Global Scientific and Academic Research Journal of Multidisciplinary Studies
ISSN: 2583-4088 (Online)
Frequency: Monthly
Published By GSAR Publishers
Journal Homepage Link- https://gsarpublishers.com/journals-gsarjebm-home/

Accessibility Analysis of Waste Collection Facilities (WCFs) in Maoming City Based on Grid G2SFCA Method

BY

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Article History

Received: 27/05/2023
Accepted: 05/06/2023
Published: 06/06/2023

Vol – 2 Issue – 6

PP: - 06-14

Abstract

With continuous socio-economic development and changes in consumption patterns, urban and rural areas are facing an increasing amount of domestic waste, and it is increasingly important for governments to improve the accessibility of waste collection facilities (WCFs) when planning environmental sanitation construction schemes. This paper evaluates the accessibility of WCFs in Maoming City, Guangdong Province, based on the grid-based Gaussian two-step movement search method (G2SFCA) and spatial analysis. The study shows that the correlation between the existing WCFs and the traffic road network is strong, and the correlation with the population is weak. When planning and constructing in the future, more attention should be paid to the central location of the area and the factors of population distribution.

KEYWORDS： *Gaussian Two-step Floating Catchment Area Method (G2SFCA)；Geography Information System (GIS)；Accessibility；Waste Collection Facilities (WCFs)；Kernel Density Analysis (KDA)*

1. Introduction

According to the 2020 Annual Report on the Prevention and Control of Solid Waste Pollution in Large and Medium-sized Cities Nationwide published by the Ministry of Ecology and Environment, in 2019, 196 large and medium-sized cities generated 235.602 million tons of domestic waste and treated 234.872 million tons, with a treatment rate of 99.7%. In the 196 large and medium-sized cities in China, the largest amount of municipal domestic waste was generated in Shanghai with 10.768 million tons, followed by Beijing, Guangzhou, Chongqing, and Shenzhen. According to the National Bureau of Statistics and Organization for Economic Co-operation and Development (OECD) data, China's domestic waste production has maintained a growth rate of around 5% in recent years.

China's domestic waste treatment industry chain is divided into the middle and upper reaches of the industry chain and downstream, of which the middle and upper reaches include the supply of equipment for domestic waste treatment as well as domestic waste collection, classification, and transfer. While the downstream is the domestic waste treatment industry, including waste incineration and disposal, sanitary landfill treatment, and other treatment technologies and resource recovery. In recent years, China's municipal domestic waste collection sites have grown year over year. By the end of 2019, 28,246 household WCFs had been built in cities, and 281,558 special vehicles and equipment for city appearance and sanitation had been built, with a clearance volume of 242.06 million tons.

The trend of the times for domestic waste disposal, which is oriented towards green, low-carbon, and circular development, has become a global consensus, the direction of the scientific and technological revolution and industrial change in this era, and an inevitable choice for China's current economic restructuring and sustainable development. The construction of urban public service facilities, which are the primary carriers of the city's services to the public, is fundamental to improving people's livelihoods and ensuring social equity and stable development. A good configuration of urban public service facilities is an important means to improve the quality of life of urban residents, their living environment, and the spatial structure of the city (Fu et al., 2017). Urban public service facilities include social infrastructure such as healthcare, education, recreation, commerce, amenities, and sanitation (including WCFs) (GB 55013-2021). Accessibility and reasonableness of WCFs are key requirements for meeting the quality of domestic waste disposal.

Hansen (1959) first introduced the concept of accessibility and defined it as the magnitude of opportunities for the interaction of various nodes in a transportation network, and it

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has gradually played an important role in urban transportation planning, facility siting, and landscape planning research. Although many accessibility analyses have been conducted in China for public service facilities such as green areas and medical facilities (Tong et al., 2021; Xu et al., 2021; Meng and Li., 2023; Gao et al., 2023; Xu, 2023; Zhang et al., 2023; Zuo et al., 2023), research on the accessibility of WCFs is relatively scarce. In addition, an important principle in the planning and construction of WCFs should take into account a balanced layout, and accessibility is an important indicator to assess whether WCFs are laid out in a balanced manner.

Based on this, this study presents an accessibility and spatial analysis of the WCFs in Maoming. It is meaningful for improving the planning and construction of public service facilities in the city, strengthening the domestic waste disposal industry chain in China, and alleviating a series of environmental pollution problems caused by the accumulation of domestic waste.

2. STUDY AREA AND DATA SOURCES

2.1 Study Area

Maoming is located between 110–114°41'E and 21°22'30"–22°42'30"N. It is bordered by the South China Sea in the south and Guangxi in the north and is situated in the tropical to subtropical transition zone, with a warm climate. It has abundant rainfall and relatively obvious resource advantages (Yang et al., 2004) (Figure 1). The city has two municipal districts (Maonan and Dianbai) and three county-level cities (Gaozhou, Huazhou, and Xinyi) under its jurisdiction, with a total of 92 towns, two pilot development zones, and 17 street offices. The city has a land area of 11,427.63 km2, a built-up area of 37.10 km2, and a resident population of 6.2197 million.

To the west of the city is the Hexi Industrial Zone, where petrochemical, thermoelectric, construction materials, tannery, and fertilizer industries are located. To the east of the city is the Hedong Commercial and Residential Zone, where party and government organs and commercial residences are located. To the northeast of the city is the Guandu Cultural and Educational Zone, where universities and colleges are relatively concentrated. To the south of the city is the Maonan Development Zone, where commercial and residential housing and light pollution industries are mainly developed. Between the Hedong Commercial and Residential Zone and the Hexi Industrial Zone is the Hexi Mixed Zone. (Huang, 2014).

There is one domestic waste incineration power plant and four biochemical pond landfills in the city. At the same time, 110 towns (streets) have built domestic waste transfer (compressor) stations, and 21,113 waste collection points have been built in villages. During the period from November 27 to December 1, 2017, according to the urban and rural cleanliness project's open inspection and unannounced inspection teams, environmental hygiene surveys of roads, villages, pueblos, and waters in all areas of the city showed that. With the existing domestic waste disposal sites becoming increasingly saturated with capacity, the appearance of urban and rural areas is generally tidy, but in non-urban areas of towns and villages, there is still the phenomenon of waste being left behind for long periods of time (Hou and Chen, 2018).

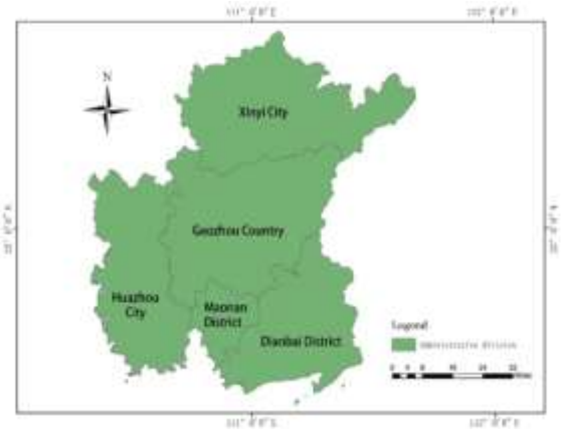

Figure1 Administrative Map of Maoming City, Guangdong Province

2.2. Database Establishment

This study integrates big data with GIS to enhance spatial information processing capabilities. Based on the web database, the collected spatial data include Maoming administrative division, WCF points, traffic road network, population raster, cell points, etc. The above data are all in the WGS 1984 UTM Zone 49 N projection coordinate system.

1) The administrative division data was vector-zed and geo-aligned using the ArcScan tool of ArcGIS and finally imported into the database.
2) The spatial data of the refuse collection facility points were acquired from Gaode Map, and the collected coordinate data and related data were imported into ArcGIS using the .dbf format to generate the point data and entered into the database.
3) The traffic network data was obtained from Open Street Map (OSM). The .osm format road data was then converted to .shp format using ArcGIS, the road data was corrected and imported into the research database, topology operations and topology checks were carried out, and then the spatial road network dataset was created.
4) The population raster data is derived from the World Pop 100m population raster data downloaded from the Worldpop website for the year 2020. After cropping by administrative district mask, the population raster data was corrected based on the data from the "Maoming Seventh National Census Bulletin" and entered into the database after processing.
5) The spatial data of Maoming cell points are generated based on the population raster of Maoming (grid instead of the cell), using ArcGIS's "Create Fishnet" tool to create a grid with a cell size of 2000m×2000m; then use the created fishnet grid

to calculate the population in each grid by "Show in Table". The population in each grid was calculated using "Subdivision Statistics", and then the grid with a population greater than 0 was filtered using the definition query function of the layer properties. The grid was converted to point elements using the "Element to Point" tool of ArcGIS and entered into the study database.

3. Methodology

3.1 Method

This study is using the data sets of the administrative division, WCFs points, traffic road network, population raster, and Maoming district data. The main analysis steps (Figure 2), respectively, are as follows:

1) Spatial and quantitative analysis of GIS as research methods; including mean centers, standard deviation ellipses, kernel density analysis, band collection statistics, G2SFCA method, GIS gridding, and network analysis as research techniques;
2) Using spatial analysis and supply-demand relationships as the entry point, construct a research database with WCFs in Maoming as the research object;
3) An analysis of the current situation of the spatial configuration of WCFs in Maoming based on ArcGIS using the mean center, standard deviation ellipse, kernel density analysis (KDA), and band collection statistics;
4) Accessibility analysis, potential saturation analysis, and blind area analysis of existing WCFs based on G2SFCA, GIS gridding, network analysis, and the quartile method;
5) Based on the results of the above analysis, the study findings are then analyzed.

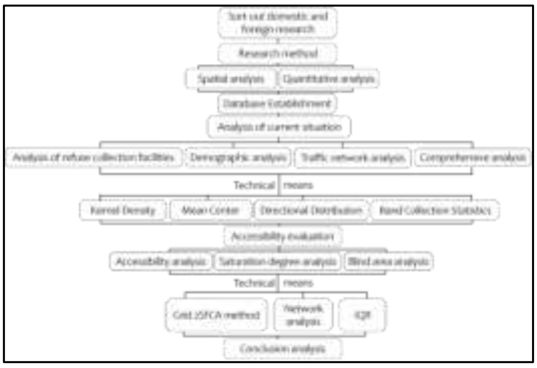

Figure 2 The Schema Flowchart of This Study

3.2 Related technical means

3.2.1Kernel Density Analysis

The kernel density analysis (KDA) tool is used to calculate the density of an element in its surrounding neighborhood, by creating a continuous layer to represent the density of the spatial point distribution. The more distant the point is from the search center, the lower the weight is, and the results are smoothly distributed. In this study, the KDA tool was used to calculate the distribution density values of WCFs, districts, and traffic road networks in Maoming by inputting the$x$coordinates, the$y$coordinates and the total number of elements, applying the calculation of Formula (1) to generate the points of$x$ coordinates and$y$ coordinates, which are thecoordinates of all facility points$x$ coordinates and$y$ The average of thecoordinates of all facility points.

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}, \quad \bar{y} = \frac{\sum_{i=1}^{n} y_i}{n} \tag{1}$$

Where x_i and y_i are the coordinates of the elements i, and n is the total number of elements.

3.2.2 Mean Center

The mean center tool is a method for calculating the geographic center or density center of a set of elements. In this study, the mean center tool was used to calculate the geographic centers of WCFs, neighborhoods, and roads in Maoming, respectively, and the generated points'x coordinates and$y$ coordinates can be considered the centers of gravity of the WCFs, subdivisions, and roads. The mean center can be expressed as Formula (2).

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}, \quad \bar{y} = \frac{\sum_{i=1}^{n} y_i}{n} \tag{2}$$

Where x_i and y_i are the coordinates of the elements i, and n is the total number of elements.

3.2.3 Directional Distribution

The directional distribution is used to summarize the spatial characteristics of the central, discrete, and directional trends of the elements by creating standard deviation ellipses. The long half-axis of its ellipse indicates the direction of element distribution, and the short half-axis indicates the range of element distribution. The greater the difference between the values of the long and short half-axes, the more obvious the directional tendency of the element, and vice versa, the less obvious the directional tendency of the element; the shorter the short half-axis of its ellipse, the more obvious the centripetal force of the element; and vice versa, the greater the dispersion of the element.

In this study, the standard deviation ellipse tool was used to calculate the WCFs, residential points, and transportation network of Maoming, respectively, and the generated points'$x$coordinates and y coordinates can be considered as the central trend, dispersion, and directional trend of the WCFs, residential points, and transportation network. The standard deviations of x and y axes are calculated as shown in Formula (3).

$$\sigma_{1,2} = \left(\frac{\left(\sum_{i=1}^{n} \tilde{x}_i^2 + \sum_{i=1}^{n} \tilde{y}_i^2\right) \pm \sqrt{\left(\sum_{i=1}^{n} \tilde{x}_i^2 - \sum_{i=1}^{n} \tilde{y}_i^2\right)^2 + 4\left(\sum_{i=1}^{n} \tilde{x}_i \tilde{y}_i\right)^2}}{2n} \right)^{1/2} \tag{3}$$

Where x and y are the coordinates of elements i, $\{\bar{x}, \bar{y}\}$ represents the average center of elements, and $n$is the total number of elements.

3.2.4 Band Collection Statistics

The band collection statistics tool is used to provide statistical values for multivariate analysis of raster band collections.

When the Calculate covariance and correlation matrix option is enabled, the covariance, correlation matrix, minimum, maximum, mean, and standard deviation are output.

The remaining elements in the covariance matrix are the covariance between all input raster pairs. The formula for calculating the covariance between layers is shown in Formula (4).

$$Cov_{ij} = \frac{\sum_{k=1}^{N}(Z_{ik}-\mu_i)(Z_{jk}-\mu_j)}{N-1} \quad (4)$$

Where $Z$is the image element value; i,$j$is the stacked layer, and μ is the average value of the layers,N is the number of image elements,$k$is the number of pixels.

The correlation matrix shows the value of the correlation coefficient, which describes the relationship between two data sets. For a set of raster layers, the correlation matrix represents the image element values in one raster layer that are associated with the image element values in another layer. The correlation between two layers can be used to measure inter-layer dependencies. The correlation is the ratio of the covariance between two layers to the product of the standard deviation of the two layers, and the formula for calculating the correlation is shown in Formula (5).

$$Corr_{ij} = \frac{Cov_{ij}}{\delta_i \delta_j} \quad (5)$$

Correlations range from +1 to -1; a positive correlation indicates a direct relationship between the two layers; a negative correlation indicates that one variable varies inversely with the other; and a zero correlation indicates that there is no dependency between the two layers.

3.2.5 G2SFCA’sImprovement and Extension

The G2SFCA is a popular measure of spatial accessibility, and its value reflects spatial accessibility. This study uses a grid-based G2SFCA to calculate the accessibility of WCFs in a neighborhood. Later, the proposed inverted G2SFCA, which reverses the order of the G2SFCA, switches the supply and demand variables, whose measurements are able to estimate the potential saturation level of the facility(Wang, 2021). The higher the value of the measure, the higher the degree of saturation, and conversely, the lower the spatial accessibility.

This paper evaluates the spatial accessibility of WCFs based on the G2SFCA, which is implemented in two steps:

In the first step, for each WCF j, a spatial distance threshold d_0 is given to form a spatial scope centered on the WCFj. For the population of each cell k in the space scope, the Gaussian equation is first used to assign weights according to the law of distance attenuation, and these weighted populations are summed up to get the number of all potential users of the WCFj. Then divide the total amount of domestic waste that can be accommodated by the WCFj by the number of all potential users to get the ratio of supply and demand R_j. The calculation method is shown in Formula (6).

$$R_j = \frac{S_j}{\sum_{k\in\{d_{kj}\le d_0\}} G(d_{kj},d_0) P_k} \quad (6)$$

In the formula:P_k is the WCFj within the spatial scope of action centered on the WCF ($d_{kj} \le d_0$) of the district k is the number of people in the cell.$d_{kj}$is the distance from the cell k to the WCFj is the spatial distance from the district to the WCF.S_j is the capacity of theWCFj is the capacity of the WCF, which is represented by the number of people in the district in this study; G(d_{kj}, d_0) is a Gaussian equation that takes into account the spatial friction problem, which is calculated as shown in Formula (7).

$$G(d_{kj}, d_0) = \begin{cases} \frac{e^{-\left(\frac{1}{2}\right)\times\left(\frac{d_{kj}}{d_0}\right)} - e^{-\left(\frac{1}{2}\right)}}{1-e^{-\left(\frac{1}{2}\right)}}, & if d_{kj} \le d_0 \\ 0, & if d_{kj} > d_0 \end{cases} \quad (7)$$

In the second step, a spatial distance threshold d_0 is set for each cell i to form another spatial scope centered on cell i. Similarly, for the supply ratio (R_l) of each WCFl located in this spatial scope, the Gaussian equation is first used to give weight according to the law of distance attenuation. These weighted supply ratios (R_l) are then added to obtain the WCF accessibility A_i of each cell i. The value of A_i can be interpreted as the per capita occupancy of the domestic waste storage space of WCFs in a certain field. The calculation method is shown in Formula (8).

$$A_i = \sum_{l\in\{d_{il}\le d_0\}} G(d_{il}, d_o) R_l \quad (8)$$

In the formula:R_l is the supply ratio of WCFl of ($d_{il} \le d_0$) in the spatial scope centered on cell i, and d_{il} is the spatial distance from cell i to WCFl.

The evaluation of the potential saturation of WCFs is based on the inverted G2SFCA method, which is implemented in the same way as the G2SFCAmethod, but switches the supply and demand variables. The cell is the supply point, and the WCF is the demand point.

Li et al. (2016) pointed out that although the G2SFCA is easy to operate and adds a distance decay function, it has the inherent drawback that there is a statistical error in the demand population during the first step of the move search. In the G2SFCA, the spatial domain is first solved for, centered on the supply area, and the demand points that fall within the spatial domain are counted. The number of people in demand is counted according to the distribution and number of demand points and the ratio of supply to demand are finally found.

However, among the many demand points, from the perspective of spatial distribution, they should be divided into two categories, which are referred to in this paper as Class I and Class II demand points. The Class I demand point is the point where the gravity center of the demand place falls within the spatial scope of the supply place, while the Class II demand point is the demand point where part of the area falls within the spatial scope of the supply place but the gravity center point does not fall into the demand point, as shown in Figure 3.

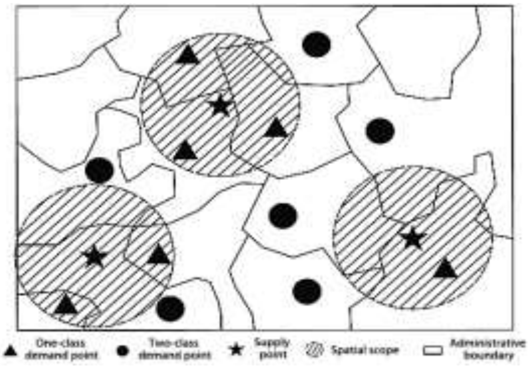

Figure3Diagram of G2SFCA (Source: Network)

In contrast, the various existing 2SFCA methods only calculate the Class I demand point in the process of counting the number of demands, while the Class II demand point is often ignored (Liu et al., 2022b). The accuracy of this type of calculation method is guaranteed when the spatial geometry of the place of demand is regular; however, in practice, administrative districts are often studied as places of demand, and most of them tend to have irregular geometry, so that a large number of Class II demand points may exist in the extracted demand points, which in turn makes the calculation results differ significantly from the actual values. Of course, this problem also exists in the second step when calculating the accessibility of the study object, as a similar search calculation method is used. Thus, Liu et al. (2022a) point out that the advantages of the grid-scale are: firstly, easy data processing, which reduces data errors to a certain extent; secondly, it helps to interpret the study results more intuitively from the perspective of geographical cells; and thirdly, it enables more specific determination of problem areas that do not meet the planning criteria.

Therefore, in this study, the demand places are gridded, and the geometric center of the grids is used to count the number of demands instead of the gravity center of the demand places to calculate the supply-demand ratio. In order to alleviate the calculation errors due to irregular shapes and thus improve the accuracy of theG2SFCAfor calculating the spatial accessibility of the research object, making it more objective, realistic, and reliable in describing the spatial distribution state of the accessibility of the research object and providing support for further decision analysis.

4. ANALYSIS AND RESULTS

4.1 City Situation Analysis

4.1.1 Population Analysis

The mapping visualization of population numbers shows that the overall distribution of the population in Maoming is denser in the south (Figure 4). The gravity center and the direction of distribution of the population were calculated using the spatial data of Maoming cell points based on the tools "mean center" and "standard deviation ellipse" of ArcGIS, and the gravity center and direction of distribution of the population was mapped (Figure 5). The analysis shows that the gravity center and geographical center of population distribution in Maoming is located in Gaozhou City. The gravity center of population distribution is to the south and the direction of population distribution is northeast-southwest, indicating that the overall spatial distribution of population is developing northeast-southwest and the gravity center tends to move northeast-southwest.

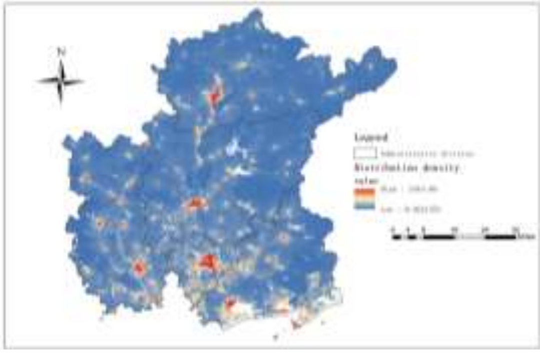

Figure4Population Distribution Map of Maoming

Figure5 Distribution Map of Population's Gravity Center and Direction

4.1.2 Transport Road Network Analysis

Based on the spatial location of the traffic road network, a nuclear density analysis of the current traffic road elements was carried out (Figure 6). It can be visually seen that the road network in Maonan District is relatively dense (e.g., areas with redder colors) and has better road accessibility, while the road network in Huzhou, Gaozhou, and Xinyi is sparse (e.g., areas with bluer colors) and has poorer road accessibility. It shows that there is an uneven spatial distribution of road accessibility in Maoming.

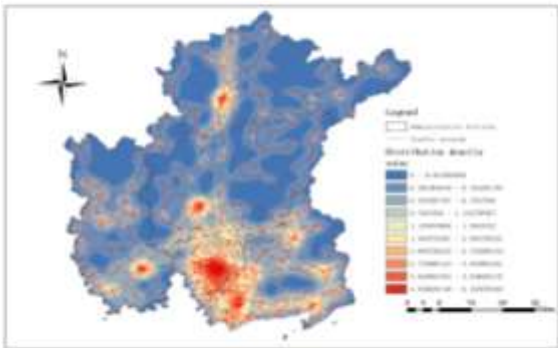

Figure6 Traffic Network Density Map of Maoming

Using the 'mean center' and 'directional distribution' tools, the gravity center and the direction of distribution of the traffic road network elements were calculated, and the density map

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was drawn (Figure 7). The analysis shows that the gravity center and the geographical center of the traffic road network are still located in Gaozhou. The gravity center of the traffic road network is located in the south direction, and the direction of distribution of the traffic road network is in the northeast-southwest direction. Indicating that the spatial distribution of the traffic road network in Maoming is developing in the northeast-southwest as a whole, and the gravity center has the tendency to move to the northeast-southwest.

Figure7 Distribution Map of Gravity Center and Direction of Traffic Network

4.1.3 WCFs Analysis

Using the spatial data of WCF points, a KDA was conducted (Figure 8). It can be visually seen that the WCFs in Huzhou, Xinyi, and Maonan districts are denser (e.g., the more red-colored areas), while the WCFs in Gaozhou and Dianbai are sparser (e.g., the more blue-colored areas). The analysis shows that there is an uneven spatial distribution of WCFs in Maoming.

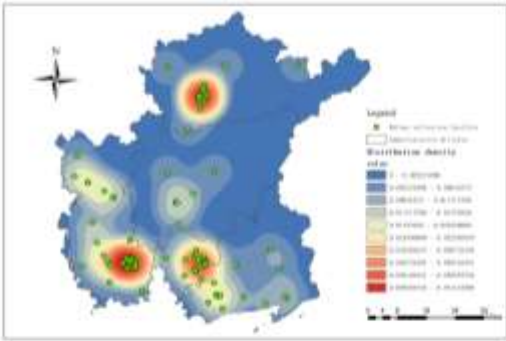

Figure8 Density Map of WCFs in Maoming

The gravity center and the direction of distribution of WCFs were calculated and plotted using the 'mean center' and 'directional distribution' tools, respectively (Figure 9). The gravity center and the geographical center of the WCFs are located in Gaozhou; the gravity center of the WCFs is located in the southwest direction. The direction of distribution of WCFs is from northeast to southwest. It indicates that the spatial distribution of WCFs in Maoming has an overall northeast-to-southwest development, and the gravity center has a tendency to move northeast to southwest.

Figure9 Distribution Map of Gravity Center and Direction of WCFs

4.1.4 Integrated Status Analysis

The correlation coefficients of population, WCFs, and traffic road network in Maoming were calculated by using the "wave set statistics" tool (Table 1). The correlation coefficient between WCFs and population is 0.23325, the correlation coefficient between WCFs and traffic network is 0.54481, and the correlation coefficient between population and traffic network is 0.35041, indicating that they are positively correlated with each other. The correlation between WCFs and the traffic road network is stronger, while the correlation between WCFs and population is weaker.

Table1Correlation Matrix of Population, WCF, and Traffic Network

	WCF	Population	Traffic Network
WCF	1	0.23325	0.54481
Population	0.23325	1	0.35041
Traffic Network	0.54481	0.35041	1

The gravity center and directional distribution maps of population numbers, WCF, and the transport road network were superimposed (Figure 10). It shows that the gravity center of population, the gravity center of WCF, the gravity center of the transport road network, and the geographical center of Maoming are all located in Gaozhou but do not overlap, indicating some deviation in the overall spatial layout. The gravity centers of the population, the WCF, and the transport network are all located to the south of the geographical center of Maoming, indicating that the overall spatial layout of the population, WCF, and transport network is to the south.

The gravity center of the population distribution and the gravity center of the traffic road network are vertically distributed, indicating that there are some deviations in the overall spatial layout of the population, WCFs, and traffic road network. The directional distribution of the WCFs, population, and transport road network all has a northeast-southwest direction, indicating that the gravity center of the population, WCFs, and transport road network tends to move in a northeast-southwest direction.

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Figure10 Distribution Map of Gravity Center and Direction of Population, WCFs, and Traffic Network

4.2. Accessibility Assessment of WCFs

4.2.1 Determination of Service Distance Thresholds for WCFs

Using the "Nearest Facility Point" tool of ArcGIS, the service distance of the WCFs was calculated using the elements of the WCFs as facility points and the cell points as event points, and a statistical map of the service distance of the WCFs was drawn (Figure 11). The analysis shows that the service distance is 16% within 0-1000m, 28% within 1000-2000m, 38% within 2000-3000m, 15% within 3000-4000m, and 3% within 4000-5000m. In addition, the third quartile of the service distance of WCFs was calculated according to the quartile method to obtain a more reasonable distance threshold, which was calculated to be 3,000 meters as the service distance threshold.

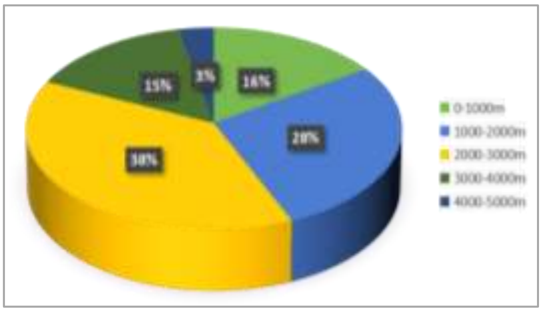

Figure11 Statistical Chart of WCFs' Service Distance in Maoming

4.2.2 WCFs' Accessibility by GridG2SFCA

Using the Fishnet command, the population raster data were gridded to a grid cell size of 2000m x 2000m; the projection was WGS 1984 UTM Zone 49N, generating a total of 5253 individual grid cells, which were automatically coded. The accessibility of the WCFs was calculated using aG2SFCA with a service distance threshold of 3000m using the Domain Analysis "Generate Proximity Table". Finally, the accessibility of the WCFs was graded into five levels, namely lower, low, average, high, and higher, using the natural interval grading method (Figure 12).

The mean accessibility value is 0.11197 and the standard deviation is 0.14090, indicating that the accessibility of WCFs in Maoming is relatively low overall, with Huazhou having relatively high accessibility, Dianbai having average accessibility, and Gaozhou, Xinyi, and Maonan having low accessibility.

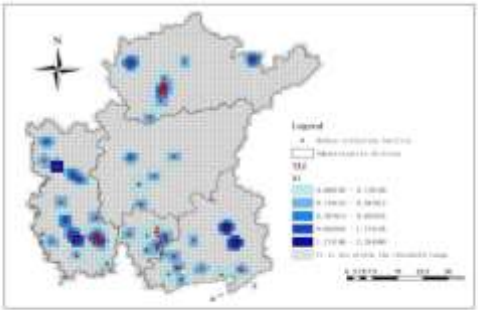

Figure12 Classification Map of WCFs' Accessibility

4.2.3 Potential Saturation Analysis of WCFs

The potential saturation of a WCF is a measure of the WCF's accessibility within a certain service distance. This study calculates the potential saturation of WCFs based on ArcGIS using the "District-WCF Cost Matrix", with a service distance threshold of 3000m and the inverted G2SFCA.

Finally, the potential saturation of WCFs was classified into five levels, namely lower, low, average, high, and higher, using the natural intermittency grading method, and the potential saturation of WCFs was plotted (Figure 13). The graph shows that Huazhou and Dianbai have a high saturation level, Gaozhou and Xinyi have an average saturation level, and Maonan has a low saturation level. Compared with Figure 12, the results are found to be in general agreement, fully indicating that there is an uneven spatial allocation of WCFs in Maoming.

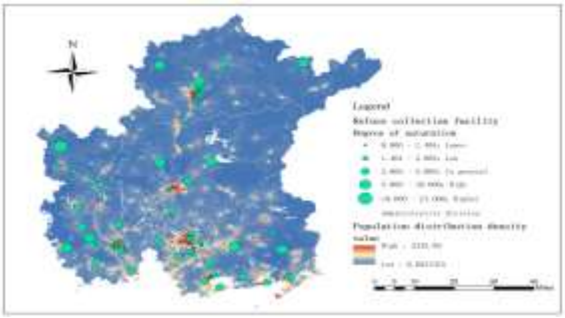

Figure13 Potential Saturation Classification Diagram of WCFs

4.2.4 Blind Spots Analysis of WCFs

In this study, the quartile method was used to screen the blind spots of WCF services, i.e., the cells with accessibility measures less than the first quartile were considered the blind areas of WCFs services, and the first quartile of the accessibility value of WCFs was calculated using Excel, and the result was 0.08684. ArcGIS was then used to extract the blind areas of WCF's services and visualize them (Figure 14). The filtering results show that there are 149 blind areas for WCFs, and Figure 14 shows that the blind areas are located in areas that are far away from the WCFs.

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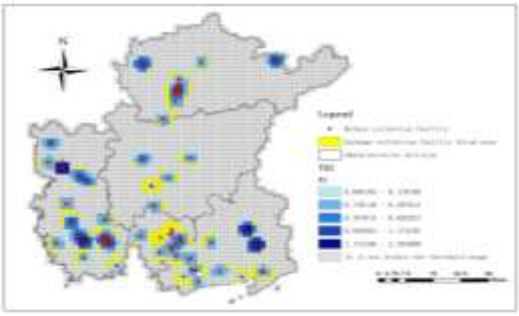

Figure14 Blind Area Distribution Map of WCFs

5. CONCLUSION

This study takes spatial analysis and supply-demand relationships as the starting points, takes Maoming as the research object, and uses mean center, directional distribution, and KDA based on ArcGIS to conduct a comprehensive analysis of the current situation of the WCFs'spatial configuration. Then, the accessibility of the WCFs was evaluated using the grid-based G2SFCA. The following conclusions are drawn from this study:

1) The overall spatial layout of Maoming's population, WCFs, and transport road network has certain deviations, and its spatial distribution is uneven, with the gravity centers all tending to move in the northeast-southwest direction.
2) WCFs are more strongly correlated with the transport road network and less correlated with population numbers.
3) The accessibility of WCFs in Maoming is relatively low within a service distance of 3,000 meters, with the accessibility of each district's center being low, with Maonan District, as the city center, having lower accessibility to WCFs than other districts.
4) When planning for future construction, more attention should be paid to the central location of the district and the distribution of population numbers should be taken into account.

ACKNOWLEDGEMENTS

The author is grateful for the research grants given to Ruei-Yuan Wang from GDUPT Talents Recruitment (No.2019rc098), Peoples R China under Grant No.702-519208, and Academic Affairs in GDUPT for Goal Problem-Oriented Teaching Innovation and Practice Project Grant No.701-234660.

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