Supply Chain Network Design in Determining Location of Solar Powered Pest Control to Increase Harvesting Effectiveness of Rojolele Rice in Delanggu

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Abstract

Pest problems are the most frightening scourge for farmers in the process of cultivating Rojolele rice which has high rice characteristics and fragrant aroma, so it is necessary to have environmentally friendly technology assistance to assist farmers in controlling pests such as sparrows and leafhoppers. Startup Ecokarsa's solar-powered pest control technology by utilizing ultrasonic waves to make sparrows uncomfortable and ultraviolet to collect leafhoppers at one point is expected to be a solution for the Sanggar Rojolele farmer group to help control pests in the rice fields of Delanggu without damaging the environment. Because this technology is considered quite expensive for the Sanggar Rojolele farmer group, an appropriate location and allocation system is needed to determine how many points are efficient and where these points are located so that the rice fields in Delanggu are safe from attacks by sparrows and leafhoppers.

Keywords
Solar Cell, Supply Chain Network Design, Location, Allocation.

1. Introduction
Rice is the staple food for about 50 percent of the population in Asia. In 2004, there were about 250 million rice fields in the Asian region (Hayami, 2004) or about 90 percent of the world's rice so that Asian food security is highly dependent on irrigated rice fields, which account for more than 75 percent of total rice production (Virk & Khush, 2004). Rice has become a witness and a commodity used for development policies in almost all of Asia because when

a country experiences a crisis, it is likely to increase the price of goods in that country. There are no Indonesian households that in 2008, 38 percent of households in rural Indonesia grew rice where agricultural employment was 58 percent of the non-poor and 75 percent of the poor working in the agricultural sector (McCulloch & Timmer, 2008).

Rojolele is a rice variety that is widely recognized as originating from Delanggu, Klaten with several advantages, namely fragrant aroma, large rice grains, white color, and soft rice texture. but post-planting maintenance tends to be more difficult because it is susceptible to planthoppers and sparrows. Rojolele rice planting around Delanggu had experienced a drastic decline due to the Green Revolution in the era of President Soeharto's leadership in 1968. The policy was intended to increase agricultural production to meet food needs in Indonesia. This is because Rojolele is susceptible to pests and the planting period reaches 6 months whereas ordinary rice only takes about 3 months to plant (Rochwulaningsih, Rinardi, & Sulistiyono, 2008). In November 2020, farmer groups assisted by Sanggar Rojolele were given the trust to plant Rojolele rice varieties from lab trials by BATAN (National Nuclear Energy Agency) so that Rojolele seeds cannot be planted outside Klaten. Sanggar Rojolele intends to cultivate this new variant of Rojolele rice with organic treatment, so pest control is not carried out using inorganic pesticides but using solar-powered ultraviolet and ultrasonic technology.

A solar pest control technology called UVUS (Ultraviolet Ultrasonic) developed by the startup Ecokarsa utilizes ultrasonic waves that have been set in frequency where these frequencies can make pests such as sparrows feel uncomfortable approaching rice fields in Delanggu village (Ogochukwu, Okechukwu, & Nnaegbo, 2012), while ultraviolet waves are used to attract pests. planthoppers to minimize the spread and proliferation of leafhoppers in the Delanggu rice fields. This technology is expected to replace the use of inorganic pesticides that are used every month to repel pests (Sudarmono, Waluyo, & Wilopo, 2020).

The supply chain design is used to determine the location and allocation of UVUS in the rice fields of Delanggu village by considering investment costs, investment feasibility, and equipment effectiveness because UVUS can affect the quantity of Rojolele rice. By determining the exact location and allocation of UVUS, several points that are considered efficient for pest control can be selected, to minimize UVUS investment costs and the Rojolele rice produced has a high quantity so that it can be said to be a good business because it implements supply chain network design (Watson, Lewis, Cacioppi, & Jayaraman, 2013).

2. Literature Review

According to (Watson, Lewis, Cacioppi, & Jayaraman, 2013) The number and location of a facility's placement are important factors in achieving success in supply chain activities. Some experts suggest that 80% of supply chain costs are locked with facility location and optimal product flow determination. Successful companies understand these problems and find solutions by forming strategies by emphasizing the determination of efficient facility placement. The discipline used to determine the optimal location and size of facilities and through the facilities is called supply chain network design. The placement of UVUS technology is very taken into account in obtaining high effectiveness because it includes area coverage and equipment investment costs so that the operating principle of an economical electric power system, namely running an electric power system operation at an economical cost is taken into account in this study (Wood, Wollenberg, & Sheble, 2013). One of the causes of the increase in operational costs is the amount of losses on the transmission line. When the power loss is greater, the greater the power loss is wasted, so steps are needed to minimize power losses (Cired L. R., 2017). The loss of this system can be minimized by redistribution in this supply chain system with Optimal Reactive Power Dispatch (ORPD) (Abido, 2006). The ORPD problem in this study uses the Flower Pollination Algorithm (FPA) method developed by Xin-She Yang in 2012, which is a meta-heuristic method inspired by flower pollination (Yang, 2012). From this case Supply Chain Network Design (SCND) is very important to determined location allocation UVUS and has a great influence on the overall performance of the supply chain (Wang, Wang, & Yu, 2020). SCND plays an important role in the overall success of the Supply Chain Network (Babazadeh, Ghodsi, & Razmi, 2013) (Zheng, Yin, & Zhang, 2019).

3. Methods

The problem statement of the problem of the SCND case for Rojolele rice in Delanggu village is the control of pests that attack new varieties of Rojolele rice with UVUS technology innovation using renewable energy to reduce the cost of purchasing pesticides every month and increasing the quality and quantity of new Rojolele rice varieties with UVUS. Determining the location of the warehouse for distribution outside the city is also in the spotlight because there are many enthusiasts who want to consume this rice but the limited number of seeds that can be circulated and the prohibition of this seed from circulating outside Klaten so that the selection of warehouses must be considered so as not to consume large production costs. The supply chain network design is shown in figure 1.

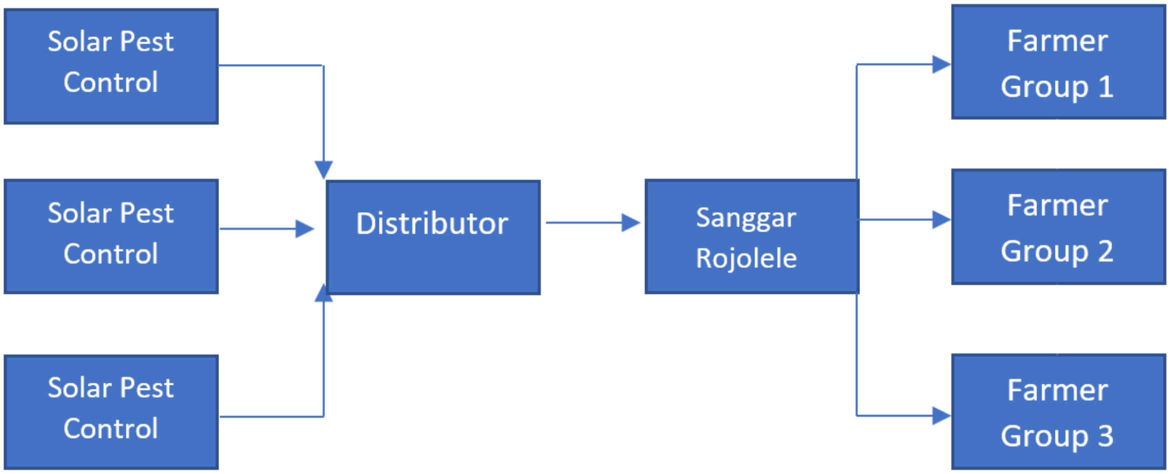

Figure 1. Framework for Supply Chain Network Design

The purpose of this optimization study is to obtain the lowest value in the production cost of Rojolele rice of new varieties to be circulated inside and outside the residency of Surakarta by considering the effect of UVUS technology to repel pests in rice fields and to improve the quality and quantity of new varieties of Rojolele rice.
An important decision from the results of this analysis is the installation of UVUS which is spread at several points in the rice fields of Delanggu village in each of its rice fields. The second decision is to determine the selling price of the product based on the new production cost after the innovation of renewable energy technology that reduces the use of pesticides so that it is more environmentally friendly and can be used for a long time. The final decision is to determine the feasibility of the investment and the estimated cost of capital.

Flower Pollination Algorithm can be defined as flower pollination algorithm is an algorithm inspired by the transfer of pollen to the pistil. Xin-She in 2012 gave the idea of nature-inspired localization especially in flower plants. Flowers are used for reproduction in species through pollination. Transfer of powders can occur with the help of pollinators such as insects, flowers and other animals.

The process of modeling the objective function so as to minimize the amount of solar-powered pest control technology. This function is used to determine the position of the point that returns the minimum value based on the condition that each rice field area must be covered by solar-powered pest control technology, so that the number of solar-powered pest control technologies installed will have a considerable influence on determining the value of the optimization function. This optimization function is shown by the equation (1)

$$Z = \sum_{i=1}^{n} \left(\left| \frac{d(m_i, b)}{r} \right| \right) + k$$

Where:
Z = Optimization function.
n = Number of area.
m_i = Location of i-th area.
b = Location of the i-th solar-powered pest control technology.
r = Radius of solar-powered pest control technology.
k = Many solar-powered pest control technologies.
$d(m_i,b)$ = Distance between area i and nearest solar-powered pest control technology.

Pollination is divided into two types, namely self-pollination and cross-pollination. Self-pollination is pollination whose process starts from the fall of pollen from a flower to the flower itself or to another flower similar to that flower. While cross-pollination is pollination whose process starts from the fall of pollen from one flower to flowers or plants of different types.

Flower Pollination Algorithm (FPA) is basically composed of four pollination rules, namely:

1. Self-pollination occurs when the pollen that falls comes from the same flower or other flowers of the same plant type. In FPA self-pollination can be defined as local pollination.
2. Cross-pollination occurs when the pollen that falls comes from flowers that come from different types of plants. This pollination is then implemented by following the Levy distribution by jumping or flying long distances. In FPA cross pollination can be defined as global pollination.
3. Local pollination and global pollination are regulated by a range of values between 0 to 1 which is called Switch Probability.
4. Flower Constancy is a collection of pollinators and flower types.

In local pollination using rule number 4 about Flower Constancy is used to find the solution to the next step (${X_i}^{t+1}$) using the value from the previous step (${X_i}^{t}$). Local pollination is shown in equation (2)

$$ {X_i}^{t+1} = {X_i}^{t} + \varepsilon\left({X_j}^{t} - {X_k}^{t}\right) $$

Subscipt i denotes the I-th powder, while ${X_j}^{t}$ and ${X_k}^{t}$ are solutions from different plant species. is a random number whose value is between 0 and 1. Based on the four rules above, switch probability (p) is used to select the type of pollination that controls the optimization process in iterations. Whereas in global pollination the second and fourth rules are used together to find the solution to the next step (${X_i}^{t+1}$) using the value from the previous step (${X_i}^{t}$). Global pollination is shown in equation (3)

$$ {X_i}^{t+1} = {X_i}^{t} + L({X_i}^{t} - g^{*}) $$

Subscript i denotes the i-th powder and equation (3) is applied to powders on flowers. g* was the best solution at the time. L is the flight distance of the Levy distribution.

4. Data Collection

UVUS technology has been applied in several rice fields in Delanggu, Berbah, Boyolali, and Karanganyar to repel sparrows and leafhoppers. As long as this technology has been installed, data related to the product are taken, such as the range of the tool, the specifications of the tool, and the durability of this tool with details as shown in table 1.

Table 1. UVUS Specifications

Specifications UVUS Technology
Solar Cell 10wp
Battery 3.5 Ah 12v
Tweeter Speaker 50Khz 12v
Ultraviolet Lamp 390-400nm 3.6v
Ultraviolet sensor turns on automatically at night
Lifetime 3 years for tools
Lifetime 10 years for solar cell
No need maintenance costs
Ultraviolet covers a radius of 125.600 m^2
Ultrasonic covers a radius of 31.400 m^2
Input 17.5 – 21V

Dimensions 30cm x 45cm x 25cm
Open Source
There is no legality and license
Investor Startup Ecokarsa

The Ecokarsa team consisting of Gilang Titah Ramadhan, Fuad Fachrizal Achsan, Krisna Wahyu Wardhana, Nambang Rizal Saputra and Faishal Najib conducted research on Solar Power Plants (PLTS) to help farmer groups in Delanggu to repel pests with the aim of providing agricultural technology education to the group. farmers, replacing old technology that is less environmentally friendly, and cutting operational costs in cultivating new varieties of Rojolele rice. The prototype of UVUS technology is shown in figure 2.

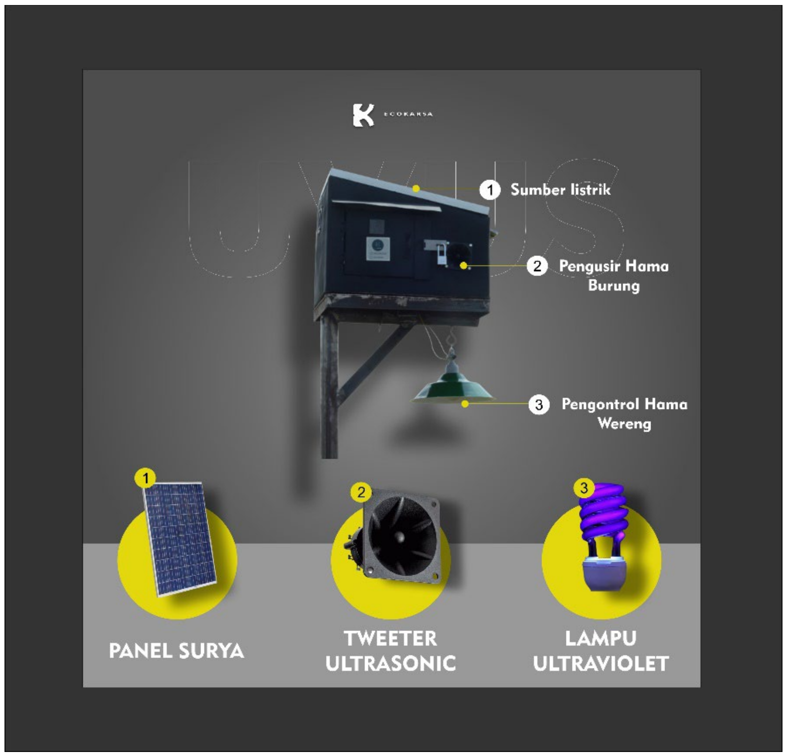

Figure 2. UVUS Prototype (Source Instagram @eco_Karsa, 2021)

This research is expected to be able to repel pests such as sparrows and leafhoppers so that the quantity and quality produced in the Delanggu rice fields can increase. UVUS technology is still in the research stage and searching for data for approximately 8 months which can later be analyzed further to find the optimal location viewed from several aspects such as infrastructure, social and economic environment. Due to the location selection and allocation in this study, great attention was paid to getting the minimum number of tools but having optimal results in repelling pests in the Delanggu rice field area of 249.085 m^2 as shown in Figure 3.

Figure 3. Delanggu Rice Field Map (Source on google maps 2021)

The map of the Delanggu rice fields was then made into a matrix with image processing using the MATLAB application and then analyzed using the Flower Pollination Algorithm (FPA) method to determine how many tools should be installed and where is the right location to cover the Delanggu rice fields. The results of converting the image into a matrix are visualized in Figure 4 as shown below:

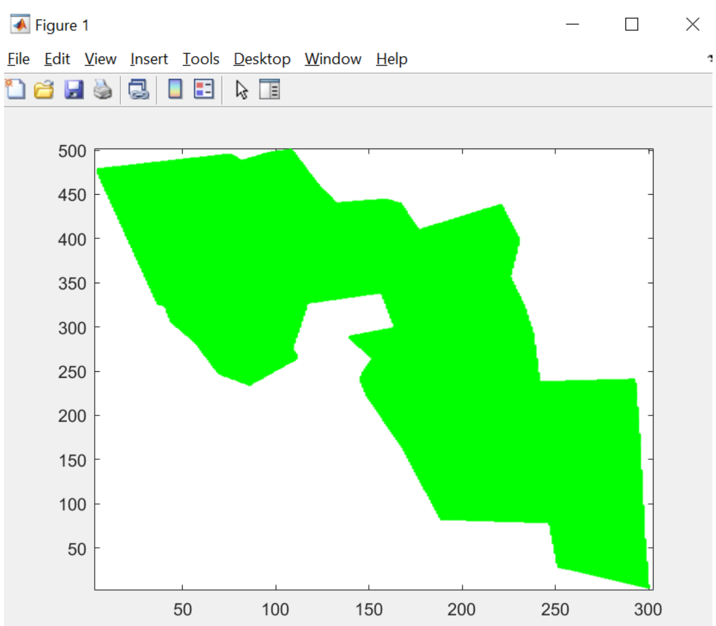

Figure 4. Plot Delanggu Rice Field Map in Matrix (Source on Ecokarsa 2021)

Then, the coordinates of the location of the solar-powered pest control technology were initiated which were already installed in the rice fields. The data is shown in table 2 and is primary data taken from Startup Ecokarsa when installing solar-powered midges.

Table 2. Coordinates of solar powered midges technology

UVUS	X	Y
1	75	400
2	186	387
3	197	243
4	242	160

5. Results and Discussion

The first step in this research is to find the optimization value of all solar-powered midges that have been installed with equation (1), while to determine the distance between solar-powered midges and rice fields, the Euclidean formula shown in equation (4) is used.

$$d(m_i, b) = \sqrt{(x_p - x_q)^2 + (y_p - y_q)^2}$$

Where:
$m_i = (x_p, y_p)$
$b = (x_i, y_i)$
x_p = x-coordinate of m_i
x_q = x-coordinate of b
y_p = y-coordinate of m_i
y_q = y-coordinate of b

Based on these calculations, it is obtained that z = 5036 is obtained when the value of k = 4. The value of z depends on the distance between the solar-powered pest control technology and the Delanggu rice field area and the number of solar-powered pest control technologies in the Delanggu rice field that have been determined. The further away the solar-powered pest control technology is from the rice field area, the greater the Z value. However, the Z value can be minimized by increasing the number of solar-powered pest control technologies so that areas that were not previously covered can be covered and the resulting Z value can be smaller.

By using iterations 5 times, finally we get z as shown in table 3 below:

Table 3. optimization value

Iteration	Z
1	6202
2	4619
3	3249
4	2173
5	2229

Judging from the z value in the 5 iterations, it can be concluded that the smallest Z is in the 5th iteration so that the coordinates taken are the coordinates of the results of the 4th iteration. The values of x and y from the 4th iteration are shown in the 4th table below:

Table 4. Coordinates of solar powered midges technology after optimalization

	X	Y
1	82	397
2	165	345
3	212	193
4	252	75

6. Conclusion

Utilization of optimization with modeling through programs is very much needed in the placement of a tool, facility, or building because the right placement will result in an efficient level of performance of the tool or facility that will be used in a location. The placement of Ecokarsa's solar-powered pest control technology installed in Delanggu's rice fields also did not consider the coordinates at first, so that many areas were not covered and many areas overlapped.

By using the flower pollination algorithm method, it can be concluded that initially the uncovered area was 19,912m^2, after optimization and new points were obtained for the four solar-powered pest control technologies, resulting in an uncovered area of 8599m^2.

With this comparison of placement locations, it is hoped that the facility in the form of solar-powered midges technology can function efficiently by looking at the installation location and reach of the tool, so that when this tool is to be implemented elsewhere, the party who will install this solar-powered midges technology can predict how much the appropriate amount for the area and where the location of the installation is effective and can reach all areas.

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