Blue space: bridging urban spatial planning as a document of flood disaster mitigation

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Abstract. Contemporary research on resilient city has important role in directing the strategies and scenarios of planning to develop more adaptive cities against disaster. This concern has been manifested in the proposal of urban spatial planning concepts such as sponge city in China and the framework for resilience-oriented planning in Europe. This effort is one of the strategies to reduce the loss due to the increasing disaster especially one caused by hydro-meteorological disaster such as flood, typhoon, and sea-level rise. Indonesia responds this issue by synchronizing the Law No. 24 Year 2007 on the disaster mitigation and Law No. 26 Year 2007 on spatial planning. Both of the laws mandate spatial planning as an instrument of disaster management. Since the form of spatial planning as disaster mitigation instrument is still unclear, this research aimed to suggest a spatial plan as a disaster mitigation instrument through blue space. Applying library research, this article elaborates the condition of climate change in Semarang City, its land use shifts from unbuilt-up area to built-up area and its opportunity for the development of spatial planning instrument by adding one planning element that is blue space.

Keyword: Blue space, spatial planning, mitigation, flood

1. Introduction
Spatial planning as disaster mitigation instrument compromised with the Law No. 24 Year 2007 (Article 35) is still being formulated. This issue is inseparable from the characters of natural disaster that has to be considered in spatial planning. On the other hand, the model of spatial planning as disaster mitigation instrument becomes more crucial to maintain the viability of 50% on Indonesian living in cities. One the natural disasters getting world’s attention is hydro-meteorological disaster such as flood, typhoon and the sea-level rise. EM-DAT, a research institution for world disaster has noted that there is a significant correlation between hydro-meteorological disaster with economic loss consisting of infrastructure damage and casualties [1]. Hydro-meteorological disaster becomes the biggest threat compared to other natural disasters. It is due to its relatively periodical and tends to increase. The correlation of type of disaster and economic loss is described in Figure 1.

This global problem also occurs in Indonesia. Based on the data and information on disaster in Indonesia (dibi.bnpb.go.id), BNPB (Badan Nasional Penganggulanagn Bencana or Indonesian National Board on Disaster Management) reported that the disaster occurred in Indonesia has been escalating since 2000 to 2018 which then impacts on the increase of government expenditure for disaster management as described in Figure 2. The loss is predicted to reach more than $900 million for only the
A flood case in Jakarta. As does for the area nearby Bengawan Solo that is estimated to reach $200 million loss each year.

![Graph](image1)

**Figure 1.** Total numbers and type of disaster year 1950-2012, economical loss is calculated based on the infrastructure damage. [EM-DAT (2012) in 1]

![Graph](image2)

**Figure 2.** The occurrences of hydro-meteorological disaster in Indonesia from 2000-2018 (DIBI BNPB in: [http://bnpb.cloud/dibi/](http://bnpb.cloud/dibi/))

The hydro-meteorological disasters in Indonesia are predicted to continuously increase due to the global climate change. Some urban planning experts even enlist this global ecology issue as one of the most influential world trinity affecting life and city development [2]. As a response, there has been various concepts proposed by the experts to develop a resilience city as an effort to build a city that has the capacity to live along the extreme changes. In the scope of city ecology, the metaphor of resilience city is often related to the attempt of disaster mitigation [3, 4], and adaptation to climate change [5, 6]. The rise of this new idea is a way to response onto the unpredictable future of the city and to answer unending global issues that may influence the sustainability of the city [7]. Spatial planning as the bridge of the present and future need [8] has been a strategic role to realize the sustainable development that is always echoed. Besides, spatial planning may serve as the connector between economic need
(developmentalism) and ecological need (environmental protection).

2. Research Methods
To reach the objection, this article was written as a suggestion for the development of flood disaster mitigation instrument through spatial planning. The case study of this research was conducted in Semarang city under the program called ACCCRN (Asian Cities Climate Change Resilience Network) and was supported by Rockefeller Foundation and Mercy Corps, thus the studies on climate change, vulnerability and flood were sufficient. Applying literature observation method, this article comprised at least three significant reviews:

1. Review on the climate change in Semarang City. Climate change has been always an issue closely related to the increasing event of flood in Semarang City. Studies climate change was conducted by CCROM [9] as one of the fundamentals in the study of climate change in Semarang City. This study served as the axiom for the research to study the climate characteristics and its trends in the future. There were two main concerns that were the condition and rainfall change in Semarang City and the average temperature rise.

2. Review on the city growth in Semarang City. The focus on studying the growth of Semarang City was to figure out the readiness of this city in receiving and “collect” rainfall. This readiness was potential water catchment area as seen in the green space area. Fewer water catchment area (more occupied green space area) indicated fewer water absorbance to soil. Therefore, it could be concluded that more areas built without concerning the green open space would lead to the potential of flood.

3. Review on the proposed concept of blue-space. Blue-space concept was a part of green and blue-space ideas. Green space, however, has been regulated in Indonesia in Law No. 26 Year 2007 on spatial planning that regulates 30% of urban space has to serve as green space. While blue-space functioning as water catchment area has not yet regulated in Indonesian Law. Therefore, this research focused on the discussion on blue space. This concept would be evaluated as one of the instruments to resolve the climate problem in cities.

From the above 3 analyses, this article would present recommendation on the opportunity to develop the element of new spatial pattern in Indonesia that is blue space. It serves as water catchment area in which water is to be absorbed, collected and channelled that become the considerations as one of the anticipative strategies addressing the extreme climate change.

3. Result and Discussion
- Climate Change in Semarang City
All cities in the world face three main problems called as the trinity world of Trinity City. In his speech at an international conference, Abdoullaev [2] explained that almost all cities in the world would encounter environmental problems, socio-economic change in the community and the rapid development of information technology. These three problems do not only influence the affected cities but globally. Taken as example was the melting of glacier in the North Pole that did not only affect the area of the North Pole also the areas nearby even all areas in the world. There was ecosystem affected. One of the global problems attracting the attention and has the biggest economic impact is hydro-meteorological disasters that are those related to flood, typhoon and sea-level rise. This type of disaster is not only recorded as the highest in the world, but also in Indonesia. From 2000-2018, the graphic describing hydro-meteorological disaster has been escalating, as does the number of occurrences in the world. The loss caused by this type of disaster inevitably follows, and it keeps growing each year including in Semarang.

Research on climate change in Semarang City was first conducted by CCROM [9] that released its report entitled vulnerability and adaptation Assessment to climate change in Semarang city. CCROM [9] concluded that there was a climate change in Semarang City that was marked by the trend and character shift from some climate aspects such as temperature and rainfall. Fifteen years before, Harger [10] had studied the air temperature in Indonesia and Philippines in which Semarang City became one of the
research location. In his research, Harger [10] used the data trend El Nine-Southern Oscillation (ENSO) from 1866-1993 and concluded that there had been temperature rise for 1.64°C (0.0132°C per year from 25.771°C to 27.409°C). Even though Harger [10] studied the temperature as one prominent element in climate change research, he had not yet concluded any climate change in Semarang Cities regardless the chances of its correlation with the greenhouse effect.

Based on the report published by CCROM [9], the variability of rainfall in Semarang City was influenced by ENSO and IOD. El Nino-Southern Oscillation (ENSO) contributed to the tropical climate in Indonesia especially the rainfall. Besides ENSO, the rainfall in Indonesia was also influenced by Indian Ocean Dipole (IOD). The research done by CCROM [9] showed that there was a strong contribution of ENSO to the variety of rainfall in Semarang City during dry season (JJA) and monsoon transition period (SON). Related to flood and drought in Semarang City, CCROM [9] found out the fluctuation of rainfall due to the extreme climate change during the occurrence of ENSO and/or IOD. Figure 3 shows the significance of rainfall change in Semarang City. During El Nino occurrence in 1972, 1983, 1987, 1994, 1995, and 1997 there was a significant drop in rainfall.

Using the data provided by Climate Research Unit (CRU), CCROM [9] analyzed the trend of climate change in Semarang City. It was concluded that there was a trend of rainfall rise especially during the Monsoon transition (SON) and the dry season (JAA). The rainfall change was indicated by the early wet season which ended slower compared to normal condition. This analysis result was also supported by the drop of rainfall during the dry season. The change of rainfall in Semarang City is described in Figure 4. It is slightly different with the seasonal trend of rainfall in Semarang City. Based on the data extracted from CRU TS2.0, CCROM [9] concluded that there was a temperature rise in each season related to the increase of daily temperature. Figure 5 shows the temperature variation in Semarang city from the year 1902 until 2002.

The critical rainfall limit for Semarang City was 302 mm equivalent to quartile 3, Q3 during rainfall and 84 mm equivalent to quartile 3, Q3 during the dry season [9]. This critical limit served as the threshold in which the rainfall exceeding 302 mm could be predicted for bigger runoff and it might lead to the flood. On the other hand, rainfall below 84 mm could be predicted as water shortage or drought. Compared to the occurrence of flood in Semarang City, however, it showed different condition. The shift of dry and wet season in Semarang City did not show any significant rainfall rise (see figure 1), yet the number of flood occurrences in Semarang City increased each year. Therefore, the next step was to study the development of the built-up area in Semarang City.
Figure 4. Seasonal trend of rainfall in Semarang City [9]

Figure 5. The Trend of the average temperature for each season in Semarang City [9]

- **Land change in Semarang City**

Studies on the correlation of urban population growth with the change of land use in Java and Semarang City was conducted by Firman [11], Handayani and Rudiarto [12], Hadi, et al. [13] and Sejati, et al. [14]. These three researchers concluded that there was the land change from open space to the built-up area that occupied the green space. The newest research from Sejati, et al. [14] informed a significant surge on the number of the built area from 56.31 Km

2 in 1990 to 89.44 Km

2 in 2000 then increased to 180 Km

2 in 2015. There was even an increasing built area from 91.09 Km

2 within 15 years (2000 – 2015). It was even higher than the rise of built-up area in 1990-2000 that was 33.13 km

2. The
Consequence from the growth of the built area was the low area of green vegetation. From the total green vegetation of 391.23 km² in 1990, it suffered a decline to 264.24 km² in 2000 than getting decreased in 2015 into 242.14 km² [14]. Figure 6 shows the built-up growth of Semarang metropolitan area.

![Figure 6](image)

**Figure 6.** The built-up growth of Semarang metropolitan area, 1990 – 2015 [14]

The high growth of land use change was inseparable from the population growth in Semarang City that reached approximately 1.4% per year [15] even though this number was not the highest for Semarang City. The research done by Firman [11] noted the population growth in Semarang City reached 2.0% in 1980-1990. It meant that it was not the first high population growth in Semarang in Semarang City. This population growth was predicted to continue that World Bank [16] projected 60% of the population of Indonesian would live in a city. Without anticipation, it was predictable that the land use change from the unbuilt area to built-up area would continue to develop.

Comparing a research by CCROM [9], Sejati, et al. [14] and Handayani and Rudiarto [12], it is logical that the high occurrence of flood in Semarang City is not only due to hydro-meteorological disaster. The insignificant rise of rainfall and climate change are indeed contradictory to the area coverage on water catchment area in Semarang City. The problem of the high occurrence of flood in Semarang City, therefore, is due to the land use. Fewer water catchment area or room for water. This main problem has to be addressed as proposed by the researcher in regards to blue space, that is space for water.

- **Blue-space: green-blue infrastructure**
  The above description clearly explains that the flood problem in Semarang City is not only caused by climate change but also the lack of city infrastructure management. One of the achievements of Semarang City that successfully reduced flood-prone area from 41.02% in 2011 to 21.4% in 2017 through river/west canal normalization has proven the effective the infrastructure has helped Semarang City from the flood. The contribution of climate change to the debit of runoff may be less significant to the main problem that is room for water. Based on the statement from the City Mayor of Semarang in the International Conference on Indonesia Social and Political Enquiries on 22 October 2018, the success to reduce the flood-prone area was due to the construction/normalization of 1 river section, while
Semarang has 2 main rivers that function as flood prevention that is the west and east canal. Referring to the similar source, East Canal has just started its normalization process. When both main rivers have their normalization finished, it is predicted the flood-prone area in Semarang City will be lower.

It has to be considered, however, that the morphology of Semarang City is unique. This city is comprised by flat area and is located in the coastal and also has a hilly area. Normalization in both canals is a downstream solution that is the city infrastructure collect the water runoff from the bill areas. According to the research by Sejati, et al. [14], there was a trend that the development of Semarang City is now heading to the west and south hilly area. If the conversion from unbuilt area to up-built area is not well controlled, the water runoff is very possible to increase. The infrastructure prepared by the city government has reached the downstream area that will collect the water runoff from the hilly area to be then channeled to the sea. Preventive steps are needed especially on the method to catch the rainwater fall in the hilly area to be absorbed there. More water in the hill that is caught and absorbed, the burden for the infrastructure in the downstream area will be reduced.

In order to catch the water runoff, the hilly area needs special rooms such as ponds, rivers, lakes, and wetlands. These water catchment areas are currently referred to as blue-space. Experts define blue space as a concept combining landscape planning and water planning. Many experts also relate blue space planning with the mental health [17] and urban image [18] of the urban society through the provision of relaxation space or recreation space. There are many figures who relate the availability of blue space with the biodiversity and the creation of new city ecosystem.

Even though blue-space can be seen from the point of view of urban recreational space, this article explains it in the view of disaster mitigation. If the city planner successfully creates a water catchment area in the hilly areas in Semarang City, the water runoff that should be collected by the rivers in the downstream area can be reduced. Blue space as bio-retention functions as the inhibitor/ runoff redactor, increase water supply, increase water reservation, improve air quality, reduce carbon emission in the air, reduce urban heat island, improve living space comfort, and increase public education and transportation. It is also possible that blue-space is also built in the downstream area as a room to collect tidal water. The conversion of rice field and fishpond in the coastal area of Semarang City is actually one of the contributing factors to the widening area of water inundation. In the 1980s, the industrialization mega project in the coastal area of Semarang City had converted fishpond and rice field area to become factories. Rice field and fishpond are natural water catchment if there is water runoff from the sea, of which now has lost its function [19].

This condition is common to happen not only in Semarang City but also in all areas in Indonesia. Figure 7 shows that flood occurrence from 1974 to 2003 globally. Indonesia was enlisted as the top countries with high flood occurrence along with China, India and some countries in the U.S.A. BNPB has also shown the fluctuation of the significant rise from year to year. The similar condition happens throughout the world. This shows that the concern on this disaster is needed and the urgent, so that the loss can be anticipated to maintain the city sustainability in Indonesia.
Figure 7. Number of Occurrences of flood disasters by country: 1974-2003 [20]

Seen from social science, Wessells [21] suggested that by conserving the environment and guaranteeing the environmental right are one of the ways to realize the development of a sustainable city. Human has the right to grow, as do animals and tree which have the same right to survive. Through blue space, it is expected that the right of environmental justice in urban areas is guaranteed and that the ecosystem balance can be realized. Pickett and Cadenasso [22] through his point of view suggested that urban planner should consider urban as a huge ecosystem to make sure resilient.

4. Conclusion
Flood in Semarang City (especially) is caused by main the city infrastructure management that has not yet been optimum. The process of city infrastructure renovation by the local government has shown the significant result. This means that the management of city infrastructure in addressing flood is relatively effective as a media for disaster mitigation. Blue space which is room for water is considered as an appropriate concept to be proposed as an alternative spatial planning-based disaster mitigation; blue space may also serve as an instrument of spatial planning-based mitigation as space to temporary reserve water. Water catchment can be in a form of a lake, ponds, wetland and others which function to catch and absorb water. The massive land conversion which is even faster than population growth shows that there is no balance between the container and the content of the city.

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**Acknowledgments**
This research is funded by Universitas Diponegoro through the Development and Application Research Scheme Year 2018 with research grant no: 474-57/UN7.P4.3/PP/2018.

This article is presented at the International Conference on Smart City Innovation 2018 that supported by the United States Agency for International Development (USAID) through the Sustainable Higher Education Research Alliance (SHERA) Program for Universitas Indonesia’s Scientific Modeling, Application, Research and Training for City-centered Innovation and Technology (SMART CITY) Project, Grant #AID-497-A-1600004, Sub Grant #IIE-00000078-UI-1.