Sustainable Blue-Green Infrastructure for Enhancing Flood Resilience in Semarang

The BuGIS Action to Promote BGI Adoption

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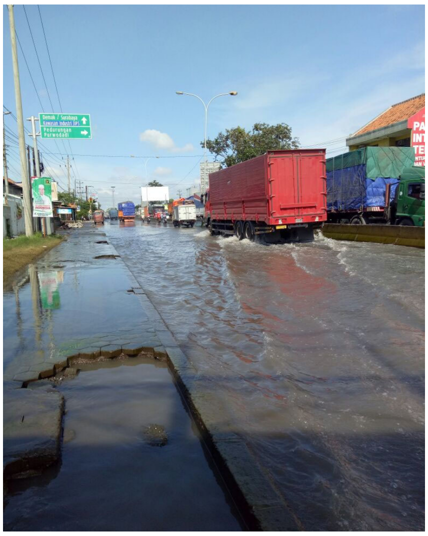
BuGIS (Blue-Green Infrastructure in Semarang, Indonesia) was a research project that aimed to increase the flood resilience of Semarang city by integrating Blue Green Infrastructure (BGI) concepts into urban development planning. The project was a collaborative effort between Loughborough University (LU) and Universitas Diponegoro (UnDip) and was jointly funded by the British Council and Ministry of Research, Technology and Higher Education of the Republic of Indonesia, through the Newton Institutional Links/KLN-INSINAS scheme. This document presents a synthesis of key findings for policy makers and stakeholders:

- BuGIS undertook a survey of existing BGI, and through data collection and stakeholder engagement, developed an understanding of socio-cultural and political issues influencing the adoption of BGI.
- BuGIS developed key principles underpinning wider adoption, and proposed an action plan, comprising ten activities, which could lay the seeds for development of future policies that promote the adoption of sustainable BGI to alleviate risk of flooding, and at the same time, bring socio-economic and cultural benefits for Semarang.

Increasing risk of flooding in Semarang: Are the current solutions sustainable?

The City of Semarang is exposed to coastal and fluvial floods that have hampered its development. Climate change, urbanisation, land-use change, deforestation, groundwater abstraction, combined with social vulnerability have increased the risk of flooding for large numbers of urban population. Since 2008, the Government of Semarang has actively engaged with resilience initiatives, such as the Asian Cities Climate Change Resilience Network (ACCCRN) and recently 100 Resilient Cities (100RC), to build resilience and capacity to climate risks. This culminated in the launch of a Resilience Strategy in 2016; the first city to develop one in Indonesia (Semarang City Government 2016). The document outlines potential shocks and stresses facing the city, and actions to enhance its resilience. High risk of water scarcity and flooding are the key challenges facing Semarang. The document highlights the need to adopt resilience approaches and learn from other cities facing similar issues. Semarang's climate change adaptation has the potential to become an exemplar for many cities in Indonesia facing similar challenges.

The drainage system has played an important role in flood resilience strategy of Semarang, and has been the key development agenda with the ratification of a Master Plan for Urban Drainage System of Semarang as a regulation in 2014. The regulation stipulates the development and improvement of the city drainage system with the allocation of a major government budget and detailed 20-year plan (2011-2031). The City has embarked on several key projects, including West Flood Canal, Jatibarang Dam, and River canalisation which were intended to channel and remove stormwater as safe and fast as possible. To address coastal flooding, Semarang is currently building a large dyke structure circumscribing its shoreline and mangrove areas. This seawall will also serve as an important highway connecting the regional traffic between the east and the west of Java (WaL 2018). Although these structural measures have alleviated the risk of flooding to some degree in the short term, they cannot completely remove the risk of flooding. The risk could even increase if the measures fail, particularly, in the lower/coastal part of the City which is undergoing severe land subsidence. The sustainability of these approaches still needs to be examined (WaL 2018). There is a need therefore, to evaluate and implement more sustainable approaches that can complement existing structural measures in order to address this complex urban resilience issue.



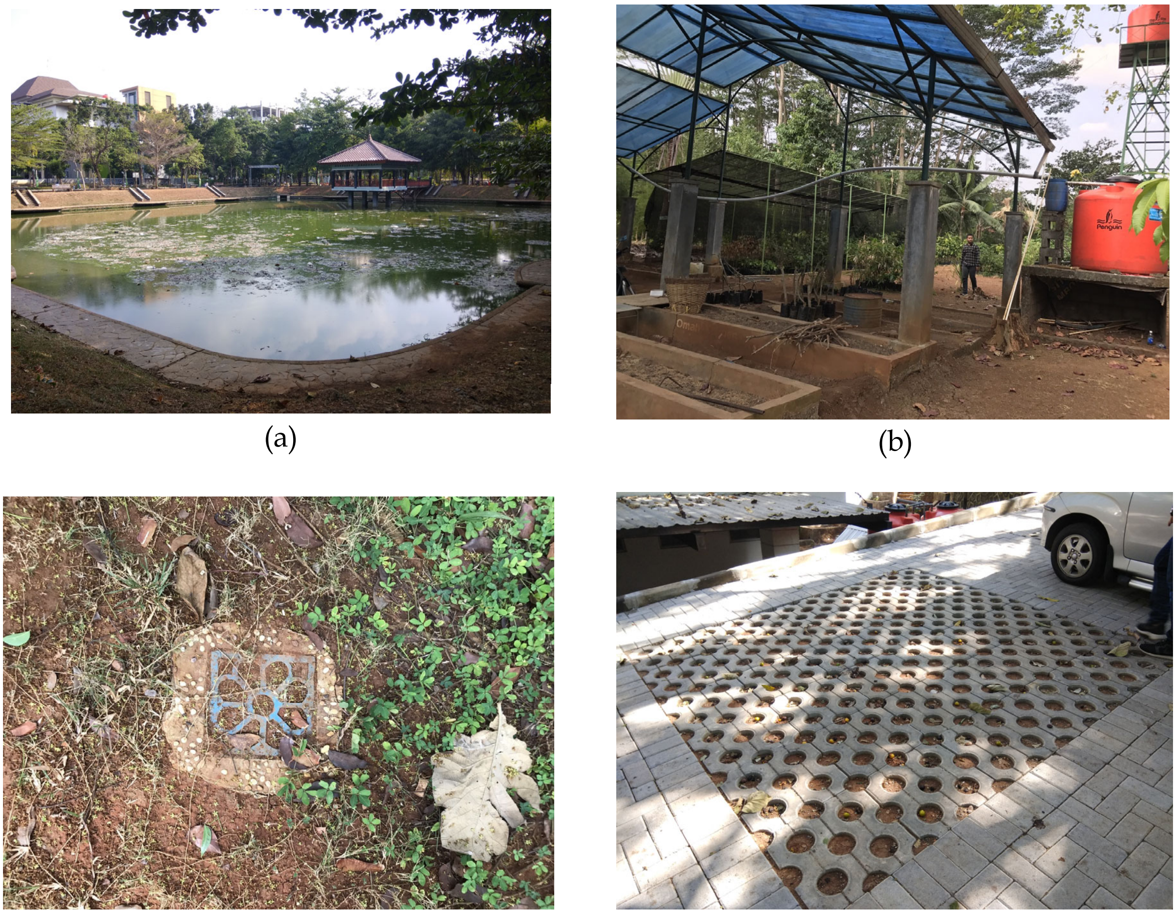
What is Blue Green Infrastructure?

Blue Green Infrastructure (BGI) is a term to describe a natural or semi-natural infrastructure with combined hydrological and ecological function for the management of stormwater within urban landscapes (Blue-Green Cities 2016). BGI, in the form of Sustainable Drainage Systems (SuDS) can increase the capacity of urban drainage and complement grey infrastructure to cope with an extreme surge of water in the event of flooding (Everett et al. 2016). BGI also brings ecosystem service and other benefits to the urban environment, such as by improving air quality and aesthetics, and is increasingly considered to be a sustainable approach for flood risk management. BGI mimics natural hydrological processes and is a strategy for 'living with water'. It is specifically intended to increase water retention, reduce water run-off and control the flow of water as it goes back to the water source or drainage system, hence reducing extreme peak flow.

Existing BGI in Semarang

BGI can provide alternative, as well as complementary approaches to managing floodwater while it simultaneously improves the urban environment. BuGIS conducted a field survey and focus group discussions with stakeholders on existing BGI in Semarang (see Figure 1). The survey was undertaken in the Banyumanik region including Gedawang and Padangsari villages, as well as the Department of Environment (DoE). In Gedawang, biopore holes were mainly created in the area around the village office with very few in individual properties. In Padangsari, the village authority provided 40 biopore-making devices which were used by the community, facilitated by local forums. Here a higher participation was noted. However, maintenance was still an issue with many holes found abandoned and dysfunctional. In addition to biopores, examples of infiltration wells were also found in Padangsari. DoE installed rainwater harvesting units to state-owned schools. Although participation from individuals was low, this BGI example was viewed to serve an educational purpose for the students. Other examples of BGI are artificial lake, water retention ponds ('embung') in property developments, and permeable pavement (i.e. grass blocks).

The following are points drawn from the survey and observations as well as a targeted review of the literature: (i) biopores are a low-cost BGI example that to be effective requires community participation in the creation and maintenance; (ii) literature on modelling the effectiveness of biopores in other Indonesian cities (Bandung and Malang) suggests that biopores are not sufficient to mitigate urban flood. Combining them with other solutions is essential. There is still however a need for further evidence on their efficacy and on the assumptions made for their evaluation; (iii) given the volume of water in the catchment areas in Semarang, millions of biopores in appropriate locations across a network are required to completely mitigate floods.



(a) (b) (c) (d)

Figure 1. Current BGI efforts in Semarang: (a) retention pond; (b) rainwater harvesting; (c) biopore hole; (d) permeable pavement.

Representatives from local government and communities were invited to participate in focus group discussions on BGI examples, including biopores, rainwater harvesting, infiltration wells, permeable pavements, artificial lakes, green roofs, and swales. The latter two were very rare in Semarang but were discussed to evaluate the possibility of their implementation. Generally, the participants had a good working knowledge of BGI, having seen some examples in their communities. Each BGI presented different advantages and applicability for Semarang. Several, that relied on water absorption capacity, were deemed unsuitable for lower Semarang where the ground water level is high and the soil is saturated. It was found that BGI implementation should also consider space and cost restraints. Swales were found suitable for less populated areas, such as those near the city airport. Cost was a key issue for widespread adoption, given that the majority were low income residents. The participants appreciated the multiple benefits of BGI in providing ecosystem services, such as improving aesthetics and subsequently encouraging tourism; however, they also warned the danger of open water as breeding ground for wrigglers and the spread of vector-based diseases. Maintenance was raised as an important challenge, particularly in communities whose majority have very little knowledge on BGI. The participants also realised that successful BGI is a multi-stakeholder effort, which should involve communities, government agencies and businesses/developers.

Potential for BGI in Semarang

Currently, the management of urban flooding risk in Semarang relies predominantly on implementation of grey infrastructure. This has led to a potentially effective solution, but the long-term sustainability of the implementation needs further assessment (WaL 2018). BGI can not only complement and enhance the flooding risk reduction capability of existing grey infrastructure, but could also lead to multiple ecosystem service benefits to Semarang. The successful implementation of BGI in Semarang is underpinned by inclusive, appropriate and proactive principles:

The **inclusive** principle elevates the important role of 'bottom-up' community participation, in combination with 'top-down' government policies, in order to encourage widespread adoption. All relevant sections of communities ought to be empowered and educated with sufficient knowledge and skills to implement BGI in their local areas.

The selected BGI solutions should be **appropriate** to the local context. This raises a few questions:

i) Can the proposed solutions function properly? For example, biopores and infiltration wells are not suitable for Trimulyo village due to its predominantly saturated soils;

ii) Can they pose higher health and safety risks to the communities? For example, safety issues (danger of children drowning) were brought up in relation to lakes and retention ponds. Green roofs were also deemed unfit as they were seen as potential mosquito breading grounds.

iii) Can they realise other socio-economic benefits? For example, workshop participants explained that a BGI strategy would be deemed appropriate if it improved the commercial interests of residents (e.g. those who run shops from their homes) and brought social benefits (e.g. durian trees planted in community parks could encourage social cohesion via gathering and sharing harvested fruits);

iv) Can strategies be developed to mitigate the negative impacts and facilitate the benefits of BGI?

The **proactive** principle not only promotes the engagement of all stakeholders in the planning, construction, operation and maintenance stages, but importantly, change attitudes and behaviours to reduce the risk and/or anticipate possible future threats (e.g. extreme flooding), before they occur. Because BGI yields multiple long-term socio-economic and environmental benefits which may outweigh short-term benefits, the proactive principle will ensure that these long-term benefits materialise. A proactive behaviour would be a requirement for all stakeholders. The sustainable adoption of BGI by local communities would require a transformation of behaviour from reactive (short-term solutions typically offered by grey infrastructure to remove storm water fast) to proactive (long-term solutions provided by BGI that adapt and mitigate the risk of flooding and climate change).

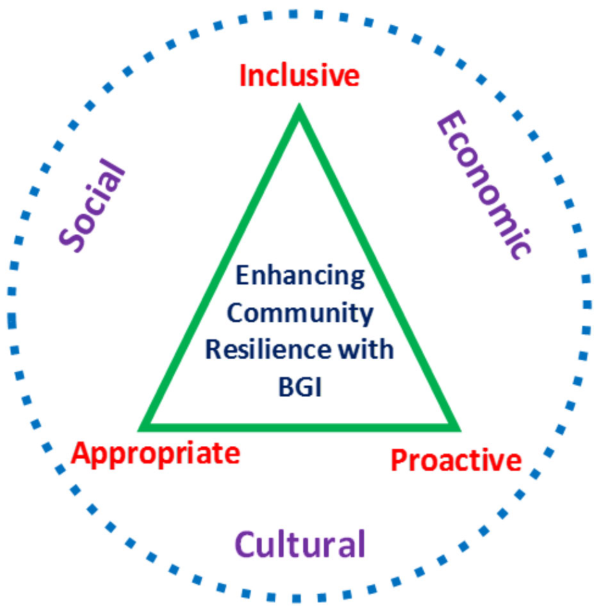


Figure 2. Conceptual model of community-centred approach to enhancing flood resilience with BGI

A conceptual model depicted in Figure 2 illustrates the key principles that need to be addressed to enhance community resilience to flooding with BGI. These can be enabled or hindered by socio-economic and cultural issues that provide the local context of BGI implementation. Thus, understanding socio-economic and cultural issues, as well as their inter-relations with the inclusive, appropriate and proactive principles is critical for the development and implementation of policies that concern sustainable flood risk management with BGI.

BuGIS Action

To facilitate wider BGI adoption, BuGIS action, comprising ten activities is proposed. These activities are grouped under three key themes, representing overlapping, inter-related activities (see Figure 3). The ten activities form a holistic approach to facilitate BGI adoption in Semarang.

Figure 3. Key themes of BGI action

1. Support existing BGI strategies and widen their implementation in Semarang communities.
Existing BGI (such as biopores and infiltration wells) should be promoted within community activities via leaders of the Disaster Preparedness Village (Kelurahan Siaga Bencana/ KSB) and Family Welfare Education (Pendidikan Kesejahteraan Keluarga/ PKK). Other forms of BGI (such as artificial pond 'embung' and bio-swales) should be considered within housing developments, particularly, in the Southern part of Semarang which has higher elevations.

2. Encourage greater community participation in BGI planning, construction, operation and maintenance stages.
Existing KSBs should act as the vehicle to promote BGI. KSB leaders hold key roles, and their knowledge and skills could be further enhanced by offering them BGI-focused quality training.

3. Consider BGI and grey infrastructure on equal footing as urban infrastructure options for planning and decision making involving FRM solutions.
The Planning Development Forum (*Musrenbang*) provides an opportunity to discuss BGI and its contribution to flood risk management. In line with the current urban planning policy (*Peraturan Daerah 11/2011*), BGI aiming to improve ecosystem services and increase green open space, should explicitly be incorporated in the annual, mid-term (RPJMD, 5-years) and long-term (RPJPD, 20-years) development planning cycle of Semarang.

4. Develop a framework for assessing costs and benefits associated with BGI implementation.
The framework must include costs as well as wider economic, social and environment benefits; stakeholders who are either beneficiaries and/or influencers; and address uncertainties associated with BGI implementation. Examples of cost and benefit analysis of BGI and nature-based solutions exist and should be considered in the development of the bespoke implementation framework for Semarang. A diagram which explicitly illustrates stakeholder involvement throughout the implementation process is a critical element of the framework to be published as part of the socialisation of future BGI-related policies.

5. Consider operation and maintenance as a critical part of BGI implementation.
The funding mechanism as well as the responsibility for operation and maintenance of BGI should be determined before hand. Although BGI could maximise benefits from the joint responsibility of local government institutions, members of communities, public and private sectors, it is critical to establish clear jurisdictional responsibility early in the project.

6. Adopt and proactively promote a holistic approach for dealing with flooding.
Such an approach should consider a range of related issues, including urban planning, solid waste management, groundwater/ borehole management, road management, drainage system, and disaster risk management.

7. Develop a closer collaboration between relevant institutions in the public and private sectors.
Communication between institutions and willingness to contribute are key to success. It is critical to develop policies that encourage investment by the private sector (for example through public-private partnerships).

8. Develop a pro-environmental behaviour in the community and public.
BuGIS research showed high levels of social responsibility among community members, suggesting that they are inclined to cooperate and contribute to the betterment of their community. However, awareness of BGI and its benefits was found to be low. Promoting pro-environmental behaviour by raising public awareness and educating future generation will support BGI adoption and sustainable flood risk management in Semarang.

9. Evaluate and enforce policies that reduce and/or eliminate groundwater abstraction.
Excessive land subsidence has exacerbated the impact of flooding and coastal inundation ('*rob*'). Although BGI can help groundwater/aquifer recharge, there is no immediate solution to recover the subsided ground elevation. Appropriate policies (e.g. via penalty and incentive) should be enforced to better regulate self-supply and utility water supply.

10. Ensure the protection and development of the mangrove forest.
The existing mangrove forest (e.g. in Tapak Tugurejo) provides coastal protection from storm surge and benefits the local community financially. The mangrove forest should be protected and developed to function as intended by nature, and the local communities further educated about its benefits.

BuGIS empirical research

BuGIS project undertook case study research in three communities in Semarang; two that have experienced flooding, Trimulyo and Karangayu; one that has not, Gunung Pati (see Figure 4 for the location of the case study areas). Fieldwork comprised:

- a site survey of flooded communities (in Trimulyo) and of those who had already implemented BGI (in Gedawang, Padangsari, Tapak Tugurejo);
- 30 resident interviews, complemented by 180 completed questionnaires from three communities.

Over a period of one year (between 2017 to 2018), BuGIS team also interviewed 8 relevant government officials, and organised 3 workshops attended by a total of 46 local government officials and community representatives (including KSB leaders), participating in 10 focus group discussions.

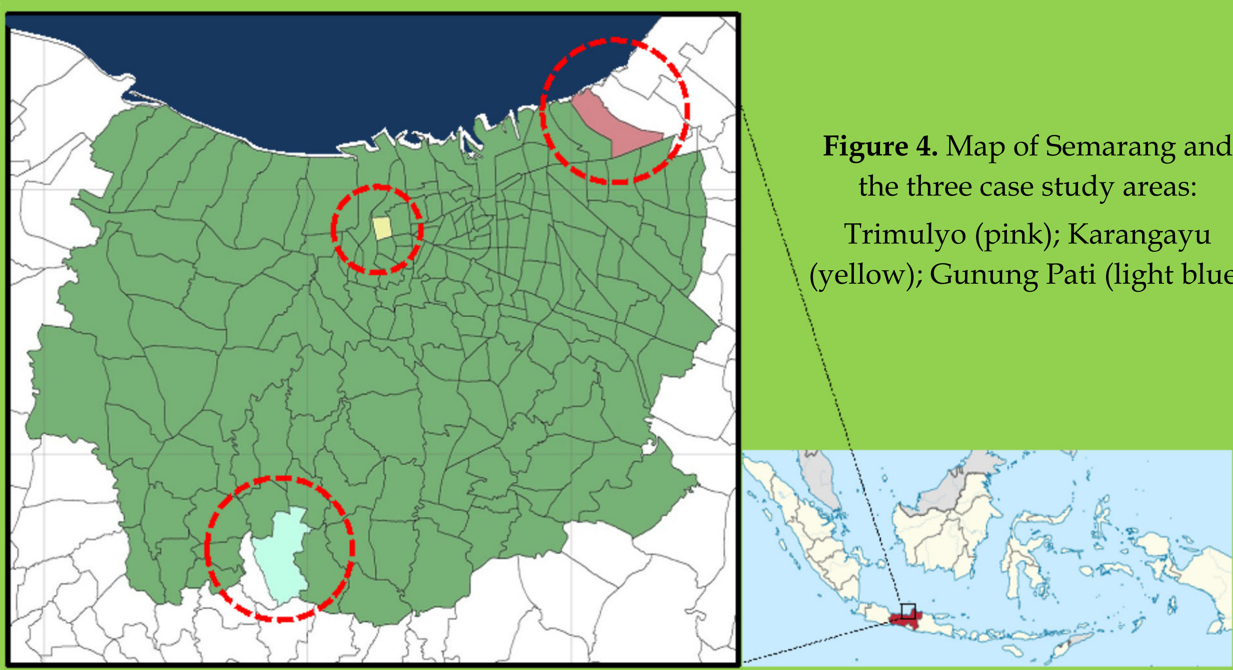


Figure 4. Map of Semarang and the three case study areas: Trimulyo (pink); Karangayu (yellow); Gunung Pati (light blue)

References

Semarang City Government (2016) Resilient Semarang: Moving together towards a resilient Semarang. Strategy book published by Semarang City Government, published in May 2016.

Blue-Green Cities (2016) The definition is adapted from: http://www.bluegreencities.ac.uk/about/blue-greencitiesdefinition.aspx

Everett, G., Lamond, J., Morzillo, A.T., Chan, F.K.S. and Matsler, A.M. (2016) Sustainable drainage systems: helping people live with water. Proceedings of the ICE, Water Management, 169, WM2, 94-104.

WaL (2018) Setting the scene for a call for action: Water as Leverage for Resilient Cities Asia. www.waterasleverage.org

Acknowledgements

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