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A GIS – Based Approach for Catchment Area Analysis of Convenience Store

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Abstract

This study is conduct to evaluate socio-economics and/or demographic attributes of convenience store based on catchment area prediction. In this preliminary analysis, we find that more specific data related to demographics of the population are needed to see the correspondence between the location of the convenience store with the distribution of the population. It also shows that GIS-based approach is a powerful method to collect data, perform spatial analysis, combine and manage both spatial and attributes data, such as finding features inside determinant region.

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Keywords: GIS; Retail; Convenience Store; Catchment Area Analysis

1. Introduction

Modern retail markets, such as hypermarket, supermarket, and minimarket/convenience store, holds a significant share and is growing, while traditional market still acount for the majority of retail food sales in Indonesia, with an average growth rate at 7.3% per year, between the years 2012 to 2017 [1]. It is in line with the increasing focus on the customer value offered by each type of market, and further submitted that convenience stores, typified by 7-Eleven, will continue to grow strongly in all countries, with a big driver of this likely to include an ever-expanding offer in food services as well as many other services aimed at making everyday life event more convenient [2].

Convenience store as modern retail formats compete with the traditional sector primarily on services, such as, food safety assurance, convenience, information, variety, and comfort [3]. In this case, although the convenience store is generally considered offers a higher price when compared to the traditional

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market, but has another value offered to the customer, including food handling system which is considered to maintain food safety, both through the particular packaging system (aseptic packing, vacuum packing), storage system, and display system that maintain product temperature; convenience of shopping related to the availability of parking space and ease the way of payment; clear information related to prices and promotions; availability of dining areas, which are often also equipped with free wi-fi access, access to electricity, allowing customers to conduct meetings, hang out, and enjoy the food and drinks they buy.

The growth of convenience stores in Japan thereby required extensive changes in the existing distribution system, which ranged from distribution channel strategies of manufacturers and wholesalers to details in the manufacturing processes of products[4]. Many factor can lead to increased patronage at the modern retailers such as customer relationship management activities, value-added services, and the product choice [5]. The experience and the convenience value when customers buy products are becoming one of attractive factor to shop at convenience stores. Berman & Evans [6] explained that retailer have to identify and understand their retail shoppers, in accordance to their demographics, lifestyles, needs and desires, shopping attitudes and behavior, their perception of retailer actions and environment.

Determining the exact location of convenience stores can be a critical factor in the economic development of a region, indirectly, with rising profits that will have an impact on government tax, and the more effective use of energy. Most organizations are interesting in analyzing regional or local markets to undestand both existing performance and to predict the impacts of changing the distribution network in some way [7]. Murray [8] stated that the integration of location science and GIS enables much to be done to support location planning and decision-making, but it also suggests new lines of inquiry and research in terms of application, solution, and theory.

This article is focused on the application of Geographical Information System as a tool to predict catchment area of convenience store, so analyst can evaluate the retail outlets in terms of socio-economics and/or demographic attributes of each outlet's trade area [9]. This research show that GIS-based approach highlights the use of GIS to collect data, perform spatial analysis, and combine the figure information which reflects the geographical position together with various kinds of information [10].

2. Geographical Information System

Malach [11] summarizes several themes from some definitions of decision support systems (DSS), that is decision support systems are information systems, used by managers in making decision, to support (but not to replace) people, used when the decision is semi structured or unstructured, incorporate a database of some sort, and incorporate models. Spatial interaction models in GIS are used to help understand and predict the location of activities and the movement of materials, people, and information; to provide a further data layer representing the transport networks along which goods and people move, to calculate real distances between origins and destinations, and to store attribute information about individual locations [12].

The term "geographic information system" is often used, appropriately, as an umbrella term for a system designed to process any type of information that traditionally would have been recorded on maps [11]. Murray [8] explained GIS is important for understanding and summarizing spatial relationships as well as offers the potential to exploit this knowledge for structuring solution techniques and new location models.

There are many studies had giving many perspectives about the impacts of GIS application in various sectors/fields. Mallach [11] shows GIS as a decision making tool, can help many industry such as freight trucking company to assist in operations and capacity planning and health insurance company to see relationships between where the doctors, hospitals, and members are and where services need to be. Duggal in her research [9] explains that GIS can easily calculate the size and the potential of the market

based on the socio-economic profile of the area in the identified trade area, for example, the circle around a store. Hai-ling, Liang-qiang, & Yong-peng [10] demonstrates the power of integrating GIS for an ecotourism application, to provide management decisions data update timely, which can realize the sustainable development of ecotourism. In other [13], GIS technology are adapted as a tool to monitor habitat changes, track community interest species, and predict future land and resource use that is essential to protect natural heritage, and to maintain a favorable conservation status.

In other service industry, GIS and GPS were using for data collection, data storage, and geospatial analysis an airport management system [14]. Chen, Hsu, Ye, & Huang [15] employed support vector machines (SVM) as an aid to select convenience store location, by define 5 influencing factors: recreation and leisure, entertainment, politics and business office, education, and footfall.

Mazinga [16] illustrates the GIS-based techniques are useful to discover spatial pattern that indicate the level of patient satisfaction with the health care industry in the region, as has been done by Murad [17], who developed GIS applications for planning retail facilities; Muray [8] who did the location modeling based on GIS; and Luo [18] which uses GIS-based approach to detect floating catchment lack of medical services in a given region.

3. Method

The object of this study is one of well-known convenience store from Japan. the scope of this research area bounded on the West Jakarta region. This brand has 17 stores in the region of West Jakarta, which is spread over 8 districts.

We obtained geographic and demographic data from BPS-Statistics Indonesia, based on census data from the year 2013. Borderline layer of West Jakarta Districts and Sub-Districts obtained from BPS-Statistics Indonesia, in UTM Projected Coordinates System GCS_WGS_1984. For background data layer of 8 districts included highways, streets, place, landuse, shop, leisure, etc was obtained from OpenStreetMap (http://openstreetmap.id/data/pbf/Jakarta.pbf). We also designed a questionnaire to study the relationship between consumer satisfaction of the convenience store and their behavioral intention, but we will discuss it in another paper.

The analytical procedures are outlined in Figure 1, adopted from Duggal [9] with some modification.

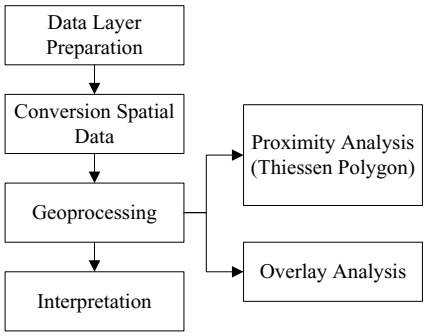

Fig. 1. Catchment Area Analytical Procedures

For this study, ArcGis® Desktop 10.0 for Windows® used for storage, processing, and analysis of spatial data and attribute data. A digital map with coverage area of West Jakarta obtained from BPS-Statistics Indonesia, in the form of sub-district polygon layer, further supplemented by the attribute data of each sub-districts, which obtained from BPS-Statistics Indonesia, using join table tool.

Background data layer of Jakarta, which download from OpenStreetMap, has a file extension .pbf. Data conversion from .pbf to .osm were using OSMconvert tool. Conversion result consists of 3 layers,

point, line, and polygon, and 32 fields, including highway, building, natural, waterway, amenity, landuse, etc. To simplify the data, selecting fields for each layer are conducted, using select tool, so we can present new layers in accordance with the needs for analysis, as we can see in Figure 2, presented as thematic map, to simplify data interpretation.

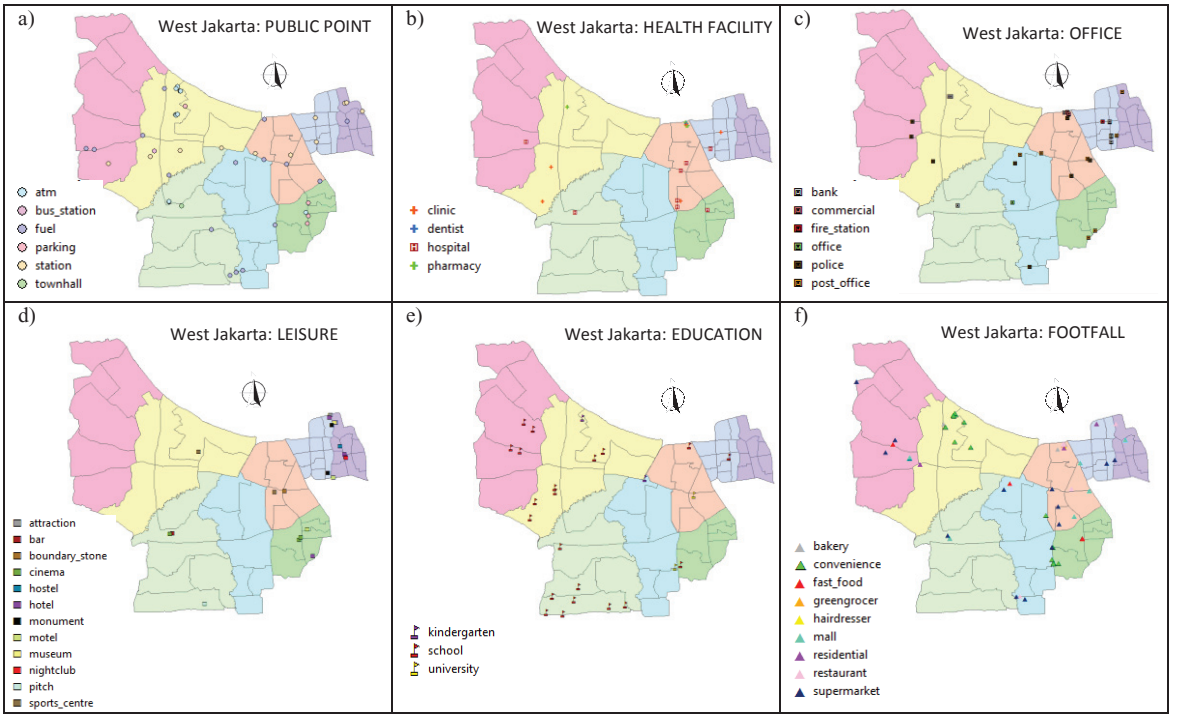

Fig. 2. West Jakarta Thematic Map to Visualize the Distribution of: (a) Public Point; (b) Health Facility; (c) Office; (d) Leisure; (e) Education; (f) Footfall

These six thematic maps are useful for data interpretation, to visualize the influencing factors of selecting a convenience store location, based on research of Chen, Hsu, Ye, & Huang [15], with some adjustment, as can be seen in Table 1.

Table 1. Influencing Factors of Selecting a Convenience Store Location

Major Attribute	Minor Attribute
Public Point	ATM, bus station, fuel, parking, station, townhall
Health Facility	Clinic, dentist, hospital, pharmacy
Office	Bank, commercial, fire station, office, police, post office
Leisure	Attraction, bar, boundary stone, cinema, hostel, hotel, monument, motel, nightclub, pitch, sports centre
Education	Kindergarten, school, university
Footfall	Bakery, convenience, fast food, green grocer, hairdresser, mall, residential, restaurant, supermarket

To obtain coordinate data of convenience store in West Jakarta area is done by using GPS. Record data from GPS converted using conversion tools from GPS(.GPX) to features. For every point in the convenience store location layer, were adding by attribute data.

Thiessen polygon represent areas of influence around a set of convenience store locations. Each Thiessen polygon contains only a single point input feature, and any location within a Thiessen polygon is closer to its convenience store than to any other convenience store. Figure 3 show the spatial structures of the Thiessen polygons around the point of convenience store in West Jakarta.

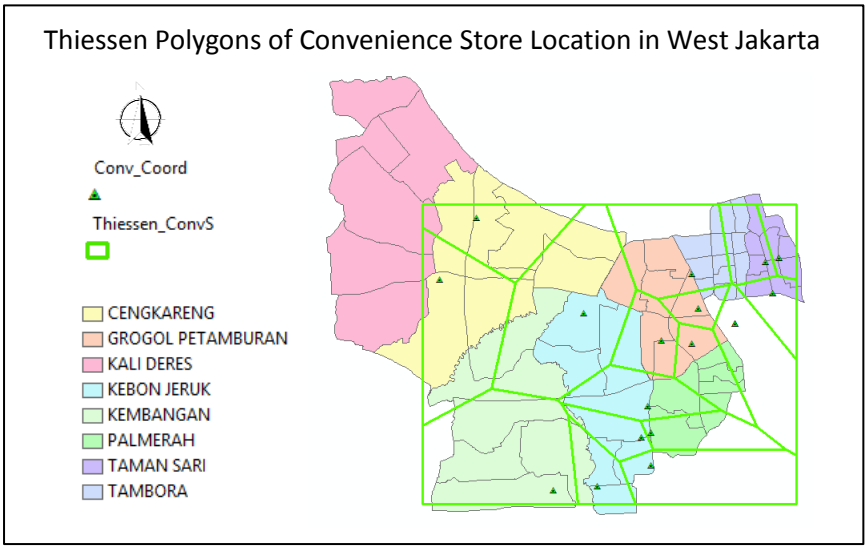

Fig. 3. Thiessen Polygons of Convenience Store Point Location in West Jakarta

4. Result and Discussion

Data of population based on census data displayed in map population density. As we can see in figure 4, the population value field symbolized with graduated colors, and also with dot density map. Analyst will easily find which region has more population, as well as find illustration of distribution of population. From this map, we can find that Cengkareng has the greatest population than other area, follow by Kalideres and Kebon Jeruk. It is an interesting thing, that if we only consider the number of people in determining the location of the convenience store, the current conditions are not suitable, because only a few number convenience stores for brands that are discussed in this study in the area which had greater population, and vice versa. More specific data related to demographics of the population would be more helpful to see the correspondence between the location of the convenience store with the distribution of the population.

Thiessen polygons used to divide the area covered by each convenience stores in West Jakarta into proximal zone. Based on graphical display, some convenience stores (such as in Cengkareng, Kembangan, and North Kebon Jeruk) cover a large area and the others cover a narrower area. Area of thiessen polygon calculated using Utilities Calculate Areas in Spatial Statistics Tools menu, and results of this calculation can be seen in figure 5.

From the Thiessen Polygons, simply we can find the quantity and the type of the features, which are the influencing factors of selecting a convenience store location, and the more we have a detailed attribute data, the more we can make a consideration about the accuracy of convenience store site selection. In the future study, we can find the correlation between the quantity and the type of the influencing factors of selecting a convenience store location with the performance of convenience store. As can be seen in figure 6, the distribution of convenience store location not always proporsional, and need further study to make an effective model, related to the performance of the store.

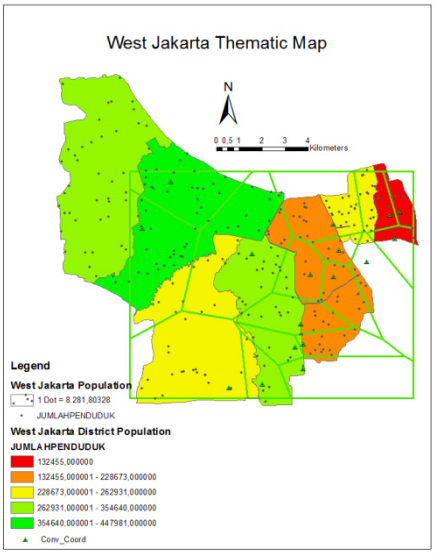

Fig. 4. Map Population Density

Table

Thiessen_ConvS_All_Calculate

OBJECTID *	Shape *	Id	Input_FID	Id_1	Nama_CS	Alamat_CS	Shape_Length	Shape_Area	F_AREA
1	Polygon	0	9	0	JOGLO	Jl. Joglo Raya No. 33 RT. 011/003,	0,144794	0,001362	16670292,266005
2	Polygon	0	10	0	KEMANGGISAN	Jl. Kemanggisan Ilir Raya no. 40 Pal	0,104909	0,000468	5726168,155648
3	Polygon	0	11	0	MANGGA BESAR	Jln. Mangga Besar Raya 41 Tangki,	0,062241	0,00019	2327212,715579
4	Polygon	0	14	0	SEASON CITY	Lobby Barat GF1 Jl. Jembatan Besi	0,113452	0,000806	9862895,137004
5	Polygon	0	6	0	TAMAN PALEM	Jl.Ruko Mutiara Taman Palem Blok	0,118294	0,000658	8055262,674195
6	Polygon	0	16	0	ANGGREK	Jl. Anggrek (SAMPING BINUS ANG	0,068699	0,000219	2680779,245464
7	Polygon	0	15	0	SYAHDAN	Jln. KH Syahdan no.1 Jakarta Barat	0,095578	0,000349	4272990,985615
8	Polygon	0	12	0	MERUYA-SRENGSENG	Jl. Pos Pengumben Raya No.10 Rt.	0,077862	0,000292	3567909,335802
9	Polygon	0	4	0	MEDITERANIA 1	Kav. 5 Tanjung Duren Raya Kelura	0,075799	0,000351	4291695,903359
10	Polygon	0	3	0	KEBAYORAN LAMA	Jln. Mesjid Al-Anwar Berdikari no.3	0,129913	0,000812	9936565,623236
11	Polygon	0	1	0	GELONG BARU	Jl. Gelong Baru Utara No. 1A Kel. T	0,087075	0,00036	4410855,283069
12	Polygon	0	13	0	OLIMO	Jl.Hayam Wuruk No.120 F-E Rt.010/	0,071274	0,000289	3537031,905639
13	Polygon	0	8	0	GRAND CENTRAL	Jl. Gajah Mada No.188, JakBar	0,07127	0,000232	2839670,646684
14	Polygon	0	7	0	BIAK	Jln. Biak no.16B Jakarta Barat	0,119727	0,00068	8324847,05222
15	Polygon	0	5	0	MUWARDI	Jl. DR Muwardi 2 No.19 Rt.014 / R	0,055661	0,00016	1961978,751355
16	Polygon	0	2	0	GREEN GARDEN	Jl.Panjang Blok A-14 No. 26, Green	0,159131	0,00159	19466210,646002
17	Polygon	0	0	0	APARTEMEN PARK VIEW	Jl. Daan Mogot Km 14 Sumur Bor, C	0,146047	0,001086	13290779,505736

1 (0 out of 17 Selected)

Thiessen_ConvS_All_Calculate

Fig. 5. Area of Thiessen Polygons

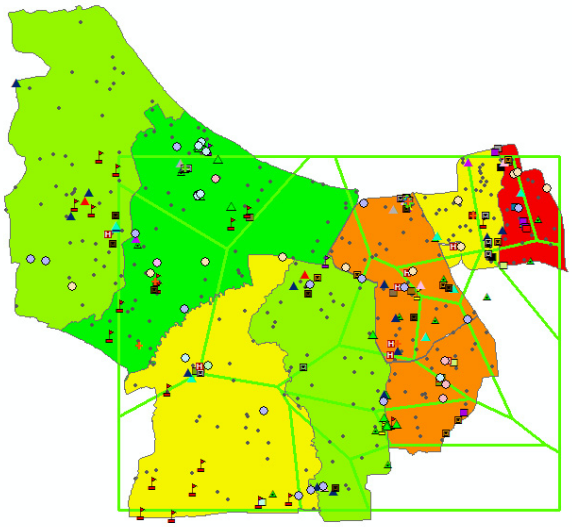

Fig. 6. Features Inside Thiessen Polygons

Either graphically or seen from the quantity of the locations which are influencing factor, found that there are indications of correlation between the existence of points which are the influencing factors in determining the location of convenience store. It needs to be proved by statistical analysis for future study.

5. Conclusion

The concept of trade area analysis has always been quite appealing and popular with retailers because it helps them to gain much needed understanding of the business potential and the competition with other retailers [9]. Thiessen polygons from GIS analysis give a better perspective to evaluate the convenience store, to find what kind of factors which can influence customer to buy.

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