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IoT System for Mushroom Cultivation in Greenhouse of Mahasarakham Communities

[1]Tharach Arreerard, [2]Woraphapa Arreerard,
[3, *]Niraj Ruangsan

[1,2]Information Technology Management Program, Faculty of Information Technology, Rajabhat Mahasarakham University, Thailand.
E-mail: dr.tharach@rmu.ac.th, dr.worapapha@rmu.ac.th
[3]Faculty of Education, Mahachulalongkornrajavidyalaya University, Khon Kaen Campus, Thailand. E-mail:: niraj_rs@outlook.com

Abstract

This research has its goal to develop the IoT system in supporting mushroom cultivation in the greenhouse (IoT-MCG) for Mahasarakham Communities in Thailand. The objectives of this study were: 1) to study elements of IoT-MCG of the communities in Mahasarakham, 2) to develop IoT-MCG, and 3) to transfer IoT-MCG to community in the research region. The target group was a planting house of Ban Dong Noi community in Khwao, Mueang, Mahasarakham. The tools of this study included 1) an assessment form of system appropriateness, 2) an assessment form of system performance, 3) that of the system effectiveness assessment, and 4) a satisfaction questionnaire of the system. The statistics used in this research were: Mean and S.D. The research results were as follows: 1) statistically rate at a high level of appropriateness, the system elements are comprised of a control system, a water supply system, a heat distribution system, an air suction system, and a heat generating system; 2) the control system has its ability to operate the systems in accordance with the set conditions and situations effectively. Assessed by experts, the system performance was at the highest level. 3) The system yielded better effectiveness as the system was able to control humidity and temperature in the studied planting house. Therefore, this lowers the damage rate of mushroom by black mold. Besides, it also increased the quality of mushrooms in terms of weight and moist and quantity as mushrooms can be preserved longer and grew regularly. The system was able to function throughout the studied year because of the heat

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generating system and the humidity control system. This satisfied the community at the highest level.

Keywords: IoT, cultivation of mushrooms, Thailand, Green house, Mahasarakham Communities

1 Introduction

Thailand produces an average of 121,000 tons of mushrooms annually, worth approximately 6,100 million baht. This has established a number of related businesses such as transportation, sales of mushroom materials and the distribution of leavening agents [1] [2]. Mushroom cultivation is important for farmers because of its low investment and use local ingredients. Mushroom consumption in the country is worth approximately 95%. 3% of total production contributes to the country's exports in the form of processed mushrooms (canned mushroom) [1].

Mushrooms are considered fungi that grow from the mycelium that gather in clumps within a few hours [3]. The ideal environment is where food, humidity and temperature are optimized. Young mushroom lumps grow larger, split, and extend into the air, revealing different parts of the mushroom [4]. Mushrooms are one of the world's most important vegetable crops [3] [5]. The general public used to collect wild mushrooms and buy them for daily consumption. Many types of mushrooms have a high nutritional value and good taste [6]. Some mushrooms, such as shiitake and Ganoderma Lingzhi, have properties as an elixir or help prevent some serious diseases, thus making people more likely to consume it [7]. Mushrooms that are commonly eaten are naturally occurring mushrooms that occur only during the season. As more and more consumers became popular, it led to the development of more commercial cultivation of mushrooms [7].

Greenhouse mushroom cultivation is a commercial practice method for mushroom production. Therefore, greenhouses are important for mushroom cultivation. Building a mushroom greenhouse requires an understanding of the optimal environment for which to grow a good mushroom. In most cases, a mushroom house must look like this: the place to grow mushrooms should be open, well-ventilated, not overly flooded or damp, having a good drainage system and free of contaminants, pesticides and mold, nature of the soil is not salty because the salinity of the soil will cause the mycelium not to form a mushroom [4]. The results were consistent with the study of Prasit Kapchan [7], stating that the construction of a mushroom greenhouse was aimed at adjusting the conditions of the greenhouse area to suit the growth of mushrooms. Most of the greenhouses built in a gable style. The materials used for construction should be readily available according to the local area. The site area should be a lowland, no sunlight, no wind, no flooding, not a crowded area or near a cattle pen. Climate is very important for mushroom

growth. Each mushroom has different temperature requirements, for example, straw mushrooms like hot climates, the optimal temperature for growth is 35- 37 degrees Celsius. Therefore, it is popular to cultivate mushrooms during the summer and the rainy season because they are suitable for mushroom growth.

However, in winter, the mushroom does not grow very much, but it can be done by covering it with plastic wrap and letting it in the sun during the day to allow the straw to collect heat. The optimum temperature for the growth of oyster mushrooms is between 25 and 35 degrees Celsius [8]. Moisture is essential for mycelium, flower and mushroom growth, but if the humidity is too much, the fibers can become very wet and die. The watered little mushrooms lurk around the fiber-to-mushroom junctions, so food cannot be delivered to them, so they can atrophy and die but in conditions that are too dry, the mushroom will become hard or cracked, and the mushroom will not be able to grow [9]. Therefore, farmers need to have constant climate control, both humidity and temperature, in order to maintain the perfect crop both in terms of quantity and quality.

Regular control of climate, humidity and temperature to maintain the perfect yield in terms of quantity and quality can be achieved through the use of technology to assist in the inspection and notify farmers to keep them informed continuously. Shashwathi, Priyam and Suhas [10] discussed the adoption of information technology in agriculture to provide higher production efficiency. The introduction of more forms of technology in management has reduced agricultural labor. Nowadays, labor in the agricultural sector will continue to decline. The more developed countries there will be fewer agricultural workers, but such countries have turned to pay more attention to agriculture. Therefore, various technologies have been applied to help in the management, resulting in the production of agricultural products of quality and quantity sufficient to meet market demand. It also gives importance to smart agriculture and should apply information technology to the agricultural sector more.

In the village of Ban Lao Noi, Village No. 10, Khwao Sub-district, Mueang District, Mahasarakham Province with a total population of 340 people, 84 households, and the main occupation is farming and the secondary occupation is vegetable farming and animal husbandry, the median income of each household per year is 159,277 and has an average income of 46,679 baht per person per year. The people of the village were united and adopted the sufficiency economy philosophy. Most agriculture is carried out using local wisdom. Therefore, in various production processes, technology has not yet been used to assist in the operation. Therefore, the yield depends on the supervision by the farmers, which may have inconsistent results, affecting the integrity of the produce both in terms of quantity and quality.

From the aforementioned circumstances, the research team realized the importance of community development for the development of a stable and sustainable foundation economy along with the development of technology systems to assist farmers in controlling agricultural produce, especially

mushroom cultivation in greenhouses that can continuously monitor the humidity and temperature for farmers. This approach will help farmers reduce the burden of inspection and can spend more time on their work. It is also able to prevent or control the humidity and temperature in the greenhouse appropriately and in a timely manner. These issues will result in farmers having the perfect produce in terms of both quantity and quality and also being able to sell their produce at reasonable prices.

2 Research Objectives

The objectives of this research were: 1) to study the components of IoT-MCG in Mahasarakham Province; 2) to develop IoT-MCG in Mahasarakham Province; 3) to transmit IoT-MCG in Mahasarakham Province to model communities.

3 Literature Review

Benjapol Ruangsak and Nathawut Khanmang [11] said that the factor affecting mushroom growth was temperature. Temperature is very important for mushroom growth. The temperature of 25-30 °C is the optimum period for the germination of mushroom spores. The fibers grow well at temperature 30-32 degrees Celsius and flowers at 25 degrees Celsius. If the weather is too hot, the mushroom will be smaller and bloom faster than usual. If the weather is too cold, the fibers will grow more slowly until they stop growing. Moisture is essential for mycelium growth, flowering and mushroom growth. Inside the mushroom, if the moisture is too much, the fibers will become very moist and die. Chunks suitable for mushrooms are 75-85%. In terms of light, although light is essential for growth and incorporation of mycelium to produce flowers, light is not necessary for mushroom growth. In contrast, the light will cause the mushroom to turn darker, unlike the dark mushroom, which is white and popular with consumers. In terms of pH, it also has an important effect on mushroom production. Straw mushrooms prefer neutral or slightly acidic conditions. The optimum pH for the straw mushroom should be 5-8. All growth of the mushroom requires air to breathe, especially at the time when it will bloom and flower.

Seksan Siwilai [12] said that the Internet of Things or called for short. IoT is where things around us are linked together in the world of the Internet. This allows us to control or control devices such as turning on-off electricity, air conditioners and televisions, etc. via the Internet network with a Smartphone, computer or other portable device. In addition to the things around us, IoT systems are used in medical, agriculture, industrial machinery, and more. Especially in the field of Smart Farming or smart agriculture, it is the application of IoT technology to agriculture to help increase productivity and solve problems: **1)** Farmland analysis, for example, using sensors to measure soil quality, humidity or weather

conditions, and use the obtained data to select the right crop for the environment. 2) Maintenance and productivity, such as automatic irrigation systems for plants that require temperature or humidity control. 3) Saving labor and reducing the burden or risk to farmers, such as using drones equipped for spraying chemicals at high altitudes or hard-to-reach areas. It also reduces the risks to farmers in direct exposure to harmful chemicals.

Supawut Phaka, Santiwongyai and Adisorn Thomya [13] researched the development of temperature and humidity control systems suitable for mushroom growth in Ban Thung Bo Pan Mushroom Farm, Pongyang Khok Subdistrict, Hang Chat District, Lampang Province. The results showed that the mushroom cultivation group of Ban Thung Bo Pan, Hang Chat Sub-district, Lampang Province had the satisfaction in terms of the quantity and quality of the mushrooms at a high level with a total mean of 4.26 and a S.D. of 0.7, increased mushroom yield by 10.1 kg per time. The research team has transferred such technology and control system to the community by providing training and knowledge on temperature control and moisture in the mushroom nursery and to build a good relationship between the mushroom farming group and the research team.

Weerasak Fong-ngoen, Suraphong Pet Han and Ratthasit Yajoh [14] have researched the application of IoT technology to control smart farms in a fairy mushroom house. The results of the research showed that the system was able to operate according to the designed conditions which yield satisfactory results. In terms of mushroom yield testing, it was found that mushrooms collected from temperature-controlled greenhouses were higher than conventional greenhouses. When the mushrooms were weighed, it was found that the mushrooms obtained from the climate-controlled greenhouse had an average weight of 1.506 kg per piece and a S.D. of 0.17. Compared with conventional green mushrooms, the average weight was 1.206 kg and the S.D. of 0.28. The results of this test confirm that temperature and humidity have an effect on mushroom growth. Besides the control system, it can be used in greenhouses; it can also be applied to control the mushroom incubation process to accelerate the growth of mushroom culture.

4 Research Methodology

4.1 *Research Tools*

1.1 IoT system suitability form for monitoring humidity and temperature to promote mushroom cultivation in greenhouses.

1.2 Evaluation form on the efficiency of IoT systems for monitoring humidity and temperature to promote mushroom cultivation in greenhouses.

1.3 Evaluation form on the effectiveness of mushroom cultivation operation in community greenhouses.

1.4 Survey of community satisfaction towards IoT system for monitoring humidity and temperature to promote mushroom cultivation in greenhouses.

4.2 *Sample*

Ban Dong Noi Community, Khwao Sub-district, Mueang District, Mahasarakham Province**.**

4.3 *The Research Processes*

This research is conducted individually and divided into 3 phases as follows:

Phase 1: Study of components of the IoT system to support mushroom cultivation in community greenhouses in Mahasarakham Province, with the following steps:

1) Studying related research documents.

2) Field study in the community on the field of greenhouses, data on house control during mushroom cultivation, and other relevant information.

3) Interview with experts on the elements of IoT-MCG in Mahasarakham Province.

4) Summary of results from field trips and interviews with experts and using data to design components of IoT-MCG in Mahasarakham Province.

5) Evaluation of the suitability of the components of IoT-MCG in Mahasarakham Province by experts.

6) A summary of the results of a feasibility assessment on the composition of IoT-MCG in Mahasarakham Province by experts.

Phase 2: Development of IoT-MCG in Mahasarakham Province, with the following steps:

1) The use of IoT-MCG in Mahasarakham Province studied in phase 1 as a framework for system design.

2) Development of IoT-MCG in Mahasarakham Province.

3) Testing the efficiency of IoT-MCG in Mahasarakham Province.

4) Evaluation of the suitability of IoT-MCG in Mahasarakham Province by experts.

5) The conclusion of the suitability assessment of IoT-MCG in Mahasarakham Province by experts.

Phase 3: IoT-MCG in Mahasarakham Province and study of the results after using the IoT system developed with the following steps:

1) Visiting the target community to create understanding of the developed system transfer.

2) Installing IoT-MCG of communities in Mahasarakham Province in the target community greenhouses.

3) Data collection for the duration of the research by the research team into the target community along with the meeting to reflect the research results from the use of IoT-MCG in Mahasarakham Province according to the specified issues.

4) Summarizing research results and prepare research reports.

4. 4 Statistics

The statistics used in the research were percentage, mean and standard deviation. The mean obtained was compared with the evaluation criteria as follows:

4.50 - 5.00 means the highest level.
3.50 - 4.49 means the high level
2.50 - 3.49 means the moderate level.
1.50 - 2.49 means the low level.
1.00 - 1.49 means the lowest level.

5 Results

5.1 The Results of a Study of the Components of Iot-MCG in Mahasarakham Province

The researcher went to the actual area to study the context of the problem condition and use it to design the components of IoT-MCG in Mahasarakham Province as shown in Figure 1. It has the following components: (1) the control system consists of 1.1) Humidity data acquisition unit, 1.2) temperature data acquisition unit, 1.3) control unit on-off command for spraying water, 1.4) the control unit for an on-off command for the exhaust fan from the house in the event of an excess of humidity inside the house, 1.5) On-off command control unit for generating house heat, 1.6) On-off command control unit for the house heat dissipation fan in case of heat generated inside the house; (2) water distribution system inside the house; (3) the heat distribution system in the house; (4) air suction system from the house, (5) house heat generation system.

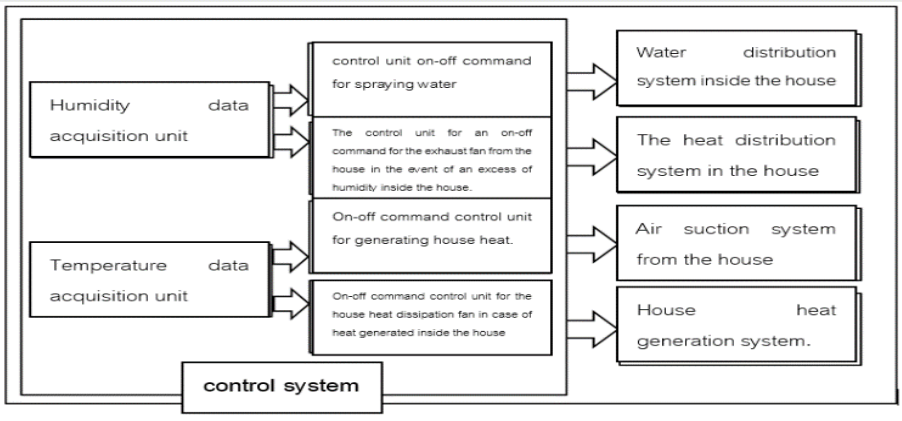


Figure 1: Components of IoT-MCG

The researchers used IoT system components to support mushroom cultivation in community greenhouses, presenting them to five experts and examining their suitability by using the assessment form. The assessment results were shown in Table 1.

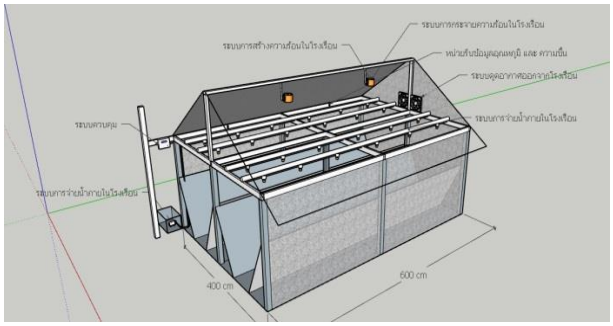
Table 1 The results of the component suitability assessment of IoT systems to support mushroom cultivation in community greenhouses.

Suitability	Assessment Results		
	$\bar{X}$	S.D.	Level
1. Control system	**4.61**	**0.47**	**highest**
1.1 Humidity information receiving unit	4.54	0.35	highest
1.2 Temperature receiving unit	4.55	0.56	highest
1.3 on-off command control unit for spraying water	4.67	0.50	highest
1.4 Control unit on-off command for the exhaust fan from the house in case of the excess humidity inside the house	4.34	0.57	high
1.5 On-off command control unit for generating house heat	4.73	0.47	highest
1.6 Fan controls the fan for heat dissipation in the house when heat is generated inside the house	4.84	0.38	highest
2. Water distribution system in the greenhouse	4.75	0.50	highest
3. System for heat dissipation in houses	4.57	0.61	highest
4. Air suction system from the house	4.55	0.56	highest
5. System for generating heat in the house	4.32	0.51	high
Total	**4.61**	**0.50**	**highest**

From Table 1, the results of the expert opinion inquiry on the suitability of overall IoT system components were at the highest level (mean = 4.61 and S.D.= 0.50). When considering each item, it was found that the suitability of the composition was at the highest level (mean = 4.32-4.84 and S.D.= 0.350.61).

5.2 Development of IoT-MCG in Mahasarakham Province

The researcher has developed a house outline and a plan for the implementation of the system to be installed in the house as shown in Figure 2 (a) and developed the system as shown in Figure 2 (b).



(a)

(b)

Figure 2: Layout of the house and the layout of the housing system to be installed and the system development.

The researcher brought the IoT system that was presented to 5experts and examined the performance using the assessment. Assessment results are shown in Table 2.

Table 2: IoT performance evaluation results to support mushroom cultivation in community greenhouses

Performance items	Assessment results		
	$\bar{X}$	S.D.	Level
1. Control system	**4.68**	**0.49**	**highest**
1.1 humidity data receiving unit can continuously transmit data to control unit	4.68	0.50	highest
1.2 temperature data receiving unit can continuously transmit data to control unit	4.80	0.41	highest
1.3 on-off command control unit for water spray can operate the relevant system according to the specified conditions	4.64	0.48	highest
1.4 on-off command for the exhaust fan can be operated according to the specified conditions, control unit	4.65	0.54	highest
1.5 the ON-OFF command for heat generation in the house, can operate the relevant system according to the specified conditions	4.51	0.59	highest
1.6 control unit, ON-OFF command for the fan to dissipate heat in the house can operate the relevant system according to the specified conditions.	4.80	0.45	highest
2. The water supply system in the house can work according to the specified conditions.	5.00	0.00	highest
3. The heat distribution system in the house can be operated according to the specified conditions.	4.80	0.45	highest
4. The system to extract the air from the house can work in accordance with the specified conditions.	4.60	0.45	highest
5. The heat generation system in the house can be operated according to the specified conditions	4.80	0.41	highest
Total	**4.72**	**0.42**	**highest**

From Table 2, the results of the expert opinion inquiry on the overall IoT system performance were at the highest level (mean = 4.72 and S.D.= 0.42). When considering each case, it was found that the suitability of efficiency was at the highest level (mean = 4.51-5.00 and S.D.= 0-0.54).

5.3 IoT-MCG Transmission Results to Support Mushroom Cultivation in Houses of Communities in Mahasarakham Province to Model Communities

Once the researcher has installed an IoT system for monitoring humidity and temperature to promote mushroom cultivation in greenhouses, the community was then coordinated with the community to put the mushroom cultivation into the house of 2,500 cubes, divided into oyster mushrooms, Hungarian mushrooms and Bhutan mushrooms as shown in Figure 3 (a) and (b).

(a)

(b)

Figure 3: Control system installation and mushroom cube placement

After 5 months of the community taking action on mushroom cultivation, the researchers interviewed people in the community on six issues which found them to be more effective than the actions of the community practices. The details are as shown in Table 3.

Table 3: Effectiveness of mushroom cultivation operation in community greenhouses

Issues	**results of operations**	
	actions by community practice	**operations using a system of controlling**
Harvesting time	3-4 months	5-6 months
Damaged mushroom cube (low fungi) rate	1) With regular supervision, the damaged mushroom nodule rate is 10% of the number of the nodules placed in the house. 2) Without regular supervision, the rate of mushroom infection is 20% of the number in the house.	The damaged mushroom cube rate is within 2% of the number in the house.
Quality of mushrooms	light weight, dry flowers	good weight, plump flowers and full of water.
Maintaining the produce	Regular care is required such as watering and opening the houses for ventilation, etc. In case of no regular supervision, there will be no harvest for each day or each harvest cycle.	there is no need for household maintenance, the community had to wait to harvest the produce alone.
The operating period	During March - October	Throughout the year because there is a suitable heating and humidity system inside the house.
Productivity (per harvest)	1-3 Kg.	3-15 Kg.
Revenue (from cost of profit 20%)	profit 20%	profit 60%

Researcher had studied community opinions on the satisfaction of IoT systems after using this system in houses for 5 months, the results of the study are shown in Table 4.

Table 4: Results of community satisfaction study towards IoT systems to support mushroom cultivation in community greenhouses.

Satisfaction items	Assessment Results		
	$\bar{X}$	S.D.	Level
1. The system allows communities to have more time because they do not need to take care of the houses such as watering and opening the houses for ventilation etc.	4.94	0.49	highest
2. The system helps the community to have less damage rate of mushroom cubes.	4.70	0.52	highest
3. The system allows communities to harvest more crops per cycle or time.	4.74	0.57	highest
4.The system allows the community to produce mushroom in the greenhouse in every season.	4.82	0.51	highest
5. The system allows communities to harvest mushrooms over a longer period of time.	4.84	0.38	highest
6. The system helps communities have full yield, good weight, plump flowers and full water.	4.75	0.50	highest
7. The system helps communities earn more.	4.67	0.61	highest
8. The system allows communities to become a model for using technology, which has resulted in other communities coming to study.	4.73	0.47	highest
9. The system helps communities join together to harvest happily and create love and unity in the community.	4.67	0.50	highest
10. The system is a medium for the community to have more relationship with Rajabhat Mahasarakham University.	4.55	0.56	highest
Total	**4.74**	**0.51**	**highest**

lts of the community satisfaction questionnaire towards the IoT system to support mushroom cultivation in community greenhouses were at the highest level (mean = 4.74 and S.D.= 0.51). When considering each item, it was found that the satisfaction was at the highest level (mean = 4.55-4.94 and S.D.= 0.38-0.61).

6 Discussion and Conclusion

From using IoT-MCG in Mahasarakham Province, it was found to be more effective than the practice of the community in the past because the IoT system can control the humidity and temperature in the greenhouse suitable for mushroom production. Therefore, it resulted in the damage rate of the mushroom nodules from the black fungus, which had a small ratio of fungi. It also affects yields to be able to harvest over a longer period of time and yield good weight, plump flowers and full of water and growing regularly, allowing a large harvest in each cycle. At the same time, the result of using

the system. It can be operated all year round because there is a system to generate heat in the house. And control the appropriate humidity within the house. The results of this research are consistent with Boonyang Singcharoen and Santisakaew [4] Likhit Ankapetch and Thongrob Aksorn [15], Supawut Phaka et al. [13], Weerasak Fong-nern et al. [14] Patmanan Isaranontakun and Chanthana Rakphong [16] and Suwalee Chuwanit and Krirkchai Thongnu [17] which has researched IoT systems and gave them performance results[18].

7 Suggestions

The results of this research have not been formulated as a pre-set that other users will be able to install and apply immediately; therefore, it is necessary for the research team to install and transfer technology for its effective use. If there are people interested in applying the research, they should contact the research team to work together.The system should be developed as a ready-made package and an operating manual for the dissemination, researchers or interested people can apply this practice kit by themselves.

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Biographies

Tharach Arreerard, Information Technology Management Program, Faculty of Information Technology, Rajabhat Mahasarakham University, Thailand.

Woraphapa Arreerard, Information Technology Management Program, Faculty of Information Technology, Rajabhat Mahasarakham University, Thailand**.**

Niraj Ruangsan, Faculty of Education, Mahachulalongkornrajavidyalaya University, Khon Kaen Campus, Thailand.