Social Vulnerability and Regional Capacity of The Cilegon City and Serang Regency from Tsunami Hazard

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Abstract. Resilience is the social ability for adaptation, which is determined by the extent to which the social system can learn from past disasters to better protect itself in the future and improve risk reduction measures. Historically, the Cilegon City and Serang Regency experienced several tsunami events with innumerable losses, which may indicate low resiliency. The research locations focused on five districts in the Cilegon City and Serang Regency, there are 30 villages, and the village area is used as a unit of analysis. Quantitative data analysis using scoring and weighting factors measures social vulnerability and regional capacity. A classification scheme was conducted to distinguish social vulnerabilities and capacities among the villages, namely low, moderate, and high. The results show that Citangkil Village has the highest social vulnerability score (0.899), while Mangunreja Village has the lowest (0.054). The Argawana Village achieved the highest score of regional capacity (0.965), and the Samang Raya Village had the lowest (0.540). This study shows that a high level of social vulnerability is directly affected by population density. Meanwhile, a high level of regional capacity is strongly influenced by disaster preparedness, disaster prevention, and mitigation.

1 Introduction

Resilience has been defined by UNISDR (2009) as the ability of a potentially exposed system, community or society to adapt by resisting or changing to achieve and maintain an acceptable level of function and structure to adapt by resisting or changing to achieve and maintain an acceptable level of function and structure. This is determined by the extent to which the social system is able to organise itself to increase its capacity to learn from past disasters in order to better protect itself in the future and to improve risk reduction measures. [1]

Meanwhile, coastal community resilience is defined as the ability of a socio-economic and natural system in a coastal environment to cope with a crisis caused by circumstances such as sea-level rise, extreme events and human impacts, by adapting to the crisis while maintaining its basic function(s) [2].

Indonesia has various potential disaster risks, such as earthquakes, tsunamis, volcanic eruptions, floods, and landslides, as a result of its geographical position, located within three colliding continental plates, the Indo-Australia to the south, Eurasia from the north, and the Pacific from the east. A tsunami has the potential to occur due to earthquakes, volcanic eruptions, extra-terrestrial objects, and or anthropogenic causes [3][4][5]. The tectonic conditions in the Sunda Strait which consist of active subduction and faulting zones have the potential to become a source of earthquakes and trigger frequent tsunamis [6].

Historical data records several tsunami events have occurred in the Sunda Strait, including (a) tsunamis caused by earthquakes (1722, 1852, and 1958); (b) volcanogenic tsunamis (416, 1883, 1928, and 2018), and (c) tsunamis of other unknown causes (1851, 1883, 1889, and 1930) [7], [8]. The biggest disaster that ever occurred in the coastal area of the Sunda Strait in Cilegon City and Serang Regency was the eruption of Mount Krakatau on August 27, 1883, which was a combination of explosions, subsidence, caldera collapse, landslides, and avalanches of the volcano that was under the sea which caused tsunamis as high as 15-40 m [9].

Nearly 45 years after the eruption, in 1927 Anak Krakatau began to appear over the ocean from the remnants of the eruption of Mount Krakatau [10]. A strong earthquake accompanied by a sea level rise occurred in Banten on 22 April 1958 [11]. Then in the last 5 years, a tsunami wave caused by the Anak Krakatau avalanche occurred on December 22, 2018, hitting the coast of the Sunda Strait, namely the Banten and Lampung regions, and causing infrastructure damage and casualties of 437 people. Figure 1 shows the area affected by the most recent Sunda Strait tsunami on 22 December 2018 [12].

Cilegon City and Serang Regency in Banten Province are the main gateways that connect Java Island with Sumatra Island and have important geostrategic values both in local, regional, and national

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constellations. Land use in these two areas is mainly for industrial activities, and a tsunami disaster will greatly impact the industry as well as the region's economy.

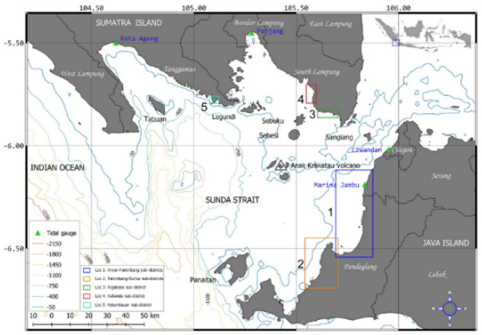

Fig. 1. The Impacted Area of the Latest Sunda Strait Tsunami on December 22, 2018 [12]

Based on the resilience terminology as defined by the UNDRR, to which the social system can organise itself to increase its capacity to learn from past disasters in order to better protect itself in the future and improve risk reduction measures. Therefore, resilience has a significant mechanism for not only reducing disaster risk but also for supporting sustainable development [13]. Considering disasters in the study area have resulted in severe damage, therefore it is necessary to assess the level of social vulnerability and capacity of the area in order to set strategic recommendations.

Social vulnerability is the potential for loss to the human community, accompanied by accompanying conditions such as age, gender, educational background, economic background, or other factors that may place them in a vulnerable state [14]. Meanwhile, capacity is the ability of the region and the community to take action to reduce threats and potential losses due to disasters in a structured, planned, and integrated manner. An assessment of social vulnerability and regional capacity levels will also reveal the extent to which the community is prepared to survive a tsunami disaster [15].

2. Method

2.1 Study Area

The research area is the coastal part of Cilegon City and the northern part of Serang Regency. There are 4 coastal districts in Cilegon City and 1 District in Serang Regency, namely: Ciwandan, Citangkil, Grogol, Pulo Merak, and Pulo Ampel. These five districts were chosen because they are located on the coast directly facing the Sunda Strait which has a high potential for tsunami hazards. A total of 30 villages comprises the study area and a village is used as an analysis unit.

2.2 References Method

The method used as a reference is the General Guidelines for Disaster Risk Assessment [15]. In order to be more relevant to the study area and the availability of datasets, a modification of its parameters and indicators is applied.

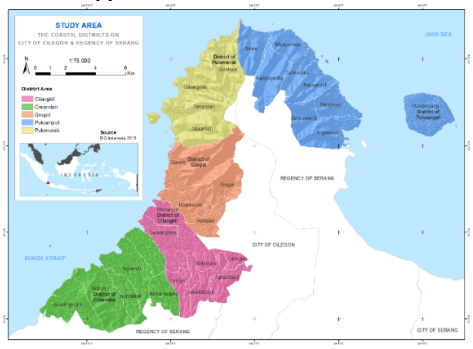

Fig. 2. Five Districts in the City of Cilegon and Serang Regency (Source: BIG, 2019)

2.2.1 Social Vulnerability Assessment

Social vulnerability, the human aspect at the community level, is directly exposed to threats (hazards). It is the main factor that leads to higher disaster risk if it is not supported by capabilities (capacity) [16]. Communities living in disaster-prone areas are said to be vulnerable, where damage and loss will often occur, for example, poverty, children, the elderly, disabilities, etc. These groups are often the least prepared for any emergencies, have the fewest resources to deal with hazards, tend to be at high risk in substandard housing conditions, and lack the knowledge or social-political connections to access resources to accelerate their recovery [17].

The modified social vulnerability assessment uses parameters of the potential population exposed to tsunami disasters and vulnerable groups to determine the class of vulnerability, with a weighting factor of 60% and 40% for each parameter [18]. Vulnerable group indicators consist of the sex ratio (10%), the number of people of vulnerable age (10%), the number of poor people (10%), and the number of people with disabilities (10%).

2.2.2 Regional Capacity Assessment

Capacity is a combination of all the strengths, characteristics and resources of a community, society or organisation that can be used to reduce the impact of disasters in the form of knowledge, skills, social relationships and policies [1]. In addition, capacity is the ability to anticipate, overcome, prevent hazards, and recover from the effects of hazards [19].

The parameters of capacity consists indicators of policy, preparedness, and community participation [15]. Capacity assessment is carried out on regional resources to overcome or withstand the impact of a disaster.

The resilience of an area from a tsunami disaster can be improved through a number of strategies and measures

1. Assessing the threat, vulnerability and risk characteristics of tsunami as the first step to build tsunami disaster resilience [20].

2. Mapping of tsunami vulnerability to support coastal resilience [21].
3. Planting mangroves and other plants along the coastline to reduce tsunami force [22].
4. Knowing the area and making evacuation routes and conducting self-rescue simulations [23], [24].

In addition, Indonesia needs to build a regionally based disaster resilience system to increase community involvement in disaster management from the lowest level. The disasters that have occurred in Indonesia over the past decade can also be specified according to the specific character of a region. This capital can be the basis for disaster prevention in each region [25]–[27].

Building regional capacity is one of the most important efforts to reduce the impact of disasters. The capacity assessment in the study areas using the regional resilience index is measured from 7 parameters and 13 indicators with their weights as shown in Table 2.

2.3 Data Collection

The assessment of social vulnerability and regional capacity level utilizes secondary data from authorized sources, such as the Central Statistics Agency and the Regional Governments, as well as accredited news (government bulletins, news agencies). This study uses statistical data for year 2021 from "Serang Regency in Figures", Cilegon City in Figures and "District in Figures", which consists of the Districts of Ciwandan, Citangkil, Grogol, Pulo Merak, and Pulo Ampel. The Village Potential Data (PODES) and Basemap (RBI) Maps for Cilegon City and Serang District at a scale of 1:25,000 were also used to support this research.

Table 1. Social Vulnerability Parameters and Scoring

Parameters	Indicators	Weight	Social Vulnerability Class		
		%	Low	Moderate	High
Potential Population of Exposed to Tsunami	Population Density	60	$\leq 0{,}336$	$0{,}337 - 0{,}617$	$\geq 0{,}618$
Vulnerable Group	Sex Ratio	10			
	Vulnerable Age Populations	10			
	Number of Poor People	10			
	Number of People with Disabilities	10			

Sources: Modification from [15], [18]

Table 2. **Regional Capacity Parameters and Scoring**

Parameters	Indicators	Weight	Social Vulnerability Class		
		%	Low	Moderate	High
Strengthening Policies and Institutions		**6**	$\leq 0{,}682$	$0{,}683 - 0{,}823$	$\geq 0{,}824$
	a. Availability of DRR Regional Regulation	3			
	b. Availability of Regional Disaster Management Agency (BPBD)	3			
Integrated Risk Assessment and Planning	Availability of Tsunami Risk Map	**6**			
Development of Information Systems, Education and Training and Logistics		**7.5**			
	a. Availability of Pusdalop	2.5			
	b. Availability of Tsunami Drill	2.5			
	c. Number of Disaster Safety Equipment	2.5			
Thematic Handling of Disaster's Prone Areas		**10.5**			
	a. Number of Health Facility	3.5			
	b. Number of Healt Workers	3.5			
	c. Availability of Disaster Resilient Village (DESTANA)	3.5			

Parameters	Indicators	Weight	Social Vulnerability Class		
		%	Low	Moderate	High
Increasing the Effectiveness of Disaster Prevention and Mitigation	Availability of DRR Movement	**21**			
Strengthening Disaster Emergency Preparedness and Handling		**35**			
	a. Number of Tsunami Early Warning System (TEWS)	17.5			
	b. Number of Signs and Evacuation Routes	17.5			
Disaster Recovery System Development	Availability of Disaster Recovery System Development	**14**			

Sources: Modification from [15], [28]

2.4 Data Analysis

Quantitative data analysis with scoring and weighting factors is used to calculate the value of social vulnerability and capacity, with the following processing steps:

1) All secondary data is transformed into tabular and spatial data.
2) Standardize data values for each parameter making up social vulnerability and capacity with a value range of 0 to 1.
3) The min-max normalization method is used to obtain a value of 0 to 1, where: each data value in a parameter is reduced by the minimum data value of that parameter, then divided by the maximum value range or data value minus the minimum data value of that parameter.

$$X_{new} = \frac{X_{old} - X_{min}}{X_{max} - X_{min}} \quad (1)$$

4) The score of each parameter making up social vulnerability and capacity parameters is obtained by calculating the normalized value multiplied by its weight.
5) The score of social vulnerability is obtained from the total score of all parameters making up social vulnerability, while the score of capacity is obtained from the total score of all parameters making up capacity.
6) Determination of the three levels of social vulnerability and the level of capacity to be LOW, MODERATE, and HIGH is calculated by dividing the class interval with the following formula:

$$X_{Interval} = \frac{(X_{max} - X_{min})}{3} \quad (2)$$

3 Result and Discussion

3.1 Potential Population Exposed to Tsunami

The population exposed to disasters is one of the primary data needed in disaster management activities such as disaster risk assessment and preparation of contingency plans. Population characteristics related to the potential number of victims and evacuees are used as a reference in disaster management plans in the event of a disaster and to support decision-making in disaster risk reduction programmes [18]. Table 3 shows the potential population exposed to tsunami disasters.

3.1.1 Population Density

The indicator of population density describes a different level of vulnerability in each village. From Table shows that Citangkil is the village with the highest vulnerability because it has the highest population density of 10,193 people/Km^2. On the other hand, the Gunung Sugih Village in Ciwandan District has the lowest population density of 407 people/km^2. Similar suggestion is proposed by Dwi et al that the highest population density shows the highest social vulnerability level.

Table 3. The Potential of the Population Exposed to the Tsunami

Region / City	District	Village	Population Density	Sex Ratio	Vulnerable Age	Poor	Difable
KOTA CILEGON	CIWANDAN	GUNUNG SUGIH	407	112,3	2.159	257	5
		KEPUH	437	106,4	2.538	302	7
		RANDAKARI	1.981	106,9	2.831	337	16
		TEGAL RATU	2.134	104,9	3.353	399	4
		BANJARNEGARA	3.259	103,2	2.334	278	11
		KUBANGSARI	1.875	104,7	2.301	274	10
	CITANGKIL	DERINGO	3.684	107,9	2.841	328	70
		LEBAK DENOK	3.143	104,7	3.047	351	2
		TAMAN BARU	2.764	101,7	2.794	322	0
		CITANGKIL	10.193	101,9	5.056	583	47
		KEBONSARI	4.078	101	4.111	474	5
		WARNASARI	2.554	100,9	4.504	519	0
		SAMANGRAYA	2.410	102,2	3.215	371	31
	GROGOL	KOTASARI	3.647	103,8	2.685	319	10
		GROGOL	954	104,9	1.420	169	7
		RAWA ARUM	3.679	104,1	4.779	569	8
		GEREM	1.148	104,2	4.282	510	7
	PULO MERAK	MEKARSARI	2.376	101,1	3.834	472	70
		TAMANSARI	4.696	103,1	4.733	582	58
		LEBAK GEDE	2.484	100,9	4.001	492	31
		SURALAYA	1.126	101,7	1.942	239	21
KABUPATEN SERANG	PULO AMPEL	ARGAWANA	1.719	103	2.199	362	13
		BANYUWANGI	767	101	1.199	197	0
		MARGASARI	1.120	102	1.200	198	0
		PULOAMPEL	566	108	855	141	0
		SUMURANJA	1.619	97	1.413	233	2
		KEDUNG SOKA	1.360	105	1.485	245	0
		MANGUNREJA	604	101	1.019	168	4
		SALIRA	1.387	105	1.433	236	0
		PULO PANJANG	443	106	982	162	12

Source: [29]–[36]

3.2 Vulnerable Group

The Vulnerable Group has 4 indicators, namely sex ratio, number of people of vulnerable age, number of poor people, and number of persons with disabilities. Each of these indicators is given a weight of 10% [15].

3.2.1 Sex Ratio

The sex Ratio is the number of male populations per 100 female population. The sex ratio calculation shows that the village with the highest sex ratio is: the Gunung Sugih Village, of the Ciwandan District, with a number of 112.3; while the lowest sex ratio is in the Serang Regency namely the Sumuranja Village, in the Pulo Ampel District of 97.

3.2.2 Vulnerable Age Populations

The total population of vulnerable age is the total population of children (age 0-14) and the total population of elderly (age > 65 years). The village that has the highest number of vulnerable residents is the Citangkil, of the Citangkil District (Cilegon City), with a number of 5,056 people; while the lowest number of vulnerable people is in the Pulo Ampel, of the Pulo Ampel District (Serang Regency), with a number of 855 peoples.

3.2.3 Number of Poor People

The number of poor people is obtained from the assumption that the percentage of poor people in Cilegon City is 3.69% and Serang Regency is 4.94% [37], [38]. The village with the most number of poor people is Citangkil, in the Citangkil District with a number of 583 peoples, while the least is Pulo Ampel Village, of the Pulo Ampel District, with a number of 141 peoples.

3.2.4 Number of People with Disabilities

Indicators of persons with disabilities consist of Blind, Deaf, Speech Impaired (Mute), Deaf-Mute, Impaired Physically (Physical Disability), Mentally Impaired (Mental Retardant) & Retarded (Emotional Disorders & Behavioral Disorders). Based on the data processing, the villages with the highest number of persons with disabilities are Deringo in Citangkil District (Cilegon City) and Mekarsari in Pulo Merak District (Cilegon City), with a total of 70 peoples; while the lowest are in Taman Baru & Warnasari Villages in Citangkil District (Cilegon City) and Banyuwangi, Margasari, Pulo Ampel & Salira Villages in Pulo Ampel District (Serang Regency) because there are no recorded persons with disabilities.

3.3 Social Vulnerability Assessment

The Social Vulnerability Index (SVI) consists of 2 parameters, namely: the potential of the population exposed to the tsunami and the population of vulnerable groups. Figure 3 shows a map of the Social Vulnerability Index and the scoring of the index is shown in table 4. Here, a high SVI indicates severe exposure, disruption, loss, and hardship; while a moderate SVI describes the potential for medium exposure to the tsunami disaster event; and a low SVI indicates a village that will have the least impact when facing a tsunami disaster.

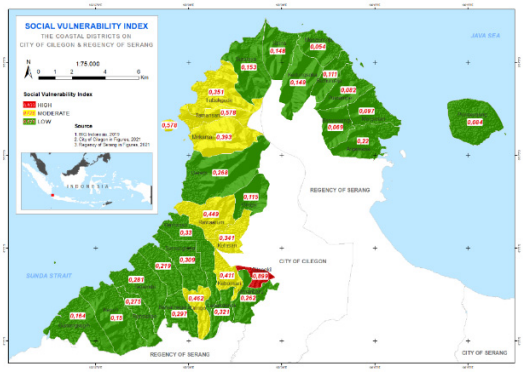

Fig. 3. Social Vulnerability Index Map (Analysis Results, 2023)

Table 4. Social Vulnerability Index

Region / City	District	Village	Social Vulnerability Index	
			Score	Class
KOTA CILEGON	CIWANDAN	GUNUNG SUGIH	0,164	LOW
		KEPUH	0,150	LOW
		RANDAKARI	0,275	LOW
		TEGAL RATU	0,281	LOW
		BANJARNEGARA	0,297	LOW
		KUBANGSARI	0,219	LOW
	CITANGKIL	DERINGO	0,462	MODERATE
		LEBAK DENOK	0,321	LOW
		TAMAN BARU	0,262	LOW
		CITANGKIL	0,899	HIGH
		KEBONSARI	0,411	MODERATE
		WARNASARI	0,330	LOW
		SAMANGRAYA	0,309	LOW
	GROGOL	KOTASARI	0,341	MODERATE
		GROGOL	0,115	LOW
		RAWA ARUM	0,449	MODERATE
		GEREM	0,268	LOW
	PULO MERAK	MEKARSARI	0,393	MODERATE
		TAMANSARI	0,578	MODERATE
		LEBAK GEDE	0,351	MODERATE
		SURALAYA	0,153	LOW
KABUPATEN SERANG	PULO AMPEL	ARGAWANA	0,220	LOW
		BANYUWANGI	0,069	LOW
		MARGASARI	0,097	LOW
		PULOAMPEL	0,082	LOW
		SUMURANJA	0,111	LOW
		KEDUNG SOKA	0,149	LOW
		MANGUNREJA	0,054	LOW
		SALIRA	0,148	LOW
		PULO PANJANG	0,084	LOW

Source : Analysis Result, 2023

For social vulnerability, Figure 3 shows that Citangkil Village in Citangkil District (Cilegon City) has the highest score (0.899), which is caused by the high level of population density, the number of people of vulnerable age, and poor people. Meanwhile, the village with the lowest score (0.054) is Mangunreja Village in Pulo Ampel District, Serang Regency due to the low population density, the number of people of vulnerable age, the number of people with disabilities, and the number of poor people.

3.4 Regional Capacity

Capacity refers to several aspects related to the strengths and resources available in communities, societies and organisations to mitigate risks and strengthen resilience to disasters [28]. The regional capacity assessment is measured using seven (7) parameters :

1) Strengthening Policy and institutions; with indicators of the availability of DRR Regional Regulations and the availability of BPBDs (the Regional Disaster Management Agency).
2) Integrated risk assessment and planning ; with indicators of availability of Disaster Risk Map.
3) Development of information systems, training, and logistics; with indicators of the availability of Pusdalop PB (the control center for disaster mitigation operation), the availability of tsunami drills, and the number of disaster safety equipment owned.
4) Thematic handling of disaster-prone areas ; with indicators of the number of health facilities, the number of health workers, and the existence of the Disaster Resilient Villages (DesTaNa).
5) Increasing the effectiveness of disaster prevention and mitigation ; with indicators of the availability of the Disaster Risk Reduction Movement.
6) Strengthening disaster emergency preparedness and handling ; with indicators of the number of TEWS (Tsunami Early Warning System) available and the number of tsunami evacuation signs and routes.
7) Development of a disaster recovery system ; with indicators of the availability of disaster recovery system development.

3.4.1 Strengthening Policies and Institutions

All of the villages in Cilegon City and Serang Regency already have Regional Regulations for Disaster Risk Reduction from the Regional Disaster Management Agency (BPBD).

3.4.2 Integrated Risk Assessment and Planning

Based on the data obtained, all villages in Cilegon City and Serang Regency have a Disaster Risk Map from the BPBD.

3.4.3 Development of Information Systems, Education, and Training and Logistics

All villages in the Cilegon City and Serang Regency have Pusdalop PB as part of the BPBD and also held a Tsunami Evacuation Simulations.

The following villages have the largest number of disaster safety equipment, namely 6, they are Gunung Sugih, Kepuh, Randakari, Banjarnegara, Kubang Sari in Ciwandan District; Deringo Village, Taman Baru in Citangkil District, Kotasari Village in Grogol District, Mekarsari Village in Pulomerak District and all villages in Pulo Ampel District (Serang Regency). While those that are less spread out in Tegal Ratu Village, Ciwandan District; Lebak Denok Village, Cingkil, Kebonsari, Warnasari, Samang Raya in Cingkil District; Grogol Village, Rawa Arum, Gerem in Grogol District and Taman Sari Village, Lebak Gede, Suralaya in Pulo Merak District, for a total of 5.

3.4.4 Thematic Handling of Disaster's Prone Areas

The villages with the highest number of health facilities are Tegal Ratu in Ciwandan District (Cilegon City), Gerem in Grogol District, Suralaya in Pulo Merak District, Sumuranja & Salira in Pulo Ampel District, namely a total of 3; while the least are in Deringo & Samang Raya in Citangkil District (Cilegon City); Banyuwangi, Kedungsoka & Pulo Panjang in Pulo Ampel District (Serang Regency), because they do not have health facilities at all.

The village with the largest number of health workers is the Kubangsari Village in Ciwandan District (Cilegon City), where they have 18 workers; while the lowest number of workers are in Margasari Village & Pulo Panjang Village in Pulo Ampel District because they do not have any health workers at all.

The villages that already have Disaster Resilient Villages (DesTaNa) recognition are Gunung Sugih Village in Ciwandan District, Gerem Village in Grogol District, Mekarsari Village, and Lebak Gede Village in Pulo Merak District. All of these DesTaNa Villages were established in 2018. Apart from that, the Taman Sari Village in Pulo Merak District, DesTaNa was also formed on November 12, 2019. All of these DesTaNa Villages are located in the City of Cilegon. Meanwhile, in the Serang Regency, Argawana Village in Pulo Ampel District has been inaugurated as a Climate and DesTaNa Village on September 15, 2021.

3.4.5 Increasing the Effectiveness of Disaster Prevention and Mitigation

All villages in Cilegon City and the Serang Regency have teams of Disaster Risk Reduction Action (*Tim Gerakan Pengurangan Risiko Bencana*).

3.4.6 Strengthening Disaster Emergency Preparedness and Handling

The villages with the highest number of EWS Tsunamis are Deringo, Lebak Denok, Taman Baru, Citangkil, Kebonsari, Warnasari in Citangkil District (Cilegon City); Kotasari, Grogol, Rawa Arum in Grogol District and all the villages in Pulo Ampel District (Serang Regency), namely 4. While the lowest number of EWS are Banjarnegara in Ciwandan District (Cilegon City) and Samangraya in Citangkil District (Cilegon City) because it does not have a Tsunami EWS.

The villages which have the most signage and evacuation routes are Banjarnegara in Ciwandan District and Taman Baru in Citangkil District (Cilegon City) and all villages in Pulo Ampel District (Serang Regency), namely 8. The lowest signage and evacuation routes are in Gunung Sugih, Kepuh, Randakari, Tegal Ratu, Kubangsari in Ciwandan District ; Deringo, Lebak Denok, Citangkil, Kebonsari, Warnasari & Samang Raya in Citangkil District and all villages in Grogol and Pulo Merak District (Serang Regency), for a total of 7.

Table 5. Regional Resources in Dealing with the Tsunami Disaster

Region / City	District	Village	DRR Regional Regulation	Regional Disaster Management Agency	Tsunami Risk Map	Pusdalop	Tsunami Drill	Disaster Safety Equipment	Health Facility	Health Workers	Disaster Resilient Village	DRR Movement	TEWS	Signs and Evacuation Routes	Disaster Recovery System Development
KOTA CILEGON	CIWANDAN	GUNUNG SUGIH	1	1	1	1	1	6	1	6	1	1	3	7	1
		KEPUH	1	1	1	1	1	6	1	2	0	1	3	7	1
		RANDAKARI	1	1	1	1	1	6	1	13	0	1	3	7	1
		TEGAL RATU	1	1	1	1	1	5	3	8	0	1	3	7	1
		BANJARNEGARA	1	1	1	1	1	6	1	11	0	1	0	8	1
		KUBANGSARI	1	1	1	1	1	6	2	18	0	1	3	7	1
	CITANGKIL	DERINGO	1	1	1	1	1	6	0	4	0	1	4	7	1
		LEBAK DENOK	1	1	1	1	1	5	2	3	0	1	4	7	1
		TAMAN BARU	1	1	1	1	1	6	1	3	0	1	4	8	1
		CITANGKIL	1	1	1	1	1	5	2	3	0	1	4	7	1
		KEBONSARI	1	1	1	1	1	5	2	4	0	1	4	7	1
		WARNASARI	1	1	1	1	1	5	1	3	0	1	4	7	1
		SAMANGRAYA	1	1	1	1	1	5	0	9	0	1	0	7	1
	GROGOL	KOTASARI	1	1	1	1	1	6	1	10	0	1	4	7	1
		GROGOL	1	1	1	1	1	5	1	7	0	1	4	7	1
		RAWA ARUM	1	1	1	1	1	5	2	9	0	1	4	7	1
		GEREM	1	1	1	1	1	5	3	5	1	1	3	7	1
	PULO MERAK	MEKARSARI	1	1	1	1	1	6	1	8	1	1	3	7	1
		TAMANSARI	1	1	1	1	1	5	1	5	1	1	3	7	1
		LEBAK GEDE	1	1	1	1	1	5	1	4	1	1	3	7	1
		SURALAYA	1	1	1	1	1	5	3	4	0	1	3	7	1
KABUPATEN SERANG	PULO AMPEL	ARGAWANA	1	1	1	1	1	6	1	5	1	1	4	8	1
		BANYUWANGI	1	1	1	1	1	6	0	1	0	1	4	8	1
		MARGASARI	1	1	1	1	1	6	2	0	0	1	4	8	1
		PULOAMPEL	1	1	1	1	1	6	1	1	0	1	4	8	1
		SUMURANJA	1	1	1	1	1	6	3	5	0	1	4	8	1
		KEDUNG SOKA	1	1	1	1	1	6	0	1	0	1	4	8	1
		MANGUNREJA	1	1	1	1	1	6	2	1	0	1	4	8	1
		SALIRA	1	1	1	1	1	6	3	4	0	1	4	8	1
		PULO PANJANG	1	1	1	1	1	6	0	0	0	1	4	8	1

Sources: [29]–[36]

3.4.7 Disaster Recovery System Development

All villages in Cilegon City and Serang District have a Disaster Recovery System Development.

3.5 Regional Capacity Index

Regional Capacity Index (RCI) is composed of 7 parameters. Based on the calculation of capacity values, regional capacity levels are in moderate level as shown in Table 6. The Regional Capacity Index map and its index valuation show that a high RCI indicates resources that are owned and managed properly, in terms of preparedness and mitigation measures. A medium RCI means of potential to be added in strengthening resilience. And a low RCI indicates a village that has few resources when facing the tsunami disaster.

For the regional capacity index, Figure 4 shows that Argawana Village in Pulo Ampel District, Serang Regency has the highest score (0.965) because it meets all regional readiness parameters. Meanwhile, the lowest score (0.540) belongs to Samang Raya Village in Citangkil District, Cilegon City because it does not yet have adequate strengthening for emergency preparedness and response.

Table 6. Regional Capacity Index

Region / City	District	Village	Regional Capacity Index	
			Score	Class
KOTA CILEGON	CIWANDAN	GUNUNG SUGIH	0,735	MODERATE
		KEPUH	0,685	MODERATE
		RANDAKARI	0,715	MODERATE
		TEGAL RATU	0,710	MODERATE
		BANJARNEGARA	0,755	MODERATE
		KUBANGSARI	0,735	MODERATE
	CITANGKIL	DERINGO	0,745	MODERATE
		LEBAK DENOK	0,730	MODERATE
		TAMAN BARU	0,925	HIGH
		CITANGKIL	0,730	MODERATE
		KEBONSARI	0,730	MODERATE
		WARNASARI	0,720	MODERATE
		SAMANGRAYA	0,540	LOW
	GROGOL	KOTASARI	0,755	MODERATE
		GROGOL	0,720	MODERATE
		RAWA ARUM	0,740	MODERATE
		GEREM	0,740	MODERATE
	PULO MERAK	MEKARSARI	0,745	MODERATE
		TAMANSARI	0,710	MODERATE
		LEBAK GEDE	0,710	MODERATE
		SURALAYA	0,700	MODERATE
KABUPATEN SERANG	PULO AMPEL	ARGAWANA	0,965	HIGH
		BANYUWANGI	0,905	HIGH
		MARGASARI	0,925	HIGH
		PULOAMPEL	0,915	HIGH
		SUMURANJA	0,955	HIGH
		KEDUNG SOKA	0,905	HIGH
		MANGUNREJA	0,925	HIGH
		SALIRA	0,955	HIGH
		PULO PANJANG	0,905	HIGH

Sources: Analysis Results, 2023

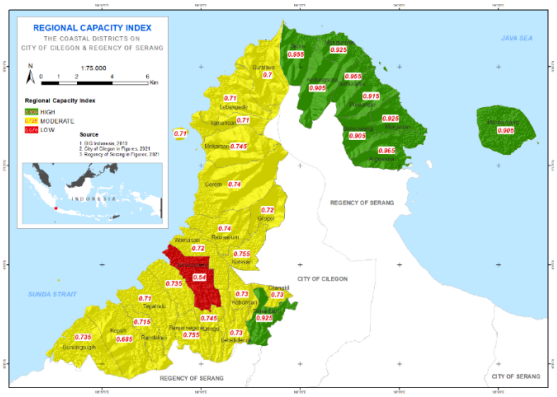

Fig. 4. Regional Capacity Index Map
(*Sources: Analysis Results, 2023)*

4 Conclusion

In general, the social vulnerability of The Cilegon City and Serang Regency from tsunami hazard is mostly considered as low as illustrated by the level of social vulnerability. The regional capacity of the of The Cilegon City and Serang Regency is mostly considered moderate as illustrated by the level of regional capacity in five coastal districts of the research area. Pulo Ampel District in Serang Regency is the area with the lowest level of social vulnerability; however, it has the highest level of capacity compared to the neighboring 4 coastal districts in Cilegon City. This is shown by the Citangkil Village has the highest level of social vulnerability, and the lowest is represented by Mangunreja Village in Pulo Ampel District. Argawana Village in Pulo Ampel District has the highest regional capacity because it has met all regional readiness parameters. On the other hand, the Samang Raya Village in Citangkil District has the lowest regional capacity due to inadequate strengthening activities of emergency preparedness and response. This study shows that a high level of social vulnerability is directly related to population density, especially those with a large population of vulnerable ages. High regional capacity is greatly influenced by activities of strengthening disaster emergency preparedness and management as well as increasing the effectiveness of disaster prevention and mitigation.

Similar analysis showed that if the level of emergency preparedness of the people was in the low category, the overall resilience rating of the city is also low, indicating that more planned, systematic and sustained efforts are needed [39].

Strategic recommendations for the villages with high social vulnerability and low capacity are to increase regional capacity. More training and rehearsals as well as information distribution for the community preparedness needs to be more routinely conducted, especially to the area with low level of social vulnerability. To enhance the capacity, it is suggested for development of information systems, more training and logistics conducted for emergency preparedness, policy and institutional strengthening; as well as increasing integrated risk assessment and planning. In addition, future studies using field data will provide up-to-date information on the status of social vulnerability and regional capacity in each unit of analysis which will complement the current study.

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