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INNOVATION OF SMART AGRICULTURAL CONTROL SYSTEM IN NFT HYDROPONIC BASED ON ARTIFICIAL INTELLIGENCE OF THINGS

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ABSTRACT

Rapid population growth has had a significant effect on increasing food demand. However, the conversion of agricultural land to non-agricultural land cannot be avoided. Currently, there are only 8.1 million hectares of agricultural land and it is estimated that this will decrease to 5.1 million hectares of agricultural land by 2045. Hydroponic agriculture is one of the solutions for efficient use of agriculturalland, one of which is the Hydroponic Nutrient Film Technique. That must be maintained and controlled are pH, Electrical Conductivity (EC), and flow. The optimum value of each parameter is pH 6, EC 5mS cm-1, and a flow of 1.5 l / m. However, the optimal value of each parameter will change with changing conditions and environment. As an innovative solution, the authors offer SANIC technology, a smart agricultural control system in NFT hydroponic based on artificial intelligence of things. The methodology used in this paper is ADDIE (Analysis, Design, Development, Implementation, and Evaluate). This technology has a multifunctional plant treatment that works automatically. The equipment is integrated with several components such as a pH sensor, Solenoid Valve, Flow Sensor and EC meter. The main system of this technology is controlled intelligently by Fuzzy Logic rules. This technology is also equipped with solar panels to support environmentally friendly energy needs.

KEYWORDS

Nutrient Film Technique, Hydroponics, Intelligent Agriculture, Artificial Intelligence of Things.

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INTRODUCTION

The high demographic bonus is inseparable from the quantity of human resources possessed, it was recorded that the total population in Indonesia in 2015 was 255.6 million and it is projected that by 2045 the population in Indonesia will reach 318.9 million [1]. The higher the population growth, the more it is in line with the needs that must be fulfilled [2]. The limited amount of free land forces the conversion of agricultural land to non-agricultural land. This of course has a bad impact on increasing the quantity of agricultural production, especially food to meet community needs.

The current agricultural land area is 8.1 million hectares, and it is projected that in 2045, only 5.1 million hectares are left [3]. Hydroponic agricultural innovation is present as an alternative solution to the efficiency of limited land use. According to Carvalho et al [4], hydroponics is a technique of cultivating plants without using soil, but using water as the medium. One type of hydroponics that has begun to be developed and adopted is the Hydroponic Nutrient Film Technique (NFT), this is because the fertigation system model that is owned is different. In order to get maximum results, the NFT hydroponic system needs to pay attention to the flow rate of water, water quality, EC (Electrical Conductivity) value, and pH of nutrient solutions [5]. All of these components play their respective important roles in optimizing hydroponic plant growth. Elemental absorption will be maximal in hydroponic systems when the pH is in the range 5.5 - 6.5 and optimal at 6.0 [6]. With this background, the idea of SANIC (Hydroponic Smart Agriculture) was created. Thissystem is an intelligent system that is able to regulate optimal maintenance automatically quickly and accurately. SANIC is expected to be an effective innovation in the maintenance of hydroponic NFT plants and become a driver of intelligent agricultural technology in the era of the industrial revolution 4.0. The purpose as an innovation to improve the maintenance system in hydroponic agriculture in Indonesia

RESEARCH METHOD

SANIC design used ADDIE method. This method is suitable for producing a particular product, and testing its effectiveness.

Research Stages

a. Analysis

At this stage, the author analyzes the problem that occurs in this era, that it is necessary to innovate a hydroponic smart control system that is intelligent and able to work automatically, namely SANIC.

b. Design

At this stage the authors designed the SANIC system innovation concept in NFT hydroponic agriculture. The conceptual design is made with a plan that includes the purpose of using the product, the target, description and explanation of components in SANIC and its functions.

c. Development

After completing design of SANIC system, the next stage is the development of the tool by testing to find out deficiencies and making improvements at the next stage.

d. Implementation

The author will implement the SANIC system in hydroponic NFT agriculture in Indonesia after receiving cooperation from various parties, such as the Government, Private Sector and the Community.

e. Evaluate

Evaluation is done after the concept of SANIC has been realized and used by farmers so that it is known the lack of SANIC system so far.

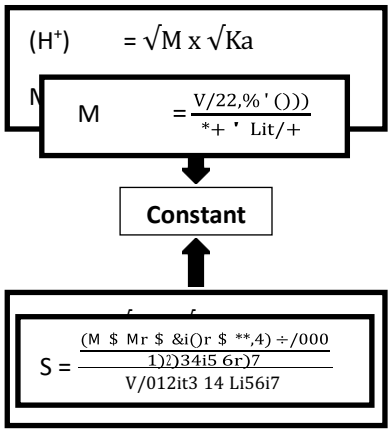
RESULT AND DISCUSSION

SANIC is an innovative smart care system for hydroponics NFT. The SANIC concept combines an intelligent control system in the form of ideal pH settings, water flow rates, and EC value requirements. The pH reading is carried out by the pH sensor, while the water flow rate is carried out by the flow sensor and the EC value is measured by the EC meter. SANIC implements an artificial intelligence fuzzy logic model system, this system can formulate the knowledge of an expert [7]. The intelligence of this system is embedded in a microcontroller which functions as the brain where all processes in SANIC are carried out.

pH Setting

There is a pH setting formula that is designed for optimal setting results, the following is the calculation of the formula used in the SANIC Program :

Value Ka = $1{,}34 \times 10^{-10}$, Value Kb = $1{,}6 \times 10^{-6}$



Substitute the value in the molarity equation to get the volume.

Substitute the molarity equation formula in the discharge calculation formula to determine the time required.

Information:

(H^+) = Concentration of Ion H^+

(OH) = Concentration of Ion OH

Ka = Acid ionization constant

K = Alkaline ionization constant

M = Molarity

Mr = Relative Molecular Mass of Acid/ Base Compounds

S = Left open solenoid

*The input value in the formulation is adjusted to the technical specifications of the tool.

Debit Setting

The process of controlling the flow of water is carried out by a flow sensor with the following physics formula :

$$Q = \frac{V}{t}$$

Information:

Q = Water Flow Discharge

V= Volume in

t = Time

As the output system uses a pump to regulate the flow rate. The ON-OFF program system is implemented in this design to activate and deactivate quickly and precisely. Flow sensors are actively taking data continuously to get more accurate data.

EC Value Setting

The EC setting process starts from measuring the EC value and continues with processing and output orders. The sensor used is an EC Meter that can measure the EC value quickly and precisely.

The system applied to the SANIC concept allows all actions and orders to work automatically and in real-time. In practice, pH sensors, EC meters, and flow sensors are placed on hydroponic plant pipes. So that it can measure pH, water flow rate, and EC value with higher accuracy. Meanwhile, the solenoid and the acid-base solution container are placed near the reservoir to facilitate the mixing of the nutrient solution and acid-base solution. The following is the SANIC application design shown in **Figure 1**.

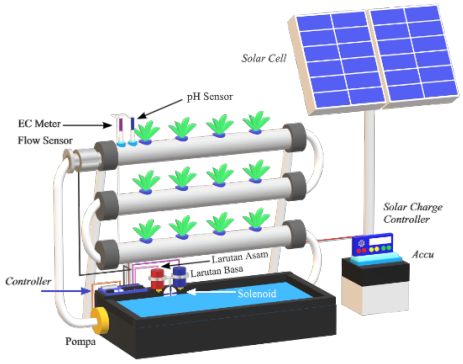


Figure 1. SANIC Design

SANIC Working Principle

This system will work when there is a change in the value of pH, EC, and the flow rate of the NFT hydroponic plant nutrient solution. The pH sensor, EC meter, and flow sensor will read and inform the microcontroller to carry out commands in the form of ON-OFF of the pump, adding nutrient solutions, or adding acid-base solutions. Technology cooperation scheme SANIC contained in **Figure 2** as follows.

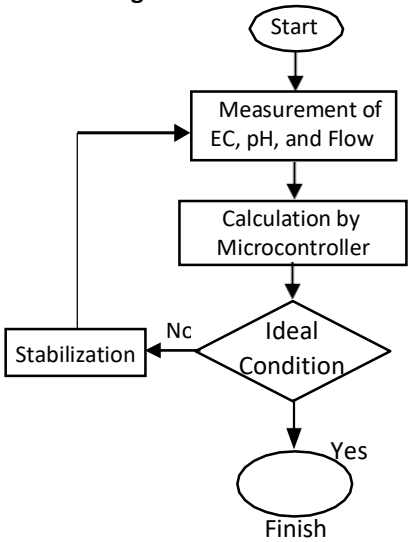


Figure 2. SANIC Flowchart

SANIC Monitoring System

In maximizing the work system of SANIC, a web automation system and monitoring of pH, EC, and flow rate of the NFT hydroponic plant nutrient solution device was created. This system works by utilizing the principles of artificial intelligence and the internet of things. With this

system, it is expected to make it easier to monitor and control the parameters of pH, EC, and nutritional value of the flow by using a smartphone or personal computer in real time. So that the quality of NFT hydroponic plants can be maintained and crop yields increase according to the target. The following is the SANIC monitoring system shown in **Figure 3.**

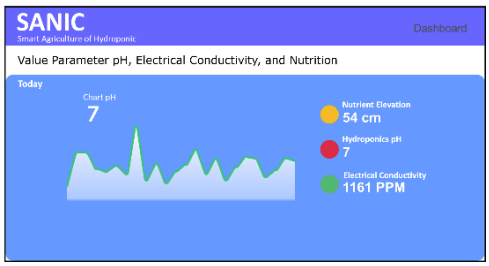


Figure 3. Interface of SANIC Website

The following is the SANIC Programming Architecture shown in **Figure 4.**

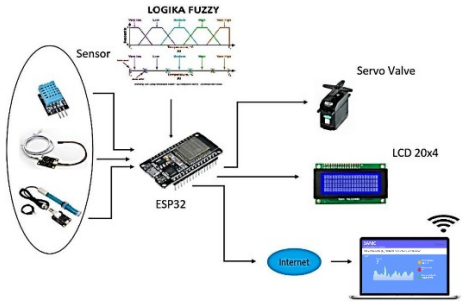


Figure 4. SANIC Programming Arsitecture

Roadmap Implementation

The implementation of SANIC concept through 5 main stages which includes :

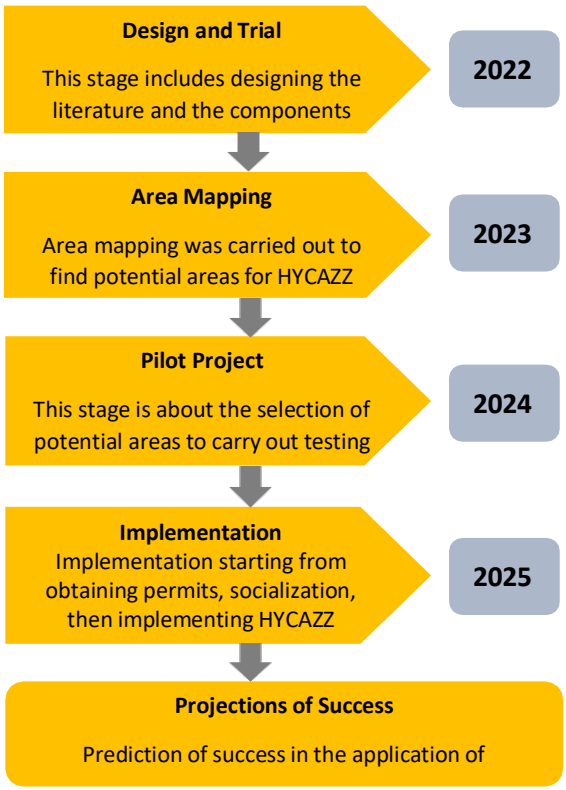


Figure 5. Roadmap Implementation

Success Projection

The success of SANIC technology is when it can accurately regulate the ideal requirements of plants. PH stability in the range of grades 6.0 capable of providing a significant impact on agricultural output of hydroponic NFT, because the absorption of growth will take place optimally. Based on the research of Kusuma et al [8], the pH value of 6.0 in tomato growth was able to increase yield in terms of plant height, the number of leaves, fruit weight, and the number of fruits. The following is a comparison of the results of the effect of pH on growth as shown in **Table 1.**

Table 1. Effect of pH Value on Plant Growth

pH	Height (cm)	Number (Sheet)	Fruit Mass (gram)	Number of Fruits
6,3	31,88	100,78	41,32	8,60
7,5	25,77	68,67	26,97	7,85
Increase	23,70%	46,76%	53,21%	9,55%

Based on these results, when successfully applied to NFT hydroponics, the percentage of success (PS) can be projected as follows :

$$\mathbf{PS} = \frac{\Sigma \mathbf{pH\ Stable} - \Sigma \mathbf{pH\ Unstable}}{\Sigma \mathbf{pH\ Unstable}} \mathbf{x\ 100}$$

$$= \frac{182{,}58 - 129{,}26}{129{,}26} \mathbf{x\ 100}$$

$$= \mathbf{41{,}25\%}$$

The EC (Electrical Conductivity) value has a impact in nutrient solutions. A stable EC value is estimated at 2.5 mS cm-1 which can provide optimal nutrient absorption [9]. The following is a comparison of the EC values shown in **Table 2.**

Table 2. The Effect of EC Value on Plant Growth

EC ($mS.cm^{-1}$)	Height (cm)	Leaf (sheet)	Leaf Area (cm^2)	Plant Weight (g)
1	4,14	5,46	3,89	17,85
2,5	4,56	5,75	4,11	28,11
Increase	9,21%	5,31%	5,7%	57,5%

Based on these results, when successfully applied to NFT hydroponics, the percentage of success (PS) can be projected as follows:

$$\mathbf{PS} = \frac{\Sigma \mathbf{EC\ Stable} - \Sigma \mathbf{EC\ Unstable}}{\Sigma \mathbf{EC\ Unstable}} \mathbf{x\ 100}$$

$$= \frac{42.53 - 31.34}{31.34} \mathbf{x\ 100}$$

$$= \mathbf{35.71\%}$$

The appropriate water flow rate can have a impact on the flow of nutrients to plant roots. The flow rate of water that is appropriate to the age of the plant roots average is in the range of 1.5 l / m [10]. The following is a comparison of the results of the effect of the water flow rate on growth shown in **Table 3**.

Table 3. Effect of Water Flow Discharge on Plant Growth

Flow Rate (L/m)	Height (cm)	Number of Leaves (sheet)
0.5 – 1.5	22.67	8.11
3.5 – 4.5	19.1	7.33
Percentage Increase	18.69%	10.64%

Based on these results, when successfully applied to NFT hydroponics, the percentage of success (PS) can be projected as follows :

$$PS = \frac{\Sigma \text{Flow Stable} - \Sigma \text{Flow Unstable}}{\Sigma \text{Flow Unstable}} \text{ x } 100$$

$$= \frac{30.78 - 26.43}{26.43} \text{ x } 100$$

$$= 16.46\%$$

As for the overall percentage of success (PK Total) can be calculated as follows :

$$PS = \frac{\Sigma \text{PS Value}}{\Sigma \text{PS Total}} \text{ x } 100$$

$$= \frac{41.25 + 35.71 + 16.46}{3} \text{ x } 100$$

$$= 31.14\%$$

So that through the use of technology SANIC afford me enhancing the NFT hydroponic agricultural production amounted to **31.14%**.

CONCLUSION

a. SANIC is an artificial intelligence-based control system for controlling the ideal pH, water flow rate, and the need for EC value as an effort to optimize NFT hydroponic agriculture.
b. The system then optimize the growth of hydrophonic plant by setting pH at 6, EC at 2.5 mS.cm-1, and flow at 1.5 l/m.
c. The SANIC concept is projected to increase plant growth by 31.14%.
d. SANIC is expected to be an effective innovation of hydroponic maintenance and is able to drive smart agricultural technology in industrial revolution 4.0.

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