Assessment of disaster resilience in Semarang City

L. Narieswari¹,², S R P Sitorus¹, H Hardjomidjojo¹, E I K Putri¹

¹Natural Resource and Environmental Management, IPB University, Kampus IPB Dramaga Bogor 16680 West Java, Indonesia
²Geospatial Information Agency (BIG), Jl. Raya Jakarta-Bogor Km. 46, Cibinong, Bogor 16911, West Java, Indonesia

E-mail: santunrps@gmail.com

Abstract. In order to build a resilient city, it is crucial to assess the current level of resilience as a baseline measurement. This study assesses the progress and status resilience building of Semarang City using a disaster resilience scorecard for cities developed by The United Nations Office for Disaster Risk Reduction (UNDRR) at the preliminary level. The scorecard assesses disaster resilience by considering Ten Essentials for Making Cities Resilient, as an operational framework of Sendai framework for disaster reduction (2015 – 2030), at the local level. The scorecard has 47 criteria, scoring between 0 to 3 where 0 representing little or no awareness and 3 representing full integration of disaster risk reduction (DRR). The finding shows that Semarang has an overall score of 69 out of 141. The analysis suggests that assign a budget for DRR and incentives to increase financial capacity, apply and enforce risk compliant building regulations and land use planning, invest and maintain critical infrastructure, and provide comprehensive post-event recovery plans needs to be improved and prioritized in disaster risk reduction toward a more resilient and safer city.

1. Introduction

The city is a complex system. It involves social, economic, and ecological factors, where many objects and processes are interrelated in space and time. Cities become vulnerable when one subsystem does not work, is damaged, or fails to adapt to new challenges [1–3]. If this situation is not handled properly, it could be fatal or devastating [1–3]. Uncertainty factors such as climate change, natural disasters, uncontrolled population, housing, transportation have a very important role in threatening urban development [4]. This is no exception to Semarang City. The unique topography of Semarang, which is mountainous in the southern suburban part but also having coastal areas in northern urban sides, causes many challenges related to water security. Climate change and urbanization are increasing the risk of cities from flooding in the mountains and the sea. In addition, long-term groundwater extraction causes land subsidence and threatens the availability of freshwater sources [5–10]. The incidence of disasters in Semarang also tends to increase, from 152 disasters in 2016, each year increasing to 355 incidents in 2019 [11]. Strategies are needed to increase resilience for a sustainable city to avoid unintended impacts due to disasters. Disaster resilience is the ability of a system, community, or community exposed to hazards to withstand, absorb, accommodate, adapt, modify, and recover from the effects of harm in a timely and efficient manner [15].

Considering the magnitude of the impact of climate change and natural disasters, it is important to carry out an assessment of the level of disaster risk, especially in urban areas. A good understanding of risks will greatly assist the government as a stakeholder in determining comprehensive policies to minimize the negative impact of disasters. Understanding of risk should be followed up with an
assessment of the level of resilience to disasters [12–14]. This paper aims to assess the progress and status of Semarang city resilience development, which can be used as a benchmark in an effort to increase the resilience of the city in ensuring sustainable development.

2. Methods
The study was held in Semarang Municipality. In the disaster aspect, Semarang City is prone to several hazards. The Semarang City Government has identified several conditions that pose urban risks, including the danger of urban disasters: floods (river and tidal floods), land subsidence, sea-level rise, landslides, fires, strong winds, and drought [5,6,16]. The hazards that have the greatest impact are flooding, land subsidence, and sea-level rise.

A disaster resilience scorecard for cities (scorecard) was used to assess the current status of disaster resilience in Semarang City. The scorecard assesses disaster resilience by considering Ten Essentials for Making Cities Resilient. The Ten Essentials for Making Cities Resilience is developed as an operational implementation of the Sendai Framework for Disaster Risk Reduction (2015-2030) at the local level. Its indicators are used to monitor actions on disaster risk reduction (DRR). The scorecard has 47 indicators. Each indicator was represented in the question, and each question has 3 choices of answers between 0–3. Score 0 representing little or no awareness, understanding, and streaming disaster risk within the city. Score 3 representing a condition where the city applied full integration of risk reduction and resilience into planning and development processes. The maximum possible scores are 141. Since each essential has different indicator numbers, the maximum possible scores for each essential will also be different. Essential 1 has 3 indicators, the maximum possible score is 9. Similarly, the maximum possible score for essential 8 is 27 as it has 9 indicators.

The assessment was based on a literature review, in-depth interview, and secondary data collected from any institution related to resilience building (table 1). The institutions are Regional Disaster Management Agency (BPBD), Statistic of Semarang (BPS), Semarang development planning board (Bappeda), Semarang health office (Dinas Kesehatan), Semarang public work office (Dinas Pekerjaan Umum), Semarang environmental office (Dinas Lingkungan Hidup), Semarang regional planning office (Dinas Penataan Ruang), Semarang communication and informatics office (Dinas Kominfo), Education office (Dinas Pendidikan), National Electrical Power Company (PLN), Local drinking water company (PDAM), and Diponegoro University. Interview and data collection were held around February – September 2020. That information was used to justify indicators scores for each essential about the current condition of the city which suitable with score choices. The answer to each question was based on justification made from information taken from an in-depth interview with a key person from multiple stakeholders who know the subject asked and verified using secondary data from institutions related to indicators. The answer is computed in tools (excel-based) provided by UNDRR to calculate the score. The results are overall and an essential score described in diagrams.

3. Results and discussion
The Ten Essentials offer a wide coverage of many issues that the city needs to be addressed to become more disaster resilient. It covers governance and financial capacity, many dimensions of planning and disaster preparation, and the disaster response itself and post-event disaster [17]. The scorecard can be interpreted as two sets of interventions to build urban disaster resilience. The first is institutional concerns; the second, physical and environmental matters. The assessment finds that the overall score of the scorecard is 69 out of 141. The grey area is the maximum possible score, and the result of the assessment is drawn in the blue area of the diagram (figure 1). The blue area described the actual score or how is the city doing on resilience building. The diagram shows the achievement and the gap for improvement to achieve maximum resilience. The result can help the decision-maker to see the weak and the strength area of the city and decide what could be the priority area that should be the focus on the next round of risk reduction planning.
| Essential                                                                 | Data/Information                                                                 | Sources                        |
|--------------------------------------------------------------------------|----------------------------------------------------------------------------------|-------------------------------|
| Organize for disaster resilience                                         | Disaster management plan 2018-2023, Disaster risk assessment document 2018-2022, DRR action plan 2019-2023, Logical framework of the disaster management plan, DRR organization charts | BPBD, Bappeda, Regional planning office |
| Identify, understand, and use current and future risk scenarios          | Risk, hazard, and vulnerability maps, statistics on local hazards, exposure, and vulnerabilities Infrastructure assets maps, risk information, damage estimation, sharing risk assessment documents (online) | BPBD                           |
| Strengthen financial capability for resilience                           | Budgetary documents, disaster risk management plan, contingency plans,           | Bappeda, BPBD                 |
| Pursue resilient urban development and design                            | Regional Regulation No. 14/2011 concerning Semarang spatial planning 2011-2031, policies on locations for new development, Minimum services standards, planning and building regulation, housing development plans (RP3KP) | Bappeda, BPBD                 |
| Safeguard natural buffers to enhance the protective functions offered by natural capital | General knowledge and information on the ecosystem and its protective function, RTH, landslide handling, protective area, biological database, greenhouse gas, waste management, green open space, Semarang Mayor Regulation No 24/2019 on Green building, river restoration | Environmental office, DPU, PDAM |
| Strengthen institutional capacity for resilience                         | Education program on DRR, news program related to disaster risk information, city data on population, demographics, vulnerabilities, flooding, a disaster even record, SEMARISK, volunteer list, training program | BPBD, BPS                     |
| Understand and strengthen societal capacity for resilience               | Media channels used (social media, mobile device), mobile application for disaster event report and Semarang disaster system information, Kelurahan Siaga Bencana, Kelurahan Tangguh Bencana, Lapor Hendi | BPBD, city’s office, Diskominfo |
| Increase infrastructure resilience                                       | Document related to lose and damage critical assets during the past disaster, school affected by disaster | BPBD, Education office         |
| Ensure effective disaster response                                       | EWS data, SOP for early warning, disaster management, preparedness plan, document or database of staffing capabilities, records of simulation, database on volunteers, documents or database equipment needed for emergency response, availability of equipment. | BPBD                           |
| Expedite recovery and build back better                                  | Rapid damage and need assessment, SOP recovery plan                              | BPBD                           |
Figure 1. The overall score of the assessment.

The diagram can be used to compare the result across essentials. It can be seen that Semarang City does quite well in essential 1, 2, 5, 6, 7, and 9, but it does not do well in essential 3, 4, 8, and 10. The city did quite well in strengthening institutional capacity for resilience by scoring 12 out of 18 (essential 6). Achieved a score of 6 out of 9 in protecting the natural ecosystem (essential 5). Similarly, achieved halfway to the maximum resilience by scoring 5 out of 9, 10 out of 15, 6 out of 16, and 12 out of 21, for organizing disaster resilience (essential 1), understanding future risk scenario (essential 2), strengthen societal capacity (essential 7), and ensuring effective disaster response (essential 9) respectively.

The city’s achievement in strengthening financial capacity for resilience (essential 3) is still low as it scored 3 out of 12. The city also lacks in applying and enforcing building regulation and land use planning (essential 4), which score 5 out of 12. Societal capacity scored regarding to infrastructure resilience as in essential 8, the city still needs to improve the efforts to invest and maintain the critical infrastructure which reduces risk, as it scores 8 out of 27. The city has not been done sustained effort in the post-event recovery and reconstruction strategy and only scored 1 out of a maximum possible score of 6 (essential 10). Those essentials need to be improved and be prioritized in urban development to increase disaster resilience.

Besides comparing it across essential, the result can also be used to compare it within essential (figure 2). The diagram shows what the resilience issue is by looking into detail of each question within the essential. Organizing disaster resilience, essential 1, is measured in terms of plan making, organization, coordination and participation, and integration (figure 2a). The city already implemented a DRR plan. However, the score for the DRR plan is still low, implying the need to improve the plan into a fully integrated DRR plan, full Sendai Framework, and coverage across all of the Ten Essentials.

Regarding risk scenario in essential 2 (figure 2b), each indicator (hazard assessment, knowledge of exposure and vulnerability, shared understanding of infrastructure risk, and availability of data and hazard maps) relatively have a good score, indicating that the city identifies and understand current risk. However, the score for cascading impacts is still low implying the need to improve the collective understanding of cascading impacts under numerous disaster scenarios.
Figure 2. Score by essential (a) organize for disaster resilience, (b) identify, understand future risk scenarios, (c) strengthen financial capability, (d) pursue resilient urban development, (e) safeguard natural buffer, (f) strengthen institutional capacity, (g) understanding and strengthen societal capacity, (h) increase infrastructure resilience, (i) ensure effective disaster, (j) expedite recovery and build back better.
Financial capacity of the city showing little or no awareness regarding the financial plan as well as contingency funds. The city is aware of various ways of attracting new investment to secure funding for DRR activities. However, there is no co-ordinated fund arrangement between agencies or organizations for local DRR. The contingency plan is only available for floods. Insurance and incentives were scored 0, due to low incentives and insurance cover exist in the city (figure 2c). Therefore, strengthen financial capacity needs to be prioritized in the next round of risk reduction planning. The efforts are assuring insurance which covers across all sectors and raising engagement of the multi-stakeholders and community in resilience building, by giving any incentive across all sectors to increase resilience. Furthermore, the city needs to have a comprehensive financial plan concerning DRR, including contingency plans.

In terms of pursuing resilient urban development, essential 4 (figure 2d), the city does quite well in land use zoning and new urban development. It indicates that the city already has adequate policy and regulation regarding city zoning and land use planning. However, the application of zoning, building codes, and the standard is still inconsistent. It implies the need to give more effort in enforcing and verifying the application of zoning rules properly. Similarly, for essential 5 (figure 2e), the city has done a fine job of understanding the ecosystem functions, promoting blue and green infrastructure on urban development, and managing natural assets beyond administrative borders. Each indicator is scored 2, indicates that the city is concerned about protecting ecosystems and natural buffers to mitigate hazards.

Concerning institutional capacity, Semarang city has done a great job in data sharing. Semarang city has a data portal which enables data sharing between organizations involved with the city’s resilience. This indicator scored 3 (figure 2f). The average score for each indicator for essential 6 is 2. It indicates the city concerns in strengthening institutional capacity by ensuring that the resource needed for pre-event planning, during and post-event response are capable, and education and training on DRR are in place.

Indicators consider assessing social capacity (essential 7) are a community organization, social networks, private sector/employers, and citizen engagement (figure 2g). Semarang has moderate awareness of community organization and social network (score 2) and a high level of citizen engagement (score 3) as the city already engage multiple media channel to communicate concerning DRR. Besides social media, radio, newspapers, the city also developed a mobile device application that enables an alert and disaster information system called SEMARISK. The private sector scored the lowest (1). The proportion of business that has a documented business continuity plan is very low due to no applied regulation concerning the matter.

Regarding infrastructure resilience, most of the indicators have a relatively low score (figure 2h). Protective infrastructure has the highest score (2), showing that protective infrastructure was built in place to reduce the disaster risk in most cases. Examples of protective infrastructure in Semarang are Banjir Kanal and a water retention pond called polder. Those infrastructures are preventing the city from flood and waterlogging. Water-potable sanitation and education have the lowest score (0). It indicates that significant loss of service in sanitation probably happens and a high percentage of education structure is at risk in the most probable disaster event.

Essential 9 is assessed in terms of early warning, event management plans, staffing, equipment, and relief supply needs, food, shelter and fuel supply, interoperability and inter-agency working, and drills (figure 2i). The early warning indicator has the lowest score, due to the low proportion of the population that can be reached by the early warning system (EWS). The city has just installed 5 flood EWS and 1 landslide EWS. Staffing and equipment scored perfectly since the capacity of the responsible disaster management authority are sufficient to respond to a disaster event. The equipment and supply need also well-defined and taking into account the role of volunteers. Drills inconsistently are done even though annually planned. A comprehensive disaster management plan is existed, prepared by the responsible disaster authority. Regarding inter-agency working, the city already initialized a forum for DRR with participation from all relevant agencies.

Lastly, both indicators in essential 10 scored 1 (figure 2j). The city has not prepared enough to cope with the post-event recovery and reconstruction. Several plans related to disaster recovery are available, but they are not comprehensive. BPBD and some institutions have prepared standard operating for a
recovery plan, but they have not coordinated. Similarly, the lesson learned indicator has not been implemented systematically [1].

The assessment using the scorecard provides a baseline to measure the current state of disaster resilience at the local level. The results of these assessments can be used by leaders to ascertain which essential they are weakest, and use those as a basis for targeted interventions for improvement. Based on the assessment scorecard, the priority for disaster resilience development in Semarang City is financial capacity, implementation and enforcement in land use planning, investment and maintenance on critical infrastructure, and provide comprehensive post-event recovery plans. This is in line with the regional capacity index document published by [1], which comprises the priority of Semarang city development which mainstreaming disaster aspects. In this document, the main priority for the development of Semarang City is spatial planning based on disaster risk reduction, increasing the effectiveness of disaster prevention and mitigation, disaster emergency preparedness and management, and development of a disaster recovery system [1]. DRR-based spatial planning must be supported by related rules. Infrastructure development priorities are also supported by research related to the disaster resilience index in Semarang City which states that infrastructure is a very influencing factor in urban disaster resilience.

This study is an initial step in measuring the baseline to assess urban disaster resilience in Semarang City. The assessment still needs improvements to ensure an accurate result. For instance, due to the availability of the literature, secondary data, and a limited number of key persons interviewed, the justification of the score may lead to bias. To ensure a more accurate assessment, the result needs to be followed up in a workshop base by engaging a multi-sectoral and multi-stakeholder to get an average or consensus score of each essential which will reduce any bias. The key is to ensure that multi-stakeholders are engaged in the assessment process to help widen understanding and conversation for collaborative action.

4. Conclusion
The paper presents an assessment of the existed level of resilience building of Semarang City. The resilient status assessed using a disaster resilience scorecard for cities developed by The United Nations Office for Disaster Risk Reduction (UNDRR) at the preliminary level. The scorecard is applicable to any local government including Semarang City. The score for each essential is justified based on the result of an interview with key persons who know the subject representatives from government institutions and academies, secondary data, and literature review.

The finding shows that Semarang has an overall score of 69 out of 141. Semarang city has moderate resilience-building progress. The city has shown good performance in essentials related to organize resilience, identify and understand risk reduction, protect the ecosystem and natural buffers, ensure the data, education program, and training are in place, and install early warning systems and emergency management capacities. Essentials that need to be improved to achieve maximum resilience are: assign a budget for DRR and incentives to increase financial capacity, apply and enforce risk-compliant building regulations and land use planning, invest and maintain critical infrastructure, and provide comprehensive post-event recovery plans. The scorecard helps to understand the potential areas of improvement and highlights where certain types of programs could best enhance disaster resilience. The result can aid the leader identified what is weak and needs to be prioritizing.

References
[1] Zhang X and Li H 2018 Urban resilience and urban sustainability: What we know and what do not know? Cities 72 141–8
[2] Wang Y, Shen J, Xiang W and Wang J Q 2018 Identifying characteristics of resilient urban communities through a case study method J. Urban Manag. 7 141–51
[3] Cai H, Lam N S N, Qiang Y, Zou L, Correll R M and Mihunov V 2018 A synthesis of disaster resilience measurement methods and indices Int. J. Disaster Risk Reduct. 31 844–55
[4] Spaans M and Waterhout B 2017 Building up resilience in cities worldwide – Rotterdam as participant in the 100 Resilient Cities Programme Cities 61 109–16
[5] Setiadi R and Wulandari F 2016 Memadukan strategi, mewujudkan pengembangan strategi
ketahanan kota J. Pengemb. Kota 4 95–105
[6] Gunawan I, Sagala S, Suryani A, Zawani H and Mangungsong R 2015 City risk diagnostic for urban resilience in Indonesia (Jakarta (ID): The World Bank
[7] Semarang City Government 2016 Resilient Semarang: moving together towards a resilient Semarang (Semarang (ID): Semarang City Government)
[8] Mulyana W, Daniel D D, Zhang S and Schensul D 2013 Climate vulnerability and adaptation in the Semarang Metropolitan Area: a spatial and demographic analysis Tech. Brief. 4–7
[9] Handoko D, Nugraha A L and Prasetyo Y 2017 Kajian pemetaan kerentanan kota semarang terhadap multi bencana berbasis pengindraan jauh dan sistem informasi geografis J. Geod. Undip 6 1–10
[10] Erlani R and Nugrahandika W H 2019 Ketangguhan Kota Semarang dalam menghadapi bencana banjir pasang air laut (Rob) J. Reg. Rural Dev. Plan. 3 47–63
[11] BPBD badan penanggulangan bencana daerah 2020 Data bencana
[12] Cutter S L, Barnes L, Berry M, Burton C, Evans E, Tate E and Webb J 2008 A place-based model for understanding community resilience to natural disasters Glob. Environ. Chang. 18 598–606
[13] Cutter S L, Ash K D and Emrich C T 2014 The geographies of community disaster resilience Glob. Environ. Chang. 29 65–77
[14] Cutter S L, Burton C G and Emrich C T 2010 Disaster resilience indicators for benchmarking baseline conditions J. Homel. Secur. Emerg. Manag. 7
[15] UN Secretary-General 2016 Report of the open-ended intergovernmental expert working group on indicators and terminology relating to disaster risk reduction 21184 1–41
[16] Puteri S M, Harliani F, Sitadevi L and Sari A D 2018 Panduan penyusunan strategi ketahanan kota City Resilience Strategi (CSR) (Jakarta (ID): Mercy Corps Indonesia)
[17] UNDRR 2017 Disaster Resilience Scorecard for Cities- Reference Note on required data/information for Preliminary Assessment 1–4

Acknowledgments
We acknowledge the Geospatial Information Agency (BIG) and Ministry of Research and Technology (Kemenristek/BRIN) for providing doctoral fellowship to the first author for undertaking this study. We would like to thank the International Collaboration Office (ICO) and Center for Transdisciplinary and Sustainability Sciences (CTSS) of IPB University to support funding for this publication.