Processing	Data storage, data filtering, data processing, and analysis services
Transport	Network protocols, application protocols
Perception	Sensor nodes, GPS

Based on Figure 9, IoT for smart farming systems consists of 4 main parts: physical structure, data acquisition, data processing, and data analytics[26]. In the Smart Farming concept, IoT technology does not stand alone but must also be applied side by side with other ICT technologies so that we can get maximum benefits. As in different IoT applications, the cloud is often used as a control center for processing data collected from IoT devices because IoT devices usually do not have the computing capacity needed for data processing. Data network technologies can connect various IoT devices, ranging from short-range wireless technologies such as Bluetooth to radio and cellular networks. Artificial intelligence technology can be applied to IoT for various purposes. As presented in Table 3, each area of the smart farming system has an IoT system that works and is interconnected to present data as a basis for decision-making.

3.4 Benefits of implementing SWPS on smart farming irrigation

Worldwide environmental concerns related to climate change and global warming are pushing to reduce fossil fuel consumption[46]. Using renewable energy, such as sunlight, to produce electricity can reduce the negative environmental impact[47]. Energy utilization is said to be effective and efficient, and it can be seen from various factors. Apart from increasing productivity, it can also be seen from location factors, resource availability, government burdens and subsidies, and technological and economic aspects of various components of the energy system[48].

The application of SWPS in the agricultural sector provides many benefits. Based on the results of interviews with farmers and developers of the SWPS system in Thailand, the benefits obtained by SWPS users in agricultural and plantation systems are:

a. Guarantee the availability of water in all seasons so that agricultural and plantation processes can be carried out without being constrained by the condition of the amount of water.
b. Agricultural and plantation production increases through the availability of adequate water, it can be harvested even in the dry season.
c. Improving the effectiveness and efficiency of agriculture and plantation
d. Improving the welfare of farmers, in the economic aspect, farmers can earn a higher income
e. Through the use of SWPS, farmers try to increase the competitiveness of agricultural and plantation products by implementing organic systems and Good Agricultural Practices (GAP).
f. SWPS is easy to maintain and does not require large costs in the maintenance process.

SWPS is a sustainable system, where building a sustainable system can support an organization in increasing the value of profitability and competitive advantage [40]. The benefits of implementing SWPS are also obtained from the ease of securing water for daily needs [8]. By looking at the ease and benefits of using solar water pumps, solar water pumps are an attractive alternative to meet the water supply needs for agricultural and plantation irrigation[13]. Although the costs and resources spent for SWPS installation are quite large, SWPS installation can return capital, including subsidies on PV modules, within six years[49]. While the installation of SWPS in India can pay back in less than four years with huge savings over 16 years[50]. In one of the installations in Thailand, it was stated that the SWPS investment returned 4.3 years after installation[51]. Installation of SMART PATAS (Solar Water Pumps) by LEN (PT Len Industri - Persero) in Gorontalo can maintain the stability of water supply to agricultural land in the dry season to avoid drought, more economical when compared to generator-powered water pumps[52]. Using a diesel engine to pump water will have an environmental impact, such as heavy metal pollution in the air[53], and can affect the quality of agricultural products due to the possibility of contamination of hazardous substances, so the use of the SWPS system can eliminate this aspect. However, the reliability and security of the PATS system are of great concern as increased costs in the event of a system failure[54 drive it].

The Thai government also uses a social approach to farmers and surrounding communities. The government provides free maintenance on government-built installations. However, in the pilot project in Buriram, the government does not pay for maintenance, so farmers form a community and make regular contributions for maintenance. According to the community, this condition is relatively manageable to farmers because the expenses are lower than conventional farming. This shows that using SWPS can have an economic impact from a farmer's operational perspective.

Another efficiency benefit of this technology compared to conventional irrigation is the need for farmer labor. Currently, the agricultural sector in several countries is experiencing a crisis of regeneration of the farming profession due to reduced interest in the farming profession by the millennial generation. With the SWPS, the resources for routine irrigation workers can be cut significantly.

Through a monitoring system and the availability of agricultural quality data, it is possible to schedule irrigation, regulate water use, remotely execute irrigation at certain times, and reduce agricultural quality and system damage that can be mitigated earlier[42]. With further development, it can be integrated with other agricultural quality indicators, such as nutrients, soil moisture, fertilization, and plant growth phase. Support for implementing artificial intelligence makes the smart farming system fully developed.

The traditional approach mostly uses data reactively. However, in a more recent approach, new technological developments allow the use of data to prevent plant problems and increase plant diagnosis accuracy (Navarro, Costa, and Pereira, 2020). In non-smart farming or traditional systems, they still use human power, intuition, and forecasting with limited data sources, so there is the potential for action and mitigation of errors in the agricultural process. Ultimately, the efficiency and effectiveness of agricultural output will become a problem. The use of IoT in smart farming can save water usage by up to 67%[42].

4. Conclusion

SWPS has many uses, one of which is to provide water to support the irrigation process in agriculture and plantations. Thailand has used SWPS for this sector to support food security as part of implementing smart farming. SWPS has proven to be effective and efficient in the water supply. This technology is easy to operate and maintain and is inexpensive to maintain. Benefits in more detail are related to saving water, human resources, time, and aspects of convenience, effectiveness, and efficiency. What is emphasized is the cost of installation, but this is offset by the results obtained during the process, which almost do not require high costs. The application of SWPS is also very much cheaper when compared to the use of diesel to drive pumps in the provision of water in agriculture or plantations, the needs of which are relatively high. Installation of SWPS without batteries will be more effective and cheaper, excess energy can be stored in the form of water, which is stored in a reservoir, so that it can be used when sunlight is minimal or for urgent needs. Based on these advantages, the application of SWPS for water supply facilities in the agricultural and plantation sectors is very suitable to support the concept of a smart farming system.

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