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Spatial Interaction Based on Sub-District Development Index in Pandeglang Regency

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Article Info	Abstract
	Population movement is a form of spatial interaction between regions. This phenomenon arises as a logical consequence of the heterogeneity of regional development that occurs. Pandeglang Regency as an underdeveloped area should not be left behind because of the many leaks of spatial interactions that are more directed outside this district. Investigating the daily mobilization of the population internally is important in determining which sub-districts play a role as a destination for economic activity. The basic data used include the survey origin destination of Banten Province in 2019 and data on Potential Villages (Podes) 2019 in the Pandeglang Regency. The method used is the Scalogram method to determine the Sub-District Development Index (SDI) and the gravity method to analyze spatial interactions. The Hierarchical classification was carried out on the SDI variable, the number of daily movements (density), and the distance between districts. This is done to see the intensity of the daily movement of the population according to density, distance, and SDI hierarchy class. The spatial interaction magnitude is estimated based on the population estimation parameters and SDI through the natural logarithmic transformation (ln) of the gravity method formula. The results show that the highest average population movement occurs in the high-density hierarchy leading to the sub-districts of the SDI 1 hierarchy. The sub-districts of Cadasari, Munjul, Patia, Saketi, and Sukaresmi as sub-districts from which spatial interaction originate will produce positive intensity values when compared to other sub-districts. Cadasari Sub-District will provide a positive spatial interaction value when it becomes the goal of the daily movement of the population.

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INTRODUCTION

Spatial interaction is an important element in regional planning. Spatial interactions are the dynamics of the flow of elements in the form of goods, residents, information, and others from one region to another (Yang et al., 2019), from the origin to the destination (Gulhan et al., 2014), forming circulation sustainable connectivity (Soja, 1969) based on attractiveness and propulsion which is influenced by costs/fees, reasons for travel, travel distance (Thompson et al., 2019), population migration, trade, tourism, daily movement, ease of transportation (Zhang et al., 2019). According to (Klapka & Halás, 2016) spatial interactions occur as a continuous logical result of the fact that the earth is physically heterogeneous, geographically, and human geographically.

Spatial interactions cause isolated areas to slowly integrate spatially with each other based on their own special structures and functions (Putra et al., 2017). The more spatial interactions increase, the more rapid the growth will be in a more advanced direction. This invisible force will have a positive influence on regional growth (Tan et al., 2016).

Pandeglang Regency is one of the districts in Banten Province which is included in the category of underdeveloped region (Perpres RI No 131/2015 and KepmenPDTT RI No 79/2019). As an underdeveloped region, of course, requires interaction both in terms of demand or supply with other regions. The expected form of interaction is that it can bring great added value in accelerated development, create linkages in order to increase symmetrical linkages between regions so that a symbiotic relationship is formed, mutualism, not an exploitative relationship marked by the backwash effect from the hinterland to the nodal region (Rustiadi et al., 2011).

Based on data on the net migration of districts/cities in Banten Province, Pandeglang Regency contributed the largest deficit with minus 150,591 people (BPS RI, 2016). This data indicates that the intensity of spatial interactions in the form of population mobilization occurs mostly outside of Pandeglang Regency. It is feared that this could create a poverty loop trap that is difficult to escape, one of which is the low mobilization of human and natural resources as well as population movement to more developed areas (Arsyad, 2010). Therefore, this study only examines the spatial interactions that arise in the internal sphere of inter-districts that have the potential to launch accelerated development in the Pandeglang Regency.

Research related to spatial interactions has been widely conducted. Beolado et al., (2012) calculated the estimated value of spatial interaction changes in North Maluku Province based on the variable estimation of population and GDP of the origin and the destination region. Wesolowski et al., (2015) conducted a study of human mobility in Sub-Saharan African as a form of spatial interaction influenced by the phenomenon of disease spread, availability and transportation costs, informal job openings. Lee & Hoshino, (2017) analyzed population demographics as a form of spatial interaction that occurs in South Korea based on economic growth inequality around industrial areas as an attraction and a driving force for regional interactions. Li et al., (2017) analyzed urban spatial interaction in four agglomeration regions in China based on the number of existing populations. However, no one has yet measured the estimated changes in spatial interactions that occur based on the variable parameters of the population and living facilities.

A research conducted by Rustariyuni (2013); Suntajaya (2014); Hakim et al., (2018) show that the availability of life support facilities can be a factor in the attractiveness of the mobility of the population from one region to another. According to Rustiadi et al., (2011), it stated that the availability of living facilities (the physical capacity of an area) can be an instrument to measure the development of a region. It is can also be calculated through the approach to human and economic capacity. The availability of economic, educational, social,

and religious facilities can be calculated into the development index of a region.

Based on a series of previous studies and theory above, the researcher is interested in calculating the estimated amount of spatial interaction that occurs from the availability of facilities (denoted in the sub-district development index) of the origin-destination sub-district and identifying daily movements from one region to another.

RESEARCH METHODS

This research was conducted in Pandeglang Regency, Banten Province, with 35 sub-districts of the analysis unit. Pandeglang Regency is geographically located between 6021'-7010'LS and 104048'-106011'BT with an area of 2,747 km2. Administratively, the north is bordered by Serang Regency, the south is bordered by the Indonesian Ocean, the west is bordered by the Sunda Strait and the east is bordered by Lebak Regency. This research was conducted from January to July 2020.

The data used in this study is secondary data in the form of population movement data per sub-district per day in 2019 obtained from the Banten Province Transportation Agency (Dinas Perhubungan) and Village Potential data for 2019 obtained from the Central Bureau of Statistics (BPS).

In the early stages, this study analyzed the Regional Development Index in the sub-district scope (Sub-District Development Index/SDI). This index is a detailed description of the availability of educational, health, economic, industrial, and religious facilities. The more complete the facilities available, the more advanced the district is, and vice versa (Muta'ali, 2014; Murtandho et al., 2018; Mulya et al., 2019; Supriyatin et al., 2020).

Using village potential data which is then aggregated into sub-district units. The SDI calculation uses Scalogram analysis. The calculations are:

$$SDI_j = \sum_i^n I'_{ij} \dots\dots\dots\dots\dots\dots\dots\dots\dots(1)$$

Where:

$$I'_{ij} = \frac{I_{ij} - I_{i\,min}}{SD(I_i)} \dots\dots\dots\dots\dots\dots\dots\dots(2)$$

Where SDI_j is j sub-district index, I_{ij} is weighted value of the i facility and j sub-district, I'_{ij} is standard value of j sub-district development index and the i facility, $I_{i\,min}$ is the minimun value of i facility (minimum), $SD(I_i)$ is standard deviation of i facility.

Table 1. Classification Method SDI Hierarchy

SDI Hierarchy	Classification Method
SDI 1 (High)	SDI > Average + SD
SDI 2 (Medium)	Average ≤ SDI ≤ Average + SD
SDI 3 (Low)	SDI < Average

The SDI value obtained is carried out by the classification process using the class division method. This is done to get a hierarchical class of regional development. The calculations based on Table 1.

Data on population movements per sub-district per day in 2019 at the Pandeglang Regency level are then classified on the variable number of daily population movements (density) and the variable distance between districts. This is done to explore the connectedness of population mobility at a close hierarchical distance from the sub-district where daily population mobility occurs. Classification uses a method similar to that in Table 1.

The gravity method is used to estimate the amount of interaction between districts that occurs in the Pandeglang Regency. The gravitational method is the result of the explanation of Newton's Law of Physics of Gravity which was developed for social science. The interaction phenomenon between two sub-districts in the gravity method is explained as a function of population and distance in two different regions (Yang et al., 2019). The calculations are as follows:

$$T_{ij} = k \frac{P_i^{\propto} P_j^{\beta}}{d_{ij}^{\gamma}} \dots\dots\dots\dots\dots\dots\dots\dots\dots(3)$$

Where P_i is population in origin sub-district i, P_j is population in destination sub-district j, d_{ij} is distance between sub-district i and j, k is constanta, α is coefficient of

population in origin sub-district i, β is coefficient of population in destination sub-district j, γ is coefficient of distance between sub-district i and j, T_{ij} is spatial interaction sub-district i to j.

Beolado et al., (2012) stated that the spatial interaction gravity method formula can be solved with a linear regression function approach by changing the equation into a natural logarithm (ln) as follows:

$$\ln T_{ij} = \ln k + \propto \ln P_i + \beta \ln P_j - \gamma \ln d_{ij} \dots\dots\dots(4)$$

The natural logarithm (ln) transformation makes T_{ij} change to $\ln T_{ij}$, k changed $\ln k$, $P_i^{\propto}$ change to $\alpha \ln P_i$, P_j^{β} turn into $\beta \ln P_j$, $/d_{ij}^{\gamma}$ change to $-\gamma \ln d_{ij}$.

The parameter values of the above analysis (α, β, γ) can illustrate the elasticity of the occurrence of spatial interactions between districts i and j on the value of the variable variables (P_i, P_j dan d_{ij}). If the values (α, β, γ) > 0, It indicates that every 1% increase will be able to increase the spatial interaction value with the percentage change in the coefficient value of each variable, and vice versa. If the value of α > β, It indicates a pattern of spatial interactions that occurs because the original sub-district acts as a production region, or in other words the

attractiveness in the originating district is greater than the destination sub-district, and vice versa. The value of α < β, It indicates a pattern of spatial interaction that occurs because the driving force in the originating district is greater than the destination sub-district or in other words, the originating district acts as a market region for economic activity (Beolado et al., 2012; Supriyatin et al., 2020).

RESULTS AND DISCUSSION

The calculation of the Scalogram analysis gets the SDI results as shown in the figure. The categorization process was then carried out to divide the SDI development class into a hierarchy of 1 (high) (SDI > 61.30), hierarchy 2 (moderate) (47.14 ≤ SDI ≤ 61.30), and hierarchy 3 (low) (SDI < 47, 14) as shown in Figure 1. It is presented that the more developed sub-districts (SDI 1 and SDI 2) are in the vicinity of the center of the Pandeglang Regency and the sub-districts that are on the border with Serang Regency and Serang City (green and orange color). Almost the majority of sub-districts in Pandeglang regency are into the category of SDI 3 (red color), starting from the central region leading to the southern region of this regency.
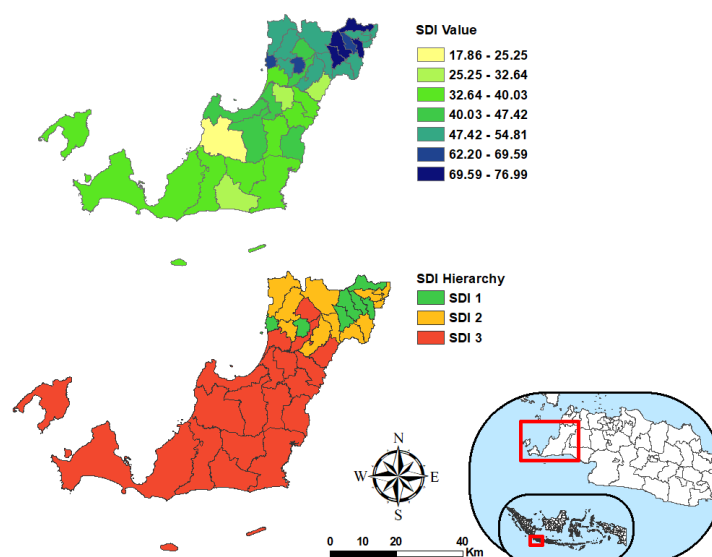

Figure 1. SDI Value and SDI Hierarchy 2019

Daily population movement data per sub-district with an analysis unit of 35 sub-districts in the Pandeglang Regency produces 1,225 data origins destinations (OD) with a total daily population movement of 216,993 people/day/sub-district. The data is denoted as density. Density and distance between sub-districts were categorized by class using a classification technique similar to that used in the SDI calculation results. The results of class categorization for density are high-density data at intervals (Density > 464), medium density (287 ≤ Density ≤ 464), and low density (Density < 287). Data on the distance between two sub-districts are categorized into long-distance data (Distance > 68.35), medium distance (24.98 ≤ Distance ≤ 68.35), and short distance (Distance < 24.98) (Figure 2).
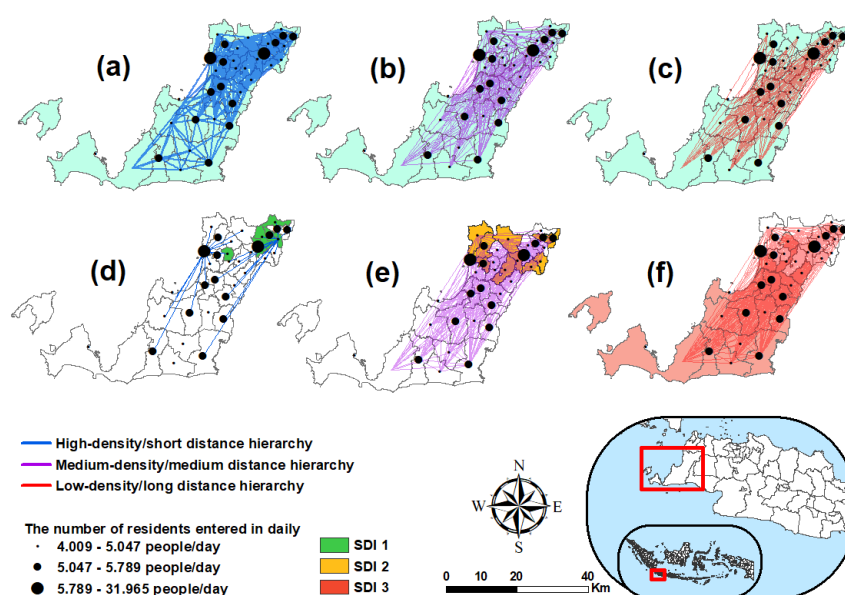

Figure 2. Daily mobility flow map based on distance hierarchy: (a) short, (b) medium, (c) long; Daily mobility flow map based on density hierarchy: (a) high, (b) medium, (c) low

Then the pivot table process of 1,225 OD data is carried out at the next stage. This step to analyze the pattern of movement of the population based on the destination sub-district (SDI), the hierarchy of the number of people mobilized daily, and the hierarchy of distance between the origins sub-district and the destinations sub-district. The calculation results are showed in Table 2, Table 3, and Table 4.

Table 2 explains that the average daily mobility of the population between sub-districts in Pandeglang Regency occurs to SDI 1 with a high-density hierarchy of 1,661 people/day.

Table 3. Average daily mobility based on distance and density hierarchy (people/day)

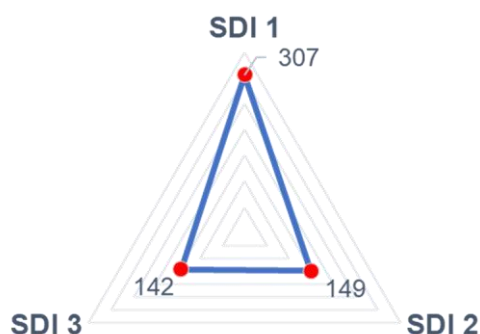| Density hierarchy	Distance hierarchy		
	Short	Medium	Long
High density	**3,011**	1,131	1,587
Medium density	249	244	238
Low density	102	105	93

In Table 3, it can be seen that the average daily population movement occurs predominantly in sub-districts with a short-range categorization.

Table 2. Average daily mobility based on density hierarchy and the SDI hierarchy of the destination sub-districts (people/day)

SDI hierarchy	Density hierarchy		
	Low	Medium	High
SDI 1	92	244	**1,661**
SDI 2	100	242	559
SDI 3	99	241	

Table 4. Average daily mobility based on distance hierarchy and the SDI hierarchy of the destination sub-districts (people/day)

SDI hierarchy	Distance hierarchy		
	Short	Medium	Long
SDI 1	**342**	214	292
SDI 2	149	140	160
SDI 3	133	149	154

Table 4 shows the data that daily population movements towards sub-districts of the SDI 1 hierarchy show a greater intensity at any distance classification. This indicates that the orientation of the majority of the population's daily mobility occurs in destination sub-districts or more developed areas (Tan et al., 2016; Li et al., 2017; Pidor et al., 2018).

Figures 2a, 2b, 2c show the average daily population movement that occurs regardless of the density hierarchy status. It can be seen that the majority of daily short-distance mobilizations are oriented towards the sub-districts of the SDI 1 hierarchy (Figure 2a). In Figure 2d, it can be interpreted that the daily mobilization of the population in the high-density hierarchy occurs at the distance between sub-districts that are close to the sub-district hierarchy of SDI 1. Figure 2e shows that the daily mobilization of the population in the majority medium density hierarchy occurs

Figure 3. Average daily mobility based on the SDI hierarchy of the destination sub-districts

towards the hierarchy of SDI 2, and the low-density hierarchy occurs in the movement of daily displacement of the population towards SDI3 (Figure 2f).

Based on the calculation of the number of population movements towards the destination sub-district per population of Pandeglang Regency, the average proportion of the population moving to the SDI 1 hierarchical sub-districts, SDI 2 hierarchical sub-districts, and SDI 3 hierarchical sub-districts were 0.89%, 0.43%, and 0.41%. Figure 3 shows that the average daily population mobility going to the

Figure 4. Average daily mobility based on the hierarchy of distances between sub-districts

sub-districts of the SDI 1 hierarchy is 307 people/day, which is higher than the average daily population going to the SDI 2 and SDI 3 hierarchical sub-districts.

Figure 4 shows that the average intensity of daily population movement occurred in the short-distance hierarchy category at 187 people/day per sub-district. This is logical considering that the smaller the distance, the more intense the interactions that occur.
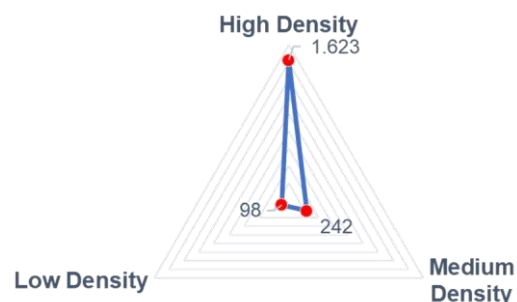

Figure 5. Average daily mobility based on the hierarchy of daily movement density

Figure 5 shows that the average daily population movement of all sub-districts in pandeglang regency is majority into the category of high- density hierarchy with the number of 1,623 people/day per sub-district. The gravity method is used in this study to obtain an estimate of changes in the value of spatial interactions that occur from changes in population size and SDI variables. The results of the calculations are presented in Table 5 and Table 6.

Table 5. The result of spatial interaction based on population and SDI variables as origins sub-district

Sub-district (origins)	Estimation parameters							
	Population				SDI			
	α	β	γ	R_{sq}	α'	β'	γ'	R_{sq}'
Angsana	0.43	0.05	-0.07	0.99	1.25	0.20	-0.12	0.99
Banjar	0.41	0.16	-0.28	0.99	2.06	-0.45	-0.41	0.99
Bojong	0.67	-0.20	-0.01	0.99	1.27	0.12	0.02	0.99
Cadasari *)	0.02	0.34	0.25	0.98	0.70	0.17	0.28	0.98
Carita	0.78	-0.06	-0.66	0.99	1.98	-0.06	-0.66	0.99
Cibaliung	0.85	-0.31	-0.20	0.99	1.46	0.10	-0.24	0.99
Cibitung	-0.04	0.53	-0.07	0.99	1.80	-0.43	0.07	0.99
Cigeulis	0.51	-0.05	-0.01	0.99	2.04	-0.41	0.13	0.99
Cikedal	-0.09	0.62	-0.25	0.98	1.48	-0.02	-0.31	0.98
Cikeusik	0.51	-0.03	0.01	0.99	1.07	0.67	-0.29	0.99
Cimanggu	-0.14	0.62	0.07	0.99	1.10	0.45	-0.06	0.99
Cimanuk	0.65	-0.11	-0.13	0.99	0.95	0.35	-0.05	0.99
Cipeucang	1.00	-0.54	0.02	0.99	0.50	0.61	0.14	0.99
Cisata	0.11	0.29	0.12	0.99	1.39	-0.21	0.05	0.99
Jiput	0.37	0.25	-0.44	0.99	1.50	0.13	-0.44	0.99
Kaduhejo	0.30	0.25	-0.26	0.99	1.29	0.04	-0.26	0.99
Karangtanjung	1.11	-0.58	-0.16	0.99	1.34	0.05	-0.14	0.98
Koroncong	0.51	0.01	-0.14	0.99	0.74	0.47	-0.01	0.99
Labuan	0.40	0.11	-0.03	0.99	1.02	0.30	0.01	0.99
Majasari	0.11	0.48	-0.21	0.99	1.41	0.07	-0.20	0.99
Mandalawangi	-0.12	0.62	-0.05	0.98	1.90	-0.45	-0.20	0.97
Mekarjaya	0.19	0.26	-0.02	0.99	0.89	0.24	0.04	0.99
Menes	-0.06	0.55	-0.01	0.98	1.36	-0.14	-0.06	0.98
Munjul *)	0.23	0.16	0.18	0.98	0.93	0.12	0.14	0.98
Pagelaran	-0.05	0.58	-0.17	0.99	1.49	0.04	-0.19	0.99
Pandeglang	0.62	-0.16	0.09	0.99	1.53	-0.34	0.02	0.99
Panimbang	0.49	0.07	-0.14	0.99	1.47	0.26	-0.29	0.99
Patia *)	0.01	0.43	0.09	0.99	1.04	0.31	0.05	0.99
Picung	-0.09	0.41	0.48	0.98	0.85	0.07	0.51	0.98
Pulosari	-0.03	0.56	-0.15	0.99	1.80	-0.25	-0.28	0.99
Saketi *)	0.18	0.24	0.15	0.98	0.05	0.92	0.37	0.98
Sindangresmi *)	0.23	0.06	0.43	0.99	0.57	0.27	0.39	0.99
Sobang	0.23	0.06	0.43	0.99	0.80	0.62	-0.15	0.99
Sukaresmi	0.41	0.11	-0.19	0.98	1.15	0.37	-0.26	0.98
Sumur	0.09	0.36	-0.04	0.99	1.23	0.21	-0.20	0.99

Table 6. The result of spatial interaction based on population and SDI variables as destinations sub-district

| Sub-district (destinations) | Estimation parameters | | | | | | | |
| | Population | | | | SDI | | | |
	α	β	γ	R_{sq}	α'	β'	γ'	R_{sq}'
Angsana	0.60	-0.20	0.16	0.99	-0.27	1.39	0.26	0.99
Banjar	0.96	-0.46	-0.09	0.99	0.92	0.22	0.16	0.99
Bojong	0.79	-0.41	0.23	0.99	0.27	0.75	0.30	0.99
Cadasari *)	0.37	0.06	0.04	0.99	0.33	0.71	0.10	0.99
Carita	1.19	-0.78	0.18	0.99	0.25	0.97	0.05	0.99
Cibaliung	0.64	-0.13	-0.11	0.99	0.26	1.31	-0.23	0.99
Cibitung	1.04	-0.54	-0.17	0.99	0.08	1.61	-0.26	0.99
Cigeulis	0.59	-0.22	0.26	0.99	0.26	1.19	0.12	0.99
Cikedal	1.03	-0.56	0.03	0.99	0.17	1.12	-0.03	0.99
Cikeusik	1.14	-0.65	0.00	0.99	0.25	0.98	0.07	0.99
Cimanggu	0.83	-0.35	0.03	0.99	0.18	1.23	0.02	0.99
Cimanuk	0.87	-0.43	0.10	0.99	0.75	0.27	0.25	0.99
Cipeucang	0.21	0.25	-0.01	0.99	0.65	0.50	0.14	0.99
Cisata	1.08	-0.69	0.17	0.99	0.37	0.78	0.16	0.99
Jiput	0.87	-0.41	0.00	0.99	0.25	1.02	-0.04	0.99
Kaduhejo	0.85	-0.41	0.07	0.99	-0.02	1.10	0.04	0.99
Karangtanjung	0.85	-0.36	-0.03	1.00	0.33	0.92	0.04	0.99
Koroncong	1.21	-0.81	0.09	0.99	0.19	0.99	0.09	0.99
Labuan	1.61	-0.72	-0.96	0.96	-1.07	3.24	-1.08	0.96
Majasari	0.56	-0.06	-0.11	0.99	0.12	1.13	-0.11	0.99
Mandalawangi	0.81	-0.33	0.02	0.99	-0.16	1.47	-0.05	0.99
Mekarjaya	0.87	-0.37	-0.14	0.99	0.39	0.93	-0.06	0.99
Menes	0.69	-0.21	-0.09	0.99	0.25	0.95	-0.08	0.99
Munjul	0.98	-0.43	-0.31	0.99	0.43	1.24	-0.43	0.99
Pagelaran	0.67	-0.20	0.00	0.99	0.21	1.12	-0.01	0.99
Pandeglang	0.50	0.30	-0.66	0.96	0.31	1.63	-0.60	0.96
Panimbang	0.62	-0.21	0.16	0.99	0.55	0.88	-0.16	0.99
Patia	0.49	-0.18	0.46	1.00	-0.01	0.98	0.46	0.99
Picung	0.72	-0.37	0.35	0.99	0.24	0.69	0.40	0.99
Pulosari	1.04	-0.55	-0.10	0.99	0.19	1.22	-0.15	0.99
Saketi	0.78	-0.26	-0.17	0.99	0.61	0.65	-0.04	0.99
Sindangresmi	0.63	-0.21	0.14	0.99	0.11	1.15	0.15	0.99
Sobang	0.86	-0.42	0.10	0.99	0.58	0.97	-0.26	0.99
Sukaresmi	0.81	-0.30	-0.11	0.99	0.11	1.35	-0.14	0.99
Sumur	0.87	-0.38	-0.07	0.99	0.52	1.34	-0.47	0.99

Table 5 and Table 6 look similar at first glance, but there are differences. The difference lies in the role of each sub-district either as a trip origin location (Table 5) or as a trip destination location (Table 6). Table 5 shows that the estimated spatial interaction that occurs will be positive in the Districts of Cadasari, Munjul, Patia, Saketi, and Sukaresmi (indicated by an *) in the table), where each change in the increase of 1% in the value of the variable will increase the regional interaction value by the precentage of changes in the coefficient value (α, β, γ). For

example, in the population estimation variable, where every 1% increase in population in the Angsana district will increase the flow of daily mobility of the population from Angsana District by 0.43%. Likewise, explanations for the results of other sub-district analyzes. Or in the other hand, SDI estimation variable where every 1% increase in the SDI value in the Angsana sub-district will increase the flow of daily mobility of the population from Angsana District by 1.25% (Beolado et al., 2012; Rizki et al., 2017; Supriyatin et al., 2020).

The comparison of α and β values where the α value is greater β value indicates that the majority of spatial interactions that arise due to the greater attractiveness in the original sub-district than in other sub-districts. Based on the population size variable if it acts as the original sub-district (Tabel 5). The districts that act as market region ($\alpha < \beta$) are Cadasari, Cibitung, Cikedal, Cimanggu, Cisata, Majasari, Mandalawangi, Mekarjaya, Menes, Pagelaran, Patia, Picung, Pulosari, Saketi, Sumur districts. And the remaining Districts play a role as a production region ($\alpha > \beta$). The criteria for determining the market and production region are also used in the estimation results of the spatial interaction parameters with the SDI variable The determination coefficient value of $R_{sq} > 0.9$ explains that independent variables (population and SDI) can describe dependent variables (spatial interactions) of > 90% and the rest are affected by variables not observed in this study.

Table 6 shows the variable population size estimator and SDI, the spatial interactions that occur will be positive only in the Cadasari Sub-District area. When examined more deeply, the data shows that only Cipeucang Sub-District is the only area with a value of $\alpha < \beta$ (positive notation). This indicates that there is an attraction that causes population mobility towards the sub-district based on the estimated parameter of the population size variable.

The findings in this article are that daily population flows tend to move to more developed areas. Moving to a sub-district that has more available social, economic, educational, and religious facilities than the origin region, the number of daily population movements with a greater density occurs at short travel distances. Labuan sub-district as a travel destination area had the highest α value (1.61) based on the calculation of the estimated population parameter variable, and the Labuan sub-district also had the highest β value (3.24) based on the analysis of the SDI parameter estimation variable. It is in line with the data showing that Labuan District is the area with the highest population density, and the results of the scalogram analysis of this sub-district included in the SDI 1 category. The results show that the Labuan Sub-District is the area that can produce the largest estimated value of spatial interaction based on the estimated population variable in the destination sub-district with an α value of 1.61. It means every 1% increase in population can increase the regional interaction value by 1.61%. Labuan sub-district in this case acts as a production region ($\alpha > \beta$) which has a stronger appeal to become a destination for population mobility.

From the results of the scalogram analysis, the Labuan sub-district obtained the SDI 1 hierarchical status so that it is logical to become a destination for population mobility due to the more diverse economic activities in this region. There is only 1 sub-district that acts as a market region ($\alpha < \beta$) based on the calculation of the estimated population parameters at the destination of the trip, namely Cipeucang Sub-District. Banjar, Cimanuk, and Cipeucang Sub-Districts act as production region from the calculation of spatial interactions using SDI estimation parameters. Banjar Sub-District has the highest α value of 0.92 and acts as a production region ($\alpha > \beta$) where every 1% increase in the SDI value can increase the regional interaction value by 0.92%. Market regions and production regions are formed as a result of interactions between sub-districts. The factors that make a sub-district a market and production region in this research rely on the attractiveness and driving force of

the population and SDI. For a more in-depth study, it is necessary to observe further research related to these factors such as road accessibility (Yi & Kim, 2018), availability of transportation, traffic density, available job vacancies, the number of unemployed (Shen, 2019), land use-land cover (Silveira & Dentinho, 2018; Zhu et al., 2020), and others.

CONCLUSION

The development of the sub-district in terms of the availability of service infrastructure shows that the more developed sub-districts are located around the center of the Pandeglang Regency and the sub-districts that are on the border with Serang Regency and Serang City. This condition causes the daily population mobility to lean towards the sub-district.

The spatial interaction with the variable estimating population size and SDI value shows different estimation figures in each sub-district but based on the value (α, β, γ) > 0 Cadasari, Munjul, Patia, Saketi, and Sukaresmi Sub-Districts as the sub-districts from which the interaction will produce positive intensity values when compared to other districts. Cadasari Sub-District will also provides a positive spatial interaction value when it becomes the goal of daily mobility of the population. This is supported by the fact that the area is directly adjacent to the Serang Regency so that it benefits from the aspect of proximity.

The hierarchy of areas studied in this study indicates that the sub-districts located in the southern part of the Pandeglang Regency need more attention. Equitable provision of infrastructure, increased connectivity and accessibility are options for accelerated development.

This study uses an estimator variable for the value of spatial interaction (daily population mobility) based only on the number of population and the SDI value of the origin and destination districts. Future research is expected to be able to examine the preferences of the subject of daily mobility actors and to compare spatial interactions with the external areas of the surrounding districts.

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