Social Resilience Assessment in Reducing Potential Risk of Earthquake in Surabaya

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***Abstract*—Surabaya has a potential risk of earthquakes, refer to the 2017 Indonesian Earthquake Source and Hazard Map issued by the National Center for Earthquake Studies (Pusat Gempa Nasional-PUSGEN). Surabaya city readiness in responding this issue is indicated by the community resilience. Therefore, it is important to assess the social resilience to find out the current capacity of communities in responding to earthquake risk. The research targeted the area around the Surabaya Fault with potentially high seismic hazard, consisting of 8 districts and 23 sub- districts. 22 variables were obtained by doing a literature review and expert judgment, that are 11 variables for social vulnerability and 11 variables for preparedness. We collect the data by distributing questionnaires to 116 respondents, the head of neighbourhood units, selected by simple random sampling. We analyze the data using Confirmatory Factor Analysis (CFA), descriptive statistics and Geographic Information Systems (GIS)-based mapping. Based on CFA, there are 7 valid variables of social vulnerability and 10 variables of preparedness for index assessment. The social vulnerability assessment has an index value of 2.27, while preparedness has an index value of 1.99. The index value shows that both of these indicators are in the low-to-medium category. Then, the social resilience index is assessed as the ratio of preparedness and social vulnerability index. By comparing these two indicators, Surabaya has an index value of 0.88 for social resilience or categorized as less resilient in responding to the earthquake risk.**

***Keywords*—Resilience, Social Vulnerability, Preparedness, CFA.**

I. INTRODUCTION

IN 2017, The National Center for Earthquake Studies (Pusat Gempa Nasional-PUSGEN), Ministry of Public Works and Public Housing, issued that Surabaya City has the potential for earthquake risk. Referring to Indonesian Earthquake Source and Hazard Map (PUSGEN, 2017), Surabaya has been passed by 2 segments of Kendeng Faults, that are Surabaya Fault and Waru Fault. This two fault are active faults with a slip rate of 0.05 mm/year and potentially cause an earthquake of 6.5 RS (Meilano, 2012). In addition, historical seismicity data showed that Surabaya has been exposed to earthquakes with a scale between VI-VII MMI, though the epicenter was not in Surabaya (Daryono, 2016). The nearest epicenter was in Sidayu with a scale of VI MMI (1902) and Mojokerto with a scale of VI-VII MMI (1937).

Surabaya city has an important role for trading activities in Southeast Asia. As the second largest city in Indonesia after Jakarta, this city is aggressively develop, especially in the economic aspect as well as trade and service sectors

Figure 1. Surabaya Fault and Waru Fault Line Map.

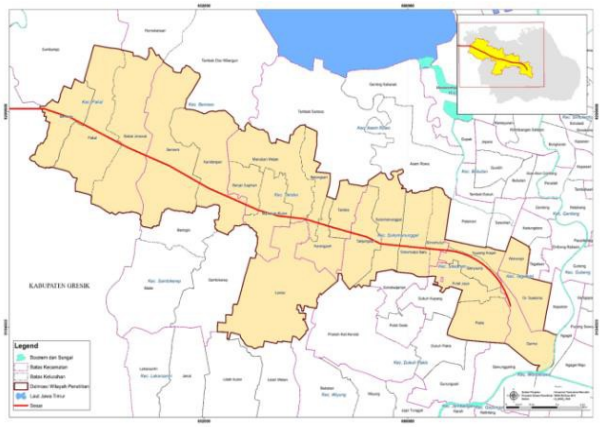

Figure 2. Study Area.

(Pamungkas *et* al., 2019). The population growth has increased significantly in the past dozen years. Referring to the Surabaya City in figures for 2002-2018, the population in 2001 was 2.57 million. In 2017, the population reached 3.07 people or experienced a population increase of 506,531 people (16.3%) for 17 years. This population growth is followed by a significant land use changes to respond the housing and settlements demand. According to Firmansyah *et* al. (2018) the settlements area in Surabaya tend to grow around 25% in 15 years (2001-2015) or a growth of around 1.67% per year.

As a densely populated city, Surabaya must have good disaster risk management. Disaster risk management aims to minimize the disaster impact through the resources optimization including planning and development practices (Simarmata & Suryandaru, 2015; Healey, 1997). Making city resilient has become a challenge for cities around the world in term of disaster risk reduction. Resilience is the results of the 2015-2030 Sendai Disaster Risk Reduction

Table 1.
Study Area

No.	District		Sub District
1	Benowo	1	Kandangan
		2	Sememi
2	Pakal	3	Babat Jerawat
		4	Benowo
		5	Pakal
3	Sambikerep	6	Lontar
4	Sawahan	7	Banyuurip
		8	Putat Jaya
		9	Kupang Krajan
		10	Pakis
5	Sukomanunggal	11	Simomulyo
		12	Simomulyo Baru
		13	Sukomanunggal
		14	Tanjungsari
6	Tandes	15	Balongsari
		16	Banjar Sugihan
		17	Karangpoh
		18	Manukan Kulon
		19	Manukan Wetan
		20	Tandes
7	Tegalsari	21	Dr. Soetomo
		22	Wonorejo
8	Wonokromo	23	Darmo

Framework adopted by the United Nations (UN) member countries at the Third World Conference on Disaster Risk Reduction in Sendai, Japan, on March 18, 2015, with the point "strengthening resilience" as the goal (UNISDR, 2015). The 9th World Urban Forum activity held in Kuala Lumpur, Malaysia on 7-13 February 2018 also emphasized resilience as a priority issue in accordance with the theme of "building inclusive, resilient, and sustainable cities and communities for all."

This research investigates the level of social vulnerability and community preparedness is currently in earthquake risk reduction in Surabaya. This is intended to find out what level of social resilience the Surabaya City currently has in responding to the earthquake risk and what efforts can be done in order to reduce the earthquake risk in Surabaya. Identifying the level of resilience of a city helps the stakeholders to prepare risk management policies to reduce the potential impact of an earthquake.

II. METHODS

According to the fault map released by PUSGEN (2017) in Figure 1, Surabaya City is bypassed by 2 active faults namely the Surabaya Fault and Waru Fault. This research focuses in the area around Surabaya Fault because it has a higher complexity. So, the research scope included 8 Districts and 23 Sub District area surrounding the Surabaya Fault line shown in Figure 2 and Table 1.

According to Mayunga (2007), disaster resilience is defined as the capacity or ability of the community to anticipate, prepare, respond, and recover quickly from the impact of disasters. A high level of resilience will potentially reduce the impact of the earthquake both in terms of number of victims and material losses. According to UNISDR (2004), resilience refers to the ability of social systems in organizing themselves in increasing their capacity to learn from past disasters, better protection in the future, and increasing disaster risk reduction efforts.

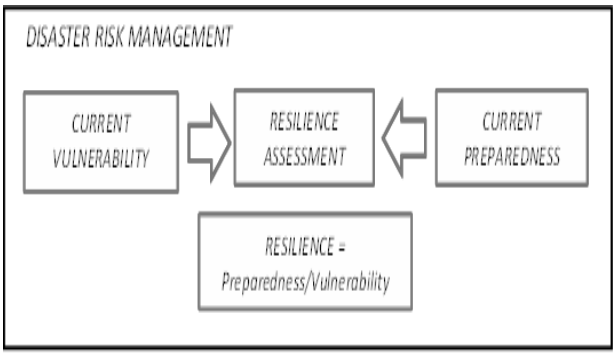

Figure 3. Relation between Vulnerability, Preparedness and Resilience Concepts in Disaster Risk Management.

There is close connection between the concept of resilience and vulnerability in disaster risk management (Pamungkas *et* al., 2013). Resilience is a theoretical framework and social process that tries to explain how society reduces the level of vulnerability in the future through adaptation (also can be associated with mitigation or preparedness). Adaptation aims to reduce the level of vulnerability so that it is expected there will be a difference between the current vulnerability and the future.

Community is the important element in assessing the disaster risk (Setyaningrum & Giyarsih, 2012). The earthquake risk level of the community is influenced by the level of vulnerability, including social vulnerability. Vulnerability is a set of conditions and/or a result of conditions that adversely affect disaster prevention and management (National Disater Management Coordinating Board-Bakornas PB, 2009). If a hazard is difficult to change, the relative vulnerability of the community can be changed. Preparedness is an effort made to anticipate the possibility of a disaster in order to avoid casualties, property losses, and changes in the future people's lives (Gregg et al., 2004; Perry & Lindell, 2008; Sutton & Tierney, 2006). Disaster preparedness indicates the ability of the community both individually and in groups to anticipate the possibility of future disasters.

Kusumastuti, *et* al. (2014) referring to Simpson's (2006) proposes that resilience is a ratio of preparedness and vulnerability. Preparedness refers to capacity in dealing with disasters, while vulnerability is defined as potential losses due to disasters. In this concept, the higher the preparedness level, the higher the resilience level. Thus, the resilience assessment refers to vulnerability and preparedness aspects. From the review of both concepts according to Pamungkas *et* al. (2013) and Kusumastuti *et* al. (2014), resilience is strongly influenced by vulnerability. But in the context of earthquake that has not yet occurred, we have difficulty in measuring the change in vulnerability. So, we propose to determine the resilience level by measuring the existing vulnerability and preparedness according to Simpson (2006) and Kusumastuti, *et* al. (2014) as Figure 3 shows.

By synthesize the literature review, we found 20 relevant variables which were then conducted by an expert judgment to validate the variables used. There are 2 additional variables obtained from experts judgement so there are 22

Table 2.
Descriptions of Social Vulnerability and Preparedness Variables

No.	Variables	Definition	Source
		Social Vulnerability Aspect	
1	Population density	Percentage of population density (people/km^2), population per area (%)	Sharma & Shaw (2011); Hastuti & Priyono (2017); Gautam (2017); Kusumastuti *et* al. (2014)
2	The existence of semi-permanent and non-permanent settlements	Percentage of population living in settlements (%) in: - Semi-permanent settlements: construction made from zinc or asbestos roofing material, wood or bamboo wall material, cement flooring material - Non-permanent settlements: construction made wood or asbestos roofing material, bamboo or bamboo wall material, ground floor material	Sharma & Shaw (2011)
3	Low-income population	Percentage of low-income population so they need the government support (%)	Kusumastuti *et* al. (2014); Yucel & Arun (2012)
4	Vulnerable age population under 14 years (children)	Percentage of non-productive age population under 14 years old (children) refers to the Statictical Board standard (%)	Sharma & Shaw (2011); Yucel & Arun (2012); Hastuti & Priyono (2017); Gautam (2017)
5	Vulnerable age population over 60 years (elderly)	Percentage of non-productive age population over 60 years (elderly) refers to the Statictical Board standard (%)	Sharma & Shaw (2011); Yucel & Arun (2012); Hastuti & Priyono (2017); Gautam (2017)
6	Population of women	Percentage of women population number compared to the men population number (%)	Hastuti & Priyono (2017); Gautam (2017)
7	Population with disabilities	Percentage of population with special needs so it is assumed that it will experience difficulties during evacuation (blind, deaf, others disabled) (%)	Kusumastuti et. al. (2014); Gautam (2017)
8	Number of social conflicts and criminal incidents over the past 15 years	Number of land or ethnic social conflicts and criminal incidents (vulnerable to robbery, theft, murder) during the last 15 years	Kusumastuti *et* al. (2014)
9	Population who has access to emergency communication tools	Percentage of people who have access to emergency communication tools, including internet, TV, radio, etc.	Sharma & Shaw (2011); Gautam (2017)
10	Population who has insurance	Percentage of people registered with insurance, i.e. good	Kusumastuti *et* al. (2014)
11	Population who has expertise in emergencies	Percentage of people who have expertise in emergencies, including doctors, nurses, medical personnel, Soldiers, Police Officer, and volunteers (%)	Expert Judgment
		Community Preparedness Aspect	
1	Community satisfaction index for leaders	Community satisfaction level with the performance of Local Leaders (Head of RW and Lurah), in terms of responding to disaster issues	Sharma & Shaw (2011)
2	Community relationship	Percentage of people who have good relationship with each other and indicate mutual cooperation between communities	Kusumastuti *et* al., 2014; Sutton & Tierney (2006)
3	Community participation in disaster management activities	Percentage of people who joined the disaster management communities (i.e.: rescue team, resilient school/Sekolah Tangguh, disaster prepared cadets/Tagana, resilient precinct/Kelurahan Tangguh, etc.)	Sharma & Shaw (2011)
4	Availability of community awareness programs and disaster trials	Availability of disaster awareness programs or training and disaster trials conducted by the Government or other institutions	Sharma & Shaw (2011)
5	Community understanding to seismic hazard	Capabilities in understanding the seismic hazard	Enders (2002); Sutton & Tierney (2006); Sharma & Shaw (2011); Lam *et* al. (2017); Kusumastuti *et* al. (2014)
6	Community understanding to emergency response instructions	Capabilities in understanding of emergency response instructions through posters, stickers, or others information (*offline* or *online*)	Enders (2002); Sutton & Tierney (2006)
7	Community ability towards the basics life support	Capabilities to the basics life support, i.e, CPR, first aid, self-rescue, etc.	Expert Judgment
8	Community ability in emergency response information planning	Capabilities in emergency response information planning or warning systems, i.e in the use of megaphone in the mosque, Handy-Talky, traditional communication tools „*kentongan*", church bell, alarm, etc.	Sharma & Shaw (2011); Lam *et* al. (2017)
9	Community understanding to emergency response communication system	Capabilities of public understanding to the city's emergency response communication system (*Command Center* 112, "ISYANA" mobile-based application)	Sutton & Tierney (2006); Lam *et* al. (2017)
10	Evacuation route and assembly point readiness	Evacuation routes and assembly point mapping and the availability of evacuation system procedures for communities	Sutton & Tierney (2006)
11	Logistics, material and disaster emergency preparedness	Capabilities in managing logistics, material and disaster emergency facilities	Sharma & Shaw (2011)

variables used. Table 2 explains the description for each variable.

Identification of the social vulnerability and preparedness level was obtained from the distribution of questionnaires to 116 respondents from a minimum samples of 94 respondents. Respondents are the head of the Local Government (Head of Rukun Tetangga/RT) from 23 Sub District around the Surabaya Fault. This 94 minimal samples were selected by simple random sampling from

Figure 4. Graph of Social Vulnerability Values.

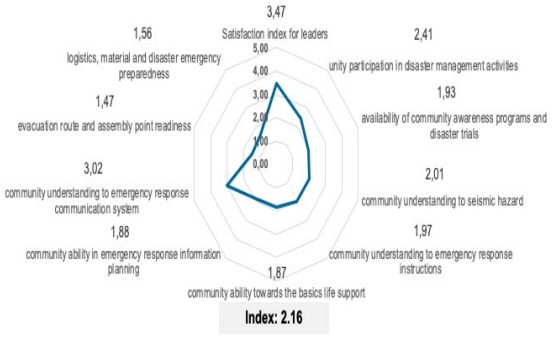

Figure 5. Graph of Preparedness Value.

1,457 populations through the Slovin formula with a *standard error of* 0,1 or 10%.

The social vulnerability and preparedness assessment is done by calculating the values and weights obtained from the *loading factor* value of the CFA analysis, so that index calculated with the following equation:

$$\frac{\sum_{i=1}^{n} w_i\, x_i}{\sum_{i=1}^{n} w_i} = \frac{(w_1 \times x_1) + (w_2 \times x_2) + (w_3 \times x_3) + \cdots + (w_n \times x_n)}{w_1 + w_2 + w_2 + \cdots + w_n} \quad (1)$$

Where:

w_1 = Weight 1 x_1 : Variable value 1
w_2 = Weight 2 x_2 : Variable value 2
w_3 = Weight 3 x_3 : Variable value 3
w_n = Weight n x_n : Variable value n

The calculation will result the index. The index value of 1 categorized as very low level, index value of 2 categorized as low level, index value of 3 categorized as middle level, index value of 4 categorized as high level, and index value of 5 categorized as very high level.

The social resilience index is determined by calculating the results of social vulnerability index and preparedness index, using the following formula (Simpson, 2006):

$$Rs = \frac{Ps}{Vs} \quad (2)$$

where:

Rs = *Resilience* (social resilience index)
Ps = *Preparedness* (preparedness index)
Vs = *Vulnerability* (social vulnerability index)

The social resilience index of <1 indicates that preparedness level is lower than the social vulnerability level or interpreted as less resilient area. Conversely, the index of >1 means that the area has sufficient preparedness

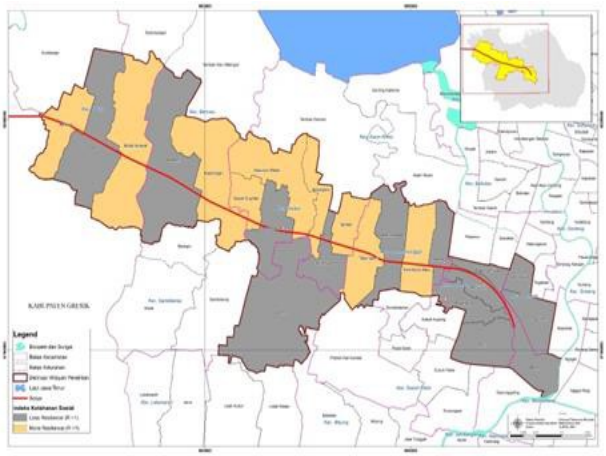

Figure 6. Social Resilience Index Map for Each Sub District.

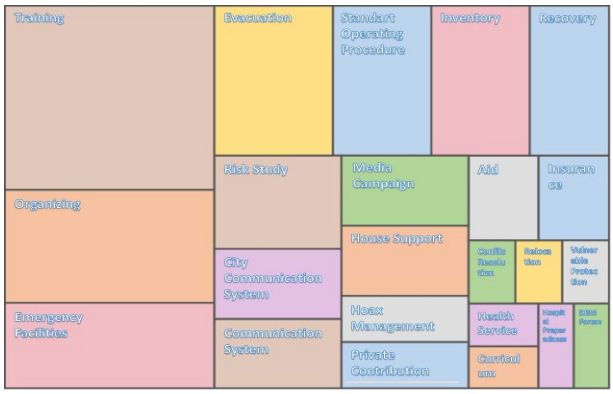

Figure 7. Hierarchy Chart Visualization.

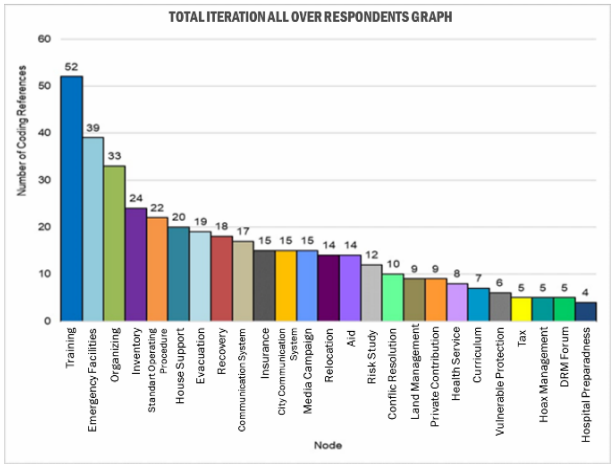

Figure 8. Graph of Number of Iterations Formulation of Efforts to Increase Social Security.

to respond the vulnerability or categorized as more resilient area.

III. RESULTS AND DISCUSSION

The assessment of social vulnerability and preparedness level are conducted by CFA by using AMOS software. In the CFA analysis there are some assumptions used, i.e. normal multivariate test, validity and reliability test, and goodness of fit index. From the CFA analysis, we will get a decent variable to measure social vulnerability and preparedness. Besides, the weight for each variable is based on loading factor as the CFA"s result. The value for each variable is

Table 3.
Distribution of Social Resilience Index per Sub District

District	Sub District	*Vs*	*Ps*	*Rs*	Conclusion
Benowo	Kandangan	2.17	2.35	1.08	*More resilient*
	Sememi	2.28	1.93	0.85	*Less resilient*
Pakal	Babat Jerawat	1.87	2.18	1.16	*More resilient*
	Benowo	2.43	3.07	1.26	*More resilient*
	Pakal	2.68	2.10	0.78	*Less resilient*
Sambikerep	Lontar	2.41	1.77	0.74	*Less resilient*
Sawahan	Banyu urip	2.65	1.53	0.58	*Less resilient*
	Putat Jaya	2.18	1.57	0.72	*Less resilient*
	Kupang Krajan	2.49	2.04	0.82	*Less resilient*
	Pakis	2.10	1.82	0.87	*Less resilient*
Sukomanunggal	Simomulyo	2.28	1.97	0.86	*Less resilient*
	Simomulyo Baru	2.34	2.39	1.02	*More resilient*
	Sukomanunggal	2.52	1.56	0.62	*Less resilient*
	Tanjungsari	1.89	2.01	1.06	*More resilient*
Tandes	Balongsari	1.98	2.30	1.16	*More resilient*
	Banjar Sugihan	2.03	2.13	1.05	*More resilient*
	Karangpoh	2.21	1.54	0.69	*Less resilient*
	Manukan Kulon	2.32	1.80	0.77	*Less resilient*
	Manukan Wetan	1.92	2.49	1.29	*More resilient*
	Tandes	1.98	2.04	1.03	*More resilient*
Tegalsari	Dr. Soetomo	2.80	2.20	0.78	*Less resilient*
	Wonorejo	2.70	1.05	0.39	*Less resilient*
Wonokromo	Darmo	2.02	1.86	0.92	*Less resilient*

obtained from the results of the questionnaire. Then, the index will be generated from weight and value calculations.

A. Social Vulnerability Index

CFA analysis result show that there are 7 significant variables to represent social vulnerability from 11 variables tested. There are population density (0.398), the existence of semi-permanent and non-permanent settlements (0.243), low-income population (0.429), vulnerable age population under 14 years (0.410), vulnerable age population over 60 years (0.451), population with special needs/disabilities (0.553), and the number of social conflicts and criminal incidents over the past 15 years (0.459). Based on the loading factor value, the variable with the greatest influence in indicating social vulnerability are the population with special needs/disabilities and the number of social conflicts and criminal incidents during the last 15 years.

The value of social vulnerability is calculated based on the accumulated value through questionnaires distribution. Figure 4 show the value for each social vulnerability variable.

Vulnerable age population below 14 years variable with a value of 3.10 is the highest vulnerability variable, meaning that the study area has quite a number of children's population (about 20-30%). Likewise with the low-income population variable with a value of 2.77, a population density variable with a value of 2.61, and vulnerable age population variable over 60 years variable with a value of 2.63. These three variables explain that the study area have about 25-40% low-income population, 20-30% of the population over 60 years, and a low to moderate population density (between 1,000 - 8,000 people/km^2). On the other hand, the number of social conflicts and criminal incidents over the past 15 years has a value of 1.79 while the population with special needs (disability) has a value of 1.17. Based on the overall value of the variable, the average value of social vulnerability in the study area is 2.32 which is included in the low to middle category. The social vulnerability index assessed by the calculation included weight and value. The total multiplications of weight and value for the overall vulnerability variables is 6.687 while the total weights is 2.943. Then, social vulnerability index is calculated below:

$$\frac{\sum_{i=1}^{n} w_i\, x_i}{\sum_{i=1}^{n} w_i} = \frac{6.687}{2.943}$$
$$\frac{\sum_{i=1}^{n} w_i\, x_i}{\sum_{i=1}^{n} w_i} = 2.27 \quad (3)$$

The social vulnerability index result is 2.27 or in the low to moderate category.

B. Preparedness Index

The analysis result 10 significant variables to represent preparedness from 11 variables tested. These significant variables are community satisfaction index for leaders (0.345), community participation in disaster management activities (0.360), availability of community awareness programs and disaster trials (0.659), community understanding to seismic hazard (0.540), community understanding to emergency response instructions (0.738), community ability towards the basics life support (0.764), community ability in emergency response information planning (0.729), community understanding to emergency response communication system (0.363), evacuation route and assembly point readiness (0.879), as well as logistics, material and disaster emergency preparedness (0.899).

The evacuation route and assembly point readiness and logistics, material and disaster emergency preparedness variable had the greatest influence in indicating preparedness. The value of preparedness is calculated based on the accumulated value through questionnaires distribution. The preparedness value for each variable can see in Figure 5.

Community satisfaction index for leaders and community understanding to emergency response communication system has a fairly good value (middle to high) which is on

Table 4.
Directions for Improving Social Resilience in the context of Earthquake Risk Reduction

No.	Direction for Increasing Social Resilience	DRR phase	Resilience Character
1	Resettlement of residents in the prone areas to earthquakes/fault zones	Mitigation	Learning and Adaptation
2	Promote life or asset insurance	Mitigation	Bounce back
3	Providing assistance to repair community houses refer to earthquake resistant building standards	Mitigation	Absorb Shock
	Providing assistance to repair community houses in the context of recovery	Rehabilitation and Reconstruction	Bounce back
4	Provision of financial assistance or basic needs	The response	Absorb Shock
5	Social, economic, cultural recovery including psychological recovery	Rehabilitation and Reconstruction	Bounce back
6	Protection of vulnerable groups (children, elderly, women, low-income population, people with disabilities) through training	Mitigation	Learning and Adaptation
	Protection of vulnerable groups of low-income people through economic empowerment	Mitigation	Bounce back
	Protection of vulnerable groups (children, elderly, women, people with disabilities) through *trauma healing*	Rehabilitation and Reconstruction	Bounce back
7	Increased affordability of health services, in the form of facilities, infrastructure and access to health services	Mitigation	Absorb Shock
8	Planning for issues management	Preparedness	Absorb Shock
9	Reconciliation and conflict resolution during emergencies	The response	Absorb Shock
10	Inventory of resources related to disaster: a. Disaster management community/volunteers (Scouts, Indonesian Red Cross, Orari, Disaster Cadets/Tagana, rescue teams, etc.) b. Disaster alert posts with all the supporting elements c. Skilled and expert personnel for environmental scale preparedness (doctors, nurses, soldiers, polices) d. Emergency support resources (transportation, toilets, *rescue* cars, emergency sanitation facilities, and other facilities as needed)	Mitigation	Absorb Shock
11	Contingency planning that includes the role and Standard Operating Procedures, which is integrated in the guidelines aspect of volunteers, emergency response plans, early warning systems, communication systems, evacuation system, health, safety, logistical, etc.	Preparedness	Absorb Shock
12	Earthquake risk assessment/analysis, rism mapping and earthquake risk dissemination towards communities	Mitigation	Learning and Adaptation
13	Eartquake mitigation training, simulation and drills for each disaster management sector: a. basic training in disaster management for officials b. providing earthquake disaster evacuation drills at public facilities and school buildings (such as ducking, head protection, hiding under desks) c. procurement of earthquake disaster evacuation drills in residential areas (including vertical housing) d. basic community first aid training, including CPR, first aid, etc.	Preparedness	Learning and Adaptation
14	Organizing: a. the formation of organizations or disaster task force units b. activation of disaster alert posts with all its supporting elements c. the empowerment of the Resilience Village/Kelurahan Tangguh	Preparedness	Learning and Adaptation
15	Communication system planning: a. early warning sirines b. early warning based on local wisdom, by hitting „kentongan", electricity poles of church bells or loudspeakers in mosques c. setting up alternative family communication tools (Radio/HT) d. broadcast warning via SMS	Preparedness	Absorb Shock
	Communication system activation: a. early warning sirines b. early warning based on local wisdom, by hitting kentongan, electricity poles of church bells or loudspeakers in mosques c. setting up alternative family communication tools (Radio/HT) d. broadcast warning via SMS	The response	Absorb Shock
16	Integrated city communication system: a. socialization of list of important numbers of parties related to earthquake management b. socialization and operation of the city's emergency response communication system (Command Centers 112 and Isyana) c. upgrade Command Center 112 as an information system and resource mobilization during the emergency phase	The response	Learning and Adaptation
17	Evacuation system planning: a. the earthquake evacuation routes and assembly point mapping b. procurement of signs and evacuation information boards c. planning the evacuation area/shelter	Preparedness	Absorb Shock

(Continued)

No.	Direction for Increasing Social Resilience	DRR phase	Resilience Character
18	Management of emergency facilities: a. provision of first aid kits/essential medicines for family first aid and public facilities b. setting up communication networks alternatives such as satellite telephone case of failure of the main communication channel during disasters c. preparation of support and mobilization of resources/logistics and distribution of assistance to victims d. socialization and procurement of disaster prepared bags, bags prepared by family members in case of emergencies, containing important papers, clothing, durable food, drinking water, medicines, cellphones, lighting aids, money, whistles, masks and toiletries	Preparedness	Bounce back
19	Pre-disaster *media campaign*: a. making brochures/leaflets/posters/pocket books/earthquake alert stickers (offline or online) b. broadcasting disaster dissemination on various media (radio, television, online media, or other official sources)	Preparedness	Learning and Adaptation
	Media campaigns during disasters through *broadcasting* disaster information on various media (radio, television, online media, or other official sources)	The response	Learning and Adaptation
20	Strengthen community contributions through Disaster Risk Reduction forums with communities, institutions, professional associations, etc.	Preparedness	Learning and Adaptation
21	Application of incentives and regulations regarding private sector participation in risk reduction through city contributions (building code standards, alternative infrastructure providing, etc.)	Mitigation	Absorb Shock
22.	Mainstreaming the disaster management in curriculum, subjects, or extracurricular content in schools and college, as well as *safety briefings*	Mitigation	Learning and Adaptation
23.	Development of hospital preparedness plans and management of mass casualties (drugs, medical personnel, equipment/ambulances)	Preparedness	Absorb Shock

a scale of 2-3. This means that mostly local government has a good performance in terms of disaster risk reduction. The city's emergency response communication system has also been widely understood by the public. Community participation in disaster management activities and community understanding to seismic hazard has a low to middle value. Approximately 25-50% of the community has been active in disaster management activities and the community has begun to increase their understanding to earthquake by finding out through various media or requesting information from the Government. On the other hand there are still 6 other variables that still have very low to low values. The average value of preparedness is 2.16 which is included in the low to middle category.

The preparedness index assessed by the calculation included weight and value. The total multiplications of weight and value for the overall vulnerability variables is 12.468 while the total weights is 6.276. Then, preparedness index is calculated below:

$$\frac{\sum_{i=1}^{n} w_i\, x_i}{\sum_{i=1}^{n} w_i} = \frac{12.468}{6.276}$$
$$\frac{\sum_{i=1}^{n} w_i\, x_i}{\sum_{i=1}^{n} w_i} = 1.99 \quad (4)$$

The preparedness index result is 1.99 or in the very low to low category.

A. Social Resilience Index

The previous results show that the social vulnerability index is 2.27 (low to middle category) and the preparedness index of 1.99 (very low to low category). Then the social resilience index is obtained from the ratio of social preparedness and vulnerability index that is equal to 0.88. Below the following calculation:

$$Rs = \frac{1.99}{2.27} \quad (5)$$

$$Rs = 0.88$$

Social resilience index is valued <1 or categorized as less resilient. Surabaya City's community preparedness is currently not able to compensate for the existing level of vulnerability. Even so, when looking at the distribution for each Sub District, some of them have a social resilience index> 1 or are categorized as *more resilient* as seen in Table 3 and visualized in Figure 6.

B. Proposed Direction to Increase Social Resilience in the context of Earthquake Risk Reduction

The formulation of proposed direction to improve social resilience is carried out through a literature review which is further confirmed by the stakeholders by using content analysis. Content analysis *was* conducted with interview transcript input from the six selected respondents and processed with Nvivo 11 Plus *software*. The analysis results are the discovery of selected efforts to increase social resilience that are relevant for earthquake risk reduction in Surabaya. The 6 (six) respondents involved in the content analysis are: Surabaya City Development and Planning Board, Public Housing and Settlement Agency, Disaster Management and Community Protection Agency, Social Agency, Masyarakat Tangguh Indonesia (MTI) Community, and ITS Research Center of Mitigation and Climate Change.

The content analysis using Nvivo 11 Plus produce *Hierarchy Charts* function to see the comparison of the number of encodings in each *node* (keywords) often discussed by the six respondents. The wider box in the *hierarchy chart* shows the more often the *node* (keyword) is discussed/mentioned. Figure 7 and Figure 8 shows that the keywords most frequently discussed by the six respondents were Training with *Number of Coding References* of 52 or 13.10%, Emergency Facilities with

Number of Coding References of 39 or 9.82%, and Organizing with *Number of Coding References* by 33 or 8.31%. Instead the keywords that were least discussed were Hospital Preparedness with a *Number of Coding References* of 4 or 1.01%.

In addition, a qualitative study was carried out further on the existence or relevance of each formulation to improve social resilience. There are 25 directions to increase social resilience from the results of the literature that asked and discussed by stakeholders related to the relevance of the Surabaya City. Of these 25 directions, there are two unconfirmed distructions, that are land management or land acquisition for the fault area and determination of high taxes in the fault area.

Based on the content analysis results there are 23 relevant directions for increasing social resilience against earthquake in Surabaya. These directives are then grouped into 4 phases of disaster risk reduction included mitigation, preparedness, response and rehabilitation. These also grouped into 3 main characteristics of resilience, included the ability to withstand changes and pressure (*absorb shock*), the ability to return to the state before the disaster (*bounce back*), and the ability to learn and adapt (*learning and adaptation).* Directions at the mitigation and preparedness stages are efforts to increase the ability to withstand changes and pressures (*absorb shock*) and to learn and adapt (*learning and adaptation*). Response phase directions are efforts to withstand changes and stresses (*absorb shock*). Meanwhile, directions at rehabilitation and reconstruction are efforts to return to the state system before the disaster (*bounce back*). The content analysis results are shown in the following Table 4.

IV. CONCLUSION

Based on the analysis results and discussion, below the following research conclusions: (1) The social vulnerability index assessment is 2.27 or in the low to middle category, while the preparedness index assessment is 1.99 or in the very low to low category. Then, the social resilience index is obtained by the ratio of preparedness and social vulnerability index. The social resilience index is 0.88 (<1) or categorized as less resilient condition. (2) Social resilience improvement is carried out through the following efforts: (a) Mitigation through relocation, insurance, economic empowerment, health services, resource inventory, risk assessment, application of incentives as a private sector contribution, and mainstreaming the earthquake response in school curriculum, subjects, extracurricular activities, as well as *safety briefings*. (b) Preparedness through issues management, contingency planning, disaster management training and drill, organizing, communication planning, evacuation system planning , emergency facilities management, *media campaign*, strengthening disaster forums, and hospital preparedness planning. (c) Response through financial assistance, reconciliation and conflict resolution during emergencies, activation of warning systems, implementation of integrated communication systems, and *media campaigns* during disasters. (d) Rehabilitation and Reconstruction through the assistance of home improvement, as well as social, economic, cultural, and psychological recovery.

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This research results can be used as a reference by the Surabaya City Government in preparing contingency plans and operations plans for earthquake emergency response. This research focuses on assessment and efforts to increase resilience from the social dimension. Further research is still needed by considering other dimensions of resilience, that are physical, economic, and institutional dimensions. By combining all dimensions, the recommendation for city resilience will more represent and correctly answer problems.

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