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Research Article

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Improving the capacity of local food network through local food hubs' development

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Abstract: The COVID-19 pandemic and humanitarian challenges such as war and conflict, climate changes, and economic crises bring unexpected humanitarian challenges, such as food insecurity. Especially for developing countries, this is a double crisis, food poverty and COVID-19 pandemic. This situation needs an alternative food network (AFN), which can improve the local food sources to fulfill the food demand. The local food hubs' (LFHs) development as an AFN that considers local producers and customers could serve as an alternative strategy to reduce the uncertainty of food availability. However, the challenge in developing LFH in developing countries is the problem of logistics efficiency. Therefore, this study discusses the development of food logistics efficiency by determining the optimum location of LFH and the fulfillment of food supply for each optimum location of LFH in rural areas. Robust optimization is applied to the Multi-Objective Many-to-Many Location-Routing Problem (MOMMLRP) model to handle the uncertain demand and production capacity. This study focused on West Java Province, Indonesia, as areas that represent developing countries. Based on our result, eight sub-districts have been determined as an optimum location to develop LFHs. This study also elaborates on the food network in the worst situation that needs regional food hubs' (RFHs) support. The RFH support can be used when the LFH faces an unexpected problem that cannot fulfill their demand.

Keywords: food security, local food hubs, regional food hubs, supply-demand matching, uncertainty

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1 Introduction

The COVID-19 pandemic is probably the most significant global crisis during this period and brings unprecedented humanitarian challenges, such as food insecurity [1,2]. The occurrence of man-made disasters such as conflict and war and climate change and economic crisis exacerbate the global communities' food insecurity situation [1,3]. The food insecurity is in line with the malnutrition, hunger, and poverty.

The core concepts of food security are when people can have access to food and have sufficient and safe food at all times for an active and healthy life [4–6]. However, the humanitarian challenges are causing people to lose jobs, income, and supply chains' disruptions. Especially for developing countries, this is a double crisis of food insecurity and COVID-19 pandemic [7].

This study only focuses on Indonesia, which faces uncertainty in food security. Based on the Global Hunger Index (GHI), Indonesia's GHI score reached 19.1 in 2020, illustrating that Indonesia is experiencing a severe hunger problem [8]. A massive challenge in solving this problem is Indonesia's total population, the fourth largest population globally [9]. Moreover, food security in Indonesia is also caused due to the inefficient logistics system.

The logistics system is one of the leading food insecurity problems in developing countries. The logistic activities during COVID-19 pandemic have been suspended, due to by strict lockdown, and the supply and demand of various products are affected by the uncertainty and complex situation [10–13]. This inefficiency of the logistics system also results in high logistics costs, increased food loss and waste, and unstable quality and quantity of food supply.

The emergence of various disruptions in the food logistics network encourages alternative food networks (AFN) through developing local food networks (LFN). LFN has become an alternative solution to fulfill food needs in tackling unexpected global situations [10,14,15]. Meanwhile, developing LFN in developing countries needs to consider that the food system is dominated by smallholder farmers, who do not have much access to improve their capacity and capability of farming [16,17]. The low competitiveness of smallholder farmers leads them to poverty due to the low profitability of the agricultural activities [18].

In addition, the characteristics of LFN in developing countries are quite complex and dynamic because of the concerns of the food chain actors which are mainly: the characteristics of agricultural land are fragmented, mismatches between supply and demand, lack of technology adoption, and lack of competitiveness [16,19,20]. The LFN in developing countries is deemed to be an effective strategy to ensure proper production, distribution, and marketing activities.

One alternative solution for developing LFN in developing countries is developing food hubs. The food hub is part of the local food system that helps local farmers develop their sustainable businesses by supporting local food production, logistics, and marketing [14,21]. In other words, a food hub is an aggregator hub that supports food security for the local communities [14]. Food hub consists of two different scopes: regional food hubs (RFHs) and local food hubs (LFHs). RFH is a hub that operates in a region or province scale, whereas LFH operates in a smaller area, such as districts within each rural area, aiming for local food sustainability [22–25].

The LFH concept can be an alternative solution that can support LFN development in developing countries. The LFH has been widely used as an AFN in various countries such as The United States of America, Canada, some European countries, Mexico, and the United Kingdom [14]. Meanwhile, LFH in developing countries is still a concept of AFN development to enhance the sustainability of food based on local production [10,14,21].

To support the development of LFH in developing countries, one must consider the effectiveness and efficiency of the food networks. Accordingly, the logistics and distribution processes are the main concerns of various researchers to improve the capability of LFH in food fulfillment. Etemadnia et al. discussed determining the optimum wholesale location to increase logistics efficiency using the Linear Programing-Mixed Integer Programing (LP-MIP) heuristic approach [26].

Meanwhile, Ge et al. mentioned that determining the optimum location of RFH helps improve the efficiency of local and regional economic scales using Mixed Integer Linear Programing Model (MILPM) [27–29]. Moreover, Perdana et al. elaborated on the analysis of the optimum location of RFH using a multi-objective many-to-many location-routing problem (MOMMLRP) [10]. No studies were able to determine the optimum location of LFH in rural areas in developing countries. Accordingly, the contribution of this article is determining the optimum location of LFH under uncertain demand and production capacity in rural areas. Determining the LFH location is also designed to fulfill food needs for rural society.

The optimum location model is part of the planning strategy to optimize the operating system of LFH in developing countries. The development of an optimum location of LFH contributed to reducing inefficiency in food logistics and supporting the sustainability of local food. Robust optimization (RO) is applied to the MOMMLRP model to handle the uncertain demand and production capacity. The model will solve the optimum location of LFH in Indonesia, as one of the representative of developing countries. The following sections discussed the literature review of this study, the methodology used in this study, and the result analysis and conclusion.

2 Literature review

2.1 Community food security and alternative local food networks

The COVID-19 pandemic brought massive challenges consequences on health and livelihood. No exception, these changes impact food security, especially in developing countries where most developing countries rely on the agricultural sector in developing the economies and livelihood [30,31]. The COVID-19 pandemic has been disrupting the development of food sustainability.

In contrast, between middle-up income and middle to the lower-income community, during the COVID-19 pandemic, the middle-up income community tend to change their lifestyle towards a healthy life [32–35]. This change brings challenges for AFN actors to provide safer, fresh, nutritious, and hygienic food [36–38]. Drastic changes in the food consumption patterns impact the production and food logistics processes. Other humanitarian challenges exacerbate the current food logistics process, such as wars and conflicts, climate change, and economic crises.

The impact of COVID-19 pandemic and humanitarian challenges have multiple impacts on health and livelihood, many people lose their jobs and income, thereby increasing the risk of food insecurity. Accordingly, LFN is needed to help local farmers to distribute their products to the local customers [39]. The LFN disruptions that need to be reduced to remain resilient are demand and supply uncertainty. Uncertainty refers to disturbances that affect consumers' willingness to buy certain food products, resulting in uncertainty in price fluctuations and product quality. The uncertainty of food supply is also a disturbance that affects the willingness of the producers to produce certain commodities [40].

Accordingly, these challenges need an appropriate strategy that could improve the food security and livelihood. This situation needs an innovative application of LFN, especially in developing countries [41]. Viewed from the other side, the COVID-19 pandemic and humanitarian challenges positively impact LFN actors to increase the capacity and capability of local food to fulfill food needs for local communities. This situation can improve the local communities to work differently, increase collaboration, and improve outcomes for those most in need [42]. Improving the LFN as AFN is also discussed as an innovative strategy to develop the sustainability of the local agricultural system and the local communities [43,44].

LFN is also an alternative to reduce dependence on imports of staple foods [45]. However, LFN development needs to be supported by capacity building and LFN actors' capability to provide food for the local society. The primary step in developing LFN in developing countries is to measure the efficiency of the food logistics system (FLS) [46,47]. The FLS is an effort to reduce the inefficiency of food logistics, especially in developing countries [46,47].

Moreover, FLS also needs to consider determining the hub location to facilitate distribution channels to retailers in the market areas [10]. The development of a FLS also increases the capability of LFN actors to estimate the availability of food supply and demand.

2.2 The potential LFHs in developing countries

Reducing the uncertainty of FLS in developing countries should consider the complex situation of the LFN. Thus, LFN in developing countries requires agile and robust AFN [15]. One alternative for developing LFN is LFHs. LFH is a distribution channel that plays a role as an aggregator hub to collect yield, conduct post-harvest and logistics services, and distribute the local food products to fulfill local customers' needs [14,25,24].

LFH is an AFN addressing to mitigate food poverty [24]. LFH is designed to meet the food availability for the local community, sourcing from local food. The area of operation of LFH is intended to serve smaller areas, such as to ensure food security in districts or cities [10,24]. LFH is designed to improve the capability of LFN actors to achieve the sustainability of food in developing countries [38,48].

LFH is designed to support the increase in value competitiveness of the local food products [14,25]. LFH is used to support the local producers to meet the local customer's requirements through providing production, logistics, and marketing services [14]. LFH is designed to increase the value of local products by increasing the quality and forecasting the availability of products in the market so the local producers can estimate the demand for the products [49]. LFH also develops, based on the community approach, the business process based on social entrepreneurship [50].

LFH develops based on a value-based approach, develops a business based on social entrepreneurship, aiming to develop the sustainability of LFN [49,51,50]. LFH brings opportunities for developing countries to increase their capability of agricultural sectors and can be an opportunity for local economies.

3 Materials and method

3.1 Case study of the research

This study focuses on West Java Province, which has the highest population in Indonesia [52]. West Java Province is also one of the main agricultural producers in Indonesia. As a buffer zone for the capital's food needs, West Java Province also needs to meet the community's food needs. In particular, we focus on the Greater Bandung area, which includes Cimahi City, Bandung District, West Bandung District, and Bandung City, as depicted in Figure 1. In this study, we focused on the level of sub-districts. A total of 80 sub-districts are considered in this issue.

Greater Bandung, the capital city of West Java Province, is a metropolitan area, and the primary production area of rice. According to the statistics of West Java, 2 of 4 cities and regencies in Greater Bandung act as rice production center [53–56]. The rice production capacity

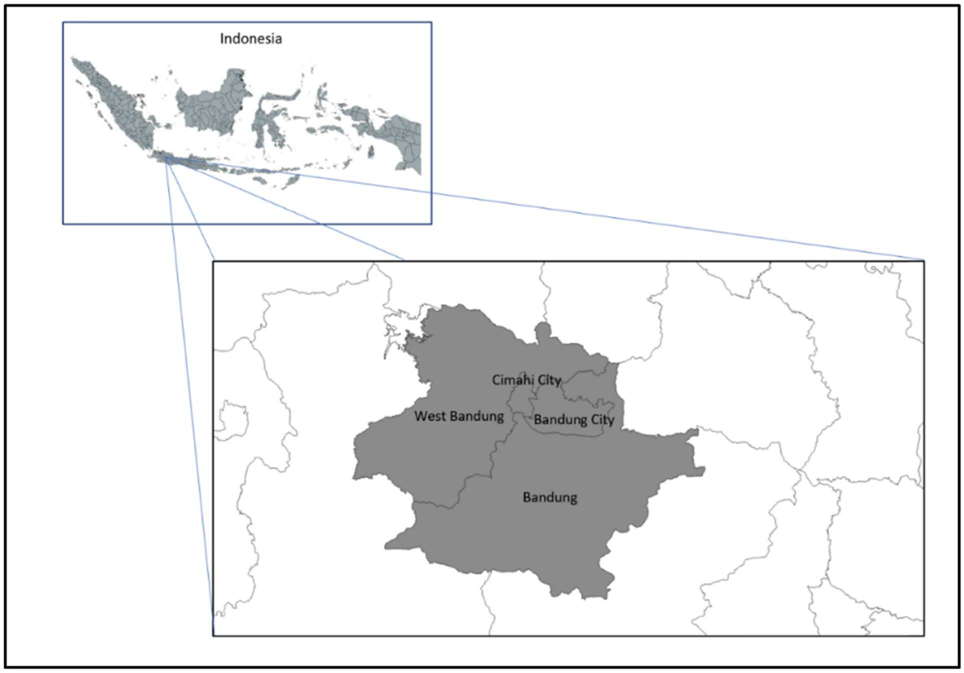

Figure 1: Location of the study.

of the cities and regencies in the Greater Bandung area are presented in Figure 2.

This article studies whether the local rice production centers in Greater Bandung are sufficient to accommodate the whole rice demand in Greater Bandung as provided by the statistics of West Java and given in Figure 2. The concept of LFH is used to collect rice produced by local farmers and distribute it to retailers to reach the end consumers. In this study, rice is defined as the staple food of the people in majority of the developing countries [57].

The related secondary data are used to develop the optimum location of LFH. The secondary data were used

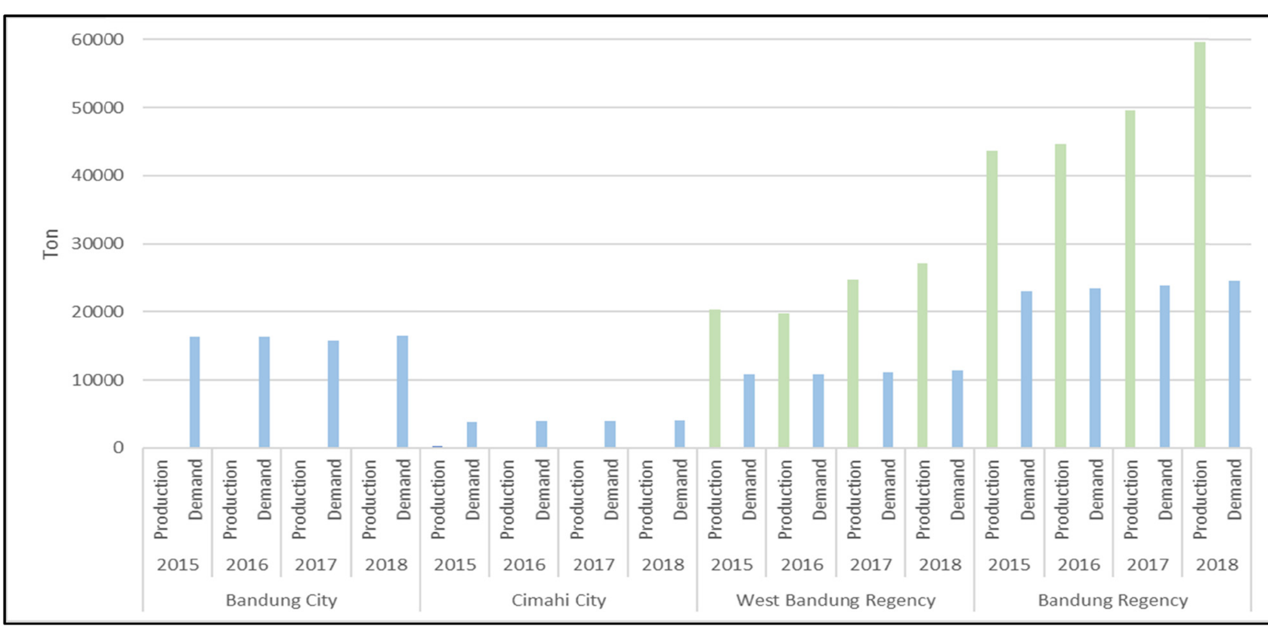

Figure 2: Rice production capacity and demand in Greater Bandung.

from each statistics agency of Greater Bandung area, data ranging between 2015 and 2018. The data represent the actual condition and uncertainty of LFN in Indonesia. The production and consumption data used in this model are based on the historical data from the statistics of West Bandung, Bandung, Cimahi, and Bandung City.

Meanwhile, operational cost data and distribution costs of rice are obtained by calculating the prices of several components set by the logistics provider services. The operational cost is a set of costs used in the warehouse and the assumption of LFH construction costs is taken from the Ministry of Trade, The Republic of Indonesia. The component set includes the cost of using gasoline and is calculated based on the distance of delivery of goods during logistics.

This study used production and distribution as objective functions based on the data obtained. If locally produced rice in Greater Bandung is insufficient to fulfill the demand, LFH leads a connection to RFH to fulfill the unsatisfied demand. Therefore, the RO model developed in this article is used to determine the optimum location of LFH to elaborate food security in Greater Bandung and construct an efficient rice supply network.

3.2 RO model

Optimization problems often face obstacles in the form of inaccurate data with the uncertainty term. The methodology in optimization that can handle the problem of data uncertainty in optimization is RO, as proposed by Ben-Tal and Nemirovski [57]. In this study, the uncertain data are rice production and rice demand. The uncertain rice production is influenced by two variables: the decreasing area of the harvested area and productivity per unit area [58]. Meanwhile, domestic retail prices, per capita income, population, and rice production influence the uncertain rice demand [59].

RO addresses the robust problems of data uncertainty on parameters, where the uncertainty is contained in an uncertainty set. The following is the general model of uncertain linear optimization [60]:

$$\min_{x}\{\boldsymbol{c}^T\boldsymbol{x} : \boldsymbol{A}\boldsymbol{x} \le \boldsymbol{b} | (\boldsymbol{c}, \boldsymbol{A}, \boldsymbol{b}) \in \mathcal{U}_{\text{box}}\}, \tag{1}$$

where $\boldsymbol{c}, \boldsymbol{x} \in \mathbb{R}^n$, $\boldsymbol{A} \in \boldsymbol{M}_{\boldsymbol{m}\times\boldsymbol{n}}(\mathbb{R})$, $\boldsymbol{b} \in \mathbb{R}^m$, and $\mathcal{U}_{\text{box}}$ are the box uncertainty sets. In other words, $\boldsymbol{c}$, $\boldsymbol{A}$, and $\boldsymbol{b}$ are the uncertainties in this model.

By fulfilling the basic assumptions of RO discussed in ref. [25], we can reformulate the uncertain linear optimization (1) as:

$$\min_{x}\{\boldsymbol{c}^T\boldsymbol{x} : \boldsymbol{a}_i^T\boldsymbol{x} + \mu_i\boldsymbol{x} \le b_i | i \in \{1, 2, \ldots, m\}\}, \tag{2}$$

where μ_i is the disturbance parameter. The robust reformulation (2) is also known as the robust counterparts (RCs), which do not contain uncertain parameters. This study applies RO to the MOMMLRP model to handle the uncertain demand and production capacity. The following subsection briefs the nominal deterministic model of MOMMLRP and its RC.

3.3 Model formulation

This subsection discusses the MOMMLRP model for optimal LFH locations and food networks, as discussed previously. The following are the sets, parameters, and decision variables used in this model:

Sets:
- K: producer areas
- J: optional LFH location
- I: consumer bases
- L: RFH location

Parameters:
- d_i: demand of rice in consumer base i
- f_k: food production capacity of rice in producer area k
- b_{ji}: distribution cost to transport rice from region j to i
- a_l: capacity of RFH location l
- h: LFH development cost
- q: food handling cost

Decision variables:
- x_j: the necessity for LFH to be built in a potential location j, $x_j \in \{0, 1\}$
- P_j: capacity of LFH built in location j
- y_{kj}: ratio of rice produced in producer area k which is transported to LFH in location j (proportional to production capacity f_k)
- w_{ji}: ratio of demand for rice in consumer base i that was fulfilled by LFH in location j (proportional to demand d_i)
- z_{lj}: ratio of rice distributed from RFH in location l to LFH in location j (proportional to capacity RFH)

Based on the given sets, parameters, and decision variables, the MOMMLRP model for LFH network design is given by functions (3)–(13). The first objective function ((3) gives the maximum rice demand fulfillment across all sub-districts in Greater Bandung. In contrast, the objective function (4) ensures the locally produced rice in Greater Bandung is prioritized to fulfill the whole demand in Greater Bandung itself before seeking additional stock from RFH. Meanwhile, the objective function (5) guarantees that the efficient rice supply network between local farmers, LFH, RFH, and retailers (consumers) is achieved with minimum operational cost.

$$\max\left\{\sum_{i\in I}\sum_{j\in J} d_i w_{ji}\right\}, \tag{3}$$

$$\max\left\{\sum_{k\in K}\sum_{j\in J} f_k y_{kj}\right\}, \tag{4}$$

$$\min\left\{h\sum_{j\in J} x_j + q\sum_{j\in J} P_j + \sum_{j\in J}\sum_{i\in I} b_{ji} d_i w_{ji} + \sum_{k\in K}\sum_{j\in J} b_{kj} f_k y_{kj} + \sum_{l\in L}\sum_{j\in J} b_{lj} a_l z_{lj}\right\}, \tag{5}$$

subject to:

$$\sum_k f_k y_{kj} + \sum_{l\in L} a_l z_{lj} = P_j,\ \forall j\in J, \tag{6}$$

$$\sum_{i\in I} d_i w_{ji} = P_j,\ \forall j\in J, \tag{7}$$

$$\sum_{j\in J} y_{kj} \le 1,\ \forall k\in K, j\in J, \tag{8}$$

$$\sum_{j\in J} w_{ji} \le 1,\ \forall i\in I, \tag{9}$$

$$\sum_{j} z_{lj} \le 1,\ \forall i\in I, \tag{10}$$

$$y_{kj} \le x_j,\ \forall k\in K,\ j\in J, \tag{11}$$

$$w_{ji} \le x_j,\ \forall j\in J,\ i\in I, \tag{12}$$

$$z_{lj} \le x_j,\ \forall l\in L,\ j\in J, \tag{13}$$

Constraint function (6) describes the inbound flow of rice supply from local farmers and RFH to LFH and calculates its capacity. In contrast, constraint function (7) describes the outbound flow from LFH to consumers. Constraint functions (8)–(10) guarantee that the rice demand fulfillment follows the production capacity, RFH capacity, and demand properly.

The RC model of the MOMMLRP gives a robust rice supply network solution against the uncertain rice demand and production capacity. Hence, the RC model is necessary to fulfill the basic assumptions of RO, which are discussed in the previous RO subsection. By fulfilling the basic assumptions of RO, we can obtain the RC of the MOMMLRP model as follows:

$$\max\{t\}, \tag{14}$$

$$\max\{u\}, \tag{15}$$

$$\min\left\{h\sum_{j\in J} x_j + q\sum_{j\in J} P_j + v + \sum_{l\in L}\sum_{j\in J} b_{lj} a_l z_{lj}\right\}, \tag{16}$$

subject to:

$$\sum_{i\in I}\sum_{j\in J} \overline{d}_i w_{ji} + \mu_i w_{ji} \ge t, \tag{17}$$

$$\sum_{k\in K}\sum_{j\in J} \overline{f}_k y_{kj} - \eta_k y_{kj} \ge u, \tag{18}$$

$$\sum_{j\in J}\sum_{i\in I} b_{ji}(\overline{d}_i w_{ji} + \mu_i w_{ji}) + \sum_{k\in K}\sum_{j\in J} b_{kj}(\overline{f}_k y_{kj} - \eta_k y_{kj}) \le v, \tag{19}$$

$$\sum_k \overline{f}_k y_{kj} - \eta_k y_{kj} + \sum_{l\in L} a_l z_{lj} = P_j,\ \forall j\in J, \tag{20}$$

$$\sum_{i\in I} \overline{d}_i w_{ji} + \mu_i w_{ji} = P_j,\ \forall j\in J, \tag{21}$$

$$\sum_{j\in J} y_{kj} \le 1,\ \forall k\in K, j\in J, \tag{22}$$

$$\sum_{j\in J} w_{ji} \le 1,\ \forall i\in I, \tag{23}$$

$$\sum_{j} z_{lj} \le 1,\ \forall i\in I, \tag{24}$$

$$y_{kj} \le x_j,\ \forall k\in K,\ j\in J, \tag{25}$$

$$w_{ji} \le x_j,\ \forall j\in J,\ i\in I, \tag{26}$$

$$z_{lj} \le x_j,\ \forall l\in L,\ j\in J, \tag{27}$$

where μ_i is the disturbance parameter to the demand capacity of each district and η_k is the disturbance parameter of the production capacity of each district.

4 Result and discussion

This section discusses the local food network result using the MOMMLRP model to determine the optimum location of LFH considering the uncertain rice demand and production capacity. The optimum location of LFH affects the LFN and its distribution system [61]. Moreover, the optimum location impacted the logistics efficiency, reduced the environmental impact, improved the traceability of local food, and increased the potential local markets and local producers [62]. Determining an optimum location of LFH also contributed to decreasing food losses and waste due to the unnecessary handling and potential damage during transport [61–63].

To obtain the optimal LFN, the MOMMLRP model was formulated with RO, which handles the uncertainties. RO provides the best–worst-case scenario following the uncertainties. In this study, the worst-case scenario of the uncertain rice demand and production occurs when the rice demand peaks during the low production capacity. The lexicographic method is applied to the model because it has two objective functions.

Optimal result shows there are eight optimal locations for LFH, consisting of Bandung Kulon, Cimahi Tengah, Saguling, Ciwidey, Majalaya, Cangkuang, Dayeuhkolot, and Cileunyi sub-districts as presented in Table 1. This optimum LFH location can help develop the local food network ecosystem, which is determined based on production and markets' location [61]. Each LFH gets a supply from various areas of production which are near Greater Bandung area.

In particular, this study's optimum location is relatively near the downtown area, where markets are located. Moreover, they are also near the production area, as shown in Figure 3. This location of LFH benefits producers and serves as a strategy to satisfy the customers' needs [64]. The optimum location near the downtown is one factor influencing customers to repurchase the products [64].

It also aims to improve the response to customer satisfaction. This network also shows that the whole rice demand in the Greater Bandung area (57,088 tons/month) is fulfilled for 80 sub-districts, as presented in Table 2. Figure 4 justifies that the eight developed LFHs reach all consumers to fulfill their demand in each sub-district (80 sub-districts) of the Greater Bandung area.

The additional rice supply must be supplied from RFH, as depicted in Figure 3, since the locally produced rice was not sufficient to meet their overall needs of rice. RFH supports the connectivity of the rice supply chain by collecting the rice from other producer areas outside the Greater Bandung area. The rice collected by RFH is distributed to LFHs, which eventually supports them to fulfill the consumers' demand within their service area. This result justifies the importance that buffer stock owned by RFH plays an essential role in transitory food insecurity through supply stability [65].

Although this study focuses on LFH, RFH is considered the primary buffer stock provider to maintain logistics and distribution cost efficiency. This also considers efficient handling cost and maintaining the quality of the products [66]. The requirement of buffer stock is justified, particularly during the worst-case scenario. This becomes a preparedness strategy for the uncertainty of production and market needs. This scenario also supports price stability, both for customers and producers [67]. Meanwhile, the buffer stock should consider the efficient distribution system, logistics network, and physical handling of the products.

Table 1: Rice supply from local farmers and regional food hub (RFH) to local food hubs (LFHs)

LFH location	Supplied from (ton)		Total supplied (ton)
	RFH	Local farmers	
Bandung Kulon	—	9165.12	9165.12
Cimahi Tengah	—	6763.49	6763.49
Saguling	—	5316.69	5316.69
Ciwidey	—	4036.73	4036.73
Majalaya	—	8858.30	8858.30
Cangkuang	4415.87	3302.75	7718.62
Dayeuhkolot	—	7595.08	7595.08
Cileunyi	—	7633.96	7633.96
Total			57,088

The results of this study can be used as a reference for government agencies regarding the importance of the LFN for the rice supply chain in West Java. Moreover, this study justifies the need to consider the connectivity between LFH and RFH, where RFH acts as a buffer stock provider. This result also shows that strengthening the food security from local sources can achieve the food sustainability goals in the uncertain situation such as today [14,15,44].

In the COVID-19 pandemic and humanitarian challenges, LFH is important to ensure the availability of food supply. LFH could help the efficiency of food supply for local customers, improve the capability of local producers, and improve the quality of products based on customers' needs [10,38,51]. LFH could improve the value of products, so the customers will increase their interest in buying local products [49,52]. Accordingly, the LFH concept is essential for developing countries to improve their capability and value of the local food products.

5 Conclusion

Improving the capacity of LFN in developing countries is a strategy to support the food-sufficient stock. LFN in this study was designed based on the LFH model that could support the local communities in food fulfillment.

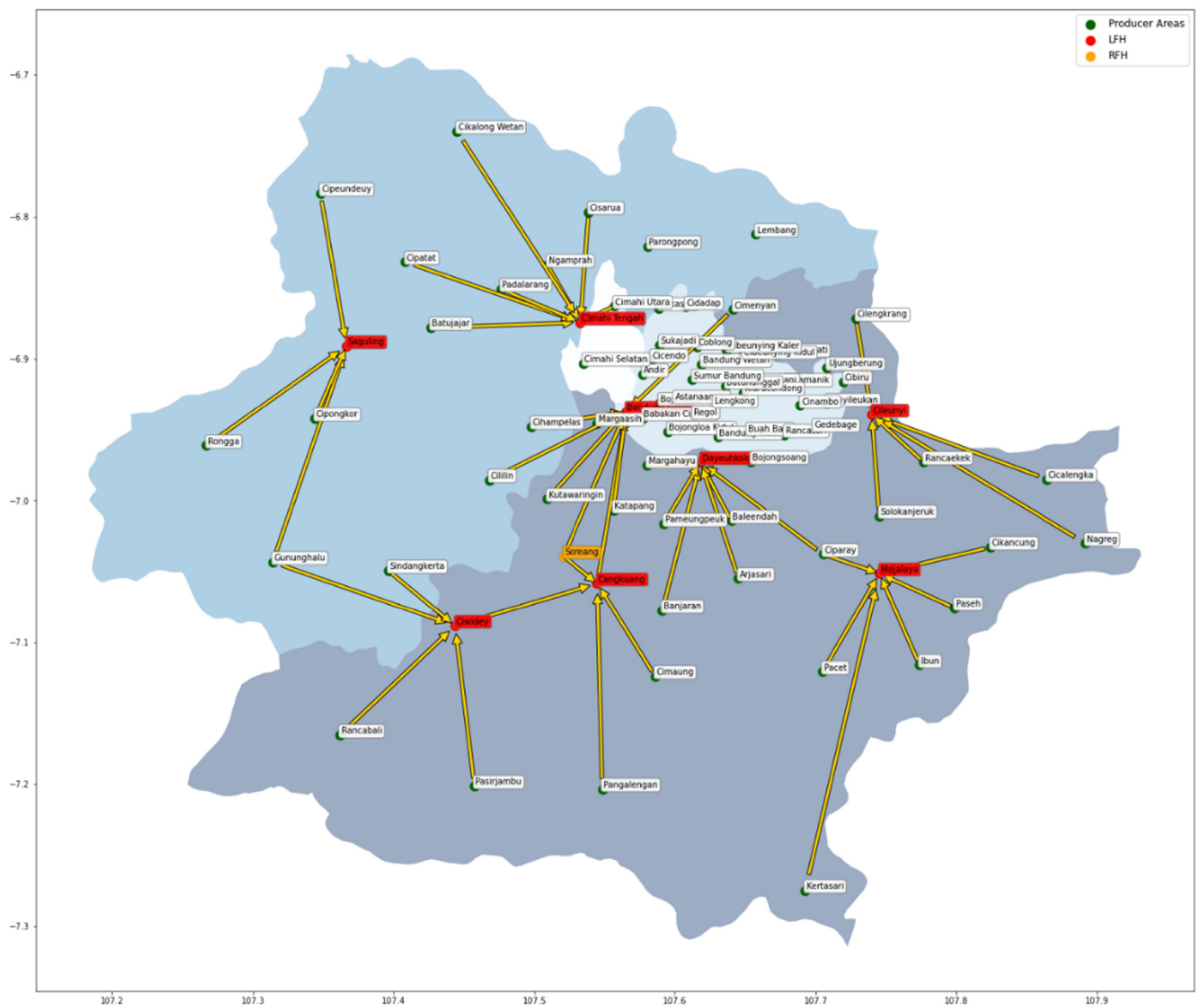

Figure 3: Food network from producer and regional food hub to local food hub.

Table 2: Fulfilled rice demand from local food hub (LFH)

LFH location	Fulfilled demand	
	Ton	**Percentage (%)**
Bandung Kulon	9165.12	16.05
Cimahi Tengah	6763.49	11.85
Saguling	5316.69	9.31
Ciwidey	4036.73	7.07
Majalaya	8858.30	15.52
Cangkuang	7718.62	13.52
Dayeuhkolot	7595.08	13.30
Cileunyi	7633.96	13.37
Total fulfilled	57088.00	100.00

Note: These metrics came from numerical result.

The mathematical model is used to design the optimum location of LFH in the developing countries, and West Java Province, Indonesia was used as an area of study. RO is used to give the optimum LFN through the MOMMLRP model under uncertain demand and production capacity.

The model determines the LFH locations and the LFN between local farmers, RFH, LFH, and the local consumers. Eight strategic locations for LFH development have been determined. The eight optimum LFH locations were built to optimize the efficiency of the LFH supply network and the supply network from local production centers to meet all the needs of local consumers in the Greater Bandung area.

In addition to receiving supplies from local producers, RFH is also designed as a buffer stock provider for LFH.

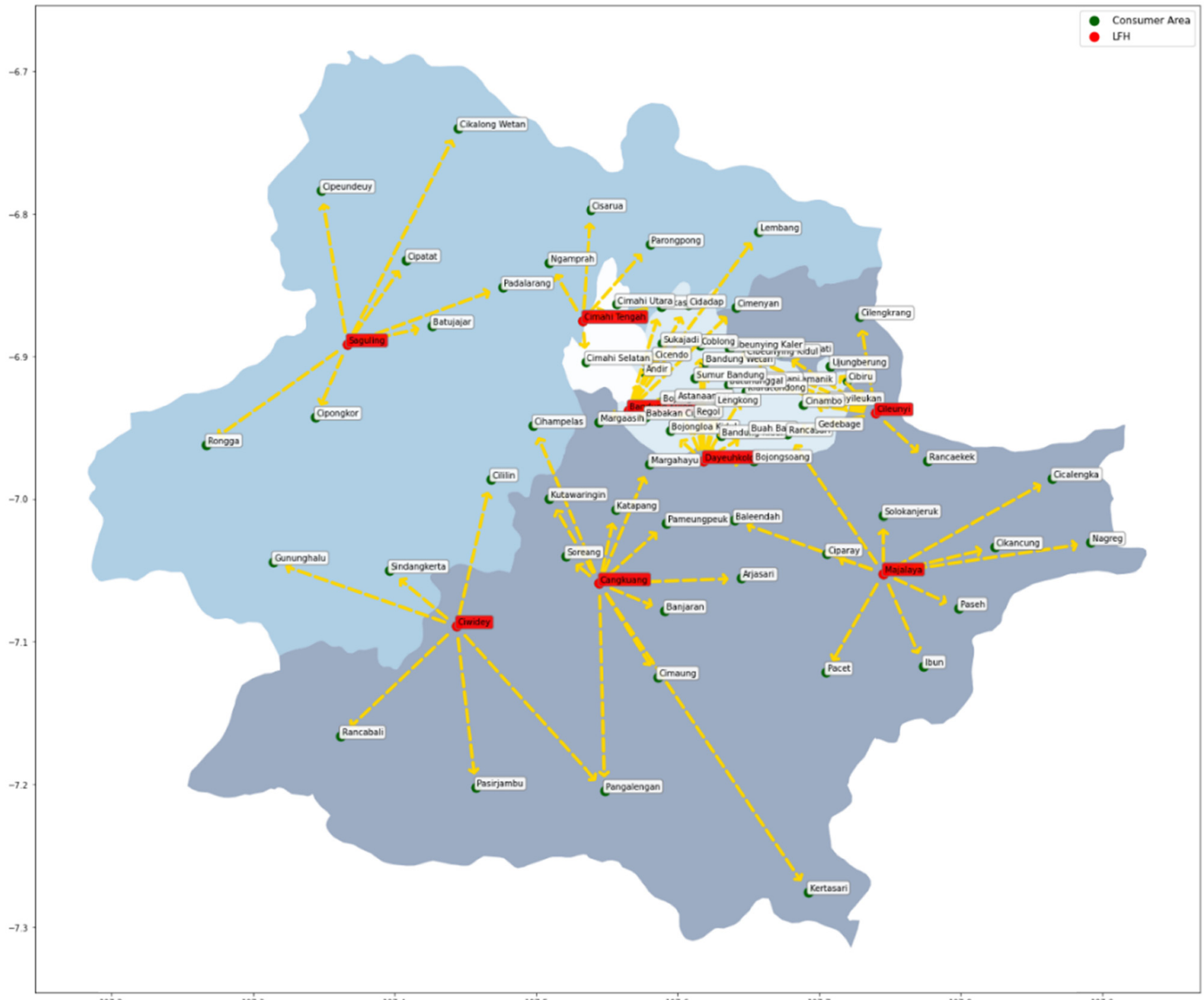

Figure 4: Food network from local food hub to consumer area.

The success of connecting production centers and consumers to form a local food supply chain is a strategic improvement to meet local food needs by maximizing the capability of local producers.

The result could be an alternative strategy to improve the local community in an uncertain situation, especially as a reference policy for the local government in improving the local source for the local community through LFH development for a better food network. The results can also be used as an alternative solution for implementing logistics systems by food supply chain stakeholders in developing countries. This LFH model can be a reference for provincial and local governments in developing regional investment in RFH or LFH and the private sector as those carrying out LFH activities and functions.

In this study, there are still several limitations that can be developed in future research. Commodities considered in this study is only rice. Hence, it can be further developed for the multi-commodities problem in subsequent developments, particularly for strategic horticulture commodities with perishable and short of life time characteristics. Another limitation of this study is the freshness factor. The fact that most of the food commodities tend to have the risk of being degraded over time, particularly for perishable products, needs to be considered in the subsequent development.

One possible topic that can be further developed in the future is designing multiple agricultural products linked to post-COVID-19 pandemic and humanitarian challenges, which causes more dynamic market demand. Studying the development of digital food services can minimize the number of transmissions caused by human interaction in the food network created.

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Conflict of interest: The authors state no conflict of interest.

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