Surabaya Resilience Index for Potential Earthquakes: An Institutional Perspective

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Abstract

The earthquake map released by the Indonesian National Earthquake Board in 2017 categorized Surabaya as prone to earthquakes caused by the Kendeng Thrust. In order to anticipate this new threat, this study assesses Surabaya's current earthquake and disaster resiliency. Despite being one of Indonesia's most successful cities, receiving many honours nationally and internationally, Surabaya's institutions still have a mediocre performance in terms of resiliency, with middle-to-high performance for resilience to general disasters and middle-to-low resilience to potential earthquakes. Surabaya has an average performance compared to 19 other cities around the Asia-Pacific; however, Surabaya scores the lowest for mainstreaming potential for earthquakes in public planning indicating that the city has not anticipated this new threat. Thus, Surabaya needs to enhance its resiliency in the near future due to the unidentified risk, response and emergency-centred actions, and limited public documents considering the risk.

Keywords: *Resilience index, Earthquake, Kendeng Thrust, Institution, Risk Management*

Surabaya is the second largest city in Indonesia, with a population of approximately 2.9 million people in 2015 (Surabaya Government, 2017). Surabaya is the capital of East Java Province and is a centre of development with trading, hotels, restaurants, catering, and industrial activities as its economic core. Currently, the growth of the gross regional domestic product of Surabaya is around 6.0% (Surabaya Government, 2017) making it one of the fastest growing cities in Indonesia. This fast growth of economic activities intensifies developments resulting in increased economic performance, driving the migration of people and workers into the city and increasing building developments. From the perspective of risk management, these fast growing phenomena can increase the vulnerability of the city in the near future.

The National Earthquake Centre of Indonesia (Pusat Gempa Nasional; PUSGEN) has released a new version of their earthquake map in which Surabaya has a significantly increased potential earthquake

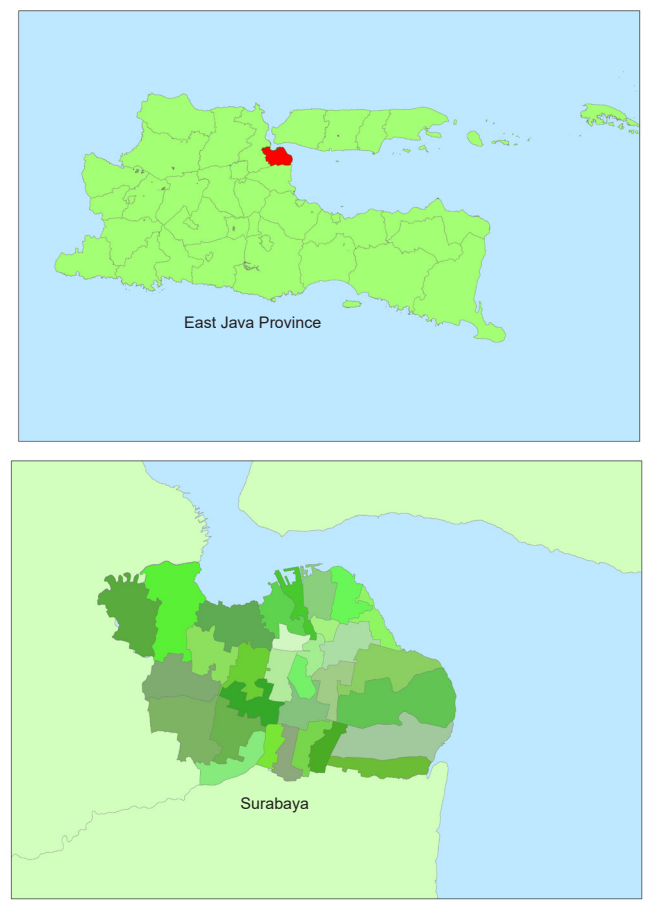

Figure 1. Location of Surabaya City.

threat (Pusat Gempa Nasional, 2017). The velocity of a potential earthquake has been increased from 0.3-0.4 G in 2010 to 0.4-0.5 G in 2017 (Figure 2). Some research related to the increased earthquake potential in Surabaya also mentions that the new *Kendeng Thrust* affects the southern part of Surabaya (Meilano, Susilo, Gunawan, Sarsito, & Abidin, 2016) and could cause a magnitude 6.5-7.5 earthquake (Irsyam, 2016). Furthermore, the potential risk is increased by the soil characteristics of the region which means that the tremors can easily travel from the epicentre to surrounding areas including the city of Surabaya (Solikhin, 2016). These research outputs highlight an increase of potential risk to Surabaya, in particular that of earthquakes.

The new earthquake map, showing that Surabaya is an earthquake-hazard area, and the fast growth of the city increasing vulnerability, leads to an increase in known risk in Surabaya, as risk is a function of vulnerability and hazard exposure (Moe, Gehbauer, Senitz, & Mueller, 2007; Shah Alam Khan, 2008). Disaster risk management uses the concept of resiliency in order to decrease earthquake risk. Resiliency refers to the ability to respond and to recover from stress (Masten et al., 1999; Wagnild & Young, 1993) and is an outcome of current adaptations (Pamungkas, 2013). Three main characteristics of resiliency are the ability to absorb shocks, to bounce back to a previous level or situation, and to improve outcomes in future disaster events via learning and adaptation (Barrett & Constas, 2013).

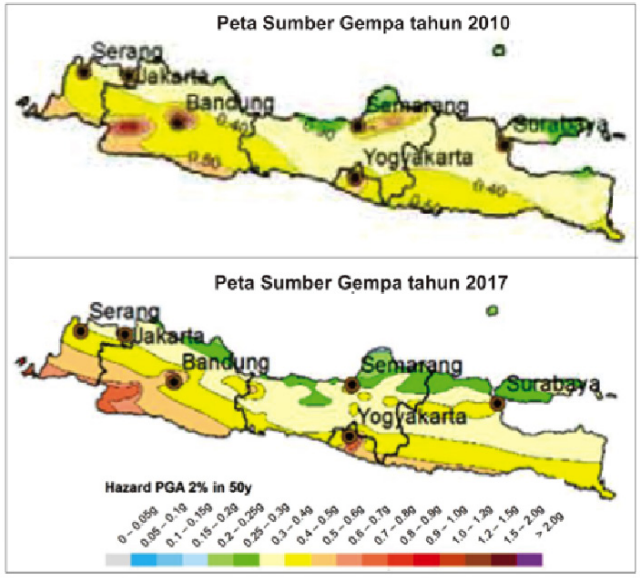

Figure 2. Study output of Peak Ground Acceleration (PGA) and short period acceleration spectral (0.2 seconds) and 1 second with augmentation possibility of 2% in 50 years based on data from 2010 to 2017. From Adjani (2017).

The United Nations in 2012 noted that the financing of US$1 in disaster risk management to enhance resiliency can decrease the cost of emergency response and recovery by US$7 (United Nations, 2012), highlighting the importance of applying the concept of resiliency in managing disaster risks.

In terms of assessing urban resilience, the assessment process is dependent upon the range of indicators and variables involved. This is due to the multi-dimensional nature of the resilience concept which requires many aspects to be taken into consideration. A more complex and wider coverage of indicators and variables leads to a more comprehensive assessment compared to when only using simple and limited coverage indicators and variables. Usamah (2013) identified four key dimensions discussed in the literature concerning resilience: physical, institutional, social, and economic. Although a complex study using a wide coverage of indicators and variables will improve the assessment process, in terms of accuracy, it is unable to uncover detailed information. The Indian Ocean Tsunami Warning System Program (IOTWS; 2007) has provided a resilience assessment scheme weighting and scoring each indicator and variable. Usamah (2013) highlighted similar weighting and scoring assessment processes as a basic calculation method in measuring resilience levels, such as in Cutter et al., (2010), Shaw and Sharma (2011), and Joerin and Shaw (2011). Although these types of weighting and scoring processes are common in resilience assessment, these studies were conducted without any in-depth discussion with the respondents, which is important to ensure that the resilience variables and indicators are correctly defined in terms of the context to which they are being applied. The discussion with participants in the assessment should be supported empirically to confirm the reliability of the weighting and scoring process. Consequently, a combination of quantitative and qualitative methods can increase the level of reliability of a resiliency assessment. This idea is the key concern of this paper.

Assessing the current resiliency level in a region is part of the early stages of developing an integrated approach for future disaster risk management. This first stage is appropriate in this context as the earthquake potential in Surabaya is considered to be a new challenge for future development. In this study, the assessment of resiliency in Surabaya will focus on the institutional aspects of resiliency rather than the whole spectrum of the index. Because there is still hesitancy at the

institutional level about this new earthquake risk, it is important to test resiliency at this level as changes here will have the largest impact. Besides the main objective of the assessment of the resiliency of Surabaya for the new threat (earthquakes), we also conducted an assessment for disasters generally (e.g., flooding) in Surabaya, as the long history of this natural hazard in the region provides a useful reference point of resilience to a well-known risk. A new type of hazard can reduce resiliency due to lack of response by the local government; however, the local government has experience responding to a range of natural hazards generally, in particular floods. Therefore, comparing the results of these two assessments can uncover relevant ideas for disaster risk management programs in Surabaya addressing the increased risk of earthquakes.

Method

The assessment of resiliency can be done in many ways. Since the idea of the assessment is to understand the strengths and weaknesses of Surabaya towards earthquakes, we use the climate and disaster resilience index (CDRI) from Sharma and Shaw (2011) as the main assessment tool. The CDRI assessment process highlights important key factors of resiliency. The use of this index here also enables us to compare Surabaya with other cities around the Asia-Pacific where this index has previously been applied. Therefore, the assessment presented here will follow the guidelines of Sharma and Shaw.

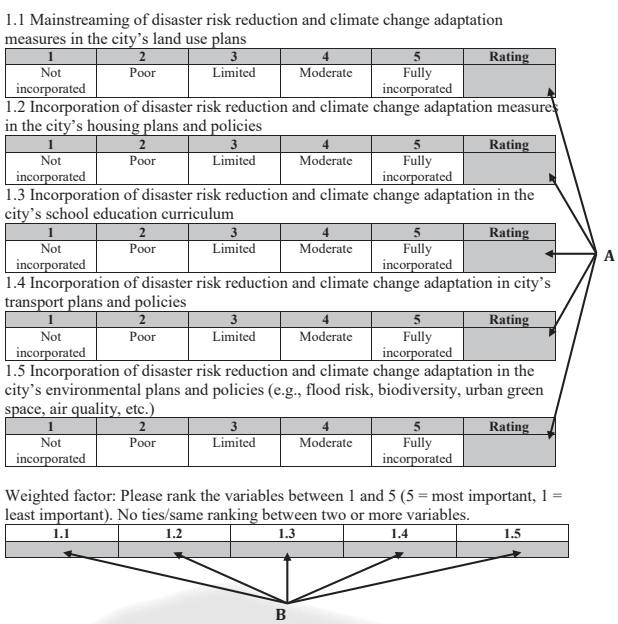

Figure 3. Instrument for assessing the institutional aspect of Surabaya's resiliency to earthquakes. The A shows the performance of each influential variable, while B reflects the importance ranking of variables within an indicator.

The CDRI has five aspects: economic, physical, social, institutional, and environmental (Sharma & Shaw, 2011). Since we focus on the institutional aspect, the main discussion of the resilience level will be around mainstreaming disaster risk reduction to local planning products, the effectiveness of crisis management, knowledge dissemination, institutional collaboration, and good governance. All five indicators were assessed based on the expert opinions of high-profile stakeholders to determine the current resiliency level of Surabaya. Each stakeholder was asked to rate the performance of Surabaya for each indicator. The rating process used Sharma and Shaw's (2011) questionnaire to increase the validity of comparing Surabaya with other cities. Figure 3 shows an example of the questionnaire.

In terms of aggregate value of the index, Sharma and Shaw (2011) provided the simple formula of calculation below;

$$\text{Index value:} \quad = \frac{\sum_{i=1}^{n} w_i x_i}{\sum_{i=1}^{n} w_i} = \frac{(w_1 \times x_1) + (w_2 \times x_2) + (w_3 \times x_3) + (w_4 \times x_4) + (w_5 \times x_5)}{w_1 + w_2 + w_3 + w_4 + w_5}$$

Note:
w = variable rank
x = variable value

Based on the formula above, the index is then categorised into five groups. The division of groups refers to Sharma and Shaw (2011) and is as follows: Very High = 5; High = 4; Middle = 3; Low = 2; and Very Low = 1.

The assessment of Surabaya's resiliency comprises a simple rating process. We took three steps to enhance the quality of assessment and ensure the validity of the self-ratings. First, this study complemented the simple rating process above with interviews to gain an in-depth knowledge of the current situation. The interviews provided insights into the key argumentation by the respondents which was used as a way to confirm the self-ratings.

Second, the respondents' ratings and comments were validated using secondary data (e.g., government publications, media reports). An additional note on the validity of the ratings is that respondents typically gave their assessment as an expert in the field rather than as a representative of a government agency which is responsible for the implementation of resiliency measures in Surabaya. This expert perspective,

combined with validation from secondary data, should improve the objectivity of the ratings. Using both interviews with the respondents and secondary data to support the accuracy of the self-ratings means that a relatively simple rating process such as that used here can demonstrate good validity.

Third, the assessment involved high-ranking respondents who are experts in the field of development in Surabaya. We used purposive sampling to find valid respondents for this study. Furthermore, we selected relevant stakeholders based on their interests and influences (Bryson, 2004; Reed et al., 2009). Table 1 describes the selected stakeholders and their relevancy for this research. We distributed our questionnaires to all nine potential stakeholders, including high-ranking local government officers, a specified national government officer of land and spatial planning, and the chairs of various types of related expert associations (i.e., urban planning, architecture, construction, and geology). From the nine potential stakeholders there were two agencies which did not provide valid responses after several rounds of contact were made: the Disaster Planning Board and Community Protection of Surabaya (BPB-Linmas) and the Housing, Residential, Public Works and Spatial Planning Agency of Surabaya (DPRKPCKTR). However, these are technical agencies with the main task of following through and implementing plans made by the Surabaya Planning Board (Bappeko). The Surabaya Planning Board has full authority over planning and strategic management of the city including for the issue of potential earthquakes. Therefore, the missing stakeholders will not influence the validity of the aggregate responses.

Findings and Discussion

Since earthquakes are a new threat in Surabaya, most of the stakeholders have not yet realised the potential hazard and its impacts. Consequently, before completing the index, the authors explained to the stakeholders about the current findings of Surabaya's earthquake potential. Afterward, the stakeholders were asked to value Surabaya's resilience in two phases: assessing for general disasters and assessing for the specified disaster of earthquakes. The findings presented below

Table 1
Relevant stakeholders in assessing the resiliency of Surabaya to potential earthquakes

Stakeholder	Interest	Influence
Geology expert	A particular concern about geological disasters.	Providing a wide perspective on earthquakes and the thrust.
Ikatan Arsitektur Indonesia – IAI (Indonesian Architecture Association – East Java Chapter)	Designing buildings that are included in the elements at risk.	Providing a wide perspective on designing resilient buildings.
Kamar Dagang dan Industri – KADIN Surabaya (Industry and Trade Chamber – East Java Chapter)	Trading most goods and services including in the property market.	Providing a wide perspective on urban economics and markets of specific goods including the property market.
Pihak Badan Perencanaan Pembangunan Kota – Bappeko (Surabaya Planning Board).	A local government body that is responsible for directing Surabaya's future development.	Authorized to direct the development process in the future.
Pihak Ahli Konstruksi – Construction Expert	A particular concern about constructions.	Providing a wide perspective on building construction and how to make constructions resilient to earthquakes.
Pihak Ikatan Ahli Perencana – IAP (Indonesian Planning Expert – East Java Chapter)	A particular concern about urban development and planning.	Providing a wide perspective on developing urban resilience to disasters.
Departemen Agraria dan Tata Ruang (Department of Agrarian and Spatial Planning)	A national government that has the responsibility to manage spatial planning.	Setting the planning standard for future development.
Badan Penanggulangan Bencana dan Linmas - BPB-LINMAS (Disaster Planning Board and Community Protection of Surabaya)	A local government that has the responsibility to manage risk in Surabaya.	Providing protection for the community in the case of disaster events.
Dinas Perumahan Rakyat dan Kawasan Permukiman Cipta Karya dan Tata Ruang (Housing, Residential, Public Works and Spatial Planning Agency of Surabaya-DPRKPCKTR)	A local government that has the responsibility to ensure the development process is in line with future challenges and standards.	Progressing the development proposals.

are based on a combination of self-ratings (corroborated by interviews) and secondary data.

Surabaya's Resiliency for General Disaster based on its Institutional Aspects

Surabaya has a high level of resiliency with an index value of 4.02 out of 5 for general disaster (see Figure 4). The knowledge dissemination and management indicator had the highest performance (4.55), while mainstreaming of disaster risk reduction performed the lowest (3.45). Based on the interviews, all stakeholders' responses are mainly focused on reducing flood risk. A long history of flooding has therefore likely contributed to Surabaya's high resiliency from an institutional perspective.

Disaster response is a key strength of Surabaya's disaster risk management. Even though Surabaya has just formed its local disaster board in January 2017 under the Mayoral Regulation No. 72 in 2016, the existence of BPB-Linmas, a board for community protection, significantly contributes to minimising the impacts of disasters. Effendi (2017) expressed that the BPB-Limnas has roles not only in disaster recovery but also in educating, socialising, and simulating community responses in times of disaster. The Surabaya Government also conducted disaster awareness training such as disaster rehabilitation and reconstruction for 40 local agencies on June 8th, 2017 in Tambaksari District, Surabaya (Surabaya.go.id, 2017). Furthermore, Surabaya also showed a special concern for its disaster response by establishing five fully-staffed emergency centres (Nurwawati, 2017).

Strong leadership by the mayor is also one of the key aspects of Surabaya's successful disaster response. Strong leadership is required for minimising the impact of disasters, and is one of the critical components in risk management (Awalia, Mappamiring, & Aksa, 2015; Baas, Ramasamy, Dey de Pryck, & Battista, 2008). Multiple cases have shown that the strong leadership of Surabaya's mayor has minimized the impacts of disasters in Surabaya (Detiknews, 2015; Hidayat, 2013; Zahro, 2017).

Surabaya's Resiliency for Potential Earthquakes from the Institutional Perspective

Compared to the high level of institutional resilience for general disasters, Surabaya has a low index for responding to potential earthquakes with a total score of 2.58 (Figure 5). Knowledge dissemination and management again scored the highest while mainstreaming of disaster risk reduction was the indicator with the lowest score. One of the major causes for the low index score is the fact that earthquakes are a new potential threat in Surabaya. The new map of earthquake risk released by PUGSEN (2017), showed that the threat to which Surabaya is prone is significantly higher than previous estimates. This new threat is not yet fully understood by stakeholders in Surabaya resulting in a lack of specific responses from the institutions to reduce the impacts of potential earthquakes. Figure 5 describes the level of performance for each variable of the institutional aspect of resiliency.

The resilience concept can be used to understand disaster preparedness. The core resilience components of bouncing back, absorbing shocks/stress, and adaptation from learning reflect preparedness towards potential future hazards. After comparing Surabaya's resiliency to general disasters and to potential

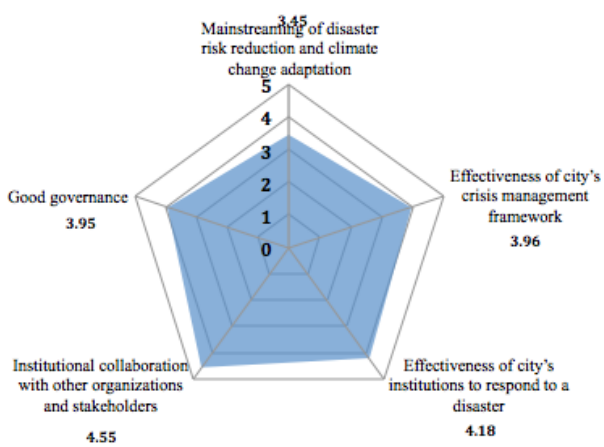

Figure 4. Resilience index for Surabaya's institutional performance in general disasters.

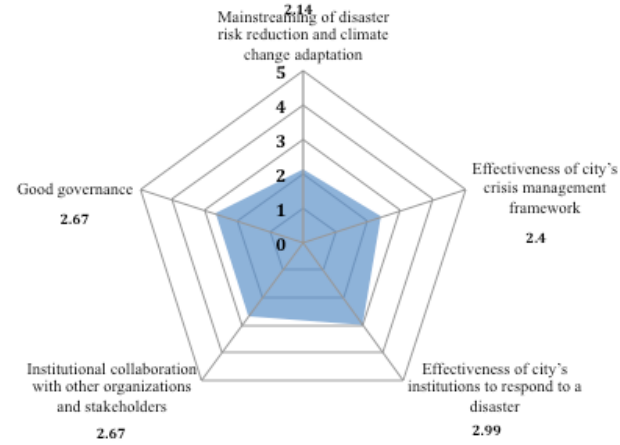

Figure 5. Resilience index for Surabaya's institutional performance in potential earthquakes.

earthquakes, we can see that Surabaya is not as prepared for potential earthquakes as it is for other, more well-known and understood hazards such as flooding. This low level of preparedness can lead to potentially high impacts for the city as the Kendeng Thrust is an active fault. Recent earthquakes around the northern part of Java (such as in Madura, 20 February 2017) confirms the earthquake potential posed by the active Kendeng Thrust (see Table 2).

Table 2
Earthquake events around Kendeng Thrust between 1900 and 2016

No.	Date	Depth (km)	Location	Magnitude
1.	27 July 1984	33.00	Bojonegoro	4.7
2.	14 May 1992	33.00	Java Sea (South of Madura)	4.7
3.	28 July 2006	10.00	Grobokan	4.5
4.	24 January 2007	35.00	Bojonegoro	4.3
5.	28 February 2015	44.06	Java Sea (South of Madura)	4.1
6.	25 June 2015	9.77	Bojonegoro	4.3
7.	4 November 2016	17.87	Ngawi	4.7
8.	20 February 2017	10.00	Madura	3.7

The total score for mainstreaming disaster risk reduction is 2.14, which means that there is little integration of earthquake risk management into government plans. The level of integration is the lowest for incorporating risk into housing plans (1.68), while the highest performance is for incorporating risk into environmental plans (2.94; Figure 6). If we compare these numbers to general disasters, mainstreaming disaster risk reduction is one of the weaknesses of Surabaya's risk management. For general disasters, mainstreaming disaster risk reduction scored between 2.50 (integrating risk into schools' curriculum) and 3.92 (integrating risk into land use plan). The biggest gap in scores is between general disasters and earthquakes in land use and housing plans and policies. The unidentified potential for earthquakes has led to this risk not being included in spatial plans. Meanwhile, other risks which have been identified and assessed by the stakeholders are incorporated in the spatial plans, thus resulting in a higher index score.

The main reason for the lack of integration of earthquake risk into disaster risk reduction is because previously there had been no identification of a potential disaster in Surabaya caused by an earthquake. Most stakeholders explained that earthquake potential had not been anticipated, and thus it had not been included in current public documents, especially in various development plans. The Surabaya Regional Spatial Plan of 2016 only mentions earthquakes as one of the hazards posed to the area with no further regulations discussing the consequences of this on spatial plans (Regional Regulation No. 12 in 2014). The limited coverage of risks in the plans can also be seen from the following comment:

> ... Sudah, sudah tergabung baik. Waktu yang di RTRW kemarin kan memang kita menyoroti karena masih framing-nya ke banjir sama kebakaran… Terus yang di RPJMD kemarin ya memang untuk yang gempa nggak spesifik disebutkan, tapi juga sudah ada gambaran... Masih terbatas kayaknya... … [disaster risk] has been very well integrated. For RTRW [the Surabaya Regional Spatial Plan], we highlighted [disaster] with special concern on flooding and fire… Then, in RPJMD [the Medium-Term Development Plan], earthquakes are not specifically mentioned, but there are some descriptions [on it] … [its discussion] still limited… (Bappeko).

Incorporating disasters in land use plans is also a new challenge in Indonesia. The national regulation does not properly define how to incorporate risk into the spatial plan. In the future regulation (as it is still in the draft version), the disaster-prone areas will be classified into protected areas, which is insufficient in terms of disaster risk management.

> … di pedoman yang baru, kita sudah masukkan konsep itu. Jadikan letak lokasi rawan bencana itu kan ya sebuah output ya, pola ruang lindung berarti ya. … in our new guideline [the draft version], we already considered that [disaster risk management] concept.

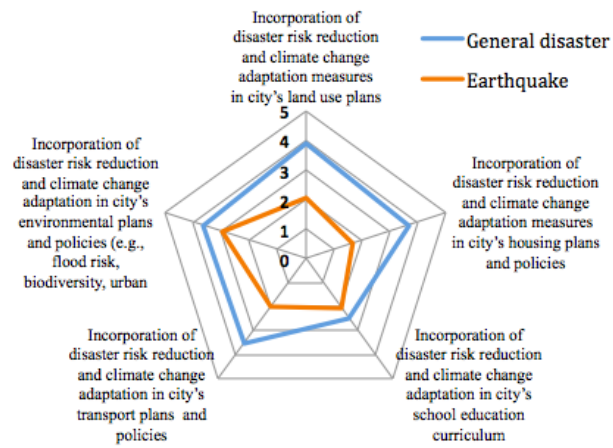

Figure 6. Surabaya's level of mainstreaming of disaster risk reduction and climate change adaptation.

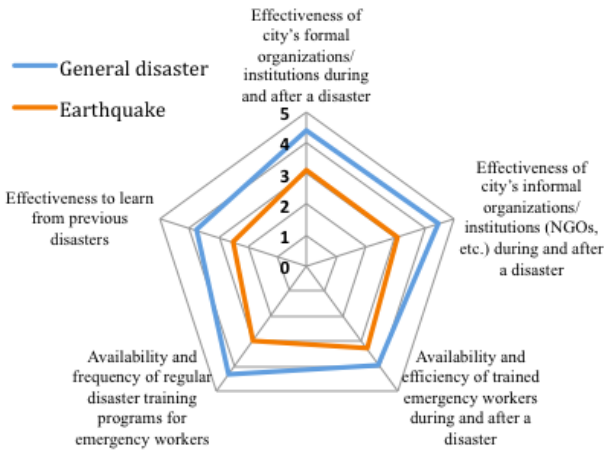

Figure 7. Level of effectiveness of the crisis management framework in Surabaya.

> [We] define the location for disaster prone areas as the output of the plan, thus [as] protected zones. (ATR).

Surabaya's crisis management indicator of earthquake resilience is still low, at only 2.40 out of 5. Among the variables in the indicator, the existence and effectiveness of emergency teams during a disaster has the highest score (3.27). BPB-Linmas, formerly named Bakesbanglinmas, is the central government agency in charge of emergency situations. The agency coordinates the relevant agencies to minimise the impact of disaster events. A long history of disaster risk management focusing on disaster response leads to a relatively good level of emergency team performance.

> Kalau secara keseluruhan masih baik. Overall [emergency response] is still good.] (Geology expert).

> Gempa kayaknya masih nomor 2 [nilai rendah], mungkin... Hampir semua [semua indikator rendah]. For earthquakes, [Surabaya is] still number 2 [low level], probably … almost all of them [most variables have low performance]. (Construction Expert)

Furthermore, strong leadership of the mayor is also key to successful emergency actions. Consequently, in terms of general disasters, the effectiveness of the disaster management plan and the emergency team are valued high (Figure 7). The 'overly' strong leadership can however lead to the belief that it is a 'one-man show', which causes the destabilization of the emergency system for the city. Therefore, the Surabaya Government is still pushing to put into place an emergency system which includes providing an emergency call service via a partnership between Surabaya City and the Ministry of Communication and Information (Putri, 2015), establishing a command centre (Liputan6, 2017), and providing CCTV for most major roads (Surya, 2017). Learning about earthquake characteristics and impacts is the initial step for preparing an effective response to a potential earthquake for all parties in Surabaya. A newly established cooperation between the Centre for Earth, Disaster, and Climate Change (PSKBPI - Pusat Studi Kebumian, Bencana dan Perubahan Iklim) and the Surabaya Disaster Management Board (BPBL) has been formed to develop a roadmap for earthquake risk management. Besides this, there are other efforts such as campaigning by an ITS team with BPBL (Figure 8) to key stakeholders in every district of Surabaya to raise awareness of the existence of the Kendeng Thrust and its impacts.

The lowest performance in crisis management is the incorporation of the uncertainties of climate change in

Figure 8. Collaboration between ITS team and BPBL in an Earthquake Awareness Campaign (own photo).

the disaster management plan. Although earthquakes are unrelated to climate change, the idea of uncertainties in the future is applied in this assessment. The score for incorporating uncertainties for future challenges is low because the main concern of the government is only on short to medium-term development, due to the current political circumstances.

Institutional collaboration in potential earthquake events also has a low performance (Figure 9). The institutional collaboration between the city and the national government during and after a disaster and the extent of dependency on external institutions and support in response and recovery were rated the highest, at 2.81 and 2.85 respectively. The variable of interconnectedness, which refers to networking and collaboration with neighbouring cities for emergency management during and after a disaster was rated the lowest at only 2.24 out of 5. When compared to the higher resilience scores for general disasters, these findings suggest that the lack of understanding of the previously unidentified earthquake risk is the main cause for having a low performance in collaboration for potential earthquakes.

> Ada [program pelatihan untuk para pekerja kedaruratan]... Kan memang masing-masing UPD yang menangani ini secara reguler sudah disiapkan rencana dan anggaran untuk training mereka. There is [a training program for emergency teams]… every local government agency deals with this [risk management] regularly, planning and budgeting has been prepared for their training. (Bappeko) Kalo gempa ya belum [efektifitas lembaga atau organisasi formal kota selama dan sesudah bencana]. For earthquakes, [formal organizations] are not yet ready [since it is newly identified]. (Geology Expert).

In terms of collaboration, strong NGO involvement and partnerships with neighbouring municipalities in responding to flooding have been a good example, as well as a good resource, for facing potential earthquakes in the future. A call centre (Putri, 2015) and the partnership between Surabaya and the Netherlands (Riski, 2014) are two examples of good partnerships between Surabaya City and other units and organisations.

In terms of good governance, the lowest performance is for the existence and frequency of drills for disaster scenarios led by the city government (2.40; Figure 10). Most stakeholders have the same opinion that governance is not yet at a good level because of unidentified risks, incompatibility of the local disaster organizational structure with the organizations in provincial and national levels, and unsupportive conditions of emergency situations.

> Yang banjir kita sudah siapkan [Early Warning System]. Yang gempa belum (Bappeko, 03/09/2017). For flooding, we have prepared [the Early Warning System]. For earthquakes, [we] have not yet. (Bappeko).
>
> Dulu sebelum kita punya BPBD itu dari provinsi dan dari nasional itu mau membantu kita itu agak sulit, bukan agak sulit, gak bisa… Nah karena nggak ada BPBD di Surabaya mereka mau mengintervensi itu agak susah, menjadi gak bisa (Bappeko, 03/09/2017). In the past before [Surabaya] BPBD [local disaster board] was founded, support from provincial and

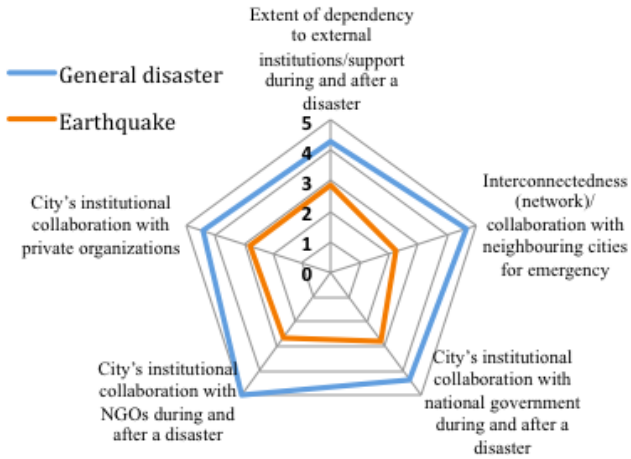

Figure 9. Institutional collaboration with other organizations and stakeholders.

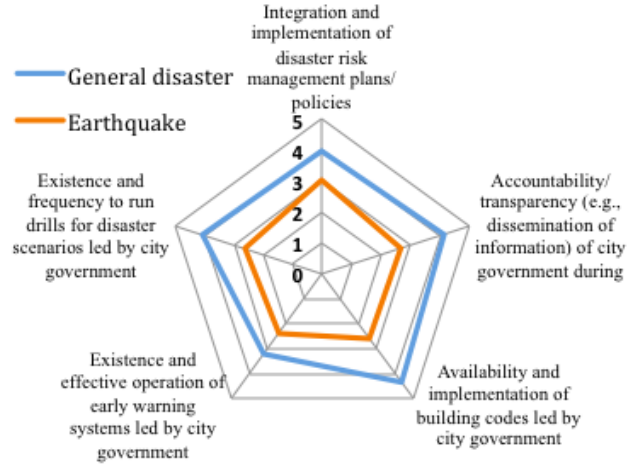

Figure 10. Scores for disaster-related governance in Surabaya, with higher scores indicating better governance.

> national level is hardly executed, not hardly executed, [but] impossible to be executed… Because there was no BPBD in Surabaya this made them [provincial and national BPBD] hard to support, more like cannot support [BPBD in Surabaya] (Bappeko).
>
> Ini, ini nih yang kadang nggak transparansi. Masalah bantuan katakanlah itu ya, itu kan bagian bagaimana distribusinya kita nggak... nggak tau gitu lho maksudnya. Buruk. This, sometimes there is no transparency. The problem is, let's say, disaster aids, in the distribution part, we do not know [cannot fully trace the distribution aids process]. Bad [practices]. (ATR).

Within the good governance indicator for resilience to general disasters, the existence and effective operation of early warning systems by the city government had the lowest position, although it is still at a mid-level performance (3.20). This is similar to the findings for earthquake resilience, where the same variable scored the lowest. As we would expect the score to be lower for earthquakes, which has not been a known risk for long enough for systems to be developed, these findings suggest that the current disaster early warning system in Surabaya needs improvement. For example, Surabaya should provide a more advanced system by incorporating an information system in disaster response as discussed in crisis management.

Surabaya's Resiliency in Relation to Other Cities

The resiliency index of 19 cities around the Asia-Pacific has been examined using the same questionnaire. Thus, we can compare Surabaya's index with these other cities as in Figure 11. From an institutional perspective,

Figure 11. Position of Surabaya's resilience score for general disasters compared to 19 Cities in the Asia-Pacific region. Adapted from Asharose (2015), Kyoto University, CITYNET, UNU, UNISDR, and RFT-URR (2009), and Sharma and Shaw (2011)

Surabaya still needs to enhance its resiliency for both general disasters and especially for potential earthquakes. The current achievements in Surabaya's development both nationally and internationally cannot guarantee that Surabaya will excel in resiliency. Some critiques made by the local stakeholders are that disaster risk management in Surabaya focuses on emergency situations, while there is limited integration with public planning processes. Moreover, the bureaucratic culture focuses only on short-term outputs, lacks the understanding of potential earthquake risks, and only focuses on selected disaster types. This is true not only for the case of Surabaya but many major cities in Indonesia which face significant challenges in harmonizing development pressure with potential future risks. Despite these challenges, the resiliency of Surabaya needs enhancement to ensure that its inhabitants risk from disasters, especially potential earthquakes, is reduced.

Conclusion

Based on the new earthquake map from the Indonesian National Earthquake Centre in 2017 (Public Works Ministry, 2018) which identifies the threat of the Kendeng Thrust, Surabaya is now deemed at risk of a damaging earthquake. Furthermore, the rapid developments in Surabaya increase its elements at risk resulting in high vulnerability in the city. Surabaya's risk from a potential earthquake is likely to increase significantly as this development continues.

As a means to anticipate the risk, the assessment of resiliency is the first step to identify the weaknesses of the city in facing potential threats such as earthquakes. After assessing resiliency using the CDRI, we found that the success of Surabaya's development has not yet increased its resiliency. In terms of responding to general disasters, Surabaya has middle to high resilience. Unfortunately, its performance decreases for responding to potential earthquakes, with middle to low performance. Among the indicators of resiliency from an institutional perspective, mainstreaming disaster risk in public planning is Surabaya's greatest weakness. From the variables of all indicators, the three greatest weaknesses are: the incorporation of disaster risk reduction and climate change adaptation measures in the city's housing plans and policies, the existence and effectiveness of the city's disaster management plan, and the incorporation of uncertainties in disaster management plans.

Since mainstreaming disaster risk in public planning has the lowest index score, discussing the new earthquake map and its impact to the stakeholders in Surabaya is critical. The PSKBP-ITS team started risk conversation via public media, social media, advocacy to government officers, and scientific meetings in 2017. These strategies have resulted in a positive response from the local government. In 2018, the ITS team had ongoing discussions with BPB-Linmas on making a roadmap to increase urban resilience to earthquakes. Bappeko and DPRKPCKTR also responded positively. These two local agencies had intensive discussions with the ITS team to integrate the potential earthquake risk into their spatial planning products such as the Surabaya Regional Plan No. 12 in 2014 (which was evaluated in 2018) and the Detailed Spatial Plan (which was legalised in 2018).

Since the rating assessment process has limitations on its validity, a more confident rating process was attained by including high-profile respondents who were involved in their capacity as experts in the field, rather than as representatives of particular agencies which could lead to biases and using interviews to understand the reasons for their ratings and thereby increase their validity. Further, the respondents' comments are clarified with objective information from secondary data. Therefore, the final score for every variable and indicator was defined more confidently than in previous studies simply applying subjective ratings on resiliency indices.

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