A GIS-based method for central kitchen location selection problem

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Abstract. Central Kitchen is a new trend in the food and beverage industry. COVID-19 pandemic causes a disruptive economy globally. The central kitchen business is being considered to be developed because of the restriction living regulation in Indonesia and the function of this central kitchen can help the micro-business actors to develop their businesses with a lower operational cost because all of the transactions are carried out via delivery. This study aims to visualize the potential areas to develop central kitchen businesses in Jabodetabek. A GIS-based approach is implemented to carry out the geoprocessing process of spatial information to perform the spatial analysis. Overlay analysis is conducted using Kernel Density Estimation map, to identify potential areas. This study identified several potential areas in several cities to develop central kitchen businesses, namely Central Jakarta, West Jakarta, South Jakarta, Tangerang City, Bekasi, and Bogor.

1. Introduction
Urbanization or centralized population occurs because many people tend to live in the city which is a major city of urban development, economic trade, and culture. However, the rapid growth of urbanization in the cities has resulted in radical social changes and the increased cost of living is seen where poverty increases annually [1]. Jakarta as the capital city of the Republic of Indonesia is one of the main contributors to the Indonesian economic sector [2] and the city of Jakarta has a 10.57 million population in 2020 (BPS, 2020) hence it Jakarta is considered as urban area. Geographically, Jakarta is surrounded by Bodetabek which is consists of Bogor, Depok, Tangerang, and Bekasi. Hence, these 5 cities merged as the Greater Jakarta area (Jabodetabek) as urban expansion, Jabodetabek is weighed as a megalcity which is the second-largest in the world after Tokyo. This expansion causes the outward spread in urban and sub-urban areas to experience a significant increase in population, urban activity, and economic trade growth [1].

The microeconomic trading market has constantly increase based on the data from the Ministry of Cooperatives' annual report from 2017 to 2018 and 2016 to 2017, UMKM (Usaha Mikro, Kecil dan Menengah) growth is 2.02% in 2018 with a total is 64,199,609 UMKM units [3] and UMKM growth is 2.06% in 2017 with the total is 62,928,077 UMKM units [4]. According to the 2019 KOMINFO annual report, 17,113,220 UMKM units have go-online or using internet services to develop their businesses [5].

[1] BPS, 2020
[2] Ministry of Industry, 2019
[3] Ministry of Cooperatives, 2018
[4] Ministry of Cooperatives, 2017
[5] KOMINFO, 2019
In 2020, pandemic COVID-19 caused economic disruption significantly in Indonesia [6] and regulations are restricting human movement to break the chain of the spread of COVID-19 viruses. The regulations’ impact on many economic sectors, in this case, will be discussed is in the food industry. The restrictions imposed have made growth contraction in the food industry sector resulting in a slowdown in growth by 7.9% - 5.2% because every food service is only allowed to provide delivery services [7]. During the digitalization era, even though restaurants could not serve dine-in and only allowed to do the delivery service, food services began to use online delivery services [8] and based on the results of the Nielsen Singapore Report survey in 2019, 58% of Indonesians chose to buy fast food through applications online. There are two biggest online food delivery services provider in Indonesia, namely GoFood and GrabFood, which increasingly focused on the development of the cloud-kitchen business or food-factory outlet[9]. The cloud kitchen service business is considered quite efficient and effective in encouraging merchants, especially during the COVID-19 pandemic. Based on a quote from Gojek's Chief of Public Policy and Government Relations, Shinto Nugroho stated that "the transactions of partners joining cloud kitchen services increased by 70% on average." Based on a statement from GrabFood's Head of Marketing, Hadi Surya stated, “CloudKitchen can reduce operational costs because most of the cloud kitchen activities are delivery-only services. So, they don't need to spend a lot of money on renting a place." [10] For now, determining the location of the cloud kitchen is based on their historical internal data, the data is consists of the route pattern, orders that are often ordered by customers via an application, and the peak time order [11]. The discussion in this paper aims to focus on determining the potential region over Greater Jakarta related to Geographic Information System (GIS) data to assist the micro-entrepreneur (UMKM) to grow their businesses and reach a wider market, especially in Food and Beverage Industry.

2. Literature Review

2.1. Food Services Facility
In the era of industrial revolution 4.0, digitalization is significantly developed, and advances in technology that have made people's work easier, both directly and indirectly, have changed people's lifestyles. Lifestyle changes encourage modern society to become a society that tends to be consumptive, this is because society needs convenience in all aspects of life with more practical principles so that it can shorten the time and do not interfere with work and this lifestyle is very visible in the modern generation which is Millenial Generation or Gen Y [12]. Thus, micro-entrepreneurs need to recognize millennial shopping behavior and make a move to improve their services and the marketer in the food and beverage sector must provide delivery services as their food services facility to encourage millennials because millennials tend to spend large amounts on food [13].

2.2. Central Kitchen Location
The central kitchen is known as a catering distribution factory or invisible kitchen which is useful for centralizing the entire process of preparing and making food catering as well as a place for distribution of semi-finished or finished products [14]. Previously the productivity of a food service facility was low enough that a central kitchen or cloud kitchen was developed which aims to increase the effectiveness of the food-making process and to increase this effectiveness central kitchen implemented an integrated automation system [15]. In Indonesia there are 2 online food delivery companies with an interest in developing a central kitchen because the demand for online food delivery application is an increase, the central kitchen is being considered by micro merchants as a way to increase business scale, and there is no need to have a place for food service because all distribution will be carried out by delivering companies so that business actors only need to focus on developing their business and all the food can only be ordered through their mobile application so that the process is integrated to help the business actors [16]. According to the Grab Indonesia website, the central kitchen location is based on their historical internal data so that this research conduct a
literature review of other researchers to obtain data or attributes on food retail stores to determine business locations.

2.3. Spatial Analysis for Location Determination

The spatial analysis approach is the powerful tool that can be used on spatial information, the spatial information that can be obtained on any national website, and these tools are used to understand the pattern of specific purposes, such as determining the location of the retail store [17]. Spatial analysis for an events point is familiar as PPA (Point Pattern Analysis) and PPA usually used for spatial scientist to develop the “hot-spots” of the event points, there are many various methods that can be used to develop the “hot-spots”. One of the methods used in this paper is Kernel Density Estimation (KDE). KDE is common that be used for analyzing a point events distribution. The KDE method’s purpose is to develop a smoothed density surface of an event point that converts the intensity of the event into a density estimation [18]. The purpose of this study was to determine the location of the food-service retail and to determine the variables that used in this study, determining variables are from other literature that has been identified by other researchers and the main focus is on the variables that have a significant effect on potential demand is the location of the food service. The location of food service tends to be close to other facilities and easy accessibility will affect potential demand which is the variables that influencing in this study consists of population density, worship facility, university, terminal, accomodation facility, school, shopping facility, hospital, food services, government office and fuel station on Greater Jakarta.[19]

3. Data Sources and Methods

3.1. Data

The required spatial data used in the present study were area boundaries (population), minor attributes location, and the central kitchen location. Greater Jakarta is divided into 10 cities that consist of West Jakarta, South Jakarta, Central Jakarta, East Jakarta, North Jakarta, Bekasi, Depok, Bogor, Tangerang, and Thousand Island. The population density data in Greater Jakarta is based on a census that has been done by “Badan Pusat Statistik”([https://www.bps.go.id/]), the borderline layer and point-of-interests (public facilities) layer that used in this study are obtained from “Geospasialuntuk Negeri”, managed by “Badan InformasiGeospasial” ([https://tanahair.indonesia.go.id/portal-web]). The coordinates of the central kitchen locations are obtained from google maps ([https://www.google.com/maps]). The coordinates data are geocoded using Quantum GIS. Figure 1 shows the distribution of central kitchen locations is relatively unequal. The central kitchen location data obtained for this study only covers the areas of Jakarta, Tangerang, Bogor, and Bekasi.

![Figure 1. Population Density in Greater Jakarta](image-url)
Referring to Tobler's first law of geography, this study has a strong assumption that the location of the central kitchen will have a relationship with the location of other facilities. Considering the trend of convenience lifestyles of consumers that using food delivery services, this study used ten public facilities that have co-location rules with fast-food restaurants [19] to determine the location of the central kitchen. These public facilities consist of accommodation facilities, food services facilities, fuel stations, government offices, hospitals, schools, shopping facilities, terminals, universities, and worship facilities, as shown in Figure 2.

![Figure 2. Minor Attributes Distribution in Greater Jakarta](image)

### 3.2. Methods

This study used 11 layers of spatial data, namely the layer of existing central kitchen location and 10 layers of public facilities. Quantum GIS software is used to manage the projection system of each layer, edit data (including clipping and merging), create KDE (Kernel Density Estimation) raster maps, and analyze the raster simultaneously using multi-overlay analysis techniques. The analysis stage of the research can be seen in Figure 3.

![Figure 3. The Analysis Stage of the Research](image)

The research stages were divided into 4 stages. The first stage was collecting spatial data from various sources. All of the attributes vector layers are projected into WGS 84/UTM zone 48S (EPSG: 32748). The geoprocessing process in this study is to create a heatmap based on the kernel density method to produce a raster layer for each attribute to obtain the representative area of density. The multi-criteria overlay analysis is conducted to obtain the potential area for the central kitchen. The raster calculator is applied to sum the raster layers to get the highest density.
4. Results and Discussion

4.1. Distribution of central kitchen

This study used 10 public facilities from Widaningrum, et al [19] that assumed will affect the determination of the location of the central kitchen, as described in table 1. Currently, during the pandemic, consumers use delivery services as a priority to order food rather than having to come to a restaurant and this lifestyle is related to the convenient lifestyle in which consumers only have limited time to get their food. So, the development of a central kitchen is one of a way to boost a convenient lifestyle for the millennial generation.

Table 1. Public Facilities

| No. | Public Facilities         | Detail of Public Facilities                      |
|-----|--------------------------|--------------------------------------------------|
| 1.  | Worship Facility         | Pura, Church, Mosque, Vihara                     |
| 2.  | University               | College, Institute, University                   |
| 3.  | Terminal                 | Bus station, bus stop, railway station, taxi     |
| 4.  | Accommodation Facility   | Guesthouse, hostel, hotel, motel                 |
| 5.  | Shopping Facility        | Convenience, department store, mall, supermarket |
| 6.  | School                   | Kindergarten, school                             |
| 7.  | Hospital                 | Pharmacy, hospital                               |
| 8.  | Food Services Facility   | Restaurant, fast food, bar, beverage, café, pub, food court, bakery |
| 9.  | Government Office        | Local government offices, police office          |
| 10. | Fuel Station             | Fuel                                             |

Figure 4 shows the density of food services and central kitchen in Greater Jakarta and the central kitchen that be investigated in this study are Rebel Foods by Gojek and Grab Kitchen that has been distributed around Greater Jakarta.

![Figure 4. Density Map](image)

Figure 4 visualized the food service facilities in Greater Jakarta. Figure 4 (a) plot, it can be seen the density of food service facilities in Greater Jakarta are not evenly where the density of food service facilities in Bogor and Bekasi is still limited and in figure 4 (b) is the density of central kitchen in the Jabodetabek area and according to Figure 4 (b) shown the density of the central kitchen is still quite centralized in the Jakarta area especially in Central Jakarta and West Jakarta and 28 central kitchen outlets are currently scattered and located in South Tangerang, Bogor City, Bekasi City and all areas of Jakarta. Depok City and Thousand Island still do not have this central kitchen facility.
4.2. Kernel Density Estimation

Kernel Density Estimation is the method that can be used to analyze a point event distribution [18] and KDE is a spatial method to overviews the centrality of any location distribution [19]. Figure 5 shows the distribution surface of public facilities.

![Heatmap of Public Facilities](image)

**Figure 5.** Heatmap of Public Facilities: (a) Accommodation Facility, (b) Fuel Station, (c) Government Office, (d) Worship Facility, (e) Food Services, (f) Terminal Station, (g) University, (h) Shopping Facility, (i) School, (j) Hospital

The density maps in figure 5 are using the RdYlGn color ramp. The green color represents the low facility density and the red color represents the high facility density in an area. However, all of the facility distribution tend to be centralized in Jakarta city, especially in Central Jakarta that based on the aggregate data that reveal the contrast of density of each public facility.

4.3. Multi-Criteria Overlay Analysis

The Multi-Criteria Overlay Analysis method helps develop a suitability map with optimal utilization based on empirical data from each minor attribute and its utilization working in raster space gives you a suitability rating - not just the most suitable site and this method also allows to easily combine multiple input layers and assign different weights to each criterion. In this study, theemultiple layers arenot given weight and are considered each element to have equal weight. In general, this is the preferred approach for site suitability. The integrated GIS-based model provides more than site-specific and spatially explicit maps of site suitability for central kitchen location in the study area and multi-criteria overlay analysis is done using a raster calculator to make a count of each raster layer get the highest density of facility area and the highest density area expressed as the potential area to expand the business of central kitchen in Greater Jakarta area. Figure 6 shows the potential area that can be used to expand the central kitchen business.
According to figure 6, the potential area in Greater Jakarta is in Jakarta city especially in central of Jakarta which has the highest density facility that can affect the consumer option to order food and the city of the outside that can be the potential area is on Tangerang Kota, Bekasi, and Bogor. In this study, the potential area is only determined based on the density of facilities that have been assumed that can affect consumer choice.

5. Conclusion

In Indonesia, especially in Jabodetabek, the central kitchen business is still relatively new so that the data coverage is still very limited and based on companies that have run this business they use historical data as a reference to determine the location of their central kitchen so that the data needed is still difficult to obtain and all the attributes used in this study are based on research from retail stores developed by other researchers. Based on the results of geoprocessing using QGIS, there are potential locations to develop a central kitchen business, which are Central Jakarta, West Jakarta, South Jakarta, Tangerang City, Bekasi, and Bogor because they have a density of facilities that are considered capable of affecting. Further, other methods can be used to evaluate the location determination.

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