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# An Application of Zoning Designated Policy to Locate the Fresh Fruit Bunch Collectors in the Oil Palm Supply Chain: Southern Thailand Case Study

**Phonnapha Nootim[1*], Wanatchapong Kongkaew[2], Nikorn Sirivongpaisal[3], Kanya Auckaraaree[4]**
[1,2,3] Department of Industrial Engineering, Faculty of Engineering, Prince of Songkla University.
[4] Department of Agro-Industrial Management, Faculty of Agro-Industry, Prince of Songkla University.
Email: phonnapha.k@gmail.com

**Abstract.** This research aims to conduct the zoning designated policy to find the appropriate number of oil palm collector (called *ramp*), which is the main player to collect and distribute the fresh fruit bunch in upstream of oil palm supply chain. The set covering problem is applied together with the consideration on the distance between ramps. In this paper, the distance on 3 kilometres is implemented on set covering model and it is solved by the premium solver platform in Microsoft Excel. As a result, it showed that the number of appropriate ramps is at 110 ramps, instead of 452 ramps found in present.

## 1. Introduction

Palm oil industry is one of important industry in ASEAN community, where is a major oil palm production in the world. In 2014-2015 Indonesia and Malaysia produced 85.91 percent of the world. Indonesia's crude palm oil produced 33 million tons per year and Malaysia produced 19.80 million tons per year, while Thailand produced 1.80 million tons per year (2.93%) and also produced as the third place of the world [1]. For Thailand, 85.41 percent of oil palm plantation area is in southern Thailand. The highest productive province is in Surat Thani, Krabi and Chumphon, respectively. In May 2016, it showed that the oil palm plantation in Krabi has increased by 5.34%, yielding totally 3,293,450 tons per year.

From research entitled "Development a model for cooperation in the upstream supply chain of palm oil and palm oil industries in Thailand: case study of Trang and Krabi." by Kanya Auckaraaree et al. [2], it found that the collection and distribution have been transported across the area (both sub-district and district) although there are ramps and refinery plant in that area. Moreover, at the present in Krabi, there are too many ramps (exactly 452 ramps) while the capacity of all refinery plant is enough to operate with the FFB produced from plantation. This only affects to the collect the fresh fruit bunch (FFB) in full-truck capacity of ramp. In order to struggle raw materials, they open the branches near oil palm plantation to collect the material even more. The average distance between the ramp and its brunch is 1.57 kilometres. This is the cause of ineffective collecting and distributing. The 45.7% of ramps can collected FFB less than 500 tons per month, the 35.7% of them has the collection volume around 500-1,000 tons per month, and the remain 18.6% can collected over 1,000 tons per month.

Locating the transshipment hubs is become increasingly important to the global logistics community. From the perspective of shippers and carriers. The selection must be consistent with the strategy to control costs and to maintain the reliability of the service provider [3]. The collecting and distributing raw materials in oil palm supply chain is occurred in a transit area or across the district, although there are ramps and refinery plant in the area. This may result in the cost of shipping raw materials higher than it should be. Since transportation costs (fuel consumption) is proportional to the distance shipping [4]. In addition, the amount of fruit ripening on the purchase, it will affect the performance of palm oil extraction plant of the same. Based on our past study [5], the result showed that the total transportation cost of Krabi province is 1,092,328 980 baht per year, in which the cost of the farmer (i.e., transportation cost from plantation area to ramp) is 823,364,750 baht per year an the cost of the ramps (i.e., transportation cost from ramp to the mill) is 275,496,259 baht per year. Therefore, if the zoning designated policy can be applied to stipulate in term of the distance between ramps and/or the distance between the ramps and the mill in the collection and distribution of FFB, the transportation of FFB in the transit or across the area will be decreased either from the farmer to the ramps or the ramps to the extraction plant. It results in lower transportation costs, comparing with the current situation.

This research aims to study and analyze the performance improvements in the collection and distribution of raw materials (fresh fruit bunch of palm oil) in the upstream supply chain, including of oil palm plantation, ramps and crude palm oil mill. As the aforementioned number of ramps, The first question in research is “Are the currently opened ramps excessive?. Hence, in this paper, the objective is to find the appropriate number of the ramps and their locations with the restriction on distance between ramps corresponding to the zoning designated policy and the coverage all points, based on the existing ramps plants.

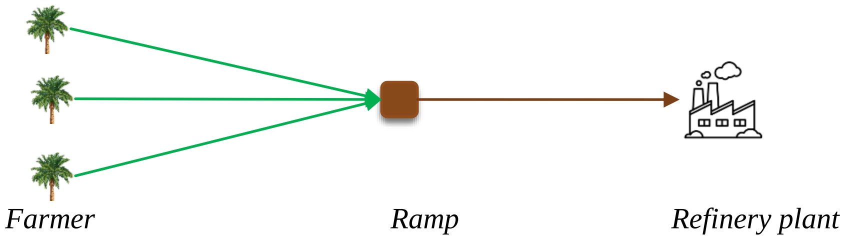



**Figure 1.** Oil palm’s collection and distribution.

## 2. Literature Review

This research aims to improve the collection and distribution of FFB in oil palm supply chain, by finding the location of the ramps which is the main actors to collect and distribute oil palm in the upstream of supply chain. To get the most promising answer, it should be study the location-allocation applications in literature and select an appropriate model to implement. For example, Karatas and Yakıcı [6] applied three models in facility location problem, including p-Median, maximal coverage and p-Center to find the number and location of emergency Becket stations. By choosing the appropriate answer of all the best from the traditional model, it should select the scenario based on the quantity and location of the service with the minimum cost.

### *2.1. Median Problems*

The solution of median problems is the location of $p$-facility with the purpose of minimizing cost of transportation between server and customer (in term of distance or time in transit). It may be also weighted according to the needs of the customers [7]. A common form of mathematical model is as below.

Minimize $\sum_i \sum_j h_i d_{ij} Y_{ij}$ (1)

subject to $\sum_j X_j = P$ (2)

$\sum_j Y_{ij} = 1$ ; $\forall i$ (3)

$Y_{ij} - X_j \leq$ ; $\forall i, \forall j$ (4)

$X_j \in \{0,1\}$ ; $\forall j$ (5)

$Y_{ij} \in \{0,1\}$ ; $\forall i, \forall j$ (6)

where $w_i$: The quantity of goods or services to a customer location $i$,
$d_{ij}$: The distance between the client's position or place where the service position $ij$,
$S_j$: The ability to service the property at that position $j$.

And, the related decision variables are

$$X_j = \begin{cases} 1 & \text{if we locate at potential facility site } j, \\ 0 & \text{otherwise,} \end{cases}$$
$$Y_{ij} = \begin{cases} 1 & \text{if demands at node } i \text{ are served by a facility at node } j, \\ 0 & \text{otherwise.} \end{cases}$$

*2.2. Set Covering Problem*

The set covering problem determines the minimum number of facilities needed to cover all demands using an exogenously specified coverage distance. The objective is to minimize the cost of facility location [7]. Mohaymany et al. [8] use the set covering problem to locate the emergency call center in order to find the center in which its service is covered all customer needs. The mathematical formulation of this problem is as follow.

$$\text{Minimize} \quad \sum_j c_j x_j \quad (7)$$
$$\text{subject to} \quad \sum_{j \in Ni} X_j \geq 1 \quad ; \forall \text{i} \quad (8)$$
$$X_j \in 1\{0,1\} \quad ; \forall j \quad (9)$$

where $c_j$: Fixed cost of facility at node $j$,
$S$: Maximum acceptable service distance (or time),
$N_i$: Set of facility sites $j$ within acceptable distance of node $i$ $(i.e., N_i = \{j | d_{ij} \leq S)$.

The decision variable is
$$X_j = \begin{cases} 1 & \text{if the center is openned at node } j, \\ 0 & \text{otherwise.} \end{cases}$$

*2.3. p-Center Problem (Minimax FLPs)*

The objective is to locate a given *p*-number of facilities in such a way that minimizes coverage distance. The *p*-Center problem is also known as the minimax problem, as seeking to minimize the maximum distance between any demand and its nearest facility [7]. The mathematical model is as follow.

$$\textit{Minimize} \quad D \quad (10)$$
$$\textit{subject to} \quad \sum_j X_j = P \quad (11)$$
$$\sum_j Y_{ij} = 1 \quad ; \forall i \quad (12)$$
$$Y_{ij} \leq X_j \quad ; \forall i, \forall j \quad (13)$$
$$D \geq \sum_j d_{ij} Y_{ij} \quad ; \forall i \quad (14)$$
$$X_j \in \{0,1\} \quad ; \forall j \quad (15)$$
$$Y_{ij} \in \{0,1\} \quad ; \forall i, \forall j \quad (16)$$

where $D$: Maximum distance between a demand node and the nearest,
$$X_j = \begin{cases} 1 & \text{if the center is openned at node } j, \\ 0 & \text{otherwise,} \end{cases}$$
$$Y_{ij} = \begin{cases} 1 & \text{if customer at node } i \text{ is seved by center } j, \\ 0 & \text{otherwise.} \end{cases}$$

## 3. Methodology

To find the appropriate number of ramps, we used the concept of set covering problem. The prescribed distance between each of the ramps is 3 kilometres to get the number of ramps and their location that cover all plantations in Krabi. The mathematical formulation is below.

$$\text{Objective function:} \quad \textit{Minimize} \quad N = \sum_j X_j \quad (17)$$
$$\textit{Subject to} \quad \sum_{j=J} X_j \geq 1 \quad ; \forall i \in I \quad (18)$$
$$\sum_{j \in J} a_{ij} X_j \geq 1 \quad ; \forall i \in I \quad (19)$$
$$X_j = \{0,1\} \quad ; j \in J \quad (20)$$
$$a_{ij} = \{0,1\} \quad ; \forall i \in I, \forall j \in J \quad (21)$$

where $X_j$ is decision variables,
$$X_j = \begin{cases} 1 & \text{if the center is openned at node } j, \\ 0 & \text{otherwise.} \end{cases}$$

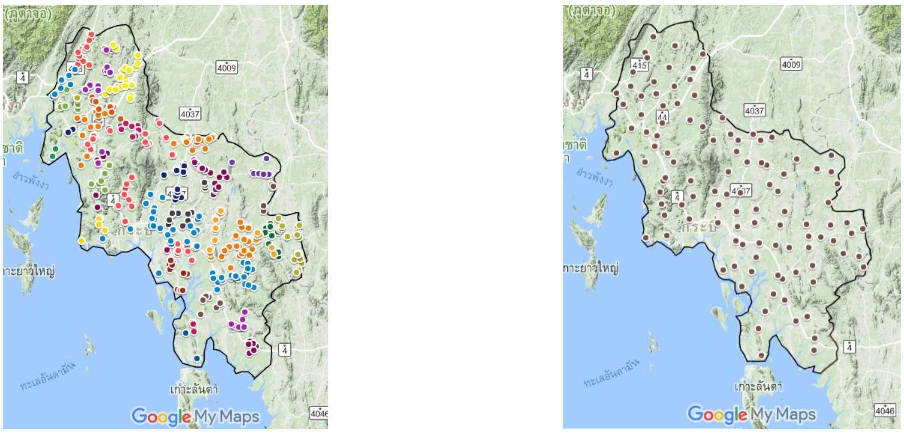
$a_{ij}$ is binary variable to consideration distance between the ramps $i$ and $j$ is under $L$ or not ($L = 3$ kilometres),

$$a_{ij} = \begin{cases} 1 \; if \; l_{ij} \leq L \\ 0 \; if \; not \end{cases}$$

$l_{ij} =$ distance from ramp $i$ and $j$, where $I = \{1,2,3, \dots ,452\}$ and $J = \{1,2,3, \dots ,452\}$,
$N =$ is the sum of ramp $j^*$, where $j^*$ is the opened ramp $j$.

## 4. Results

The number of the ramps and their location, covered by the 3 kilometres of distance, are obtained from the model. The result showed that the suitable number of ramps is 110 ramps, decreased by 342 ramps from 452 ramps. The plot of comparison on the location of ramps is shown in Figure 2.



*(a) Current locations (452 ramps)* *(b) Proposed locations (110 ramps)*

**Figure 2.** The position of the ramps.

## 5. Conclusion

This research aims to conduct the Zoning designate policy to find the appropriate number of oil palm ramp, which is the main player to collect and distribute fresh fruit bunch (FFB) in the upstream of oil palm supply chain. The set covering problem was applied to finding the suitable number and location of ramps under the restriction on the 3 kilometres of coverage distance between ramps. The result showed that the suitable number of ramps was 110 ramps, decreased by 342 ramps from 452 ramps, which can be the resolution in the future with the expectation that the farmers will cooperate in gathering the FFB, whether it is a ramp, cooperative or other forms not only aimed. The cost of transportation can be reduced, and it also helps strengthen bargaining power for farmers. To sustain the survival of farmers, this should be done with the government's policy of promoting agriculture because it can make an opportunity to support smallholder farmers with the integration of large production areas concept to effectively manage production and marketing together from production planning throughout the supply chain.

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