Mapping the distribution network of a government non-cash food assistance in Kulon Progo Regency using geospatial information system

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Abstract. Indonesia government provides non-cash food assistance to people. Every household gets rice and egg in the equivalent of IDR 110,000 per month. In Kulon Progo Regency, the number of recipients amounted to around 53,000 households. Rice and eggs to be distributed should come from local farmers and breeders. The delivery is conducted by e-Warong, a community-owned small kiosk. However, the location of rice supplier and e-Warong have not been known. This paper aims to describe the mapping of these parties and analyze their spatial implication. The following geospatial data: administrative boundary, road network, and digital elevation model (DEM). List of recipients, e-Warong and Gapoktan were provided by the Social Agency of Kulon Progo Regency. Mobile Topographer apps were used to map the location of 13 rice suppliers, 111 e-Warongs, and parts of household recipients. Egg suppliers are not mapped because for each month each E-Warong can change suppliers, adjusting the availability of eggs. They were processed using spatial analysis operation. The result is maps of the distribution network and service area. Spatially and visually, the inequality of the distribution network is evident. This inequality is caused by distance and topography, factors that were not visible in the textual data currently in use. Where the E-Warong area in the northern part of the district is a plateau or hilly which makes mobility more difficult than E-Warong in the southern part which is a lowland. GIS has been used to create maps of the distribution network in visually attractive and spatially descriptive models.

1. Introduction

Poverty alleviation is still a major issue in Indonesia. Several government initiatives were established to reduce poverty level. Among them is providing non-cash food assistance (Bantuan Pangan Non Tunai: BPNT) to poor people. It is meant to eliminate one of the poor indicators. Recipients of this program do not receive money. Instead, they get rice and egg in a certain amount, which is currently set at Rp. 110,000.

The distribution of this non-cash food assistance is not conducted through a regular market mechanism. It is executed using E-Warong network. E-Warong is Electronic Warung Gotong Royong, set up as per the requirement of the Regulation of the Minister of Social Affairs 25/2016 [1]. E-Warong tasks are to distribute government assistance in the form of food and/or cash money electronically,
groceries items, and products from community groups (Kelompok Usaha Bersama: KUBE). Each E-Warong is supposed to be able to serve 500-1,000 recipients of BPNT.

Kulon Progo Regency is also running the BPNT program. In 2019, there are around 53,000 BPNT recipients and 111 E-Warongs. Local policy dictates that rice and eggs to be distributed through the program should come from local rice farmers and breeders. The policy meant to multiply the impact of the received funds, as it will be spent in the regency. As such, 12 farmer groups (Gabungan Kelompok Tani: Gapoktan) were tasked to provide the required rice. For the provision of egg, there are more providers than rice, which is not the scope of this investigation.

Based on the topography, Kulon Progo can be divided into two distinct terrain, flat areas in the southern and middle part, and hilly regions in the north and northwest. The population and agricultural field were concentrated in the south part. In the context of BPNT distribution, this creates a situation where Gapoktan in the south has to serve the requirements of E-Warong in the north. However, up to now, it is only known theoretically since the map-based representation of E-Warong, Gapoktan, and BPNT recipients are not available.

The absence of this maps hindering visual analytics of the spread of three elements in the distribution of BPNT, and the distance and travel time of them. This paper presents the process of mapping these three elements and analyzing their spatial relation. It enhances the analysis provided in [1].

The primary method of spatial analysis used in this research is network analysis. It can be used to find the optimal route, closest facility, service area, and OD Cost Matrix [2]. OD Cost Matrix is used in finding the minimum and optimum distance from the origin to destination [3]. The result is a straight line with the actual distance is stored in its attribute table [4].

Creation of service area developed in this research is similar to the development of ambulances’ service area in Yogyakarta by [5]. The difference is that [5] used OSM road network, while this research uses official road network dataset. OD Cost Matrix utilization has also been used by many researchers, such as used by [6] and [7].

2. Method

2.1. Data and location
This research was conducted in Kulon Progo Regency. It is the westernmost regency in Daerah Istimewa Yogyakarta. The regency consists of 12 districts and 88 villages with a total land area of 586.28 km². The topography of Kulon Progo is varying, with a flat area in the south and middle part, and hilly area in the north and west. According to the land elevation, 44.37% of the land is situated above 100 m. The population in 2018 is 421,295 [8].

The administrative boundary and road network was downloaded from the geoportal of DIY. Address of E-Warong, Gapoktan, and BPNT recipients was obtained from the Agency of Social Affairs, Kulon Progo. The address is in textual form without any coordinates. The location of E-Warong, Gapoktan, and sample of BPNT recipients was surveyed directly. In addition, the location of houses in Kulon Progo was also added, based on the data from Village Mapping Project of the Dinas Pertanahan and Tata Ruang DIY.

The location of 111 E-Warongs and 12 Gapoktan were recorded using Mobile Topographer apps on a smartphone. Mobile GIS apps like this can give coordinates of places anywhere in the field [9]. Its coordinates have sufficient accuracy for several applications, including this research. Field survey had to be conducted because there was no geocoded address, a problem identified in [10]. Besides location, photos of E-Warongs and Gapoktan were also taken. On the BPNT recipients, only a small portion of them was mapped as sample. BPNT recipients always purchase rice and eggs on the nearest E-Warong. To navigate to the E-Warong, Gapoktan, and BPNT recipients, address from Social Affairs Agency was used as a guide to the nearest location.
2.2. Data processing
The first step in data processing is inputting administrative boundary and road network as the base data. It was then followed by entering the coordinates of the three elements in BPNT distribution: E-Warongs, Gapoktan, and sample of BPNT recipients’ houses. These data were initially in shapefile format. They were converted into feature dataset in a geodatabase environment. For the road network, the next step was creating the topological network and developing network dataset. The topologically correct network is a requirement if it is to be used in finding the shortest route using Dijkstra or Bellman Fordi algorithm [11]. Dijkstra algorithm is one of the best in network analysis [12]. In this network dataset, speed parameters for the network analysis were inputted. The speed parameters were set according to the Law 38/2004 on Road. For arterial road, the speed is set at 60 km/hour, followed by 40 km/hour for collector road, 20 km/hour for local road, and 10/hour for other types of road. The minimum speed limit permissible by the law is used in the processing [13].

Based on the parameters, the time travel from each Gapoktan to E-Warong, and from BPNT recipients to E-Warong were calculated. The time travel is calculated in minutes, using the following formulae.

\[
\text{Time travel (minutes)} = \frac{\text{Road length (m) \times 60}}{\text{Speed (km/hours) \times 1000}}
\] (1)

2.3. Visualization
Three visualization products were developed. Visualization aimed to convey the finding to the audiences [14]. The first maps visualize distance and travel time from Gapoktan to E-Warong. All 12 Gapoktan and 111 E-Warong were displayed on the map. In the OD Coast Matrix, the origin was the Gapoktan while the destination was the E-Warong. The relationship is one-to-many.

The second maps visualize distance and travel time from E-Warong to BPNT recipients’ houses. Due to the huge number of BPNT recipients, a small portion of recipients was chosen, based on 5 E-Warongs location. The origin is E-Warong, while the destination is BPNT recipients’ houses. The relationship is one-to-many.

The third maps visualize the complete picture of the spatial distribution of E-Warong and Gapoktan in the regency. The maps complemented by hillshade and heatmap of population density in Kulon Progo. Hillshade is a shadowed relief of raster with taking into account the azimuth and elevation of the light source (the sun) to create a realistic impression of the terrain [15]. Heatmap, which also known as density analysis, is obtained by calculating the density value of a raster [16].

3. Results and Discussions

3.1. Field survey results
A field survey was conducted between February and May 2019. Coordinates of 111 E-Warongs and 12 Gapoktan were recorded, along with their photos. In addition, BPNT recipients’ houses were also recorded in three villages. Thirty-nine houses in Karangsari, 34 in Sendangsari, and 20 in Karangwuni. The selection of these three villages was based on the availability of administrative boundary up to sub-village (Dusun) and neighborhood (RT) level. Sample of survey results is presented in Figure 1.
3.2. Distribution of E-Warong and Gapoktan

The number of E-Warong is not evenly distributed. Some E-Warongs are serving several villages, in other condition, two to three E-Warongs serve one village. Detailed information on the distribution of E-Warong is presented in Table 1.

| District | Village | E-Warong | Gapoktan | District | Village | E-Warong | Gapoktan |
|----------|---------|----------|----------|----------|---------|----------|----------|
| Temon    | 15      | 4        | 1        | Kokap    | 5       | 8        | -        |
| Wates    | 7       | 9        | 2        | Pengasih | 5       | 10       | 1        |
| Panjatan | 11      | 10       | 2        | Nanggulan| 6       | 9        | 1        |
| Galur    | 7       | 7        | 2        | Girimulyo| 4       | 7        | -        |
| Lendah   | 6       | 9        | -        | Kalibawang| 4     | 10       | -        |
| Sentolo  | 8       | 15       | 3        | Samigaluh| 7      | 12       | -        |

Gapoktan is the rice producer. Their existence is not available in all districts. Due to the topography, the rice field does not exist in all districts. Rice field is located in District Temon, Wates, Panjatan, Galur, Sentolo, Pengasih, and Nanggulan. Five other district has a limited amount of rice fields, and therefore they do not have Gapoktan.

The location of all E-Warong and Gapoktan have been surveyed. Their coordinates were entered into a GIS. The spatial distribution E-Warong and Gapoktan are presented in Figure 2.
Figure 2. Spatial distribution of E-Warong (left) and Gapoktan (right) in Kulon Progo.

The spatial distribution of E-Warong is presented on top of population density heatmap. E-Warong is not evenly distributed in Kulon Progo. They concentrated in the middle and southeast of the regency, in District Wates, Sentolo, Panjatan and Galur. These districts have higher population compared to other districts. If the number of BPNT recipients is proportional to the number of population, the number of E-Warong will also be higher.

The number of E-Warong is less in the west and northern part of Kulon Progo since the number population is also less. The regulation stipulates that one E-Warong should serve at least 500 households. This requirement cannot be fulfilled in a less dense area. Therefore, in these hilly and less populated regions, E-Warong can serve less number of households. Otherwise, the distance and travel time from BPNT recipients to E-Warong will be higher.

3.3. Distance and travel time from Gapoktan to E-Warong
Gapoktan is the provider of rice for E-Warong. The less the distance between them, the less cost associated with transporting the rice. As mentioned in the previous section, the location of Gapoktan is concentrated in the south of the regency. Inevitably, there will be Gapoktan in the south that has to serve E-Warong in the north.

The capacity of Gapoktan will also define how many E-Warong they can supply. There are different capacity and number of E-Warong they serve, as detailed in Table 2. Gapoktan Pancea Manunggal supplies the most, 15 E-Warong. Gapoktan Makmur Sejahtera has the most area to supply, four districts. Only one Gapoktan, Karya Sejahtera in Nanggulan, who serve E-Warong in one district located in their area. Further, the map of supply capacity for every Gapoktan is presented in Figure 3.
Table 2. Supply area and capacity of Gapoktan.

| Gapoktan Location Distribution area | E-Warong | Gapoktan Location Distribution area | E-Warong |
|-------------------------------------|----------|-------------------------------------|----------|
| Among Tani Temon, Kokap, Nanggulan | 6        | KT. Sedyo, Rukun, Galur             | 7        |
| Panca Manunggal Wates, Kokap, Nanggulan | 15      | Sumber Makmur, Sentolo, Sentolo, Samigaluh | 14      |
| Ngesti Raharjo Wates, Pengasih, Kokap | 9        | Makmur Sejahtera, Sentolo, Sentolo, Lendah, Samigaluh, Girimulyo | 14      |
| Sido Maju Panjatan Panjatan, Kalibawang | 11      | Rukun Makaryo, Sentolo, Girimulyo, Samigaluh | 8        |
| Sutera Panjatan Panjatan Sari Mulyo, Pengasih, Samigaluh | 9       | Pengasih Sejahtera, Nanggulan Nanggulan | 6        |
| Cipta Boga Galur Lendah Karya Sejahtera | 8        | Nanggulan, Nanggulan               | 6        |

Figure 3. shows a large number of E-Warong served by each Gapoktan using proportional symbols. The more e-warong they served, the larger the symbol displayed. The high supply capacity of Gapoktan located in the ‘rice belt’ of Kulon Progo. This is the location of rice fields. However, they are located in
the southern part of the regency. To supply E-Warong located further north the delivery vehicle has to travel far. The decision on which Gapoktan supply which E-Warong is a consensus between Gapoktan and E-Warong coordinator in every district. Due to the number and location of Gapoktan and E-Warong, spatial inequality is unavoidable. Figure 4. illustrates the distance and travel time between Gapoktan and E-Warong they supply.

Distance in Figure 4. left is classified into three classes: <10, 10-20, and >20 km. On the travel time, the classification is similar: <10, 10-20, and >20 minutes. They were symbolized using green, yellow, and red color, respectively. In both maps, the red color dominates the lines that through the northern part. It is an indication that both distance and travel time 20 km or 20 minutes.

The average distance between Gapoktan and E-Warong is 11.28 m, with the farthest distance is 40.29 km for Gapoktan Makmur Sejahtera. Five Gapoktan have to supply E-Warong with >20 distance, Sido Maju, Sutera, Sumber Makmur, Makmur Sejahtera, and Rukun Makaryo. There are four districts dominated with red color in both maps: Nanggulan, Kalibawang, Samigaluh, and Girimulyo.

On the southeast region, there are a few connections which reveal that the distance is represented in yellow color but the travel time is more than 20 minutes. The average travel time from Gapoktan to E-Warong is 20 minutes. The longest travel time is 77 minutes, from Gapoktan Makmur Sejahtera in Sentolo to E-Warong Samigaluh VIII in Pagerharjo village, District of Samigaluh.
3.4. Distance and travel time from E-Warong to BPNT recipients

In these visualizations, only five E-Warong in three villages were used as a sample. They include E-Warong Pengasih I and E-Warong Pengasih II in Karangsari village, E-Warong Pengasih VIII and E-Warong Pengasih IX in Desa Sendangsari, and E-Warong Wates X in Karangwuni village. The coordinates of some BPNT recipients’ houses were recorded. These three villages also have administrative boundary map up to the neighborhood level.

The distance between BPNT recipients’ houses and E-Warong was classified into three classes: <2,5, 2,5 - 5 dan >5 km. The average distance to E-Warong Pengasih I and Pengasih II are 1,47 km and 0,98 km, respectively. The farthest distance is 3,18 km. In Sendangsari village, the figure is slightly different. The average distance to E-Warong Pengasih VIII and Pengasih IX are 2,49 km and 2,39 km, respectively. The farthest distance is 3,23 km.

For the last example, Karangwuni village, the distance is shorter. The average distance is 1,26 km, while the farthest is 2,04 km. Karangwuni is the smallest village among the three. The distance maps from E-Warong to BPNT recipients is presented in Figure 5.

![Distance from E-Warong to BPNT recipients in Karangsari (a), Sendangsari (b), and Karangwuni (c).](image-url)
3.5. *E-Warong service area*

The service area of E-Warong was made to illustrate the distance of every house to E-Warong. It is beneficial if there are some changes to the BPNT recipients data. If other data become available, such as complete administrative boundary map up to the neighborhood level or location of every BPNT recipients were recorded, they can be put into this map.

Besides E-Warong position, this map relied on buildings map available from the Village Mapping Project. The project was carried out by Dinas Pertanahan dan Tata Ruang, Daerah Istimewa Yogyakarta. In this service area map, the distance from E-Warongs to every house is calculated and visualized. The distance was classified into three classes, similar to the previous section. The map is presented in Figure 6.

![Figure 6. The service area map of E-Warong in Kulon Progo.](image)

From Figure 6, it is evident most houses in Kulon Progo is located less than 2.5 km from E-Warong. A small portion is located in an area situated between 2.5 to 5 km, while only a little number of the houses located farther than 5 km from E-Warong. The area with a longer distance to E-Warong located in the District of Kokap, Girimulyo, Samigaluh, and Kalibawang. However, despite the uneven distribution of E-Warong, largest population of Kulon Progo is served by nearby one.
4. Conclusion
Current practices in many local governments show that locational information has not been used extensively. Information that should spatial footprint still treated as by-name and by-address, without adding by-coordinates information. Consequently, spatial based visualization and analytics were rare. Here we developed maps of the distribution network of non-cash food assistance (BPNT) in Kulon Progo Regency. The spatial distribution of Gapoktan (rice producer), and E-Warong (distributor) were visualized in maps. The spatial linkage between Gapoktan, E-Warong, and BPNT recipients was also presented in maps. Maps visualization helps to understand spatial equity of the BPNT distribution network. Through service area map, it is shown that the majority of people in Kulon Progo can be served by relatively near E-Warong.

5. References
[1] Wulandari M D 2019 Pemetaan Sebaran dan Daerah Layanan E-Warong di Kabupaten Kulon Progo, Undergraduate Thesis, Department of Geodetic Engineering, Universitas Gadjah Mada, Yogyakarta (unpublished).
[2] Pemerintah Republik Indonesia 2017 Peraturan Menteri Sosial Republik Indonesia Nomor 25 Tahun 2016. Bantuan pengembangan sarana usaha melalui Elektronik warung gotong royong kelompok usaha bersama Program Keluarga Harapan. Jakarta: s.n.
[3] Verbyla D L 2002 Practical GIS Analysis. Taylor & Francis, London.
[4] Wang F 2015 Quantitative Methods and Socio-Economic Applications in GIS. CRC Press, Boca Raton, FL.
[5] ESRI 2018 OD Cost Matrix Analysis Available at: http://desktop.arcgis.com/en/arcmap/latest/extensions/network-analyst/od-cost-matrix.htm [accessed on 27 November 2018]
[6] Astuti S D 2016 Perhitungan Wilayah Pelayanan Ambulans di Wilayah Kota Yogyakarta dan Sekitarnya Skripsi. Department of Geodetic Engineering, Universitas Gadjah Mada, Yogyakarta.
[7] Wang F and Xu Y 2011 Estimating O-D Travel Time Matrix by Google Maps API: Implementation, Advantages, and Implications. Taylor & Francis, Vol. 17. No.4.
[8] Badan Pusat Statistik Kabupaten Kulon Progo 2018 Kulon Progo dalam Angka BPS Kabupaten Kulon Progo.
[9] El-Bakry H M, Shabana BT and Sharaf N 2017 GIS Utilization for Delivering a Time Condition Products. IJACSA. Vol. 8. No.3
[10] Sutanta H Chintya NPP Syarafina Z 2016 Issues and challenges in developing geocoded address in Indonesia AIP Conference Proceedings 1755, 070010
[11] Warf B 2010 Encyclopedia of Geography. SAGE Publications, California.
[12] Ramdani F 2017 Pengantar Ilmu Geoinformatika. UB Press. Malang.
[13] Curtin KM 2008 Network Analysis in Geographic Information Science: Review, Assessment, and Projections. Cartography and Geographic Information Science 34, 103–111.
[14] Pemerintah Republik Indonesia 2004 Undang-Undang Republik Indonesia No.38 Tahun 2004 Tentang Jalan. Jakarta: s.n.
[15] Lobben A Brittell M E and Perdue N A 2015 Inclusive Cartographic Design: Overcoming Ocular-Centric Cartographies. Springer, Switzerland.
[16] Burke R Napoleon E and Ormsby T 2004 Getting to Know ArcGIS Desktop: Basics of ArcView, ArcEditor, and ArcInfo. ESRI Press. Redlands
[17] Hasri MI A and Santosa PB 2018 The Use of Location Based Instagram Data for Tourism Potential Analysis in Kabupaten Gunung Kidul. JGISE. Vol.1. No.1

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