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Decision support system to determine hydroponic vegetable cultivation based on Internet of Things (IoT)

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Abstract. Currently, hydroponic vegetables have become a trend because of its efficient construction requires a minimum resource management. Determining the correct type of hydroponic vegetable before planting would affect the yield of the vegetables produced. However, the experiments conducted in this research resulted in deadlocks to determine the exact type of vegetable cultivated at the farm where the type of hydroponic vegetable depends on several factors that affect the quality and quantity, size weights, the number of leaves and the weight of plants. A decision support system is applied as a solution to the problem and IoT is performed to gain criteria data input. AHP method is conducted to measure criteria such as raw water PH, PPM of a nutritional solution, air temperature and sunlight illumination intensity and to find alternatives determined namely, lettuce, Pakcoy, Mustard greens, Spinach, Kale, Celery, and Chinese Kale. Results showed that Pakcoy in the first rank with a value of 0.25% and the second is spinach with a value of 0.16%, the Decision support system has proven to determine the type of vegetable on hydroponic vegetables.

1. Introduction

Indonesia is a country that has great potential in the agricultural sector [1]. Agriculture is an activity of planting plants in the soil or other growing media to be cultivated. Efforts to develop agricultural activities are needed not only to improve the quality of agriculture but also to be able to compete in the international market share. One method of developing agricultural activities that have been carried out by many Indonesian people is the hydroponic method. Hydroponics is a way to grow crops without using soil as a medium for growth [2,3]. Hydroponic systems can provide a more controlled plant growth environment [4]. Technological developments and the combination of hydroponic systems with membranes are able to utilize water, nutrients, and pesticides significantly more efficiently than soil cultures, especially for short-lived plant species [5-7]. But the yields of hydroponic vegetable species in each region can be different. Determination of the type of plant and the desired location can affect the quality and quantity of the crop. Need a Decision Support System approach which is used to select the right type of hydroponic vegetable to be cultivated at Nilano Farm based on predetermined criteria and alternatives. Decision Support System approach is used to strengthen the study in choosing the right type of vegetables to be cultivated. The method used to support decision making is the Analytical Hierarchy Process (AHP) method. The AHP method selection in recommending a decision will make comparisons between criteria based on perception.

2. Methods

2.1. Internet of things data acquisition

Data acquisition is a system used to retrieve, collect and prepare data that is running and further processed in a computer for certain purposes. Data distribution in a data acquisition system can be done in series or parallel from the instrument to the computer. The Data acquisition system in this study gathers data from the Internet of things with pH, PPM, Temperature, and Light Intensity sensors [8,9]. The total sample of each criterion to be taken more than 30 samples. Data that has been taken by the sensor is then collected to be included in the alternative criteria for decision making using the AHP method. The data acquisition work process can be seen in Figure 1.

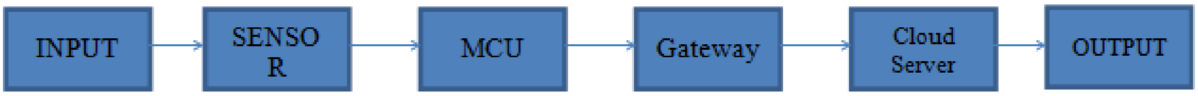

Figure 1. IoT device mechanism.

In Figure 1, is the process of data acquisition criteria to be inputted into an alternative for later used in the AHP method. The sensor module device is connected to a microcontroller, the server receives the data then stored into the cloud server and processed in the web-based AHP Decision Support System.

2.2 Method AHP

Analytical Hierarchy Process (AHP) is a method that can be used in assessing the best choice of a complex problem. AHP can be complex if the structure of the problem is not accurate. In solving the problems of Hydroponic plants [10-12], using the Analytical Hierarchy Process (AHP) which can be seen in Figure 2.

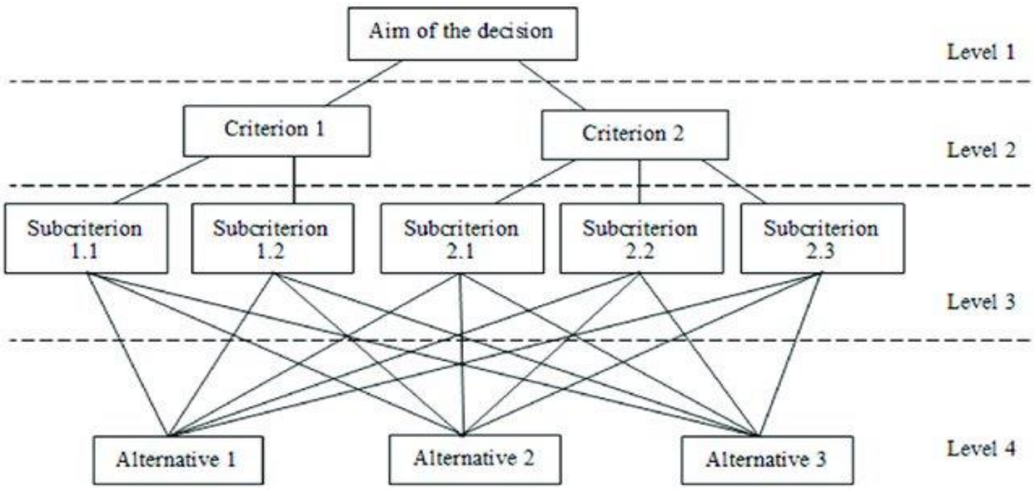

Figure 2. Analytical hierarchy process method.

The picture in Figure 2 shows how the AHP process is carried out where the Comparison of criteria and their alternative are weighted with the use of a pairwise comparison matrix. Each matrix should be reciprocal and positive.

3. Results and discussion

3.1.Hydroponics scheme based on Internet of Thing

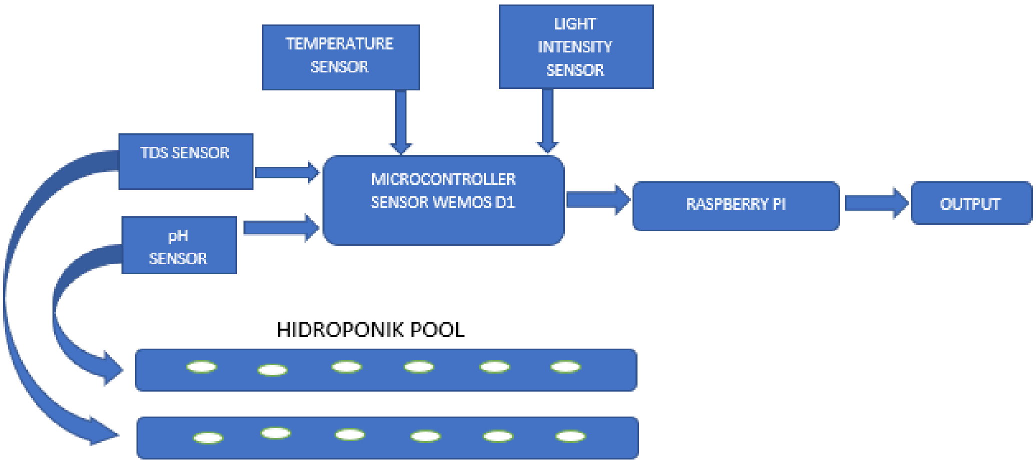

Figure 3. Hydroponics scheme based on the Internet of Thing.

in Figure 3, data collection is carried out in a hydroponic using Ph, PPM, temperature, and light intensity sensors. The Ph and PPM sensor is inserted into a hydroponic pond containing water to monitor changes in Ph and PPM while the Temperature and Light Intensity sensors are placed around the hydroponic greenhouse. The four sensors are then connected to a Microcontroller (Wemos D1) and Raspberry Pi to send data monitoring to the Cloud Server.

3.2. Sensor data acquisition

The data retrieval process is done by placing all sensors in a Hydroponic Garden Greenhouse, the time of data collection is done for 7 days from 07.00 AM until 05.00 PM. Incoming data is monitored through a PC that has an internet network connection. The following is a sensor image in Figure 4 placed in the Greenhouse area of the Nilano Farm.

Figure 4. Internet of Things device for data retrieval.

The data measurement results from each sensor that is sent into the MySQL Database server automatically stored at the cloud and can be viewed directly on the AHP WEB cloud server API.

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3.3. AHP method measurement

There are 4 criteria used in this study, namely PH, PPM, Temperature, and Lighting Intensity, then the criteria are weighted and calculated by eigenvector and priority vector as in Table 1 and Table 2.

Table 1. Criteria weighting.

Criteria	PH	TDS/PPM	Temperature	Lighting Intensity
Ph	1	3	1	1
TDS/PPM	0,33	1	1	0,33
Temperature	1	1	1	1
Lighting Intensity	1	3	1	1
Total	3,33	8	4	0,33

Table 2. Eigenvector and priority vector criteria results.

Criteria	PH	TDS/PPM	Temperature	Lighting Intensity	Total	Eigenvector	Priority Vector
Ph	0,3	0,375	0,25	0,3	1,225	5,18	1,295
TDS/PPM	0,1	0,125	0,25	0,1	0,575	2,365	0,5915
Temperature	0,3	0,125	0,25	0,3	0,975	4	1
Lighting Intensity	0,3	0,375	0,25	0,3	1,225	4,65	1,162
Maximum Total							4,048

After calculating the weighting of the criteria, further consideration is made of alternatives. The alternatives set in this study amounted to 7 plants namely, Pakcoy, Mustard greens, Lettuce, Spinach, Kale, Celery, and Chinese kale, and weighting calculations were carried out and will produce an eigenvector and priority vector comparison of each alternative that can be seen starting from Table 3 to Table 6.

Table 3. Eigenvector and priority vector on PH criteria results.

PH Criteria	Pakcoy	Mustard greens	Lettuce	Spinach	Kale	Celery	Chinese kale	Total	Eigenvector	Priority Vector
Pakcoy	0,33	0,33	0,254	0,254	0,263	0,263	0,263	2,340	13,33	1,904
Mustard greens	0,066	0,066	0,084	0,084	0,052	0,052	0,052	0,446	3,115	0,445
Lettuce	0,333	0,2	0,254	0,254	0,263	0,263	0,263	1,703	12,38	1,768
Spinach	0,66	0,2	0,254	0,254	0,263	0,263	0,263	1,436	12,43	1,775
Kale	0,66	0,66	0,050	0,050	0,052	0,052	0,052	0,367	2,66	0,38
Celery	0,66	0,66	0,050	0,050	0,052	0,052	0,052	0,367	2,66	0,38
Chinese Kale	0,66	0,66	0,050	0,050	0,052	0,052	0,052	0,367	2,66	0,38
Maximum Total										7,032

Table 4. Eigenvector and priority vector on TDS/PPM alternative criteria results.

TDS Criteria	Pakcoy	Mustard greens	Lettuce	Spinach	Kale	Celery	Chinese kale	Total	Eigenvector	Priority Vector
Pakcoy	0,33	0,33	0,254	0,254	0,263	0,263	0,263	2,340	13,33	1,904
Mustard greens	0,066	0,066	0,084	0,084	0,052	0,052	0,052	0,446	3,115	0,445
Lettuce	0,333	0,2	0,254	0,254	0,263	0,263	0,263	1,703	12,38	1,768

Table 4. Cont.

Spinach	0,66	0,2	0,254	0,254	0,263	0,263	0,263	1,436	12,43	1,775
Kale	0,66	0,66	0,050	0,050	0,052	0,052	0,052	0,367	2,66	0,38
Celery	0,66	0,66	0,050	0,050	0,052	0,052	0,052	0,367	2,66	0,38
Chinese Kale	0,66	0,66	0,050	0,050	0,052	0,052	0,052	0,367	2,66	0,38
Maximum Total										7,032

Table 5. Eigenvector and Priority Vector on Temperature Alternative Criteria Results

Temperature	Pakcoy	Mustard greens	Lettuce	Spinach	Kale	Celery	Chinese kale	Total	Eigenvector	Priority Vector
Pakcoy	0,33	0,33	0,254	0,254	0,263	0,263	0,263	2,340	13,33	1,904
Mustard greens	0,066	0,066	0,084	0,084	0,052	0,052	0,052	0,446	3,115	0,445
Lettuce	0,333	0,2	0,254	0,254	0,263	0,263	0,263	1,703	12,38	1,768
Spinach	0,66	0,2	0,254	0,254	0,263	0,263	0,263	1,436	12,43	1,775
Kale	0,66	0,66	0,050	0,050	0,052	0,052	0,052	0,367	2,66	0,38
Celery	0,66	0,66	0,050	0,050	0,052	0,052	0,052	0,367	2,66	0,38
Chinese Kale	0,66	0,66	0,050	0,050	0,052	0,052	0,052	0,367	2,66	0,38
Maximum Total										7,032

Table 6. Eigenvector and priority vector on lghting intesity alternative criteria results.

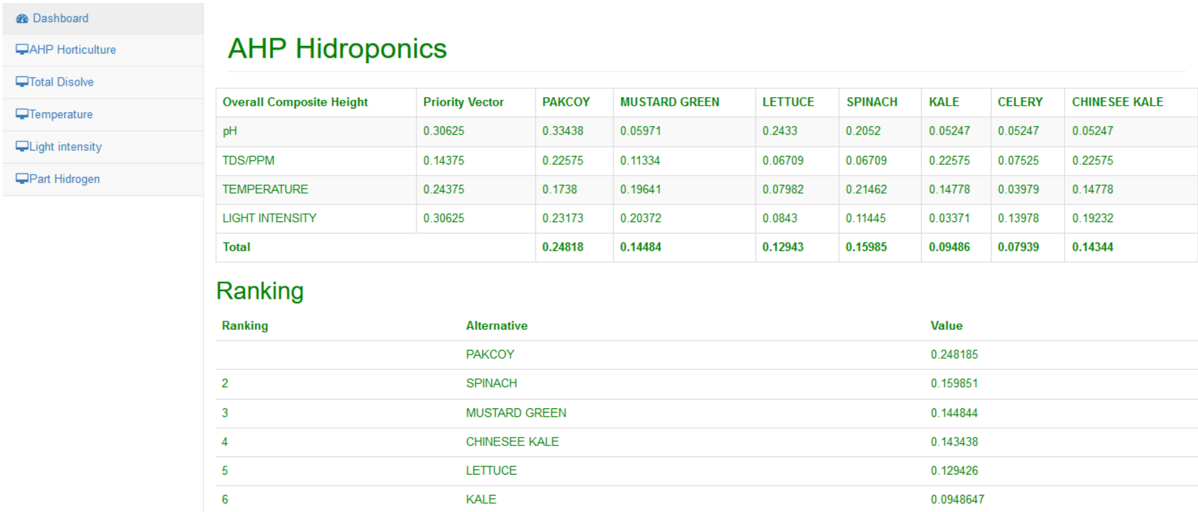
TDS Criteria	Pakcoy	Mustard greens	Lettuce	Spinach	Kale	Celery	Chinese kale	Total	Eigenvector	Priority Vector
Pakcoy	0,33	0,33	0,254	0,254	0,263	0,263	0,263	2,340	13,33	1,904
Mustard greens	0,066	0,066	0,084	0,084	0,052	0,052	0,052	0,446	3,115	0,445
Lettuce	0,333	0,2	0,254	0,254	0,263	0,263	0,263	1,703	12,38	1,768
Spinach	0,66	0,2	0,254	0,254	0,263	0,263	0,263	1,436	12,43	1,775
Kale	0,66	0,66	0,050	0,050	0,052	0,052	0,052	0,367	2,66	0,38
Celery	0,66	0,66	0,050	0,050	0,052	0,052	0,052	0,367	2,66	0,38
Chinese Kale	0,66	0,66	0,050	0,050	0,052	0,052	0,052	0,367	2,66	0,38
Maximum Total										7,032

After calculating the weighting for each alternative, then proceed by comparing the criteria and alternatives to get the best alternative recommendation value that can be seen in Table 7.

Table 7. Criteria and alternative comparison result.

Criteria and Alternative	Pakcoy	Mustard greens	Lettuce	Spinach	Kale	Celery	Chinese kale
pH	0,33	0,33	0,254	0,254	0,263	0,263	0,263
TDS/PPM	0,066	0,066	0,084	0,084	0,052	0,052	0,052
Temperature	0,333	0,2	0,254	0,254	0,263	0,263	0,263
Lighting Intensity	0,66	0,2	0,254	0,254	0,263	0,263	0,263
Total	0,66	0,66	0,050	0,050	0,052	0,052	0,052

The final results of AHP Web Program Calculations obtained from the calculation results of data that has been analyzed Decisions Support System alternatives determined namely, lettuce, Pakcoy, Mustard greens, Spinach, Kale, Celery, and Chinese Kale.previously can be seen in the Figure 5.



Overall Composite Height	Priority Vector	PAKCOY	MUSTARD GREEN	LETTUCE	SPINACH	KALE	CELERY	CHINESEE KALE
pH	0.30625	0.33438	0.05971	0.2433	0.2052	0.05247	0.05247	0.05247
TDS/PPM	0.14375	0.22575	0.11334	0.06709	0.06709	0.22575	0.07525	0.22575
TEMPERATURE	0.24375	0.1738	0.19641	0.07982	0.21462	0.14778	0.03979	0.14778
LIGHT INTENSITY	0.30625	0.23173	0.20372	0.0843	0.11445	0.03371	0.13978	0.19232
Total		**0.24818**	**0.14484**	**0.12943**	**0.15985**	**0.09486**	**0.07939**	**0.14344**

Ranking

Ranking	Alternative	Value
	PAKCOY	0.248185
2	SPINACH	0.159851
3	MUSTARD GREEN	0.144844
4	CHINESEE KALE	0.143438
5	LETTUCE	0.129426
6	KALE	0.0948647

Figure 5. Decision support system web application results.

4. Conclusion

Based on the results of the research that has been done, it can be concluded that the process of data acquisition can be applied to the process of data analysis in the decision support system with AHP method that produces the right type of vegetable decision to be cultivated, Pakcoy as the first rank with a value of 0.25% and the second order of Spinach with a value of 0.16%. AHP's Internet-based decision support system can help Nilano farm's hydroponic garden managers in determining the right type of vegetables to be cultivated.

References

[1] David W and Ardiansyah 2017 Organic agriculture in Indonesia: challenges and opportunities *Org. Agric.*

[2] Siswanto D and Widoretno W 2017 Design and construction of a vertical hydroponic system with semi-continuous and continuous nutrient cycling *AIP Conference Proceedings*

[3] Putera P, Novita S A, Laksmana I, Hamid M I and Syafii 2015 Development and evaluation of solar-powered instrument for hydroponic system in Limapuluh Kota, Indonesia *Int. J. Adv. Sci. Eng. Inf. Technol.*

[4] Maucieri C, Nicoletto C, Junge R, Schmautz Z, Sambo P and Borin M 2018 Hydroponic systems and water management in aquaponics: A review *Ital. J. Agron.*

[5] Mehra M, Saxena S, Sankaranarayanan S, Tom R J and Veeramanikandan M 2018 IoT based hydroponics system using Deep Neural Networks *Comput. Electron. Agric.*

[6] Triawan M A, Hindersah H, Yolanda D and Hadiatna F 2017 Internet of Things using publish and subscribe method cloud-based application to NFT-based hydroponic system *Proceedings of the 2016 6th International Conference on System Engineering and Technology, ICSET 2016*

[7] Bakhtar N, Chhabria V, Chougle I, Vidhrani H and Hande R 2018 IoT based hydroponic farm *Proceedings of the International Conference on Smart Systems and Inventive Technology, ICSSIT 2018*

[8] Song Y H, Shim J S, Kinmonth-Schultz H A and Imaizumi T 2015 Photoperiodic Flowering: Time Measurement Mechanisms in Leaves *Annu. Rev. Plant Biol.*

[9] Yaddarabullah, Muttaqin M F and Rafiansyah M 2019 Service-Oriented Architecture for E-

Marketplace Model Based on Multi-Platform Distributed System *IOP Conference Series: Materials Science and Engineering*

[10] Blanusa T, Garratt M, Cathcart-James M, Hunt L and Cameron R W F 2019 Urban hedges: A review of plant species and cultivars for ecosystem service delivery in north-west Europe *Urban For. Urban Green.*

[11] Wei H, Huang Z and Lin M 2017 A decision support system for plant optimization in urban areas with diversified solar radiation *Sustain.*

[12] Handy Permana S D, Bayu Yogha Bintoro K, Arifitama B, Syahputra A and Cendana M 2020 Improvisation of Minimax Algorithm with Multi Criteria Decision Maker (MCDM) in the Intelligent Agent of Card Battle Game