Coastal settlement resilience to water-related disasters in Semarang City

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Abstract. The Semarang coastal areas face water and sediment-related disasters such as floods, land subsidence, and erosion that threaten its communities' livelihood and undermine the environment's coastal resources and quality. Likewise, the lack of adequate infrastructure and facilities makes the coastal area included as a slum area. Hence, living in slum settlements and facing water-related disasters makes people more vulnerable and difficult to face disasters. Therefore, this study focuses on assessing the physical quality of settlements as part of physical capital that reduces vulnerability and increases the community's adaptive capacity to overcome adversities. The study adopted a quantitative approach through the scoring and descriptive comparative analysis by comparing each resilient settlement's physical condition based on the indicator set.

1. Introduction
The coastal area is an important part of a city because of its strategic location and rich natural resources. The coastal area is also considered an important biosphere element because it sustains habitat diversity [1]. However, climate change has caused extreme weather changes and increased the incidence of disasters these past few years, especially in the coastal areas as the front line [1]. Climate change exposed the coastal areas to various challenges, most of which are water and sediment-related disasters [1]. The coastal area's location, close to the ocean, makes this area largely exposed to coastal flooding and erosion [2–4]. In addition, the coastal area also encountered non-physical challenges related to socio-economic and health. Characteristics of the population, which are largely low-income households, resulted in improperly constructed houses with a lack of adequate infrastructure and facilities. This situation, in return, created the poor physical quality of settlements and their residents. Poor quality of life makes people more vulnerable to disasters and possess limited financial and human capacity to build back better after disasters [1].

Several studies have been conducted to measure the vulnerability of coastal areas in facing disasters. Research on coastal area resilience assessments conducted so far has emphasized community vulnerability from the aspect of flooding [5–7], land subsidence [8], and the community [9–11]. A review of these studies shows that most research conducted mainly focuses on the context of vulnerability (pressure) and community or victims’ ability to adapt (response). However, thorough research of resilience coastal community, particularly from community capitals for building resilience, has not been carried out in-depth. An assessment of community capital using a capital index has been proposed by Mayunga (2007). However, Mayunga’s (2007) capital index is still newly formulated and not being
implemented or tested in the field just yet. In this light, the assessment of capital carried out in this study is still preliminary, so this research only takes the context of physical capital. This physical capital specifically focused on the physical quality of settlements, including housing and infrastructure.

There have been studies conducted to assess the physical quality of resilient settlements, only that they have not been focused on the aspects of settlements as a whole. A study conducted by Dasgupta (2015) in India uses a resilience assessment framework consisting of five dimensions, namely, socio-economic, physical (structural), institutional, Coastal Zone Management (ecological) and environmental/natural resilience. The physical dimension was consisting of infrastructure and housing indicators [13]. However, the assessment framework conducted by Dasgupta (2015) focuses on the assessment of community resilience, not settlement as a whole. The physical vulnerability of settlements can be seen from the aspect of construction [14]. However, the study is limited to the context of slums in the general context and not in the context of coastal areas. Therefore, it can be concluded that limited parameters are specifically made to assess the settlement's physical resilience in coastal areas.

Many countries experience various problems in the coastal areas, including Indonesia. As an archipelago consisting of 17,000 islands, Indonesia is constantly exposed to floods, tides, abrasion, and land subsidence are threats to its coastal areas. One of the coastal areas experiencing these problems is the Seribu Islands (one of the regencies in DKI Jakarta Province). Various studies have been conducted to analyze the coastal resilience in the Seribu Islands that assessed four factors that affect landscape conditions in the Seribu Islands [15]. Farhan (2011) adopted the GIS method to observe these four factors' dynamics and assessed the Seribu Islands landscape condition's effects. Semarang, the capital of Central Java, is one of the coastal areas on the north coast also experiences various coastal problems. Semarang's coastal area covers 20 districts (see figure 1) spanning from Tugu District to Genuk District [16–18]. Three settlements are located in Tugu District, namely Mangkang Kulon, Mangunharjo and Mangkang Wetan Village, experiencing the most severe tidal floods and land subsidence [19]. Moreover, these three villages are located adjacent to two main watersheds, namely Plumbon and Bringin, so that these villages are also categorized as “Prone to River Flood” areas [20].

Mangkang Kulon, Mangunharjo and Mangkang Wetan experience severe water-related problems. In comparison, river flood occurs during the rainy season (October to February) due to the Plumbon River's overflowing and the Bringin River. River floods that occur every year cause sedimentation in the settlement environment. Sedimentation caused by river floods is further exacerbated by land subsidence when many buildings in the study area were lower than the ground level. In addition, flooding also affects the quality of infrastructure. Roads are damaged, accessibility is impaired, and there is a shortage of clean water supply. Sources of water in the study area were obtained from artesian wells, and PAMSIMAS (Provision of Community–Based Drinking Water and Sanitation) is one of the programs implemented by the Government of Indonesia with support from the World Bank for communities in rural and suburban areas that are not served by the clean water pipeline network provided by the government or PDAM – pamsimas.org). However, water obtained from wells and PAMSIMAS only safe for washing clothes and showering and not suitable for drink or consumption.

As a result, settlements in Mangkang Kulon, Mangunharjo, and Mangkang Wetan villages ended up as slum quarters. These villages are included in the Neighborhood Upgrading and Shelter Project Phase 2 (NUSP-2) of the City without Slums (Kotaku) program established by the Semarang City Government to prevent the spread of socio-economic issues. Of all the three settlements, Mangunharjo was given higher priority. In addition, the socio-economic condition of the people is also low, the higher incidence of poverty hence making the community in this area vulnerable to disasters [19]. However, how and what kind of capital is owned by the community to be resilient still requires further examination. Therefore, to analyze this area's resilience, researchers conducted an assessment of the physical quality of settlements as part of physical capital that reduces vulnerability and increases the community's adaptive capacity.
The context of resilience in this study is defined as a more technical matter focused on housing and infrastructure's physical aspects. According to Liao (2012), the concept of resilient settlement that focuses on the physical aspects of housing and infrastructure is adapted to engineering resilience. The concept emphasized the community's ability to maintain stability and be resistant to events that occur [21]. The assessment of the settlement's physical resilience was carried out based on the standard of habitable housing and the recommendation of housing for the coastal area (table 1).

Table 1. Settlements physical resilience indicators.

| Indicators                  | Standards                                                                 | Source                                             |
|-----------------------------|----------------------------------------------------------------------------|----------------------------------------------------|
| 1. Land topography          | Slopes that suitable for residential land use are 0-15%                    | Regulation of the Minister of Public Works and Public Housing |
| 2. Coastal buffer zone      | The coastal buffer zone is at least 100m away from the highest tide point. | Semarang City Spatial Planning 2011-2031            |
| 3. River stream buffer      | The river stream buffer that has dikes within urban areas is determined to be at least 3 (three) meters from the dike's outer edge along the river channel. | Regulation of the Minister of Public Works and Public Housing Number 28/PRT/M/2015 |
2. Methodology

This study uses a quantitative approach that requires an understanding of theories to build a strong research foundation. The theoretical framework that has been compiled is used to determine the research model related to selecting variables and the determination of the initial deduction of research [22]. Resilience is a condition where a system or community can fight, absorb or recover from danger by rearranging through adaptive processes and actions [13, 23]. The concept of settlement resilience can be interpreted as the ability of a settlement system to adapt [24], whereas in this study, settlement resilience is focused on the physical context. Physical resilience can be seen through physical capital available to support the system or community in achieving resilient resettlement. This physical capital focused on the built environment, including housing and infrastructure [12].

Data collection is carried out through questionnaires, field observations, and document reviews. Questionnaires were distributed based on simple random sampling to the population sample using open and closed questions [25, 26]. The determination of sample size uses the Slovin calculation (error rate 10%) on the population of 4,972 households [27]. The sample size obtained is consists of 100 households. Observations were carried out to obtain information about the availability and quality of housing and infrastructure in the study area. In comparison, a document review was carried out to find information about the study area's demographic condition.

The assessment utilizes 13 indicators. The assessment conducted for each indicator is based on answers given by respondents whereby the value of “0” denoted “not compatible” and “1” denoted
“compatible”. Each indicator's value will be added up to obtain the final score for the physical assessment of settlements. In this light, the respondents' maximum score would be 13, and the minimum score is 0. The range of scores will serve as a basis in determining category intervals. With three classes, the intervals for each class are 5. The first category is "not resilient" with intervals of 0-4, the second category is "less resilient" with intervals of 5-9, and the third category is "resilient" with intervals of 10-14.

3. Results and discussion
This research was comparing indicators of settlements physical resilience with existing conditions of each settlement in the field. The scoring process is based on standards compiled from Indonesia's policies and regulations related to the provision of good housing and facilities in settlements. The assessment of the settlement's physical resilience in Mangkang Kulon, Mangunharjo, and Mangkang Wetan villages is described in table 2.

Table 2. The assessment of settlements physical resilience.

| Indicators                              | Mangkang Kulon | Mangunharjo | Mangkang Wetan |
|-----------------------------------------|----------------|-------------|---------------|
| **Results**                             | Not yet fulfilled | Not yet fulfilled | The lack of clean water storage services |
| **Land topography**                     | Compatible 1 | Compatible 1 | Compatible 1 |
| **Coastal buffer zone**                 | Compatible 1 | Compatible 1 | Compatible 1 |
| **River stream buffer zone**            | Compatible 1 | Compatible 1 | Compatible 1 |
| **Density of population**               | Low exposure 1 | Low exposure 1 | Low exposure 1 |
| **Density of buildings**                | Low density 1 | Low density 1 | Low density 1 |
| **Quality of housing constructions**    | 49% of total unit housings is permanent | 61.6% of total unit housings is permanent | 51% of total unit housings is permanent |
| **Water demand and consumption**        | The supply of Pamsimas tanks is still not evenly distributed | The clean water network that is used does not meet service standards | The lack of clean water storage services |
| **Water supply**                       | Available 1 | Available 1 | Available 1 |
| **Water quality**                      | Bad water quality 0 | Bad water quality 0 | Bad water quality 0 |
| **Drainage systems**                   | Not available 0 | Not available 0 | Not available 0 |
The results indicated that a physical, resilient settlement could be achieved if its components meet the criteria of 13 indicators, as mentioned in table 2. Based on the resilience of urban form’s framework made by Sharifi (2019), these 13 indicators are included in the “Resilience of What” quadrant, which in detail outlined shocks and stress that identified from this study floods, land subsidence and sedimentation. The indicators used to assess the settlement’s physical activity are related to water-related problems that occur in coastal areas and the basic needs of settlement, such as sanitation and clean water supply. Settlements are not only about housings but also infrastructure and the environment.

In general, these three villages have several similarities. First, most of the houses (54%) are included as permanent category (house whose walls are made of walls or wood, the roof is made of zinc or tile or shingle or asbestos, and the floor is made of tiles or ceramics). Secondly, all rivers in these villages have 8 m river stream buffer but facing sedimentation to overflows during high water discharge or the rainy season. Third, all villages use PAMSIMAS and deep groundwater wells to fulfill their water needs; fourth, all villages have tried to plant mangroves as a barrier to anticipate sea erosion. Although the progress of developing this mangrove is different, Mangunharjo has the highest mangrove area (9 ha) compared to Mangkang Wetan (0.84 ha) and Mangkang Kulon (1.04 ha). This is because community groups are concerned about mangroves (namely Mangrove Lestari) that concern and cooperate with other parties, such as academics and private sectors.

Regarding the score, the Mangkang Kulon Village has the lowest score because the number of permanent houses is the least compared to the two villages. However, the existing physical condition shows that Mangkang Wetan Village is more vulnerable than Mangunharjo and Mangkang Kulon villages. Several things cause this; first, most of the Mangkang Wetan Village settlements are located in the coastal area. They are always experience tides, while settlements in the other two villages are more linearly distributed along the road to the south. Hence, flooding in these two villages is more due to river sedimentation so that the water overflowed or the river embankment collapsed. Moreover, Mangkang Wetan Village also has the highest slum area (13.59 ha) compared to Mangunharjo (1.56 ha) and Mangkang Kulon (3.79 ha). Likewise, Mangkang Wetan Village is also considered to have the highest sanitation risk in the entire Tugu District. It means that this village has experienced a decline in the quality of life, public health, buildings and the environment due to poor sanitation management and

| Indicators                        | Mangkang Kulon | Mangunharjo | Mangkang Wetan |
|-----------------------------------|---------------|-------------|---------------|
| Sanitation systems                | Not compatible| Compatible  | Not compatible|
| directly channeled into tertiary | 0             | 1           | 0             |
| drainage channel that empties     | 0             | 0           | 0             |
| into the sea without any further | 0             | 0           | 0             |
| processing                         | 0             | 0           | 0             |
| Coastal defense structures        | No barrier    | No barrier  | No barrier    |
| No beach or breakwater as a barrier | 0           | 0           | 0             |
| Mitigation activities have not    | 0             | 0           | 0             |
| been carried out                  | 0             | 0           | 0             |
| Accessibility to the evacuation   | Not available | Not available| Not available|
| route                             | 0             | 0           | 0             |
| Mitigation activities have not    | 0             | 0           | 0             |
| been carried out                  | 0             | 0           | 0             |

Final Score: 6 8 7

Source: analysis results from various sources, 2019
unhealthy community behavior (kotaku.pu.go.id). Sanitation management in Mangkang Wetan Village is carried out by dumping it directly into the sea, similar to Mangkang Kulon Village. Whereas in Mangunharjo Village, it has communal sanitation management even though it can only cover a few households; currently, the condition is also poorly maintained and sedimentation.

The unhealthy community behavior also shows sanitation risk by throwing garbage into the river so that water flow is obstructed; the Mangkang Wetan government does nothing in this regard. While communities in the Mangunharjo and Mangkang Kulon villages dump garbage in the trash then transported to a temporary landfill. The local village government carries out waste management; the community pays 20,000 rupiahs/month for garbage fees.

4. Conclusion
Overall, the settlement quality in Mangkang Kulon, Mangunharjo and Mangkang Wetan is compatible with the indicators of resilient settlement. However, several indicators have not yet been met, which are related to the availability of clean water, retention ponds, and drainage pumps to prevent flooding. Besides that, the sanitation system in Mangkang Kulon and Mangkang Wetan tends to be conventional, namely by channeling sanitation networks to the sea. Another critical factor that has not been fulfilled is the absence of barriers or walls between land and sea. The total score shows that the three villages are included in the "less resilient" class because they can only meet 6–8 of the 13 available indicators.

Mangkang Kulon, Mangunharjo, and Mangkang Wetan Kelurahan are included in the "less resilient" class because the government programs established in these three villages are only concerned about prevention that minimizes the impact of flooding on communities such as mangrove planting and road elevation. Another problem related to clean water and sanitation has not been intervened by the government so that people are more vulnerable because of the lack of community capital. It is shown from the result that the indicators fulfilled by the three villages are related to the basic things of habitable settlements, including the suitability of land use, proximity to the coast and sea borders and housing permanency. Whereas indicators that are not fulfilled are closely related to infrastructures such as sanitation and water systems and disaster mitigation systems.

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References
[1] Uy N, Takeuchi Y, and Shaw R 2011 Environ. Hazards 10(2) 139–153
[2] Knutson, T.R., McBride, J.L., Chan, J., Emanuel, K., Holland, G., Landsea, C., Held, I., Kossin, J.P., Srivastava, A.K. and Sugi, M. 2010 Nat. Geosci. 3(3) 157
[3] Nicholls R J and Cazenave A 2010 Science (80-. ) 328(5985) 1517–1520
[4] Senior S N 2017 Ocean Coast. Manag. 1–16
[5] Adeniyi O S, Perera, K Gimige and Y Feng 2019 Sustain. Cities Soc. 101778
[6] Bertilsson L, Wiklund K, Tebaldi I D M, Rezende O M, A P Veról and M G Miguez 2018 J. Hydrol. 573 970–982
[7] E C Matthews, C J Friedland and F Orooji 2016 J. Build. Eng. 8 141-151
[8] Husnayaen et al. 2018 Adv. Sp. Res. 61(8) 2159-2179
[9] Chowdhooree I 2019 Int. J. Disaster Risk Reduct 40 101259
[10] Bott, L M and Braun B 2019 Int. J. Disaster Risk Reduct. 37 101177
[11] Sajjad M and Chan J C L 2019 Sci. Total Environ. 671 339–350
[12] Mayunga J S 2007 Summer Acad. Soc. vulnerability Resil. Build. 1(1) 1–16
[13] Dasgupta R and Shaw R 2015 J. Coast. Conserv. 19 85–101
[14] Usamah M, Handmer J, Mitchell D and Ahmed I 2014 Int. J. Disaster Risk Reduct 10 178–189
[15] Farhan A R and Lim S 2011 Ocean Coast. Manag. 54(5) 391–400
[16] Marfai M and King L 2008 Environ. Geol. 55 1507–1518
[17] Marfai M. and King L 2008 Environ. Geol. 54(6) 1235–1245
[18] Marfai M, L King, J Sartohadi, Sudrajat S, Budiani S R, and Yulianto F 2008 The Environmentalist 28(3) 237–248
[19] Ambariyanto and N Denny 2012 Riptek 6(2) 29–38
[20] Setyani R E and Saputra R 2016 Procedia - Soc. Behav. Sci. 227 378–386
[21] Liao K H 2012 Ecol. Soc. 17(4)
[22] Fischer H, Boone W and Neumann K 2014 Quantitative Research Designs and Approaches pp. 18–37
[23] BSN, 2017 SNI Desa dan Kelurahan Tangguh Bencana
[24] Alarslan E 2009 Disaster Resilient Urban Settlements
[25] Alvi M 2016 A manual for Selecting Sampling Techniques in Research
[26] J. Bacon-Shone 2015 Introduction to Quantitative Research Methods
[27] BPS 2018 Kecamatan Tugu dalam Angka 2018 (Semarang)
[28] Sharifi A 2019 Cities 93 238–252