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ECONOMIC VULNERABILITY AND EARTHQUAKE HAZARD POTENTIAL ANALYSIS AS THE DEVELOPMENT PLANNING RECOMMENDATION DKI JAKARTA PROVINCE

ANALISIS KERENTANAN EKONOMI DAN POTENSI BAHAYA GEMPABUMI SEBAGAI REKOMENDASI PERENCANAAN PEMBANGUNAN PROVINSI DKI JAKARTA

Ahmad Rowatul Irham[1*], Pandu Adi Mirnarno[1]

[1] Institut Teknologi Bandung, Bandung, Indonesia

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Abstract

Development planning is essential in reducing damage and losses caused by disasters. Development planning in an area can look at the vulnerabilities in the area, from social vulnerability, physical vulnerability, economic vulnerability, and social vulnerability. Disaster mitigation-based development planning is urgently needed in an area to reduce the impact of disasters. However, many regions still have not paid attention to the importance of disaster mitigation in development planning. One type of disaster mitigation-based development planning that can be applied is to build an area or community that is resilient to disasters by taking into account the frequency and impact of disasters, also economic vulnerability due to these disasters, especially in areas around subduction zones that have a depth of fewer than 40 meters (megathrust zone). DKI Jakarta Province is one of Indonesia's provinces, located around the subduction zone. A hazard analysis using the value of peak ground acceleration in bedrock and economic vulnerability will map the impact of risks that will occur due to an upcoming earthquake so that it can be a recommendation for each municipality in determining development plans.

Kata Kunci

Perencanaan Pembangunan; Mitigasi Bencana; Kerentanan Ekonomi.

Abstrak

Perencanaan pembangunan memegang peranan yang penting dalam rangka mengurangi kerusakan dan kerugian yang diakibatkan terjadinya bencana. Perencanaan pembangunan pada sebuah daerah dapat melihat pada kerentanan yang terdapat pada daerah tersebut, baik dari kerentanan sosial, kerentanan fisik, kerentanan ekonomi, dan kerentanan sosial. Perencanaan pembangunan berbasis mitigasi bencana sangat dibutuhkan pada sebuah daerah untuk mengurangi dampak dari bencana, namun demikian masih banyak daerah yang belum memperhatikan pentingnya mitigasi bencana dalam perencanaan pembangunan. Salah satu jenis perencanaan pembangunan berbasis mitigasi bencana yang dapat diterapkan adalah membangun sebuah daerah atau masyarakat yang tangguh terhadap bencana dengan memperhatikan frekuensi dan dampak kebencanaan dan kerentananan ekonomi akibat bencana tersebut,

khususnya di daerah yang berada di sekitar zona subduksi yang memiliki kedalaman kurang dari 40 meter (zona *megathrust*). Provinsi DKI Jakarta adalah salah satu provinsi di Indonesia yang berada di sekitar zona subduksi. Analisis bahaya menggunakan nilai percepatan tanah maksimum dan kerentanan ekonomi akan memetakan dampak risiko yang akan terjadi akibat gempa yang akan datang sehingga dapat menjadi rekomendasi bagi setiap kotamadya dalam menentukan rencana pembangunan.

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***Corresponding Author:**

Ahmad Rowatul Irham
Email: ahmadirham097@gmail.com

INTRODUCTION

Indonesia is a country located in the subduction zone, which has a depth of fewer than 40 meters (the Megahtrust Zone). The location of Indonesia results in frequent natural disasters caused by plate movements. Law No. 24 of 2007 concerning Disaster Management defines a *disaster* as an event or series of events that threatens and disrupts people's lives and livelihoods caused by natural and non-natural factors and human factors, resulting in human casualties, environmental damage, and losses. Property, and psychological impact. One of the natural disasters that often occurs is an earthquake. *Earthquakes* are vibrations that occur on earth. Earthquakes can occur due to volcanic eruptions, meteor falls, avalanches, bomb explosions, and many others, but they generally occur due to movements in the earth's crust along the fault plane (Abott, 2004). PGA is the largest ground vibration acceleration value that has ever occurred in a place caused by an earthquake. For a long time, the maximum ground acceleration value has been used as a parameter to express the strength of an earthquake (Kumala and Wahyudi, 2016).

Planning has an essential role in reducing damage and losses caused by earthquakes. Planning in an area can look at the vulnerabilities contained in the area, from social vulnerability, physical vulnerability, economic vulnerability, and social vulnerability. One type of planning that can be due is development planning, based on (Tjokroamidjojo, 1984); development planning is a directive on the use of development resources (including economic resources) that are limited to achieving specific goals based on the prevailing socio-economic conditions better effectively and efficiently. Disaster mitigation-based

development planning is needed in an area to reduce the impact of disasters due to the lack of development planning that pays attention to disaster mitigation. One type of development planning that can be applied is to build an area and community that is resilient to disasters by looking at the history of disasters and the vulnerabilities in the area. Based on Salami, et al (2017), a community or city is called vulnerable when its characteristics and surroundings make it vulnerable to the damaging effects of risk. One of the vulnerabilities that can describe the condition of an area or region is economic vulnerability. The level of economic vulnerability can describe the inability or level of fragility of the economic sector in the event of a disaster (Widodo and Hizbaron, 2017). DKI Jakarta Province is a province in Indonesia that includes in a province that has a high economic level. However, DKI Jakarta Province is surrounded by an extensive fault system, namely the Semangko Fault and the Cimandiri Fault (Irsyam, 2010). The results of this study are an analysis that could be the recommendation for the government in DKI Jakarta Province to do a development planning

RESEARCH METHODS

Hazard Analysis Based On PGA Value

The hazard analysis in this study refers to the PGA (Peak Ground Acceleration) value of DKI Jakarta Province; this PGA value is obtained by calculating the seismic parameters obtained from the United State Geological Survey earthquake catalog, and the BMKG Earthquake catalog, the earthquake source that used in this research is the source of the earthquake in the period from 1900 to 2020. The earthquake data used in this study amounted to 3665 earthquake events with central coordinates in DKI Jakarta Province. The parameters obtained include earthquake magnitude, the position of the epicenter (hypocenter and epicenter), and depth (Adya et al., 2021).

An additional parameter is needed to get the PGA value in the form of the distance between the earthquake epicenter to the earthquake research point (Adya et al., 2021); where to get the parameter value, can use the following equation (1):

$$D^2 = (x_2 - x_1)^2 + (y_2 - y_1)^2$$

Where :

D = Distance from the earthquake epicenter to the earthquake research point (km)

x_1 = Latitude of the epicenter

x_2 = Latitude of the earthquake research point

y_1 = Longitude of the epicenter

y_2 = Longitude of the earthquake research point

After obtaining the value of the distance between the earthquake epicenter and the earthquake research point, the hypocenter distance of the earthquake can be calculated using the following equation (2):

$$R = \sqrt{D^2 + H^2}$$

R= Distance of earthquake hypocenter (km)

D = distance between the earthquake epicenter and the earthquake research point (km)

H = Depth of earthquake (km)

The parameters that have been obtained from the calculations, as well as those obtained from the earthquake catalog, can then be used to calculate the PGA value. The distribution of PGA values obtained from this study can then be used for hazard analysis in the research area. According to Purwanto (2017), an area that has a high PGA Value will have a greater risk of damage.

Economic Vulnerability Analysis

Economic vulnerability analysis is an analysis of the economic conditions of a community or society that lead to or cause an inability to face the threat of disaster (Perka BNPB No. 02 of 2012) where this economic vulnerability analysis refers to the area of productive land in rupiah and the GDP of the vulnerable sector. Indicators of productive land and GDP are available in secondary data sources in the form of Regency/City documents in published figures from the 2022 Badan Pusat Statistik.

Based on Perka BNPB No. 02 of 2012, the economic vulnerability of a region can be calculated using the following calculation scheme (Table 1):

Table 1. Economic Vulnerability Parameter

Parameter	Weight (%)	Class			Score
		Low	Medium	High	
Productive Land	60	<50 million	50-200 million	>200 million	Class
GDP	40	<100 million	100-300 million	>300 million	

Source : Perka BNPB No.02 Tahun 2012

The analysis of economic vulnerability in this study is divided into two calculations of economic vulnerability parameters; the parameters are as follows:

1. Productive Land

   The productive land parameter is a calculation based on productive land in the research area, based on the Damage and Loss Assessment (DALA) in Peningkatan Kualitas Tata Ruang Untuk Mewujudkan Kota Tangguh Bencana dan Berketahanan Perubahan Iklim Kota Bandung (2016) what is meant by productive land is rice fields, ponds, and plantations. The area of productive land used in this study was obtained from a land use map which was then converted into rupiah so that the value of the land area in rupiah was obtained (Nugraha et al., 2022). The calculation of the conversion of the land area into rupiah can use the equation (3):

$$NRLP = \frac{LKK}{TLP} xPSL$$

   Where:

   NRLP = Productive Land in Rupiah (Rp)

   LKK = The area of Productive Land in Region (Ha)

   TLP = Total area of Productive Land in Province (Ha)

   PSL = GDP's Province in Productive Land Sector (Rp)

2. GDP

   The GDP parameter in this study is GDP at constant prices in each Regency/City in a Province, where the GDP value at this change price can be obtained from the Central Statistics Agency in each Regency/City. GDP is used as a parameter of the economic level of a region or country; this is because the higher the income of a region or country, the more vulnerable the area is to shock, for example, natural disasters (Wiratama, 2021)

So based on Table 1, the equation for calculating the Total Economic Vulnerability is obtained as follows (3) :

Total Economic Vulnerability = (40%*Productive Land) + (60%*GDP)

RESULT AND DISCUSSION

Earthquake Hazard Analysis Based on PGA Value

The hazard analysis of this study was carried out using the calculation of PGA values in DKI Jakarta Province; the distribution of PGA values in DKI Jakarta Province can be seen in Figure 1.

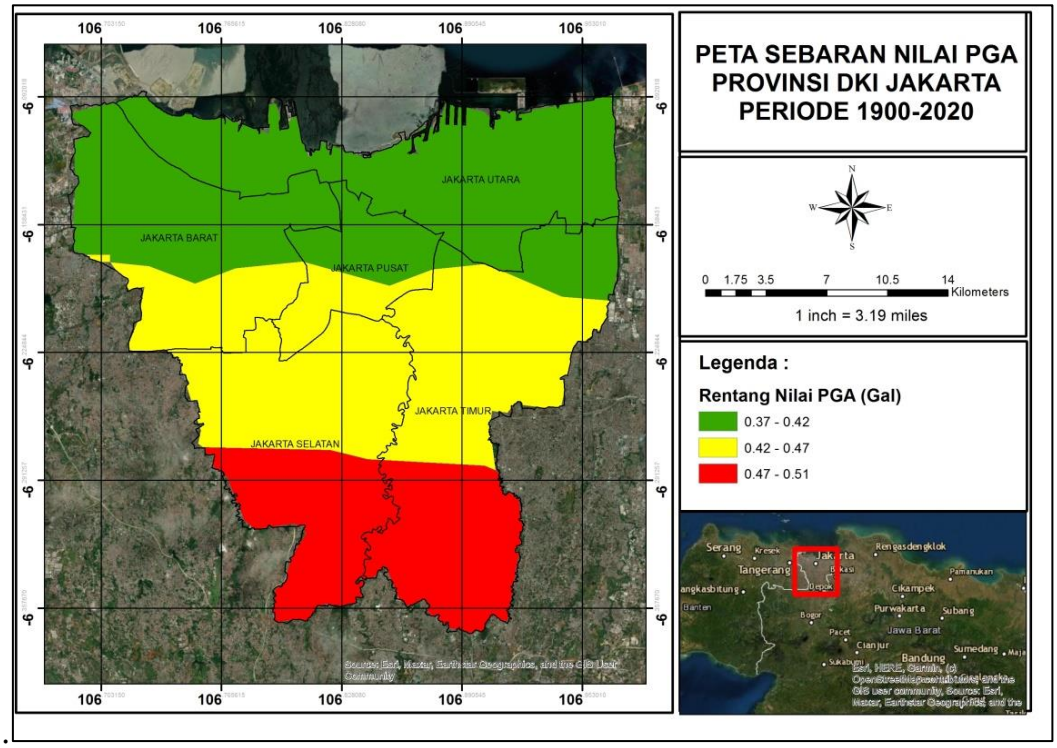

Figure 1. Distribution Map of PGA Value DKI Jakarta Province

The PGA value distribution map shows the maximum soil acceleration distribution value in bedrock; based on the calculation results, the PGA value in DKI Jakarta Province shows that North Jakarta City has a PGA value of 0.37 to 0.42 Gal. West Jakarta City and Central Jakarta City have a PGA value distribution that is in the range of 0.37 to 0.47 Gal. South Jakarta City has a PGA distribution value range of 0.42 – 0.51 Gal, while East Jakarta City has a PGA value distribution in the 0.37 – 0.51 Gal range.

The distribution of PGA values represents the risk that will occur in the research area; the higher the PGA value, the more risky the area or area is to experience damage due to earthquake disasters (Purwanto et al., 2017). In Figure 1, the distribution pattern of PGA values increases towards the South; this distribution pattern is triggered by the presence of DKI Jakarta Province, which is in the northern part of Java Island when seen in Figure 2, the

megathrust zone on Java Island is in the southern part, so this indicates The increase in the PGA value in DKI Jakarta Province towards the South was triggered by the closer the research point to the earthquake source, in this case, the subduction and megathrust zones.

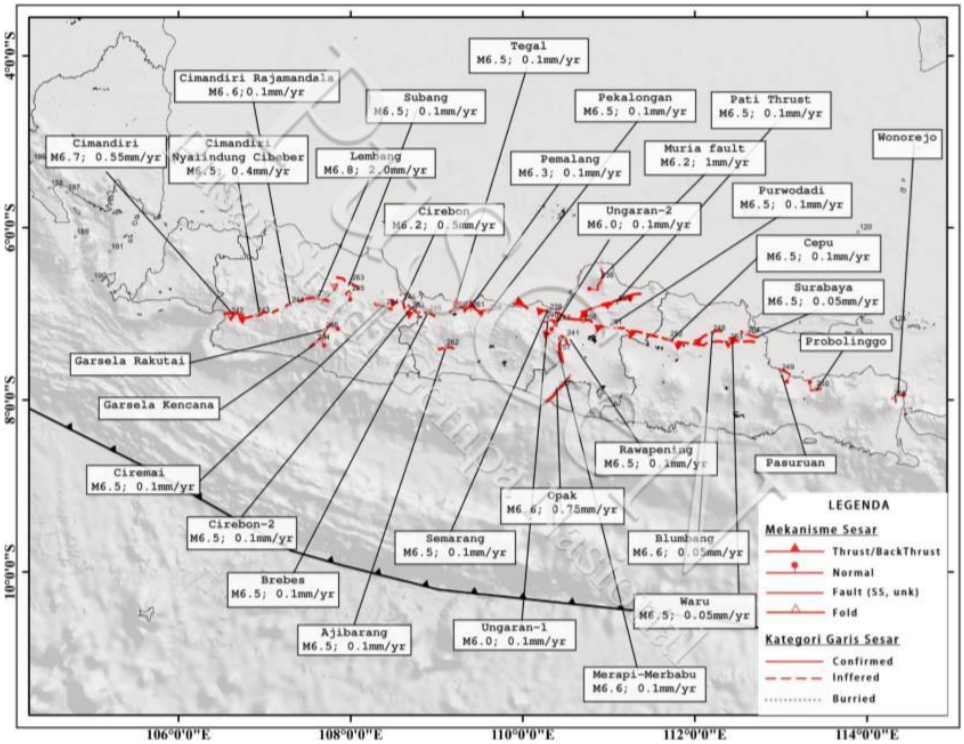

Figure 2. Active Fault Java Island Map

(Source : Tim Pusat Studi Gempa Nasional, 2017)

Economic Vulnerability Analysis

According to Bakornas PB (2007), economic vulnerability is the level of economic fragility of a region facing a disaster threat. Economic vulnerability analysis in the research area is an analysis carried out to map vulnerable areas in an area; this economic vulnerability analysis uses the Gross Domestic Product (GDP) parameters of each city and uses productive land parameters, while the total value of productive land and GDP is obtained from Kota Jakarta Utara Dalam Angka (2021), Kota Jakarta Selatan Dalam Angka (2021), Kota Jakarta Barat Dalam Angka (2021), Kota Jakarta Timur Dalam Angka (2021), and Kota Jakarta Pusat Dalam Angka (2021), the calculation is carried out for getting a score for each parameter that will be the basis for classifying vulnerable areas. The results of the calculation of the level of the economic vulnerability of DKI Jakarta Province are divided into three parts; table 2 shows the calculation of the value of economic vulnerability using the

parameters of the productive land from the agricultural and plantation sectors; table 3 shows the calculation of the value of economic vulnerability using the GDP parameter; table 4 shows the calculation of the value of the Economic Vulnerability Total.

Table 2. Productive Land Parameter Calculation

City	Productive Land (Ha)	Price (Rp)	Productive Land Score	Productive Land Value
North Jakarta	798.092566	Rp 2,002,832,258.29	3	1.80
East Jakarta	136.336807	Rp 342,140,456.74	3	1.80
West Jakarta	5.065962	Rp 12,713,152.01	1	0.60
Central Jakarta	0	Rp -	1	0.60
South Jakarta	11.565594	Rp 29,024,132.96	1	0.60

Source : Analysis Result, 2022

Based on the calculation of Table 2, North Jakarta City has the highest economic vulnerability on productive land parameters, East Jakarta City has the medium economic vulnerability, and those with low economic vulnerability are West Jakarta, Central Jakarta, and South Jakarta; this is due to the land area of the agricultural sector. In North Jakarta, which is high, the score for productive land 1 is low vulnerability, score 2 is moderate vulnerability, and 3 is high vulnerability. The GDP land value is the product of the productive land score multiplied by 60% of the Total Economic Vulnerability Value.

Table 3. PDB Parameter Calculation

City	Price (Rp)	GDP Scoring	GDP Value
North Jakarta	Rp 536,036,559,440.00	3	1.2
East Jakarta	Rp 500,607,661,040.00	3	1.2
West Jakarta	Rp 493,800,863,000.00	3	1.2
Central Jakarta	Rp 728,386,100,770.00	3	1.2
South Jakarta	Rp 668,661,660,010.00	3	1.2

Source : Analysis Result, 2022

Based on the calculation of Table 3, GDP in all region in DKI Jakarta Province has a high level of vulnerability; this is because the Gross Domestic Product (GDP) at changes

prices has a value above Rp. 300,000,000,000 so the GDP value is 1.2 which the product of the GDP scores multiplied by 40% of the Total Economic Vulnerability Value.

Table 4. Total Economic Vulnerability Classification

City	Total Economic Vulnerability Value	Classifying
North Jakarta	3.00	Tinggi
East Jakarta	3.00	Tinggi
West Jakarta	1.80	Sedang
Central Jakarta	1.80	Sedang
South Jakarta	1.80	Sedang

Source : Analysis Result, 2022

Table 4 shows the results of calculating the value of total economic vulnerability and classification of economic vulnerability in each city in DKI Jakarta Province; based on calculations, North Jakarta and East Jakarta have a high economic vulnerability classification, while the cities of West Jakarta, South Jakarta, and Central Jakarta have a classification of economic vulnerability has a medium economic vulnerability classification. The results of the calculation of economic vulnerability are then shown in Figure 3.

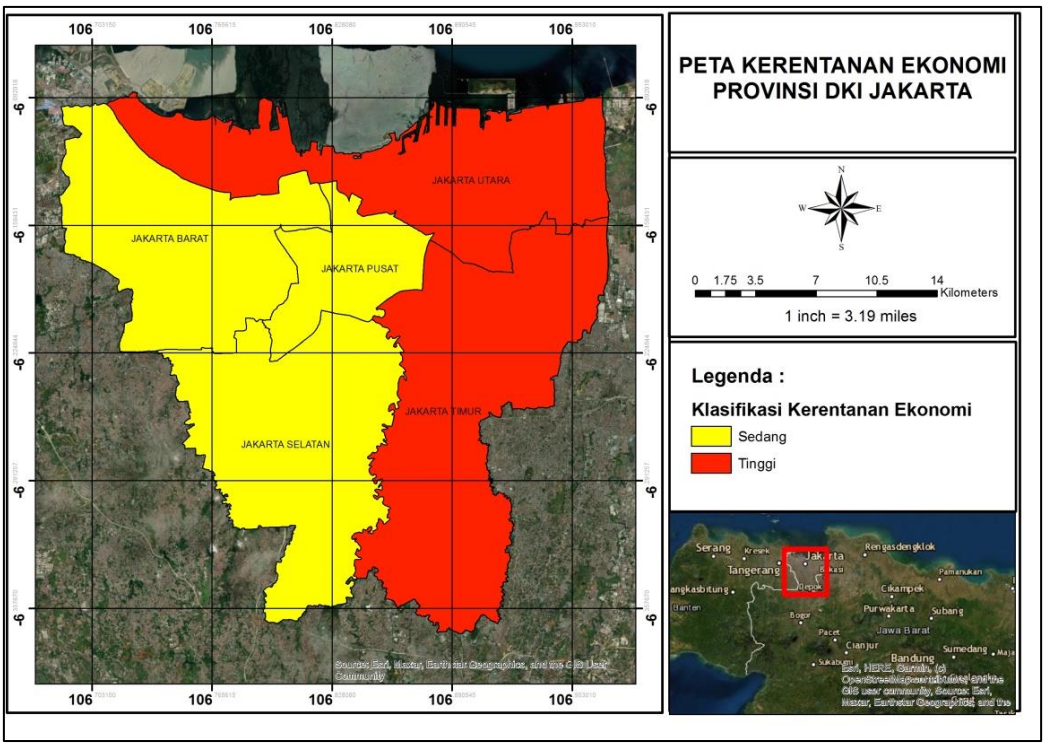

Figure 3. Economic Vulnerability Map of DKI Jakarta

Economic Vulnerability Analysis Based on PGA Value

After obtaining the results of the analysis of economic hazard and vulnerability, it can be analyzed the influence of the distribution of PGA values on economic vulnerability (Figure 4), where this analysis is carried out as the basis for preparing the development planning of DKI Jakarta Province while the results of the overlay are as follows:

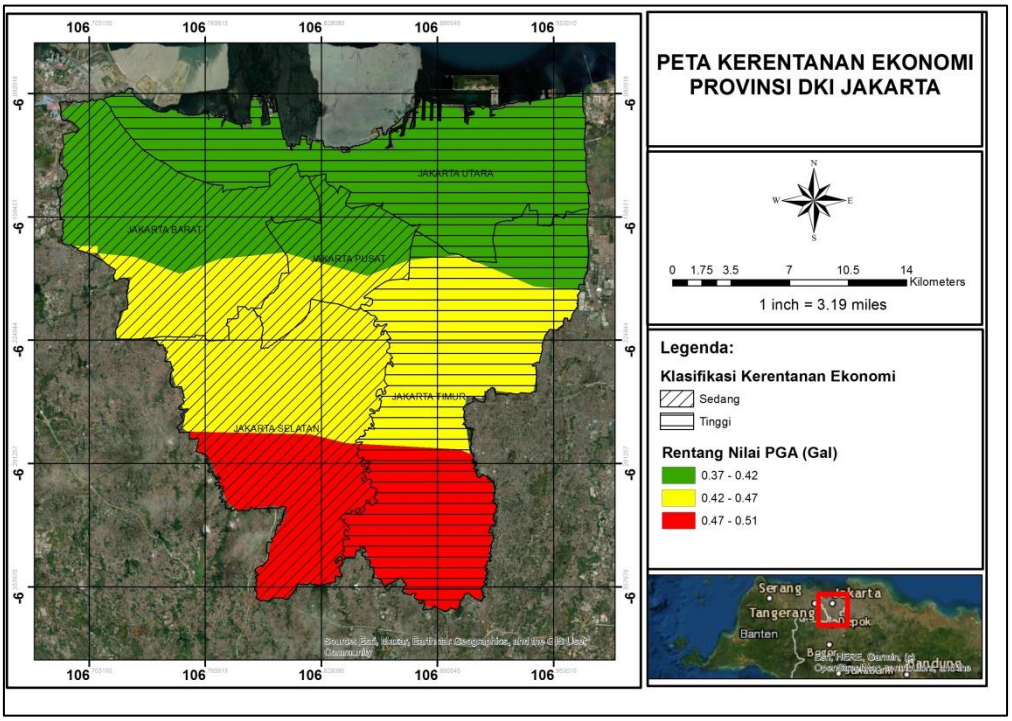

Figure 4. Economic Vulnerability Map overlay PGA Value DKI Jakarta

Analysis of economic vulnerability to the distribution of PGA values can be related to the relationship between vulnerability and hazard. According to Smith (2013), the relationship between these two factors can be divided into four categories:

1. Areas with low hazard levels and low vulnerability are ideal areas
2. Areas with a low level of hazard and high vulnerability are dangerous areas
3. Areas with a high level of danger and low vulnerability are areas that are not dangerous
4. Areas with a high level of danger and high vulnerability are areas that have a high threat.

Based on the categories proposed by Smith, the relationship between economic vulnerability and the distribution of PGA values in DKI Jakarta Province can be analyzed as follows:

1. North Jakarta City has a distribution of PGA values in the range of 0.37 – 0.45 Gal with a high economic vulnerability classification; this greatly affects the level of risk due to an

earthquake that will hit North Jakarta City. The high level of risk in the City of Jakarta is due to the high level of productive land in North Jakarta covering an area of 798 Ha and also the value of GDP 2021, which has a value of Rp 536,036,559,440 so that the City of North Jakarta is categorized as a dangerous area.

2. East Jakarta City has a distribution of PGA values in the range of 0.37 – 0.51 Gal with a high economic vulnerability classification, so most areas in East Jakarta City have a high level of earthquake disaster risk. The distribution of high PGA values caused by the proximity of East Jakarta City to earthquake sources located in the southern part of Java Island and high economic vulnerability factors led to the need for disaster mitigation-based development planning in East Jakarta City in particular because East Jakarta City is categorized as an area with a high threat.
3. The distribution of PGA values in Central Jakarta City is in the range of values of 0.42 – 0.47 Gal; the classification of economic vulnerability in Central Jakarta City is moderate; this is because the area of productive land in Central Jakarta City is the smallest compared to other cities in DKI Province. Jakarta, which is Rp 0, but Central Jakarta City has the largest 2021 GDP value among other cities in DKI Jakarta Province; Central Jakarta City is categorized as an ideal area.
4. The PGA value in West Jakarta City has a distribution in the range of 0.37 – 0.47 Gal with a medium economic vulnerability classification. Moderate economic vulnerability in West Jakarta City is caused by the area of productive land in West Jakarta City, which is only 5 hectares; when compared to other cities, the area of productive land is still relatively low; West Jakarta City is categorized as an ideal area.
5. The PGA value in South Jakarta City has a distribution in the range of 0.42 – 0.51 Gal; this is due to the position of South Jakarta City, which is close to the southern part of Java Island, which is the source of the earthquake felt in DKI Jakarta Province, although the classification of moderate economic vulnerability, the City of South Jakarta needs to carry out development planning based on disaster mitigation, South Jakarta City is categorized as a dangerous area.

CONCLUSION

The regional categories that have been discussed can be used as a reference for urban development planning strategies in the DKI Jakarta Province by considering the risk and hazard analysis of the results of the research analysis.

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