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Determination of the Center for Economic Growth in Surakarta City, Indonesia: Geospatial Approach

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ABSTRACT

Regarding the case of urban areas, especially in the developing city of Surakarta, of course it cannot be separated from the problem of regional development, especially those related to development inequality, so that determining the center point is the most important thing to do. The purpose of this study is to identify areas in Surakarta that have the potential to become central places. Quantitative approach is applied by analysis of marshall centrality index, scalogram, and gravity index as analytical tools. The results showed that Banjarsari Sub-district has the potential to as a central place in Surakarta City which has 22 types of service facilities and a total of 5177 units. This affects the strength of spatial interaction between sub-districts in Surakarta City. The highest spatial interaction value is Banjarsari Sub-district with Laweyan of 1,358,589,502 and the lowest is Banjarsari Sub-district with Serengan of 393,687,919. These results can be a consideration for local governments to determine the direction of regional development. By optimizing the central places, the problem of development inequality and uneven distribution of facilities in Surakarta City can be avoided and resolved optimally.

1. INTRODUCTION

The phenomenon of urban growth in many cases affects urban areas, especially in developing countries. Urban areas are no longer administratively restricted cities, but rather service functions. Due to the growing population, the demand for space needs in economic, social, political and cultural aspects will increase. Availability of space in the city will not increase and tends to be limited. So that the limited space will penetrate and fill the suburban areas. The suburban area is a supporting area of the city whose activities were not originally urban activities and then turned into a settlement service center. Over time the area grew to become an Urban Fairy Territory or a satellite city to its parent city. In the end, an agglomeration of urban areas was formed, which was a merger of the Peri Urban Region and the city center.

Urban growth is a process of increasing or growing physical spatial and demographic numbers as a result of increasing urban functions. Urban growth has implications for multidimensional changes in social, economic and environmental aspects [1]. Even though urban growth has stimulated economic development and improved the quality of life of the people, it has simultaneously brought negative impacts, such as loss of agricultural land [2], regional changes [3] and disparities between regions [4].

Gaps and equity in development are crucial national and regional issues [5]. The phenomenon of inequality between regions leads to poverty and underdevelopment [6]. Disparities are a phenomenon of differences between regions due to uneven development between regions and one way that can be done to overcome these disparities is to optimize service centers [7].

Service centers or better known as central places according to Walter Christaller (1893-1969) are cities that provide goods and services to the people in the surrounding area by forming a hierarchy based on the range and threshold of the population [7]. The division of the service hierarchy, results in a city (with the highest service hierarchy) naturally having the potential for great attraction and great influence for areas with smaller strengths, where the city has the ability to attract potential, resources from other regions and cities. underneath. So service centers are an agglomeration of various activities or activities as well as agglomeration of various infrastructure and facilities that can support regional growth and development.

The downtown hierarchy is formed as a result of being influenced by population [8, 9]. An area becomes a development priority if it is estimated to develop rapidly in the future and has adequate facilities and infrastructure so that it can encourage the surrounding area. Besides that, driving factors such as investors can also affect the speed of regional development [10].

Surakarta City is one of the major cities in Indonesia, with an area of 44.03 km^2 and a population of 522,728 in 2022, and has 5 subdistricts. The city of Surakarta is the center of Development Area VIII of Central Java Province and the National Activity Center (PKN) for the Subosukawonosraten Development Area so that it has a strategic role for regional development in Central Java Province. Geographically, the location of the city of Surakarta is very strategic because it is the crossroads of regional transportation routes, as well as a destination and generation of movement.

As the center of the VIII Development Area, Surakarta City has a very rapid urban growth rate which can be seen from the economic growth and activity system of the city center of the

city's physical growth. The physical development of Surakarta City tends to spread to the suburbs due to the dense activity in the city center. The expansion of the area caused by the growth of cities on the outskirts formed a Peri Urban Area (WPU) as a result of the external development of Surakarta City such as the areas of Solo Baru, Kartasura, Palur, Colomadu, Baki, Ngemplak, and Gondangrejo. This trend shows symptoms of urban growth towards urban agglomeration.

Surakarta City is inseparable from regional development problems, especially those related to service centers. With the infrastructure development carried out by the City of Surakarta in the north and its surroundings, such as the construction of the North Ring Toll Road and the Semarang - Solo - Kertosono Toll Road, this has made investment attractive for the community, so that the direction of the city's physical development trend has shifted and is concentrated in the northern region, thus causing inequality between the northern region and the southern region.

The problems that occur related to the inequality of service centers and hinterlands are the uneven distribution of facilities and the high concentration of service facilities in certain areas, which are generally the central regions. The tendency for regional development to concentrate only on the center and ignore the role of the hinterland will clarify the disparities between regions. The development gap in Surakarta City occurs between the northern, central and southern regions. So that the determination of the service center is an important thing to do. The local government also mandates the development of functional, hierarchical and integrated service centers, because the key to growth as well as equity in an area is through the creation of mutually beneficial relationships (linkages) between growth centers as well as their areas of influence [11].

Spatial or spatial interaction models in geographic systems refer to Newton's theory of gravity (1687) that two objects that have a certain mass will have an attractive force between the two which is known as the gravitational force. The gravity model adapted from Reilly is the model used in this study, to measure the strength of regional interactions between sub-districts in Surakarta City.

Referring to several phenomena that have been described previously, researchers are interested in determining the center of growth in Surakarta City and seeing how the power of centrality, as well as the spatial interaction relationship of the sub-district as the center of growth with the hinterland area in Surakarta City.

2. LITERATURE REVIEW

2.1 Growth Pole

Growth Poles Theory introduced by the economist [12], Francis Perroux explains Perroux's theory of pole croisanse or pole de development, which means the center of growth as a set of industries that are experiencing development and are located in an urban area and encourage further development of economic activity through the area influence. Economic growth tends to be concentrated in certain areas driven by agglomeration (agglomeration economies) that arise due to the concentration of these economic activities. The emergence of some of these concentrations of economic activity has further encouraged an increase in the efficiency of economic activity which has a positive impact on national economic development.

Based on this definition, there are 4 main characteristics of growth centers, the first is the presence of a group of economic activities that are concentrated in a certain location, the second is that the concentration of economic activity is able to encourage dynamic economic growth in the economy, the third is that there is a strong input and output linkage between fellow economic activities at the center, and the fourth. Within the economic activity group there is a parent industry that encourages the development of economic activities at the center.

Factors that cause growth centers to emerge are the strategic location of a region causing a region to become a center of growth, the availability of natural resources in an area will cause the region to become a center of growth, the strength of agglomeration, and the factor of government investment that is deliberately made (artificial) [13].

Basically, the regional center has a hierarchy. The hierarchy of a center is determined by several factors, namely the number of people living in the center, the number of public service facilities available, and the number of types of public service facilities available. The hierarchy of these places shows that there is a relationship between the central places that are used as growth centers and the surrounding areas, some of which are areas that support resources for growth centers and there are areas that become efficient traffic lanes for growth centers and their supporting areas [14].

The division of the service hierarchy, results in a city (with the highest service hierarchy) naturally having the potential for great attraction and great influence for areas with smaller powers [15].

2.2 Central place theory

Central place theory was put forward by a geographer, Walter Christaller. Christaller's theory explains the central city which is the center for the surrounding area which is a trade link with other regions [16]. According to Christaller each order has its own hexagonal region. The form of this hexagonal service pattern is theoretically able to obtain optimization in terms of efficiency in transportation, marketing and administration [17]. The city as a service center is expected to have service facilities such as, firstly centers and shops as the focus point of a city, secondly the existence of transportation facilities and infrastructure, thirdly the availability of places for recreation and sports. and educational facilities, health, tourism objects are available. Thus, the city provides all the facilities for both social and economic life, so that both residence and work and creativity can be carried out in the city [18].

Central Place Theory attempts to analyze the relationship between the size, number, and geographical distribution of activity centers. The identity of the activity center in this case is indicated by the existence of services and trading activities. The developed model is based on a belief in the existence of regularity in determining activity centers, especially those related to their function as markets and services in the service sector. In this central place theory, two terms are introduced, namely range and threshold. Range or reach is the distance that humans need to travel to get the goods they need at a certain time. While the threshold is the minimum number of residents required for the smooth and balanced supply of goods.

2.3 Regional economic growth theory

Concept of Hirschman's theory states that it prioritizes its attention on unbalanced regional growth. Where geographically the economic growth of the region will be influenced by progress in a region at one point of place which creates an impetus towards the development of the next points or places. Hirschman's theory sees the level of development in a region tends to be achieved at several growth points. Where economic activities or activities are more centered on the area because of the availability and completeness of service facilities compared to other places. The impact will be an increase in migration from outside areas to growing center areas.

2.4 The concept of sub-district as service center

One of the important factors in regional development is the spatial aspect, namely the rightness of a service facility so that it can provide the best possible service to the people who need it [19]. The theory of the service center (central place theory) put forward by Christaller is defined as a basic residential unit unit equipped with service centers in it. The intended settlement unit can be a large city, small towns, urban areas or certain residential neighborhood units. The characteristic of a service center is that the center provides services (commodities and services) for the residential area itself and the larger surrounding area [20].

The problem of service facilities both regarding location and quality and quantity, closely related to the level of community welfare [19]. Development cannot run smoothly if service facilities are not available properly. So service facilities can be considered as a potential factor in determining the future of the development of an area, both urban and rural, so that efforts to increase the development of economic activity must continue to be increased, especially in a region.

Service facilities can be grouped according to functions that are very useful for all cultures, both in economic life and social life. In socio-economic activities there is a term that is threshold which means the minimum number of residents needed to support certain functions so that they can run smoothly. For example, a type of service that has a higher function, or that is needed by a large number of residents (markets, secondary schools, etc.), must be located in a wider service coverage area. These cultural facilities can be distinguished according to their function into two groups, namely:

1. Social services (in the form of networks and in the form of spaces/buildings) are found in family activities, government, religion, health, education, recreation, social insurance/assistance, defense and security, transportation and communication, information and data.
2. Economic services (which are formed by networks or spaces/buildings) are in agricultural/plantation/forestry activities, industry, building construction, tourism and hotels, trade and other service companies, transportation and communication as well as information and data.

2.5 Determination of development areas

Determination of development areas needs to be done so that the application of regional development policies can be determined clearly and firmly up to where the coverage area is [12]. Determination of development areas needs to pay attention to four main aspects, namely:

a. Similarity of conditions, problems and general potential of the regions both in the economic, social and geographical fields (Homogeneous Region).
b. Close linkages between regions that are members of the relevant development area (Nodal Region).
c. The similarity of geographical characteristics between regions that are incorporated in the development area (Functional Area).
d. Unity of government administrative areas that are incorporated in the development area concerned (Planning Region).

In determining the location of a growth center, it is necessary to pay attention to the various locational advantages possessed by the region concerned. In this case the first attention needs to be directed to the availability of a road network that can reach the entire coverage area [21].

2.6 Spatial interaction

Spatial interaction is the relationship between one area and another. reciprocal relationships that influence each other between two or more areas can cause new symptoms, appearances, or problems [22]. Spatial interaction is something that includes all movements or mobility in a space or area caused by human behavior such as travel to work, migration, the flow of goods and services and information, movement of students for educational reasons, and activities others include the use of public facilities and the dissemination of knowledge [23].

Its strength is strongly influenced by three main factors, namely regions that are complementary (regional complementary), there is an opportunity to intervene (interventing opportunity), and there is ease of transfer or transfer in space (spatial transfer ability) [24]. Spatial interaction applications can be used in development planning, such as locating service centers and developing transportation infrastructure.

2.7 Geographic information system

Geographic Information System is a set of computer-based systems for storing and managing information, manipulating, analyzing data that has complex and important terrestrial references for humans [25]. Geographic information systems are composed of various components that are interrelated and coordinated. Geographic information systems are divided into two types, namely vector-based and raster-based. The research was conducted using a vector-based geographic information system. In order to obtain the results of the distribution patterns in this study, the processing is also carried out through geographic information system devices.

2.8 Gravity theory

Theory of gravity was first introduced to physics by Utoyo [22]. The essence of the theory of gravity that two objects that have a certain mass will have an attractive force between them which is known as the gravitational force. The strength of interaction between two different areas can be measured by taking into account the factors of population size and distance between the two regions.

The gravity model is a model used to estimate the attractiveness of a potential that is at a location compared to

other locations. This model is often used to see the relationship between the potential of a location and the size of the area of influence of that potential, as well as to show the attractiveness of a location.

For example, there are two cities (city X and Y) that are close together, we want to know how much interaction occurs between the two cities, this interaction is determined by several factors. The first factor is the size of the two cities, which can be measured by population, number of jobs, total income, number or area of buildings, number of public interest facilities, and so on.

The ease of obtaining data makes the size of the population more often used as a measuring tool. The size of the population is not arbitrary because the population is also directly related to the various other measures stated above. The second factor affecting interaction is the distance between cities X and Y. Distance influences people to travel because traveling that distance requires time, effort, and costs.

3. METHODS

In this study the scope of research to be examined is the City of Surakarta, Central Java Province (Figure 1) with the boundaries of the administrative area of Surakarta City, which is bordered to the north by Boyolali Regency, to the east by Karanganyar Regency, and to the south and west by with Sukoharjo Regency. Administratively, Surakarta City consists of 5 (five) sub-districts, namely Laweyan, Serengan, Pasar Kliwon, Jebres and Banjarsari. Its area reaches 44.1 square kilometers which is 0.14% of the total area of Central Java Province (Table 1).

Table 1. Administrative region of Surakarta City, 2022

Sub-District	Total Population	Area (m^2)	Density Population
Banjarsari	161.958	14.81	10.936
Laweyan	88.601	8.64	10.255
Serengan	44.944	3.19	14.089
Pasar Kliwon	76.463	4.82	15.864
Jebres	142.132	12.58	11.298
Total	**514.098**	**44.04**	

Source: BPS-Statistics of Surakarta City, 2022

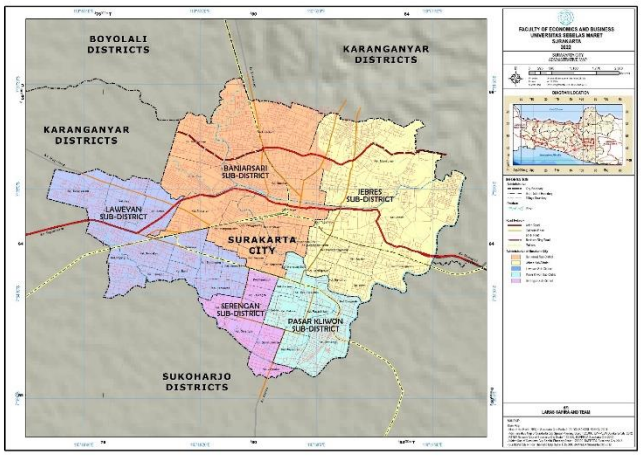

Figure 1. Map of research area
Source: Authors design,2022

This research uses secondary data in 2018, which comes from the publication of the Surakarta City Central Bureau of Statistics. The data used are in the form of population data, data on health facilities, education, worship, economy, tourism, and transportation. The subjects in this study were 5 sub-districts in Surakarta City, namely Laweyan, Serengan, Pasar Kliwon, Jebres and Banjarsari.

3.1 Analysis model

The research method uses a quantitative approach with data analysis using scalogram analysis, centrality index analysis and spatial interaction analysis with the following stages [7, 26, 27]:

3.3.1 Scalogram analysis

This study assesses facilities that provide both social and economic services. The types of facilities assessed include: health, education, worship, economic, tourism and transportation facilities (Table 2). The facilities used in calculating scalograms: facilities that characterize the function of social and economic services with the criteria of a single and measurable object and as far as possible have hierarchical or tiered characteristics [27].

Table 2. List of service facility types in Surakarta City

No	Facility Type	No	Facility Type
1	Hospital	12	Church
2	Medicinal Center	13	Vihara
3	Public Health Center	14	Pura
4	Assistant Public Health Center	15	Traditional Market
5	Pharmacy	16	Supermarket
6	Elementary School	17	Stores/Kiosks/Stalls
7	Junior High School	18	Koperasi
8	High School	19	Hotel
9	College	20	Restaurant
10	Mosque	21	Train Station
11	Musholla	22	Bus Station

Source: BPS-Statistics of Surakarta City, 2022

In the scalogram calculation, the assumption used is that the area with the most complete facilities is of the highest order and is designated as a service center. Calculations were made using the present and absent technique, where areas that have facilities are given a value of 1 while areas that do not have facilities are given a value of 0.

Furthermore, in the calculation of this method, the stages of preparing the scalogram analysis are as follows: 1) Make a sequence of cities based on the number of residents on the left of the table; 2) Create a sequence of facilities defined by frequency at the top; 3) Draw lines of columns and rows so that the worksheet forms a matrix that displays the facilities available in each city area; 4) Use mark (1) in cells that indicate the presence of a facility in a region and mark (0) on cells that do not have facilities; 5) Rearrange rows and columns based on the frequency with which facilities exist, the more facilities there are in an area of the city, the higher the area is, the more areas that have these facilities, the type of facility is in the left column; 6) The last step is to identify the city's ranking/hierarchy that can be interpreted based on the value of the presence of facilities in an area. The higher the value, the higher the city's hierarchy will be [28].

Test the feasibility of the scalogram by calculating the Coefficient of Reproducibility (COR). The coefficient is considered feasible if the value is 0.9 - 1 [29].

$$COR = \frac{1-(\Sigma e)}{NxK} \quad (1)$$

where, *e*: Number of errors; *N*: Number of subjects/city; *K*: Number of objects/facilities.

Analyzing the number of classes from each sub-district, as growth centers, the Sturgess method is used, with the following formula:

$$K = 1 + 3.3\ Log\ n \quad (2)$$

where, *n*: Number of Sub-district.

Next determine the size of the class interval, to determine the regional hierarchy by:

$$I = \frac{(A-B)}{K} \quad (3)$$

where, *I*: Interval; *K*: Number of classes; *A*: The highest number of facilities; B: The lowest number of facilities.

The growth center area can be determined based on the service capability of a region, Regions with higher service capacity will be the center of growth, while areas with less service capacity will be the back areas (hinterland).

3.3.2 Centrality index analysis

The number of availabilities of infrastructure facilities shows that infrastructure facilities are scattered and available in an area [14]. Measurement of the level of centrality is based on the amount of availability of infrastructure facilities in an area based on these facilities in the related area. In this study, the combined centralization value was chosen to be 100. The weighting of the number of facility units (C), which is referred to as the facility centrality value, with the following formula:

$$C = \frac{x}{X} \quad (4)$$

where,
C: Weight of function attributes x;
x: the value of centrality combined = 100 (example);
X: total number of attributes in the system.

Based on the weighting, the facility center value of an area can be calculated by:

(1) Multiplying the facility centrality value by the number of facility units concerned from each Sub-district.

$$\text{Centrality Index} = F \text{ x } C \quad (5)$$

where,
F: number of each facility in each sub-district;
C: weight per facility.

(2) Add up the multiplication results for each Sub-district. The result of this sum is called the facility centering value;

(3) Doing a hierarchical classification of regions based on the order of centrality values.

3.3.3 Gravity index analysis

Analysis is used to find out how the growth center area interacts with other areas around it. The variables used in this analysis are the number of residents and the distance between 2 regions. With gravity index analysis, an interaction number will be produced that describes how the interaction between regions in the research location will be. The higher number of interactions, it shows that the interaction between regions in terms of economy and other aspects is getting stronger or vice versa [26].

The gravity model is one of the most commonly used models in explaining the phenomenon of interaction between regions or analyzing spatial interaction patterns, the use of this technique will be able to calculate the relative strength of the relationship between regions [30]. The gravity index formula that is generally used:

$$I_{A.B} = k\frac{P_A P_B}{(d_{A.B})^2} \quad (6)$$

where,
IAB: Interaction between areas A & B;
PA: Total population of area A;
PB: Total population of area B;
dAB: Distance between areas A & B;
k: empirical constant (assumed 1).

3.3.4 Overlay analysis

Analysis process with GIS is the process of combining information from several different data layers using certain spatial operations where we start from ideas that we develop and apply in various ways. The usefulness of this application is to display spatial data, create maps, and perform spatial data analysis.

The GIS approach using ArcGIS software is a spatial analysis technique used in analyzing spatial or spatial studies [31]. This method is used to describe the results of the scalogram analysis, centrality index, and gravity index analysis to make it easier for readers to understand the results of data processing. Visualization in the form of a map will provide an overview of how the location and condition of Surakarta City are actually after an analysis has been carried out with predetermined analytical tools.

4. RESULTS AND DISCUSSION

4.1 Scalogram analysis of Surakarta City growth center

Scalogram analysis is one of the analytical tools used to determine the existence and condition of facilities and potential resources in the City of Surakarta which consists of 5 sub-districts by looking at how large the number of facilities and their availability are in each existing sub-district, then analyzing how much they need to be developed. The scalogram analysis will also determine which sub-district area is the center of growth according to the hierarchy and potential of existing resources. By determining the growth centers in Surakarta City, it will be clear that the influential administrative areas as growth centers will be seen.

Based on the results of calculating the completeness of the facilities for each sub-district in Table 3, there is an error number of 5 so that the COR value is 0.990, which means that this method is feasible to continue in determining the sub-district order. It is known that there are 22 types of functions used to analyze the scalogram in this study. Of the 5 sub-districts in Surakarta City, the highest total type of function is 22 and the lowest is 19. By taking into account the number of functions in the sub-district and the difference between the highest and lowest functions using the scalogram method, it can be seen that the distance between intervals is 1 and based on the completeness of each facility -Each sub-district has 3 levels of order or sub-district hierarchy which are described in Table 3.

Table 3. Results of scalogram analysis based on the completeness of facilities in the City of Surakarta

Sub-District	Total Population	Facility																					Total	Error	Orde
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V			
Banjarsari	175.379	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	22	0	I
Jebres	148.442	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	21	0	II
Laweyan	109.264	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	21	0	II
Pasar Kliwon	91.772	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	20	1	III
Serengan	61.179	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	0	0	19	4	III
Total		5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	4	4	1	103	5	

Source: Authors calculation, 2022

Information:

A. Hospital	B. Medicinal Center	C. Public Health Center	D. Assistant Public Health Center	E. Pharmacy
F. Traditional Market	G. Supermarket	H. Stores/Kiosks/Stalls	I. Koperasi	J. Hotel
K. Restaurant	L. Mosque	M. Musholla	N. Church	O. Vihara
P. Pura	Q. Elementary School	R. Junior taHigh School	S. High School	T. College
U. Train Station	V. Bus Station			

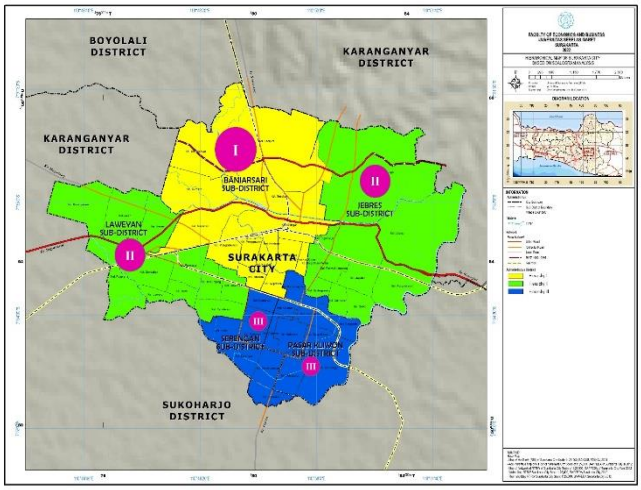

Figure 2. Hierarchical map of Surakarta City area based on Scalogram analysis

Source: Authors calculation, 2022

From Table 3 the results of the scalogram analysis in the Surakarta City area can be seen the number of facilities from each sub-district in three different groups of facilities, as well as the total number of all facility units in each sub-district. It can be seen that those included in order I are sub-districts with the highest number of facility units so that they can be used as growth centers. In the results of the scalogram analysis in Table 3, it is known that there is 1 sub-district that meets the requirements to become order I as a growth center sub-district in Surakarta City, namely Banjarsari which has the most complete facilities of 22 types of facilities. Then the second order is Jebres and Laweyan sub-districts with 21 types of facilities because they do not have transportation facilities, namely the unavailability of bus terminals in Jebres and Laweyan sub-districts. Then those who become order III are Pasar Kliwon and Serengan sub-districts because the facilities they have are not as complete as those of Order I and Order II. Pasar Kliwon sub-district has 20 types of facilities occupying the third order because it does not have educational facilities, namely the unavailability of higher education institutions and transportation facilities, namely the unavailability of bus terminals, while the Serengan Sub-district has 19 types of facilities, occupying the third order due to not having religious facilities, namely the unavailability of temples, and do not have means of transportation, namely the unavailability of a train station and bus terminal.

The results of this analysis illustrate that Banjarsari sub-district has the potential to become a service center because its service facilities are the most complete among other sub-districts. Besides that, this illustrates the existence of high accessibility in Banjarsari sub-district, where areas with more complete and better facilities are in areas with high accessibility [32].

Spatially, the regional hierarchy can be seen in Figure 2. The results of mapping using the GIS method show that in Figure 2 there are three hierarchies in Surakarta City based on the availability and diversity of types of facilities in each sub-district. Banjarsari Sub-district is hierarchy I (yellow) with the most complete number of facilities and is the center of growth and public services in Surakarta City. Laweyan and Jebres Sub-districts are hierarchical II (green) and are also centers of growth and public services. The blue color is a symbol of hierarchy III occupied by Pasar Kliwon Sub-district, Serengan Sub-district.

4.2 Analysis of centrality index of Surakarta City growth center

Centrality index analysis is used to see the level of centrality of service facilities in an area, this analysis is not only based on the number of facilities but based on the availability of facilities in the region if it has a high level of hierarchy then the area has a high centrality value. Analysis of the availability of service facilities supporting the functions of the city of Surakarta was carried out based on the frequency of the presence of service facilities in each sub-district (Table 4), the Marshall Centrality Index (IS) weight divides the sub-districts into 3 orders (Table 5). This analysis aims to determine the hierarchical level of service centers in Surakarta City in terms of the number available, the number of types of facilities available, and the ability to serve the community or society.

Order I is a sub-district that has the highest number of facilities, namely Banjarsari Sub-district has 5177 units of facilities; order II is a Sub-district that has fewer facilities than order I, namely Laweyan Sub-district which has 3623 units of facilities; then order III is an area with fewer facilities than order I and II, namely Jebres Sub-district which has 2053 facility units; then Pasar Kliwon Sub-district has 1919 facility units and Serengan Sub-district has 2444 facility units. This shows that a center with a higher order has a greater number of facilities and types of service facilities and infrastructure than those with a lower order. The order level map can be seen in Figure 3 [33].

Table 4. Number of facilities for each sub-district in Surakarta City

Sub-District	Facility																					Total
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	
Banjarsari	4	6	6	8	37	16	44	4096	97	84	266	218	72	62	4	1	80	22	36	16	1	1	5177
Jebres	9	8	3	3	43	7	22	1203	135	48	240	139	59	28	0	1	54	16	20	14	1	0	2053
Laweyan	7	3	4	6	32	10	15	2969	110	6	70	171	52	69	3	3	54	17	14	7	1	0	3623
Pasar Kliwon	2	7	2	3	12	8	10	1465	72	12	95	99	43	26	0	1	45	12	4	0	1	0	1919
Serengan	3	7	2	4	14	2	26	2069	62	9	107	52	20	19	1	0	26	10	7	4	0	0	2444
Total	25	31	17	24	138	43	117	11.802	476	159	778	679	246	204	8	6	259	77	81	41	4	1	15216

Source: Authors calculation, 2022

Information:

A. Hospital	B. Medicinal Center	C. Public Health Center	D. Assistant Public Health Center	E. Pharmacy
F. Traditional Market	G. Supermarket	H. Stores/Kiosks/Stalls	I. Koperasi	J. Hotel
K. Restaurant	L. Mosque	M. Musholla	N. Church	O. Vihara
P. Pura	Q. Elementary School	R. Junior taHigh School	S. High School	T. College
U. Train Station	V. Bus Station			

Table 5. Hierarchy results of Marshall centrality index of Surakarta City

Sub-District	Total Population	Total Facility	Centrality Index	Hierarchy	Hierarchical Value Division
Banjarsari	175.379	5177	819.99	1	634.56 - 819.99
Laweyan	109.264	3623	552.07	2	449.13 - 634.56
Jebres	148.442	2053	401.19	3	263.70 - 449.13
Pasar Kliwon	91.772	1919	284.46	3	263.70 - 449.13
Serengan	61.179	2444	263.70	3	263.70 - 449.13

Source: Authors calculation, 2022

The results of the Marshall Centrality Index analysis illustrate that Banjarsari Subdistrict still has the potential to become a service center because the number of facilities owned is the highest among other sub-districts, namely 5177 units. By comparing the results of the analysis of the Marshall Centrality Index (Table 5) with the results of the scalogram analysis (Table 3) it produces a difference in order in Jebres Subdistrict. Jebres Subdistrict is ranked III because it has fewer facility units than Laweyan Subdistrict, but has more complete facilities. This indicates that all sub-districts in this case can also potentially be at a higher order through modification of the availability and increasing the number of health facilities, education, worship, economy, tourism, and transportation.

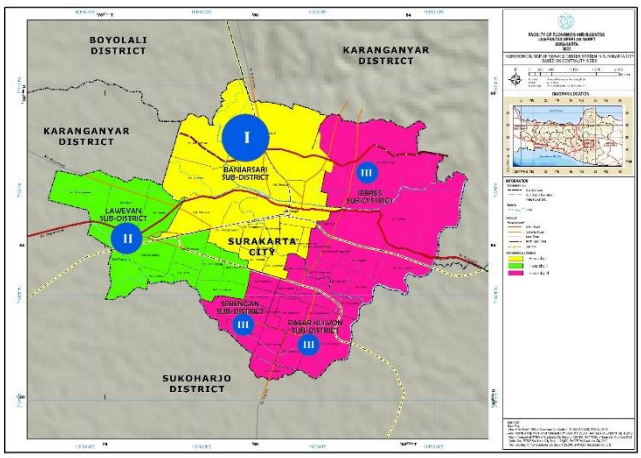

Figure 3. Hierarchical map of service center system in Surakarta City based on centrality index
Source: Authors calculation, 2022

The results of mapping using the GIS method show that in Figure 3 there are three hierarchies in Surakarta City based on the availability and variety of types of facilities in each sub-district. Banjarsari sub-district is a hierarchical sub-district I (yellow) with the most complete number of facilities and is the center of growth and public services in Surakarta City with the highest centrality index value of 819.99. Laweyan sub-district is in hierarchy II (green color) with a moderate centrality index value of 552.07 and is also a center of growth and public services. The pink color is a symbol of hierarchy III which is occupied by Jebres Sub-district with a centrality index value of 401.19, Pasar Kliwon Sub-district with a centrality index value of 284.46, and Serengan Sub-district with a centrality index value of 263.70.

4.3 Gravity analysis of spatial interaction of Surakarta City

The interaction of gravity index analysis is carried out to determine hinterland of the growth center that has been identified previously. The gravity index analysis in this research makes Banjarsari Sub-district the destination area because in the previous process and Centrality Index analysis process, Banjarsari Sub-district is an area that functions as a regional service center so that this area has a strong attraction to attract other sub-districts in Surakarta City. From calculations using the concept of interaction or gravity can be known interactions from the growth center with the surrounding sub-districts as hinterland. By multiplying the population between sub-districts as the center growth with other sub-districts and divided by the distance at the center growth with other sub-districts, there will be an interaction relationship between the sub-district, where the largest number will be a supporting area (hinterland) for growth centers. Index number that is larger than the growth center others reflect that the growth center has more interaction stronger than other growth centers in influencing the sub-district. Such a large influence makes it a hinterland for a sub-district which is declared a growth center.

Based on the results of the gravity index analysis, the strength of the spatial interaction between Banjarasari Sub-

district and other areas in Surakarta City in 2014-2018 was obtained, results are presented in Table 6.

Table 6. Result of gravity analysis of Surakarta City

Gravity Interaction	Distance (km)	Iab (Interaction Value between Regions)	Hierarchy
Banjarsari – Laweyan	3.25	1.358.589.502	I
Banjarsari – Jebres	4.3	920.802.788	II
Banjarsari – Pasar Kliwon	5.25	449.310.909	III
Banjarsari - Serengan	5	393.687.919	IV

Source: Authors calculation, 2022

From the Table above shows that there is a strong spatial interaction in Banjarsari and Laweyan Sub-district (ranked I) with a value of 1,358,589,502. Second, Banjarasari and Jebres Sub-district (second rank) with a value of 920,802,788, Third, Pasar Kliwon Sub-District (third rank) with a gravity value of 449,310,909, and the smallest interaction strength are Banjarsari Sub-District with Serengan Sub-District with a gravity value of 393,687,919.

If seen from Table 6, shows that the highest spatial interaction in Surakarta City is in Banjarsari and Laweyan subistrict with a total interaction value reaching 1,358,589,502. Based on its location, Banjarsari Sub-District is hierarchically connected to all other sub-districts in Surakarta City, and vice versa. Because the number of sub districts consists of only five sub-districts, the distance between one sub-district is not far from each other (on average only 4 km). Supported by easy access, then to do mobile between sub-districts also does not experience significant obstacles.

However, the reason that makes Banjarsari and Laweyan as the sub-district with the highest interaction cannot be separated from their role as hierarchy I. The availability of complete facilities and needs related to public administration activities make residents interact a lot with this sub-district. Not to mention the supermarkets and traditional markets that agglomerate in Banjarsari and Laweyan sub-districts, adding to the strength of interaction between residents of other areas in the sub-district.

Meanwhile, lowest spatial interaction between Banjarsari and Serengan sub-district with a figure of 393,687,919. The thing that causes the interaction between Banjarsari and Serengan sub-district to have the lowest value is not due to difficult access, but this can be caused, among others, by the population factor. Serengan sub-district occupies the lowest position of the five sub-districts in total population density in Surakarta City. Of course, with a smaller population, the proportion of interactions is also small. In addition, health facilities in Serengan Sub-district such as hospitals, occupy the lowest number compared to other sub-districts in Surakarta City. These factors have the opportunity to make a low contribution to the value of interaction between regions. Meanwhile, in addition to showing the highest interaction value in an area, the calculation results of this gravity model can also show which area has the position as the center and which area has the position as the hinterland. The following table shows the position of the hinterland in Surakarta City which is presented in Table 7.

Based on Table 6, the determinant to the status as center-hinterland is not due to the distance between regions. If based on distance, all sub-districts are interconnected and on average only 4 km between one sub-district and another. The determination hinterland for Surakarta City is based more on the existence of infrastructure in each sub-district.

Table 7. Position Center-*Hinterland* Surakarta City

Growth Center	*Hinterland*
Banjarsari Sub-District	Laweyan Sub-District, Jebres Sub-District, Pasar Kliwon Sub-District, Serengan Sub-District

Source: Authors calculation, 2022

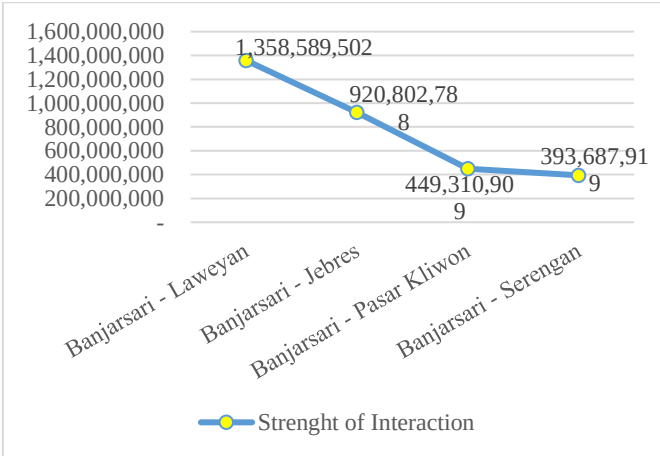

Figure 4. Linear strength of Banjarsari's spatial interaction againts other regions in Surakarta City
Source: Authors calculation, 2022

Based on that rule, from a number of sub-districts in Surakarta City, Banjarsari Sub-district has the most complete facilities and with more numbers than other sub-districts. In addition, centers of economic activity, education, and health are also located in this sub-district. Thus, the dependence on Banjarsari Sub-district becomes very high, which at the same time has an impact on the high value of interaction to the sub-district. To see a graph of the strength of gravity between Banjarasari Sub-district and its surroundings, see Figure 4.

From the Figure 4 above, it can be seen that the linear line has a positive curve and between Banjarsari and Laweyan sub-districts, the curve increases significantly increases significantly, while the linear line curve moves downwards when passing through the interaction part between Banjarsari and Jebres, Pasar Kliwon, and Serengan sub-district.

The Gravity Index analysis is not calculated annually because there are the same rankings or hierarchical levels during the research year, namely 2014 to 2018, seen from the resident in five sub-districts in Surakarta City, the curve shifts in a positive direction with a proportion of a rise of around 10% to 20%, and the difference in distance between the regions connecting the center points of Surakarta (Banjarsari) with other areas in 2014 until 2018 there is no change. Based on calculations of the ranking of spatial interactions shows that the results do not change so that the results are relatively constant, so that the average strength value can be determined from the gravity index analysis.

5. CONCLUSIONS

Based on the results of scalogram analysis, centrality index analysis and gravity index analysis that have been carried out, the sub-district that has the potential to become a service center in Surakarta City is Banjarsari Sub-district, because it has the most and most complete facilities among other sub-districts, namely 22 types of facilities totaling 5177 units. This is supported by the highest spatial interaction value of 1,358,589,502 between Banjarasari and Laweyan sub-districts. Banjarsari District also has the potential to develop.

It can be seen from the results of using the ArcGIS method (Figure 5), it can be seen that Banjarsari Sub-District as the center of growth has the strongest interaction value with the sub-district or surrounding area which has the closest distance. The closer the distance between the two feeding regions, the greater the interaction value produced by the two regions. Meanwhile, sub-districts that are not directly adjacent or far away create a weak interaction value.

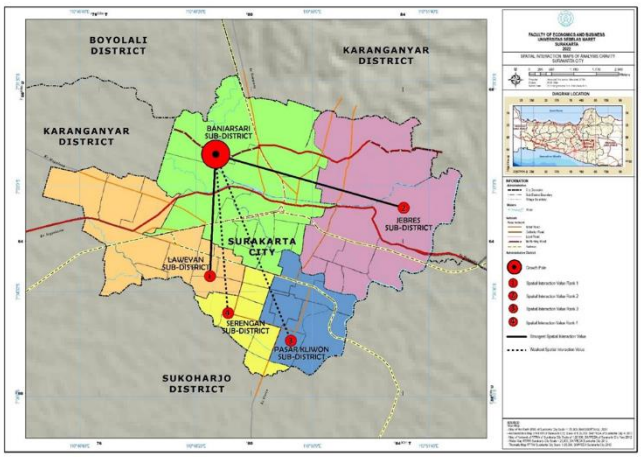

Figure 5. Map of the strength of spatial interaction of Surakarta City
Source: Authors calculation, 2022

The results of the research can be taken into consideration by the Surakarta City government in reducing inter-regional disparities in Surakarta City by optimizing service centers and by shifting the direction of developing service facilities in areas that have urban hierarchies and low spatial interaction values.

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