

Original Article

Identifying the Growth Centers in Banda Aceh City, Indonesia: Before and After Tsunami

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Abstract: The city of Banda Aceh continues to grow and develop to this day after being hit by the tsunami disaster in 2004. The growth and development of Banda Aceh did not happen simultaneously. It can be seen in Meuraxa District, Jaya Baru District, and other districts affected by the Tsunami. As a result, the growth centers shifted in Banda Aceh City. The high level of development until 2021, using the GRDP of Banda Aceh City, which is 19.93 trillion rupiah, means that economic growth will also increase by 1.25 percent from 2003 before the Tsunami to 2021, thereby creating economic potential in Banda Aceh City. The developing economic interaction between sub-districts in Banda Aceh City will create the strongest interaction as a new growth center on the basis of data from before and after the Tsunami, namely the number of population increases and the absolute distance between the two regions. The gravity analysis model identifies interactions between sub-districts in Banda Aceh City. It means they have strong economic interactions as growth centers by gaining the strength of interaction between two regions in Banda Aceh City. The gravity analysis model produces interaction areas with the strongest interaction values in 2004 (before Tsunami), 2005 (after the Tsunami), and 2021 (currently), which are the interactions between Kuta Alam and Baiturrahman Districts with interaction values for each year of 283,084,961,591; 161,382,469,959 and 190,617,812,346.

Keywords: Gravity Approach; Growth center; Before and after Tsunami.



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1. Introduction

Banda Aceh was one of the cities hit by the tsunami disaster in 2004, resulting in a shift in the growth poles and centers of city activities and services in the city of Banda Aceh. The city of Banda Aceh continues to grow and develop after the tsunami disaster. Cities grow and develop not simultaneously but gradually in certain places with different intensities. The concept of a growth center is on the basis of the concept of economic space proposed by Francois Perroux. Perroux stated that growth does not appear in various regions simultaneously; it will appear at the growth poles with different intensities and consequences (Emalia & Farida, 2018). A growth center (growth pole) is a concept of growth poles used as a concrete spatial concept. A growth center is a (geographical) set of all activities. Growth centers are cities or urban

areas that have a complex propulsive industry. Its development growth is very rapid compared to other regions, so it can be used as a development center that can influence the growth of other areas around it (Pasaribu et al., 2014).

Growth centers do not occur everywhere but are limited to places with various variables and intensities. (Rahayu, 2014). Suppose growth poles achieve their integrative calling as best as possible and implement collaborative networks innovatively in polycentric regions. In that case, they will create conditions that enable society to use the better valence of economic integration to develop these regions. In addition, the growth poles use integrative cooperation between each integrative region and between small and medium-sized cities, both on the internal borders and outside the external borders of each respective integrative region (Avram and Braga, 2017). The high level of development in a large city means that economic growth also increased after the Tsunami, giving rise to economic potential in the city of Banda Aceh based on the existing conditions of the spatial structure of the city area. With increasing economic potential, economic interaction between sub-districts in Banda Aceh City will develop. The growing economic interaction between sub-districts in Banda Aceh City will create the strongest interaction area as a new growth pole based on data from before and after the Tsunami in Banda Aceh City.

On the basis of the Banda Aceh City Central Statistics Agency, the population before the Tsunami, namely in 2004, was 265,098 people; after the Tsunami, namely in 2005, it was 177,881 people. The tsunami disaster in Banda Aceh City caused a significant decrease of 32.9% in population in 2004 and 2005. Meanwhile, currently, in 2021, the population is 255,029 people. It shows that there has been an increase in population since 2005 after the Tsunami, namely 43.37%.

2. Materials and Methods

The location of this research is in Banda Aceh City with coordinates between $5^{\circ}16'15'' - 5^{\circ}36'16''$ N and $95^{\circ}16'15'' - 95^{\circ}22'35''$ E. The map of the research location, namely the map of Banda Aceh City, is presented in Figure 1.

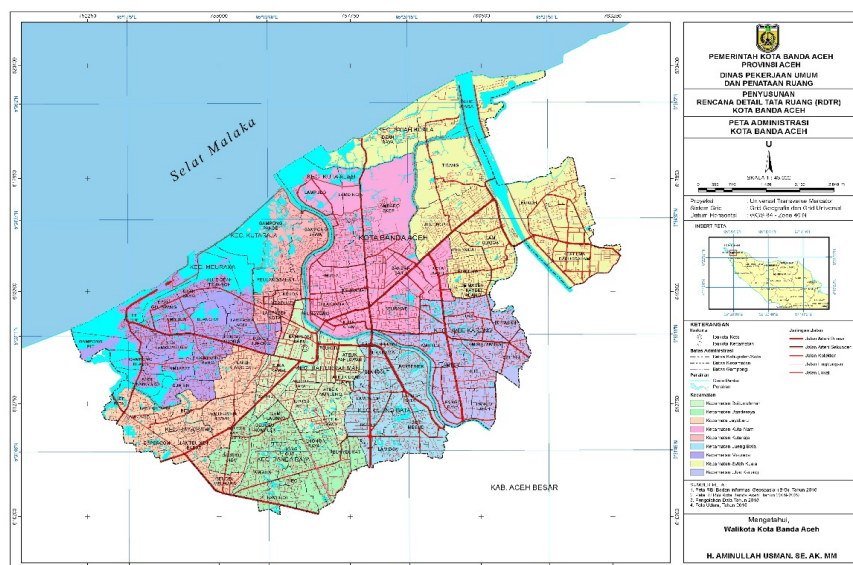


Figure 1. Map of research locations

The method used in this research is quantitative and conveys objectively to answer the research objectives. The growth pole theory supports quantitative data. The type of data used in this research is secondary data in the form of available data that has been processed and published by other parties. The secondary data used was obtained from the Central Statistics Agency (BPS) of Banda Aceh City, the Detailed Spatial Planning Plan (RDTR) of Banda Aceh City, and journal articles and literature related to the research. The gravity analysis model is the most widely used model to see the magnitude of the attraction of a potential at a location. This model is used to identify the district's economic interactions with other surrounding districts that have strong economic interactions as centers of growth. This theory is the concept of physical laws proposed by Issac Newton and expanded into use in geography by W. J Reilly. Reilly believes that the strength of interaction between two or more regions on the earth's surface can be measured

by paying attention to the population and the absolute distance between the two regions (Damayanti, 2019). The general gravity formula is as follows:

$$I_{1-2} = k \frac{P_1 \cdot P_2}{(J_{1-2})^2} \quad (1)$$

Whereas:

- I_{1-2} = interaction strength of regions 1 and 2
- k = empirical constant (generally 1)
- P_1 = population of region 1
- P_2 = population of region 2
- J_{1-2} = absolute distance between regions 1 and 2

The basic concept of the gravity analysis model in this research is to discuss the value of interactions between sub-districts in Banda Aceh City, which have strong economic interactions as growth poles in each year 2004, 2005, and 2021 according to the conditions before and after the Tsunami occurred in Banda Aceh City.

3. Results

The calculation of the gravity analysis model to obtain the strength of interaction between two areas in Banda Aceh City can be measured by using or paying attention to the number of residents and the absolute distance between these two regions. Population data was obtained from the Banda Aceh City Central Statistics Agency according to the years before and after the Tsunami occurred in Banda Aceh City, namely 2004 (before the Tsunami), 2005 (after the Tsunami), and 2021 (currently). For more details, the population data is presented in Table 1.

Table 1. Population by District in Banda Aceh City

No.	Sub-district	Total Population		
		2004	2005	2021
1	Meuraxa	34.592	2.221	27.273
2	Jaya Baru	21.305	12.340	26.273
3	Banda Raya	23.995	24.257	25.615
4	Baiturrahman	37.715	33.582	32.629
5	Lueng Bata	19.232	19.284	24.360
6	Kuta Alam	54.718	35.033	42.588
7	Kuta Raja	21.632	2.978	15.515
8	Syiah Kuala	32.590	25.418	33.100
9	Ulee Kareng	19.319	22.768	27.676
Banda Aceh city		265.098	177.881	255.029

Table 1 shows the population by sub-district in Banda Aceh City in 2004, 2005 and 2021 according to before and after the Tsunami in Banda Aceh City. The district with the largest population in 2004 was Kuta Alam District, with 54,718 people; the lowest population was Lueng Bata District, with 19,232 people. In 2005, the largest population was Kuta Alam District, with 35,033 people; the lowest was Meuraxa District, with 2,221 people. In 2021, the largest population is Kuta Alam District, amounting to 42,588 people, and the lowest population is Kuta Raja District, amounting to 15,515 people. The data above shows a significant decline in the sub-district in 2004 and 2005 after the Tsunami. These sub-districts are Meuraxa District and Kuta Raja District, which experienced a population decline of 93.58% and 86.23%, respectively. The gravity model analysis was calculated between sub-districts in Banda Aceh City in each year 2004, 2005 and 2021 according to the conditions before and after the Tsunami occurred in Banda Aceh City. Gravity calculations between sub-districts in Banda Aceh City in 2004, 2005, and 2021 are presented in Table 2 to Table 10.

Table 2. Result of Gravity for Meuraxa District, Banda Aceh City, 2004, 2005 and 2021

Subdistrict	Distance (dij)/ Km	Distance ² (dij) ² / Km	2004 Total Population (Pi) / Life	Interaction
Meuraxa			34.592	
Jaya Baru	3,5	12,25	21.305	60.161.841,633
Banda Raya	7,5	56,25	23.995	14.756.178,489
Baiturrahman	4,1	16,81	37.715	77.610.784,057
Lueng Bata	7,2	51,84	19.232	12.833.204,938
Kuta Alam	6,3	39,69	54.718	47.689.721,744
Kuta Raja	4,6	21,16	21.632	35.363.617,391
Syiah Kuala	10,8	116,6	32.590	9.665.237,311
Ulee Kareng	10,3	106,1	19.319	6.299.206,787

Table 2. Result of Gravity for Meuraxa District, Banda Aceh City, 2004, 2005 and 2021 (Cont'd)

Subdistrict	2005 Total Population (Pi) / Life	Interaction	2021 Total Population (Pi) / Life	Interaction
Meuraxa	2.221		27.273	
Jaya Baru	12.340	2.237.317,551	26.273	58.493.349,306
Banda Raya	24.257	957.774,169	25.615	12.419.518,133
Baiturrahman	33.582	4.436.979,298	32.629	52.938.174,717
Lueng Bata	19.284	826.191,435	24.360	12.815.784,722
Kuta Alam	35.033	1.960.400,428	42.588	29.264.361,905
Kuta Raja	2.978	312.577,410	15.515	19.997.192,580
Syiah Kuala	25.418	483.996,725	33.100	7.739.508,745
Ulee Kareng	22.768	476.649,335	27.676	7.114.785,069

Table 2 captures the gravity calculation for each sub-district for Meuraxa District in Banda Aceh City in 2004, which had the strongest interaction value. Baiturrahman District had a value of 77,610,784.057. The calculation results show that the sub-district with the weakest interaction value with Meuraxa District in 2004 was Ulee Kareng District, with a value of 6,299,206,787. In 2005, the one with the strongest interaction value for Meuraxa District, Banda Aceh City, was Baiturrahman District, with a value of 4,436,979,298. The subdistrict with the weakest interaction value with Meuraxa Subdistrict in 2005 was Kuta Raja Subdistrict, with a value of 312,577.41. The calculation results also show that the strongest interaction value for Meuraxa District, Banda Aceh City, in 2021 is Jaya Baru District, with a value of 58,493,349,306. The sub-district with the weakest interaction value with Meuraxa District in 2021 is Ulee Kareng District, which is 7,114,785,069.

Table 3. Result of Gravity for Jaya Baru District, Banda Aceh City, 2004, 2005 and 2021

Subdistrict	Distance (dij) / Km	Distance ² (dij) ² / Km	2004 Total Population (Pi) / Life	Interaction
Meuraxa	3,5	12,25	34.592	60.161.841,633
Jaya Baru			21.305	
Banda Raya	3,2	10,24	23.995	49.923.190,918
Baiturrahman	4,5	20,25	37.715	39.679.904,938
Lueng Bata	8	64	19.232	6.402.152,500
Kuta Alam	7,1	50,41	54.718	23.125.708,986
Kuta Raja	7,6	57,76	21.632	7.979.047,091
Syiah Kuala	11,7	136,9	32.590	5.072.174,374
Ulee Kareng	11,1	123,2	19.319	3.340.567,283

Table 3. Result of Gravity for Jaya Baru District, Banda Aceh City, 2004, 2005 and 2021 (Cont'd)

Subdistrict	2005		2021	
	Total Population (Pi) / Life	Interaction	Total Population (Pi) / Life	Interaction
Meuraxa	2.221	2.237.317,551	27.273	58.493.349,306
Jaya Baru	12.340		26.273	
Banda Raya	24.257	29.231.580,078	25.615	65.720.985,840
Baiturrahman	33.582	20.464.290,370	32.629	42.333.911,951
Lueng Bata	19.284	3.718.196,250	24.360	10.000.160,625
Kuta Alam	35.033	8.575.822,654	42.588	22.196.280,976
Kuta Raja	2.978	636.227,839	15.515	7.057.229,830
Syiah Kuala	25.418	2.291.315,070	33.100	6.352.811,016
Ulee Kareng	22.768	2.280.311,014	27.676	5.901.562,763

Table 3 captures the gravity calculation for each Jaya Baru Sub District sub-district in Banda Aceh City in 2004. The strongest interaction value was Meuraxa Subdistrict, with a value of 60,161,841.633. The calculation results show that the sub-district with the weakest interaction value with Jaya Baru Sub-district in 2004 was Ulee Kareng Sub-district, with a value of 3,340,567,283. In 2005, the one with the strongest interaction value for Jaya Baru District, Banda Aceh City, was Banda Raya District with a value of 29,231,580.078. The subdistrict with the weakest interaction value with Jaya Baru Sub District in 2005 was Kuta Raja Subdistrict, with a value of 636,227,839. The calculation results also show that the strongest interaction value for Jaya Baru District, Banda Aceh City, in 2021 is Banda Raya District, with a value of 65,720,985,840. The sub-district with the weakest interaction value with Jaya Baru Sub-district in 2021 is Ulee Kareng Sub-district with a value of 5,901,562,763.

Table 4. Result of Gravity for Bandaraya District, Banda Aceh City, 2004, 2005 and 2021

Subdistrict	Distance (dij) / Km	Distance ² (dij) ² / Km	2004	
			Total Population (Pi) / Life	Interaction
Meuraxa	7,5	56,25	34.592	14.756.178,489
Jaya Baru	3,2	10,24	21.305	49.923.190,918
Banda Raya			23.995	
Baiturrahman	3,8	14,44	37.715	62.671.151,316
Lueng Bata	5	25	19.232	18.458.873,600
Kuta Alam	6,2	38,44	54.718	34.156.046,046
Kuta Raja	6,6	43,56	21.632	11.915.974,288
Syiah Kuala	10,8	116,6	32.590	6.704.364,283
Ulee Kareng	7,1	50,41	19.319	9.195.782,682

Table 4. Result of Gravity for Bandaraya District, Banda Aceh City, 2004, 2005 and 2021 (Cont'd)

Subdistrict	2005		2021	
	Total Population (Pi) / Life	Interaction	Total Population (Pi) / Life	Interaction
Meuraxa	2.221	957.774,169	27.273	12.419.518,133
Jaya Baru	12.340	29.231.580,078	26.273	65.720.985,840
Banda Raya	24.257		25.615	
Baiturrahman	33.582	56.412.643,629	32.629	57.880.320,983
Lueng Bata	19.284	18.710.879,520	24.360	24.959.256,000
Kuta Alam	35.033	22.107.062,461	42.588	28.379.074,402
Kuta Raja	2.978	1.658.341,276	15.515	9.123.432,622
Syiah Kuala	25.418	5.286.046,176	33.100	7.269.002,915
Ulee Kareng	22.768	10.955.829,716	27.676	14.063.097,401

Table 4 shows that the gravity calculation for each sub-district for Banda Raya District in Banda Aceh City in 2004, which had the strongest interaction value, was Baiturrahman District with a value of 62,671,151.316. From the calculation results, the sub-district with the weakest interaction value with Banda Raya Sub-district in 2004 was Syiah Kuala Sub-district, with a value of 6,704,364,283. In 2005, the district with the strongest interaction value for Banda Raya, Banda Aceh City, was Baiturrahman District, with a value of 56,412,643,629. The sub-district with the weakest interaction value with Banda Raya Subdistrict in 2005 was the Kuta Raja Subdistrict, with a value of 1,658,341.276. The calculation results also show that the strongest interaction value for Banda Raya District, Banda Aceh City, in 2021 is Jaya Baru District, with a value of 65,720,985,840. The sub-district with the weakest interaction value with Banda Raya District in 2021 is Syiah Kuala District, with a value of 7,269,002,915.

Table 5. Result of Gravity for Baiturrahman District, Banda Aceh City, 2004, 2005 and 2021

Subdistrict	Distance (dij) / Km	Distance ² (dij) ² / Km	2004 Total Population (Pi) / Life	Interaction
Meuraxa	4,1	16,81	34.592	77.610.784,057
Jaya Baru	4,5	20,25	21.305	39.679.904,938
Banda Raya	3,8	14,44	23.995	62.671.151,316
Baiturrahman			37.715	
Lueng Bata	3,6	12,96	19.232	55.967.197,531
Kuta Alam	2,7	7,29	54.718	283.084.961,591
Kuta Raja	2,8	7,84	21.632	104.062.612,245
Syiah Kuala	7,3	53,29	32.590	23.064.962,470
Ulee Kareng	6,6	43,56	19.319	16.726.723,714

Table 5. Result of Gravity for Baiturrahman District, Banda Aceh City, 2004, 2005 and 2021(Cont'd)

Subdistrict	2005 Total Population (Pi) / Life	Interaction	2021 Total Population (Pi) / Life	Interaction
Meuraxa	2.221	4.436.979,298	27.273	52.938.174,717
Jaya Baru	12.340	20.464.290,370	26.273	42.333.911,951
Banda Raya	24.257	56.412.643,629	25.615	57.880.320,983
Baiturrahman	33.582		32.629	
Lueng Bata	19.284	49.968.772,222	24.360	61.330.435,185
Kuta Alam	35.033	161.382.469,959	42.588	190.617.812,346
Kuta Raja	2.978	12.756.019,898	15.515	64.571.292,730
Syiah Kuala	25.418	16.017.775,868	33.100	20.266.839,932
Ulee Kareng	22.768	17.552.685,399	27.676	20.730.950,505

Table 5 describes the gravity calculation for each sub-district for Baiturrahman District in Banda Aceh City in 2004, which had the strongest interaction value. Kuta Alam District had 283,084,961.591. The calculation results show that the sub-district with the weakest interaction value with Baiturrahman Sub-district in 2004 was Ulee Kareng Sub-district with a value of 16,726,723,714. In 2005, the one with the strongest interaction value for Baiturrahman District, Banda Aceh City, was Kuta Alam District, with 161,382,469,959. The sub-district with the weakest interaction value with Baiturrahman Sub District in 2005 was Kuta Raja Subdistrict, with a value of 12,756,019,898. The calculation results also show that the strongest interaction value for Baiturrahman District, Banda Aceh City, in 2021 is Kuta Alam District, with a value of 190,617,812,346. The sub-district with the weakest interaction value with Baiturrahman District in 2021 is Syiah Kuala District, which has a value of 20,266,839.932.

Table 6. Result of Gravity for Lueng Bata District, Banda Aceh City, 2004, 2005 and 2021

Subdistrict	Distance (dij) / Km	Distance² (dij)² / Km	2004 Total Population (Pi) / Life	Interaction
Meuraxa	7,2	51,84	34.592	12.833.204,938
Jaya Baru	8	64	21.305	6.402.152,500
Banda Raya	5	25	23.995	18.458.873,600
Baiturrahman	3,6	12,96	37.715	55.967.197,531
Lueng Bata			19.232	
Kuta Alam	3,3	10,89	54.718	96.633.294,399
Kuta Raja	5,2	27,04	21.632	15.385.600,000
Syiah Kuala	7,7	59,29	32.590	10.571.274,751
Ulee Kareng	3,6	12,96	19.319	28.668.441,975

Table 6. Result of Gravity for Lueng Bata District, Banda Aceh City, 2004, 2005 and 2021 (Cont'd)

Subdistrict	2005 Total Population (Pi) / Life	Interaction	2021 Total Population (Pi) / Life	Interaction
Meuraxa	2.221	826.191,435	27.273	12.815.784,722
Jaya Baru	12.340	3.718.196,250	26.273	10.000.160,625
Banda Raya	24.257	18.710.879,520	25.615	24.959.256,000
Baiturrahman	33.582	49.968.772,222	32.629	61.330.435,185
Lueng Bata	19.284		24.360	
Kuta Alam	35.033	96.633.294,399	42.588	95.265.719,008
Kuta Raja	2.978	15.385.600,000	15.515	13.977.270,710
Syiah Kuala	25.418	10.571.274,751	33.100	13.599.527,745
Ulee Kareng	22.768	28.668.441,975	27.676	52.020.629,630

Table 6 shows the gravity calculation for each sub-district for Lueng Bata District in Banda Aceh City in 2004, which had the strongest interaction value. Kuta Alam District had the strongest interaction value. The calculation results show that the sub-district with the weakest interaction value with Lueng Bata Sub-district in 2004 was Jaya Baru Sub-district, with a value of 6,402,152,500. In 2005, the one with the strongest interaction value for Lueng Bata District, Banda Aceh City, was Kuta Alam District, with 96,633,294,399. The subdistrict with the weakest interaction value with Lueng Bata Subdistrict in 2005 was Meuraxa Subdistrict, with a value of 826,191.435. The calculation results also show that the strongest interaction value for Lueng Bata District, Banda Aceh City, in 2021 is Kuta Alam District, with a value of 95,265,719,008. The sub-district with the weakest interaction value with Lueng Bata Sub-district in 2021 is Jaya Baru Sub-district, with a value of 10,000,160,625.

Table 7. Result of Gravity for Kuta Alam District, Banda Aceh City, 2004, 2005 and 2021

Subdistrict	Distance (dij) / Km	Distance² (dij)² / Km	2004 Total Population (Pi) / Life	Interaction
Meuraxa	6,3	39,69	34.592	47.689.721,744
Jaya Baru	7,1	50,41	21.305	23.125.708,986
Banda Raya	6,2	38,44	23.995	34.156.046,046
Baiturrahman	2,7	7,29	37.715	283.084.961,591
Lueng Bata	3,3	10,89	19.232	96.633.294,399
Kuta Alam			54.718	
Kuta Raja	2,6	6,76	21.632	175.097.600,000
Syiah Kuala	5,6	31,36	32.590	56.864.146,046
Ulee Kareng	5,4	29,16	19.319	36.251.613,237

Table 7. Result of Gravity for Kuta Alam District, Banda Aceh City, 2004, 2005 and 2021 (Cont'd)

Subdistrict	2005		2021	
	Total Population (Pi) / Life	Interaction	Total Population (Pi) / Life	Interaction
Meuraxa	2.221	1.960.400,428	27.273	29.264.361,905
Jaya Baru	12.340	8.575.822,654	26.273	22.196.280,976
Banda Raya	24.257	22.107.062,461	25.615	28.379.074,402
Baiturrahman	33.582	161.382.469,959	32.629	190.617.812,346
Lueng Bata	19.284	62.036.397,796	24.360	95.265.719,008
Kuta Alam	35.033		42.588	
Kuta Raja	2.978	15.433.176,627	15.515	97.744.500,000
Syiah Kuala	25.418	28.395.050,829	33.100	44.950.982,143
Ulee Kareng	22.768	27.353.612,620	27.676	40.420.627,160

Table 7 shows that the gravity calculation for each sub-district for Kuta Alam Subdistrict in Banda Aceh City in 2004, which had the strongest interaction value was Baiturrahman Subdistrict with a value of 283,084,961.591. The calculation results show that the sub-district with the weakest interaction value with Kuta Alam Sub-district in 2004 was Jaya Baru Sub-district, with a value of 23,125,708,986. In 2005, the one with the strongest interaction value for Kuta Alam District, Banda Aceh City, was Baiturrahman District, with a value of 161,382,469,959. The sub-district with the weakest interaction value with Kuta Alam Subdistrict in 2005 was Meuraxa Subdistrict, with a value of 1,960,400.428. The calculation results also show that the strongest interaction value for Kuta Alam District, Banda Aceh City, in 2021 is Baiturrahman District, with a value of 190,617,812,346. The sub-district with the weakest interaction value with Kuta Alam Sub-district in 2021 is Jaya Baru Sub-district with a value of 22,196,280,976.

Table 8. Result of Gravity for Kutaraja District, Banda Aceh City, 2004, 2005 and 2021

Subdistrict	Distance (dij) / Km	Distance ² (dij) ² / Km	2004	
			Total Population (Pi) / Life	Interaction
Meuraxa	4,6	21,16	34.592	35.363.617,391
Jaya Baru	7,6	57,76	21.305	7.979.047,091
Banda Raya	6,6	43,56	23.995	11.915.974,288
Baiturrahman	2,8	7,84	37.715	104.062.612,245
Lueng Bata	5,2	27,04	19.232	15.385.600,000
Kuta Alam	2,6	6,76	54.718	175.097.600,000
Kuta Raja			21.632	
Syiah Kuala	6,8	46,24	32.590	15.246.256,055
Ulee Kareng	7,2	51,84	19.319	8.061.508,642

Table 8. Result of Gravity for Kutaraja District, Banda Aceh City, 2004, 2005 and 2021 (Cont'd)

Subdistrict	2005		2021	
	Total Population (Pi) / Life	Interaction	Total Population (Pi) / Life	Interaction
Meuraxa	2.221	312.577,410	27.273	19.997.192,580
Jaya Baru	12.340	636.227,839	26.273	7.057.229,830
Banda Raya	24.257	1.658.341,276	25.615	9.123.432,622
Baiturrahman	33.582	12.756.019,898	32.629	64.571.292,730
Lueng Bata	19.284	2.123.807,396	24.360	13.977.270,710
Kuta Alam	35.033	15.433.176,627	42.588	97.744.500,000
Kuta Raja	2.978		15.515	
Syiah Kuala	25.418	1.636.998,356	33.100	11.106.109,429
Ulee Kareng	22.768	1.307.930,247	27.676	8.283.046,682

Table 8 shows the gravity calculation for each sub-district for Kuta Raja District in Banda Aceh City in 2004, which had the strongest interaction value, Kuta Alam District, with a value of 175,097,600,000. The calculation results show that the sub-district with the weakest interaction value with Kuta Raja Sub-district in 2004 was Jaya Baru Sub-district, with a value of 7,979,047,091. In 2005, the one with the strongest interaction value for Kutaraja District, Banda Aceh City, was Kuta Alam District, with a value of 15,433,176,627. The sub-district with the weakest interaction value with Kuta Alam Subdistrict in 2005 was Meuraxa Subdistrict, with a value of 312,577,410. The calculation results also show that the strongest interaction value for Kutaraja District, Banda Aceh City, in 2021 is Kuta Alam District, with a value of 97,744,500,000. The sub-district with the weakest interaction value with the Kuta Raja Sub-district in 2021 is Jaya Baru Sub-district, with a value of 7,057,229,830.

Table 9. Result of Gravity for Syiah Kuala District, Banda Aceh City, 2004, 2005 and 2021

Subdistrict	Distance (dij) / Km	Distance ² (dij) ² / Km	2004	
			Total Population (Pi) / Life	Interaction
Meuraxa	10,8	116,6	34.592	9.665.237,311
Jaya Baru	11,7	136,9	21.305	5.072.174,374
Banda Raya	10,8	116,6	23.995	6.704.364,283
Baiturrahman	7,3	53,29	37.715	23.064.962,470
Lueng Bata	7,7	59,29	19.232	10.571.274,751
Kuta Alam	5,6	31,36	54.718	56.864.146,046
Kuta Raja	6,8	46,24	21.632	15.246.256,055
Syiah Kuala			32.590	
Ulee Kareng	5,8	33,64	19.319	18.715.999,108

Table 9. Result of Gravity for Syiah Kuala District, Banda Aceh City, 2004, 2005 and 2021 (Cont'd)

Subdistrict	2005		2021	
	Total Population (Pi) / Life	Interaction	Total Population (Pi) / Life	Interaction
Meuraxa	2.221	483.996,725	27.273	7.739.508,745
Jaya Baru	12.340	2.291.315,070	26.273	6.352.811,016
Banda Raya	24.257	5.286.046,176	25.615	7.269.002,915
Baiturrahman	33.582	16.017.775,868	32.629	20.266.839,932
Lueng Bata	19.284	8.267.173,419	24.360	13.599.527,745
Kuta Alam	35.033	28.395.050,829	42.588	44.950.982,143
Kuta Raja	2.978	1.636.998,356	15.515	11.106.109,429
Syiah Kuala	25.418		33.100	
Ulee Kareng	22.768	17.203.240,904	27.676	27.231.736,029

Table 9 captures the gravity calculation for each sub-district for Syiah Kuala District in Banda Aceh City in 2004, which had the strongest interaction value, Kuta Alam District, with a value of 56,864,146,046. The calculation results show that the sub-district with the weakest interaction value with Syiah Kuala Sub-district in 2004 was Jaya Baru Sub-district, with a value of 5,072,174,374. In 2005, the one with the strongest interaction value for the Syiah Kuala District of Banda Aceh City was Kuta Alam District, with a value of 28,395,050,829. The sub-district with the weakest interaction value with Kuta Alam Subdistrict in 2005 was Meuraxa Subdistrict, with a value of 483,996,725. The calculation results also show that the strongest interaction value for Syiah Kuala District, Banda Aceh City, in 2021 is Kuta Alam District, with a value of 44,950,982,143. The sub-district with the weakest interaction value with Syiah Kuala Sub-district in 2021 is Jaya Baru Sub-district, with a value of 6,352,811,016.

Table 10. Result of Gravity for Ulee Kareng District, Banda Aceh City, 2004, 2005 and 2021

Subdistrict	Distance (dij) / Km	Distance ² (dij) ² / Km	2004	
			Total Population (Pi) / Life	Interaction
Meuraxa	10,3	106,1	34.592	6.299.206,787
Jaya Baru	11,1	123,2	21.305	3.340.567,283
Banda Raya	7,1	50,41	23.995	9.195.782,682
Baiturrahman	6,6	43,56	37.715	16.726.723,714
Lueng Bata	3,6	12,96	19.232	28.668.441,975
Kuta Alam	5,4	29,16	54.718	36.251.613,237
Kuta Raja	7,2	51,84	21.632	8.061.508,642
Syiah Kuala	5,8	33,64	32.590	18.715.999,108
Ulee Kareng			19.319	

Table 10. Result of Gravity for Ulee Kareng District, Banda Aceh City, 2004, 2005 and 2021 (Cont'd)

Subdistrict	2005		2021	
	Total Population (Pi) / Life	Interaction	Total Population (Pi) / Life	Interaction
Meuraxa	2.221	476.649,335	27.273	7.114.785,069
Jaya Baru	12.340	2.280.311,014	26.273	5.901.562,763
Banda Raya	24.257	10.955.829,716	25.615	14.063.097,401
Baiturrahman	33.582	17.552.685,399	32.629	20.730.950,505
Lueng Bata	19.284	33.877.940,741	24.360	52.020.629,630
Kuta Alam	35.033	27.353.612,620	42.588	40.420.627,160
Kuta Raja	2.978	1.307.930,247	15.515	8.283.046,682
Syiah Kuala	25.418	17.203.240,904	33.100	27.231.736,029
Ulee Kareng	22.768		27.676	

Table 10 indicates that the gravity calculation for each sub-district for Ulee Kareng District in Banda Aceh City in 2004, which had the strongest interaction value, was Kuta Alam District, with a value of 36,251,613.237. The calculation results show that the sub-district with the weakest interaction value with Ulee Kareng Sub-district in 2004 was Jaya Baru Sub-district, with a value of 3,340,567,283. In 2005, the one with the strongest interaction value for Ulee Kareng District, Banda Aceh City, was Lueng Bata District, with a value of 33,877,940,741. The subdistrict with the weakest interaction value with Ulee Kareng Subdistrict in 2005 was Meuraxa Subdistrict, with a value of 476,649.335. The calculation results also show that the strongest interaction value for Ulee Kareng District, Banda Aceh City, in 2021 is Lueng Bata District, with a value of 52,020,629,630. The sub-district with the weakest interaction value with Ulee Kareng Sub-district in 2021 is Jaya Baru Sub-district, with a value of 5,901,562,763.

The gravity calculations show changes in the areas of strongest interaction in each sub-district in Banda Aceh City before and after the Tsunami. Based on the gravity analysis model calculations previously described, the area of strongest interaction will be the center of growth (growth pole) in Banda Aceh City. Below is presented regional recapitulation data with the strongest interaction values from each sub-district in Banda Aceh City in 2004, 2005, and 2021, before and after the Tsunami occurred in Banda Aceh City in Table 11.

Table 11. Recapitulation of the Strongest Interaction Areas in Districts in Banda Aceh City in 2004, 2005 and 2021

Time	Gravity Strongest Area		Weakest Area	
	Interaction	Subdistrict	Interaction	Subdistrict
2004 (before Tsunami)	283.084.961,591	Kuta Alam District → Baiturrahman District	3.340.567,283	Ulee Kareng District → Jaya Baru District

2005 (after Tsunami)	161.382.469,959	Kuta Alam District → Baiturrahman District	312.577,410	Kuta District Raja → Meuraxa District
2021 (Currently)	190.617.812,346	Kuta Alam District → Baiturrahman District	5.901.562,763	Ulee Kareng District → Jaya Baru District

Table 11 explains the recapitulation of all gravity calculations for each sub-district in Banda Aceh City by obtaining the strongest and weakest interaction values to make these areas the strongest and weakest interaction areas. The strongest interaction area was the same in 2004 (before the Tsunami), 2005 (after/post-tsunami), and 2021 (currently), namely the interaction between Kuta Alam District and Baiturrahman District with respective interaction values of 283,084,961,591, 161,382,469,959 and 190,617,812,346. It can be seen from this value that there was a decrease in the interaction value between 2004 and 2005. It was due to the tsunami disaster in Banda Aceh City, which reduced the population in the Banda Aceh City sub-district, so this affected the interaction value obtained. Meanwhile, the weakest interaction areas were the same in 2004 (before the Tsunami) and 2021 (currently) in Ulee Kareng District and Jaya Baru District, with interaction values of 3,340,567,283 and 5,901,562,763. It is due to the geographical location factor, with a distance of 11.1 km, which is quite far between the two sub-districts. However, in 2005 (after/after the Tsunami), the weakest interaction area was in Kuta Raja District and Meuraxa District, with an interaction value of 312,577,410. This value is less when compared to the interaction value obtained in 2004 and 2021, looking at the geographical location factor with a distance of 4.6 km, which is not too far away like the sub-district which is an area of weak interaction in 2004 and 2021, this is because Kuta District Raja and Meuraxa sub-districts were sub-districts that were more heavily affected by the Tsunami than other sub-districts in Banda Aceh City, which caused a significant population reduction.

4. Conclusions

The gravity analysis model produces the results of the interaction area with the strongest interaction value as the center of growth (growth pole) in Banda Aceh City before and after the Tsunami. The strongest area of interaction in 2004 (before the Tsunami), 2005 (after Tsunami), and 2021 (currently) was the interaction between Kuta Alam District and Baiturrahman District, with the interaction value for each year being 283,084,961,591, 161,382,469,959 and 190,617,812,346. The gravity analysis model also obtained results for interaction areas with the weakest interaction values between sub-districts in Banda Aceh City, seen before and after the Tsunami. The weakest interaction area was found to be the same in 2004 (before the Tsunami) and 2021 (currently) in Ulee Kareng District and Jaya Baru District, with interaction values of 3,340,567.283 and 5,901,562.763. Meanwhile, in 2005 (after Tsunami), the weakest interaction area was in Kuta Raja District against Meuraxa District with an interaction value of 312,577,410. This is because Kuta Raja District and Meuraxa District were more heavily affected by the Tsunami than other districts in Banda Aceh City, Indonesia.

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