

# Regional Development Inequality Classification

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**ABSTRACT:** *Development inequality is a situation in which there are differences in development achievements between one region and another. There are many approaches to measure and to classify development inequality, but there is no focus on measuring inequality based on distance between data of development achievement, such as using data of Gross Regional Domestic Product (GRDP). This research aims to classify regional development inequality based on distance between data of development achievement using Fuzzy-Klassen approach. Analysis data sample is GRDP of West Java in 2015 and 2016. The result of this research shows that there are 89% of regencies/cities included in rapid-developing category (K1), 7% are in the category of developed but depressed (K2), while 4% of them are in the category of underdeveloped regions (K4).*

**Keywords:** Development Inequality, GRDP, Classification of Development Inequality, Distance Between Data of Development Achievement, Fuzzy-klassen

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## 1. Introduction

Development disparities becomes a global issue that happens everywhere around the world as in Romania [1], China [2], Slovakia [3] and India [4]. It occurs due to the uneven development process in various regions, causing massive urbanization from least-developed area to other developed area. It happens not only in countries around the world, but also in Indonesia as in [5], [6], [7], and [8].

Development disparities is basically can be identified based on the available data of development. Some approaches that can be applied are Location Quotient (LQ), Growth Ratio Model (GRM), Elasticity Employment, and Typology Klassen [9], [10], [11]. Besides conventional approaches, computation approaches are currently used to examine the development inequality such as classification of development using decision tree C4.5, CHAID, CART and Kassen Typology [12], as well as data classification of regional development using the combination of Klassen and Naïve Bayes method [13].

Some previous researches mostly use LQ, Klassen, GRM, and soon to measure and to classify development inequality. However,

the only method used is to measure statistics by comparing development achievement and other development achievement. In the previous research conducted by [14], measurement and classification of development inequality are actually possible to be conducted based on the distance between data of development achievement of an area and another area, which is using Fuzzy-Klassen approach that combines Klassen typology and Fuzzy logic theory. This concept tries to calculate fuzzy value of GRDP data of an area, and then, the rate of growth as well as its contribution will be valued through defuzzification stage. After that, classification step is carried out based on Klassen typology rules.

In this research, Fuzzy-Klassen is used to categorize regional development inequality, especially in West Java. Fuzzy-Klassen has more strengths than other approaches. It is able to handle development data containing fuzzy value. The calculation of the rate of growth value and contribution of the development using FK is carried out based on the possibility of a development value that is included in more than one domain. FK is a combination of Fuzzy Logic concept and Klassen typology, in which the final classification of development inequality is based on Klassen rules.

This paper is divided into five parts. The first part contains theoretical review, while the second one is about literary review related to the theory. The third part discusses about research methodology, the fourth part is discussion and result, while the last part is conclusion.

## 2. Literature Review

### 2.1. Gross Regional Domestic Product

Gross Regional Domestic Product (GRDP) is the economic output value of an area in accordance with the economic activities it performs (both Province and District/City) during certain periods of time, including Agriculture, Mining and Excavation, Processing Industry, Electricity, Gas and Clean Water, Buildings, Trade, Hotels and Restaurants, Transportation and Communication, Finance, Rental and Company Services, and other services. The amount of gross added value is the amount produced by all business units in a certain area or the value of the final number of goods and services produced by all units of economic activity [15].

### 2.2. Model Fuzzy-Klassen

Fuzzy-Klassen is a combination of Fuzzy System and Klassen Typology [14]. Fuzzy Mandani is the basic concept to develop Fuzzy-Klassen. The rule used is an extraction result of classifying the existing data of regional development inequality using decision tree technique or comparing the current year's GRDP to the comparison year. This rule is then used for evaluation step on Fuzzy-Klassen. The steps are as follow:

#### 2.2.1. Fuzzyfication

In this process, the data is the result of development of GRDP that is used to search for the value of Growth Rate (RD) and Contribution Value (RC) of Cities/Regencies and Province. The set of RC and RD is divided into two, which are Low and High, as presented in Figure 1. Value  $a$  and  $b$  are interval values of GRDP domain of a region, and  $x$  is GRDP value of which RC are RD will be calculated.

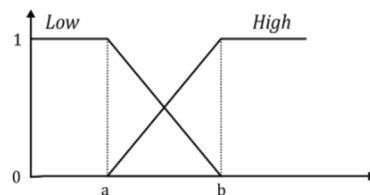


Figure 1. Linear Representation of Low and High Sets

Based on Figure 1, membership function for Low Set is obtained as in equation (1).

$$\mu_{Low} = \begin{cases} 1 & x \leq a \\ \frac{b-x}{b-a} & a < x < b \\ 0 & x \geq b \end{cases} \quad (1)$$

Meanwhile, membership function for High Set is obtained as in equation (2).

$$\mu_{High} = \begin{cases} 1 & x \geq b \\ \frac{x-a}{b-a} & a < x < b \\ 0 & x \leq a \end{cases} \quad (2)$$

### 2.2.2. Rule Evaluation / Implication Function

As stated previously, the rules used in this step are: first, extraction result of classification data of development; second, using the standard rules obtained by comparing the current year's GRDP data to the comparison year. The rule or standard rules are shown in equation (3).

$$\text{IF } V_i(n) = V_{if(n)} \text{ AND } V_i(n-1) = V_{if}(n-1)$$

$$\text{THEN } RDe(V_i) = RDV_{if} \text{ ALSO } RCe(V_i) = RCV_{if} \quad (3)$$

Where  $V$  shows the Regional GRDP,  $i$  is the area  $I$ ,  $n$  shows the year of GRDP data,  $f$  is the value of the membership degree,  $RCe$  is the contribution value of the evaluation of the rule, while  $RDe$  is the value of the growth rate of the rule evaluation results.

### 2.2.3. Rule Composition

At this stage, fuzzy set solutions are obtained by using the OR operator or taking the maximum value of the rule. The equation is shown in equation (4).

$$\begin{aligned} \mu RDk &= \max(\mu_{sf}(xi), \mu_{kf}(xi)) \\ \mu RCk &= \max(\mu_{sf}(xi), \mu_{kf}(xi)) \end{aligned} \quad (4)$$

Where  $\mu RDk$  is the  $RD$  composition value and  $\mu RCk$  is the  $RC$  composition value. Then find the  $z$  value using equations (5) and (6).

$$z\mu Low = [b - z = (b - a) * x] \quad (5)$$

$$z\mu High = [z - a = (b - a) * x] \quad (6)$$

Where  $a$  is the minimum set value,  $b$  is the maximum set value, and  $x$  is the value of the composition rule.

### 2.2.4. Defuzzification

The method used at this stage is the Centroid Method (Composite Moment). The crisp solution is obtained by taking the center point ( $z^*$ ) of the fuzzy region [17]. In general, the formula is shown in equation (7).

$$z^* = \frac{\int_z z\mu(z)dz}{\int_z \mu(z)dz} \quad (7)$$

### 2.2.5. Klassen Typology Rules

After then,  $RD$  and  $RC$  values that have been defuzzified are processed using Klassen Typology. Klassen Typology classifies the level of development into four main quadrants [10] as shown in Table 1.

<b>Quadrant I</b> Advanced and rapidly growing regions (Developed Region) $r_i \geq r$ and $y_i \geq y$	<b>Kuadran III</b> Developing Regions $r_i \geq r$ dan $y_i < y$
<b>Quadrant II</b> Grow but depressed regions (Stagnant Region) $r_i < r$ dan $y_i \geq y$	<b>Kuadran IV</b> Underdeveloped reltivity Regions $r_i < r$ dan $y_i < y$

Table 1. Quadrant of Development of Klassen Typology

Where  $r_i$  is the growth rate of GRPD of the first Regency or City,  $r$  is the province's GRDP growth rate,  $Y_i$  is the value of the contribution of GRDP of the  $i$  Regency or City and  $Y$  is the contribution of the Provincial GRDP.

### 3. Research Methodology

The research is begun by collecting data from [15] to obtain GRDP value, Growth Rate, and Contribution Value of City/Regency in West Java. The data is processed using Fuzzy system to obtain fuzzy RD and RC output values. After then, the data is processed using Klassen Typology to classify regional development quadrants. The stages are shown in Figure 2.

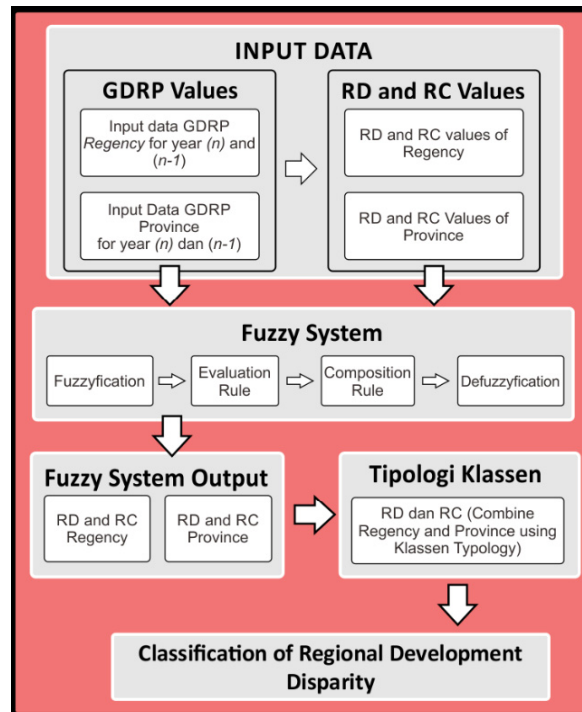


Figure 2. Research Methodology

### 4. Result and Discussion

Data used as example are GRDP Data of 2015 and 2016, RD and RC Value of Kabupaten Bandung.

#### 4.1. Fuzzyfication

Search for Membership Values of Bandung using equation (1) and (2). The steps are:

- Membership Functions of GRDP of Kabupaten Bandung in 2015 and 2016:

$$\mu_{Low}[2015] = \begin{cases} 1 & x \leq 2.624 \\ \frac{2.624 - x}{203,3} & 2.624 < x < 205,9 \\ 0 & x \geq 205,9 \end{cases} \quad (8)$$

$$Kab.BDG[2015] = 64.7$$

$$\mu_{Low\_Kab.BDG}[2015] = \frac{2.624 - 64.7}{203.3} = 0.69 \quad (9)$$

$$\mu_{High}[2015] = \begin{cases} 0 & x \leq 2.624 \\ \frac{x - 2.624}{203.3} & 2.624 < x < 205.9 \\ 1 & x \geq 205.9 \end{cases} \quad (10)$$

$$Kab.BDG[2015] = 64.7$$

$$\mu_{High\_Kab.BDG}[2015] = \frac{64.7 - 2.624}{203.3} = 0.31 \quad (11)$$

$$\mu_{Low}[2016] = \begin{cases} 1 & x \leq 2.778 \\ \frac{2.159 - x}{213.2} & 2.778 < x < 215.9 \\ 0 & x \geq 215.9 \end{cases} \quad (12)$$

$$Kab.BDG[2016] = 68.79$$

$$\mu_{Low\_Kab.BDG}[2016] = \frac{2.15.9 - 68.79}{213.2} = 0.69 \quad (13)$$

$$\mu_{High}[2016] = \begin{cases} 0 & x \leq 2.778 \\ \frac{x - 2.778}{213.2} & 2.778 < x < 215.9 \\ 1 & x \geq 215.9 \end{cases} \quad (14)$$

$$Kab.BDG[2016] = 68.7$$

$$\mu_{High\_Kab.BDG}[2016] = \frac{64.7 - 2.778}{213.2} = 0.31 \quad (15)$$

• Membership Functions of *RD* Variable of Kabupaten Bandung:

$$\mu_{Low}[RDKab] = \begin{cases} 1 & x \leq 0.08 \\ \frac{7.79 - x}{7.71} & 0.08 < x < 7.79 \\ 0 & x \geq 7.79 \end{cases} \quad (16)$$

$$RD[Kab.BDG] = 6.33$$

$$\mu_{Low\_RDf}[Kab.BDG] = \frac{7.79 - 6.33}{7.71} = 0.19 \quad (17)$$

$$\mu_{High}[RDKab] = \begin{cases} 0 & x \leq 0.08 \\ \frac{x - 0.08}{7.71} & 0.08 < x < 7.79 \\ 1 & x \geq 7.79 \end{cases} \quad (18)$$

$$RD[Kab.BDG] = 6.33$$

$$\mu_{High\_RDf}[Kab.BDG] = \frac{7.79 - 6.33}{7.71} = 0.81 \quad (19)$$

• Membership Functions of RC Variable of Kabupaten Bandung:

$$\mu_{Low}[RCKab] = \begin{cases} 1 & x \leq 0.22 \\ \frac{12.52 - x}{12.30} & 0.22 < x < 12.52 \\ 0 & x \geq 12.52 \end{cases} \quad (20)$$

$$RC[Kab.BDG] = 5.38$$

$$\mu_{Low\_RCf}[Kab.BDG] = \frac{12.52 - 5.38}{12.30} = 0,58 \quad (21)$$

$$\mu_{High}[RCKab] = \begin{cases} 0 & x \leq 0.22 \\ \frac{x - 0.22}{12.30} & 0.22 < x < 12.52 \\ 1 & x \geq 12.52 \end{cases} \quad (22)$$

$$RC[Kab.BDG] = 5.38$$

$$\mu_{High\_RCf}[Kab.BDG] = \frac{5.38 - 0.22}{12.30} = 0,42 \quad (23)$$

#### 4.2. Evaluation Rules

Implication function of this study uses the rule in equation (4) which is modified from the previous research [14], namely:

$$\begin{aligned} [R1]. \text{ IF } V_i(n) = \text{Low AND } V_i(n-1) = \text{Low THEN} \\ RDe[1] = RDe(V_i)_{Low} \text{ ALSO } RCe[1] = RCe(V_i)_{Low} \end{aligned} \quad (24)$$

$$\begin{aligned} [R2]. \text{ IF } V_i(n) = \text{Low AND } V_i(n-1) = \text{High THEN } RD[2] \\ = RDe(V_i)_{Low} \text{ ALSO } RCf[2] = RCf(V_i)_{Low} \end{aligned} \quad (25)$$

$$\begin{aligned} [R3]. \text{ IF } V_i(n) = \text{High AND } V_i(n-1) = \text{Low THEN } RD[3] \\ = RDe(V_i)_{Low} \text{ ALSO } RCf[3] = RCf(V_i)_{High} \end{aligned} \quad (26)$$

$$\begin{aligned} [R4]. \text{ IF } V_i(n) = \text{High AND } V_i(n-1) = \text{High THEN} \\ RDe[4] = RDe(V_i)_{High} \text{ AND } RCf[4] = RCf(V_i)_{High} \end{aligned} \quad (27)$$

Variable Evaluation of Kabupaten Bandung using the rules such as equations (24), (25), (26) and (27):

#### • R1] Kab.Bandung :

$$\begin{aligned} \text{IF } Kab.BDG(2016) = 0,69 \text{ AND } Kab.Bdg(2015) 0,69 \\ \text{THEN } RDe[1] = 0,19 \text{ ALSO } RCe[1] = 0,58 \end{aligned} \quad (28)$$

#### Obtainedh :

$$\begin{aligned} RDe[1] = \max[\min((0,69 \cdot 0,69), 0,19), 1 - (0,69 \cdot 0,69)] \\ = \max[0,19, 0,52] \end{aligned} \quad (29)$$

$$RDe[1] = 0,52$$

Dan

$$\begin{aligned} RCe[1] = \max[\min((0,69 \cdot 0,69), 0,58), 1 - (0,69 \cdot 0,69)] = \max[0,47, 0,52] \\ = \max[0,19, 0,52] \end{aligned} \quad (30)$$

• **[R2] Kab.Bandung :**  
 IF Kab.BDG(2016) = **0,69** AND Kab.Bdg(2015) = **0,31** THEN RDe[2] = **0,19** ALSO RCe[2] = **0,58** (31)

**Obtainedh :**  
 $RDe[2] = \max[\min((0,69 \cdot 0,31), 0,19), 1 - (0,69 \cdot 0,31)] = \max[0,19, 0,789]$  (32)

RDe[2] = 0,789

Dan

$RCe[2] = \max[\min((0,69 \cdot 0,31), 0,58), 1 - (0,69 \cdot 0,31)] = \max[0,21, 0,789]$  (33)

RCe[2] = 0,789

• **[R3] Kab.Bandung :**  
 IF *Kab.BDG*(2016) = 0,31 AND *Kab.Bdg*(2015) = 0,69  
 THEN RDe[3] = 0,19 ALSO RCe[3] = 0,42 (34)

**Obtainedh :**  
 $RDe[3] = \max[\min((0,31 \cdot 0,69), 0,19), 1 - (0,31 \cdot 0,69)] = \max[0,19, 0,785]$  (35)

RDe[3] = 0,785

Dan

$RCe[3] = \max[\min((0,31 \cdot 0,69), 0,42), 1 - (0,31 \cdot 0,69)] = \max[0,21, 0,785]$  (36)

RCe[3] = 0,785

• **[R4] Kab.Bandung :**  
 IF Kab.BDG(2016) = 0,31 AND Kab.Bdg(2015) = 0,31  
 THEN RDe[4] = 0,81 ALSO RCe[4] = 0,42 (37)

**Obtainedh :**  
 $RDe[4] = \max[\min((0,31 \cdot 0,31), 0,81), 1 - (0,31 \cdot 0,31)] = \max[0,096, 0,905]$  (38)

RDe[4] = 0,905

Dan

$RCe[4] = \max[\min((0,31 \cdot 0,31), 0,42), 1 - (0,31 \cdot 0,31)] = \max[0,096, 0,905]$  (39)

RCe[4] = 0,905

### 4.3. Composition Rule

After then, the composition of the evaluation results of RD and RC of Bandung uses equation (4).

$z\mu_{Low\_RDk}(Kab.BDG)$

$$RD_{k(1)} = \max[ RDe_{[1]}, RDe_{[2]}, RDe_{[3]} ]$$

$$RD_{k(1)} = \max[ 0,520, 0,789, 0,785 ]$$

$$RD_{k(1)} = 0,789 \quad (40)$$

$z\mu_{High\_RDk}(Kab.BDG)$

$$RD_{k(2)} = \max[ RDe[4] ]$$

$$RD_{k(2)} = 0,905 \quad (41)$$

$z\mu_{Low\_RCk}(Kab.BDG)$

$$RC_{k(2)} = \max[ RCe_{[1]}, RCe_{[2]} ] \quad (42)$$

$$\begin{aligned}
RC_{k(2)} &= \max[0.520, 0.789] \\
RC_{k(2)} &= 0.789 \\
z\mu_{High\_RCk}(Kab.BDG) \\
RC_{k(2)} &= \max[RCe_{[3]}, RCe_{[4]}] \\
RC_{k(2)} &= \max[0.785, 0.905] \\
RC_{k(2)} &= 0.905
\end{aligned} \tag{43}$$

Then, find out the values of  $z_1$  and  $z_2$  using equation (5) for  $RD$  and equation (6) for  $RC$ .

•  $z$  value for  $RD$  :

$$\begin{aligned}
b - z_{(1)} &= (b-a) * z\mu_{Low\_RDk} \\
7,79 - z_{(1)} &= 7,71 * 0,789 \\
-z_{(1)} &= 6,083 - 7,79 \\
-z_{(1)} &= -1,70 \\
RDz_{(1)} &= 1,70
\end{aligned} \tag{44}$$

$$\begin{aligned}
z(2) - a &= (b-a) * z\mu_{High\_RDk} \\
z(2) - 0,08 &= 7,71 * 0,905 \\
z(2) &= 6,977 + 0,08 \\
RDz_{(2)} &= 7,06
\end{aligned} \tag{45}$$

•  $z$  value for  $RC$  :

$$\begin{aligned}
b - z_{(1)} &= (b-a) * z\mu_{Low\_RCk} \\
16,99 - z_{(1)} &= 16,78 * 0,79 \\
-z_{(1)} &= 13,256 - 16,99 \\
-z_{(1)} &= -3,75 \\
RCz(1) &= 3,75
\end{aligned} \tag{46}$$

$$\begin{aligned}
z_{(2)} - a &= (b-a) * z\mu_{High\_RCk} \\
z_{(2)} - 0,22 &= 16,78 * 0,91 \\
z_{(2)} &= 15,269 + 0,22 \\
RCz_{(2)} &= 7,41
\end{aligned} \tag{47}$$

#### 4.4. Defuzzification

At this stage, the method used is the centroid method as in equation (7) to obtain Defuzzification value  $RD$  ( $RDdz$ ) and  $RC$  ( $RCdz$ ).  $RDdz\_Kab.Bandung$

$$\begin{aligned}
&= \frac{(RDz(1) * RDk(1)) + (RDz(2) * RDk(2))}{RDk(1) + RDk(2)} \\
&= \frac{(1,70 * 0,79) + (7,06 * 0,91)}{0,79 + 0,91} \cdot \frac{7,76}{1,7} = 4.56
\end{aligned} \tag{48}$$



$$RDdz\_Kab.Bandung = 4,56$$

$RCdz\_Kab.Bandung$

$$= \frac{(RCz(1) * RCk(1)) + (RCz(2) * RCk(2))}{RCk(1) + RCk(2)} \quad (49)$$

$$= \frac{(3,75 * 0,79) + (15,40 * 0,91)}{0,79 + 0,91} = \frac{16,97}{1,7} = 9,98$$

$$RCdz\_Kab.Bandung = 9,98$$

The result of Defuzzification for Bandung obtains an  $RDdz$  value of 4.5 and  $RCdz$  value of 9.98. After then, do the same steps for other districts.

After then, calculate the Provincial  $RD$  and  $RC$  values using the same way at the previous Fuzzy stage, so the  $RDdz$  value of West Java is 2.36 and  $RCdz$  is 5.01.

#### 4.5. Klassen Rules

In this stage, the  $RDdz$  and  $RCdz$  values are compared to the Provincial  $RDdz$  and  $RCdz$  using the Klassen Typology Rules in accordance with the formulation of Table 1 to see the results of the Classification of Development Disparities in West Java as seen in Table 2.

Based on Table 2, Regencies/Cities in West Java are dominated by the Quadrant 1 (K1) category, which is a developed and rapidly growing region. Kabupaten Bekasi and Kota Bandung are in the Quadrant 2 (K2) or can be said as advanced but depressed category, and there is only Kota Tasik included in quadrant 4 (K4), which is a relatively underdeveloped region.

#### 5. Conclusion

Classification disparities in regional development is not This study discusses about the classification of regional development inequality using the Fuzzy-Klassen method. The data used is the annual GRDP data of a region. Annual GRDP data has advantages since it is more general and represents the economic situation in the region. It is due to geographical conditions, cultural conditions of society, and other factors. Therefore, this research is considered to be able to complement the previous research since the reference of this study is based on the total value of regional GRDP. The data used is general and represents the economic situation of the region. Thus, both local and regional governments are expected to prioritize development based on the economic conditions, both in terms of regional conditions and sectoral conditions to minimize jealousy between regions or urbanization as happened in Romania [1].

The results show that there are 89% of regencies/cities included in the category of rapid-developing ( $k1$ ), 7% are in the category of developed but depressed ( $k2$ ), while 4% is in the category of underdeveloped regions. These results are quite different from the Traditional Klassen Typology Method in which there is 3.7% of Regencies/Citie in quadrant ( $k2$ ), 25.9% is in quadrant ( $k4$ ), while 70.4% is included in the Category ( $k3$ ) or region developing. This can be caused by the improper rule. Thus, the future research is expected to use more proper rules to obtain more accurate quadrant output.

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No	Kota/Kabupaten	RD	RC	Classification
1	Kab. Bandung	4,56	9,98	K1
2	Kab. Bandung Barat	4,42	9,68	K1
3	Kab. Bekasi	1,91	8,61	K2
4	Kab. Bogor	2,87	7,61	K1
5	Kab. Ciamis	4,29	9,39	K1
6	Kab. Cianjur	4,42	9,67	K1
7	Kab. Cirebon	4,45	9,74	K1
8	Kab. Garut	4,51	9,86	K1
9	Kab. Indramayu	4,58	10,17	K1
10	Kab. Karawang	2,48	7,36	K1
11	Kab. Kuningan	4,20	9,19	K1
12	Kab. Majalengka	4,27	9,34	K1
13	Kab. Pangandaran	4,03	8,82	K1
14	Kab. Purwakarta	4,56	9,98	K1
15	Kab. Subang	4,40	9,62	K1
16	Kab. Sukabumi	4,56	9,97	K1
17	Kab. Sumedang	4,31	9,44	K1
18	Kab. Tasik	4,33	9,47	K1
19	Kota Bandung	1,94	7,00	K2
20	Kota Banjar	3,93	8,61	K1
21	Kota Bekasi	4,61	10,08	K1
22	Kota Bogor	4,42	9,67	K1
23	Kota Cimahi	4,29	9,40	K1
24	Kota Cirebon	4,20	9,19	K1
25	Kota Depok	4,55	9,96	K1
26	Kota Sukabumi	4,05	8,86	K1
27	Kota Tasik	0,43	0,98	K4
	<b>Jawa Barat Province</b>	<b>2,36</b>	<b>5,01</b>	

Table 2. Result of Classification of Regency / City Development Disparities in West Java

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