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## Proposed Concept of Flood Green Infrastructure for Semarang City

**Praditya Adhitama**

*Resilience Development Initiative,  
Indonesia*

**Saut Sagala**

*Institute of Technology Bandung, Bandung  
Indonesia*

**Alpian Angga Pratama**

*Resilience Development Initiative,  
Bandung, Indonesia*

**Efraim Sitinjak**

*Resilience Development Initiative,  
Bandung, Indonesia*

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**Praditya Adhitama<sup>1</sup>, Saut Aritua Hasiholan Sagala<sup>2</sup>, Alpian Angga Pratama<sup>1</sup>, and Efraim Sitingjak<sup>3</sup>**

<sup>1</sup> *Resilience Development Initiative, Bandung, Indonesia.*

<sup>2</sup> *School of Architecture, Planning, and Policy Development, Institute of Technology Bandung.*

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**Alamat:** Jalan Imperial II No. 52, Bandung 40135  
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**Telepon:** +62 22 2536574  
**Email:** rdi@rdi.or.id  
**Website:** www.rdi.or.id

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## Content

Abstract.....	5
1. Introduction.....	5
2. Literature Review.....	6
2.1. Flood Mitigation Measure in Urban Area.....	6
2.2. Green Infrastructure Concept.....	7
2.3. Infrastructure in Flood Mitigation.....	8
3. Methodology.....	8
4. Result and Discussion.....	10
4.1. How Can Green Infrastructure serve in flood mitigation?.....	10
4.2. Proposed Concept of East Flood Canal Green Infrastructure in Semarang.....	10
5. Conclusion and Recommendation.....	13
Reference.....	14

# Proposed Concept of Flood Green Infrastructure for Semarang City

Praditya Adhitama<sup>1</sup>, Saut Aritua Hasiholan Sagala<sup>2</sup>, Alpian Angga Pratama<sup>1</sup>, and Efraim Sitinjak<sup>3</sup>

<sup>1</sup> Resilience Development Initiative, Bandung, Indonesia.

<sup>2</sup> School of Architecture, Planning, and Policy Development, Institute of Technology Bandung.

## Abstract

*Semarang City is one of flood prone areas in east coast of Java Island. High intensity of rainfall, land subsidence, land inundation and bad drainage condition are the causes that contribute to the flood in Semarang City. To mitigate the risk of flood in Semarang City, flood canals were built. There are two main flood canals in Semarang City, The West Flood Canal and The East Flood Canal. The development of these canals forms an interconnecting infrastructure corridor. This corridor can be functioned as a green infrastructure that brings benefits to its surroundings such as increasing water infiltration and reducing run off on the land. Those benefits are in line with flood canal's function in flood risk mitigation context in Semarang City. Therefore, Green Infrastructure Concept can be integrated with further development of West and East Flood Canal as an alternative for flood mitigation measure. This paper discusses about the implementation of Green Infrastructure concept in mitigating flood risk by utilizing the flood canals in Semarang City as an example. Main objective of this paper is to analyze the opportunity of intergrating between green infrastructure and flood mitigation infrastructure through descriptive analysis and GIS based spatial analysis as support in proposing allocation scenario.*

**Keywords:** Flood, mitigate, green infrastructure

## 1. Introduction

Semarang is a seaport city located on the north Coast of Java Island. It is the capital of Central Java Province. The city boundaries are Java Sea in the north, Demak District in the east, Semarang District in the south, and Kendal District in the west. Due to urbanization, Semarang City has slowly evolved into a metropolitan city formed by the urban agglomeration of its surrounding cities and suburbs. Industrial activities together with other economic activities trigger a massive development in Semarang. As a result of the development, along with the increasing urbanization, the built-up areas of the city continue to expand towards the surrounding rural areas and riverbank areas. The constructions of university complexes, settlements, industries, hotels and restaurants have taken place on agricultural lands and riverbank area. The denser and larger built-up areas poses environmental issues including flood, water availability and land subsidence.

Flood is one of the major disasters in Semarang. So far, flood occurred more frequently in northern part of Semarang and which was mostly caused by tidal flood and poor drainage system. According to several sources, there are 91 villages in Semarang that are prone to flood hazard (ACCCRN, 2010). Flood impact area is affecting the north area of Semarang city and covering could inundate 5,668.83 Ha of the north part of Semarang region. This is caused by high rainfall intensity, land subsidence, and poor drainage system (The World Bank & The Municipality of Semarang, 2013)

Consequently, flood risk reduction and various flood mitigation measures is an important thing to should be done in Semarang. Therefore, various flood mitigation measures are needed. There have been several flood mitigation measures that were developed in Semarang. For example as stated in Semarang Urban Plan (RTRW), the strategies for managing and development of coastal areas in relation to control flood and tidal flood, are develop a water retention pool in North Semarang sub district was planned to be built to control tidal flood; River normalization would be conducted in the

entire region of Semarang; and Control built-up areas in Gunungpati, Mijen, and Ngaliyan would be controlled.

On the other hand, the sprawling development has not only brought flood issue but also other issues like social and ecology problem. The vast development has converted a lot numerous of open space in urban area into buildings that made cities lack of public space. Open space is the place for people to socialize and do outdoor activities which bring a lot various of benefits and this which is very important and necessary for the society. The urban development has also disturbed the balance in nature and made severe damage for degrade the ecology by converting the land in the upstream catchment area for settlement, similarly or built major industries were built in y area that disturb the coastal ecology area. The effects is pretty severe serious; like reducing the space ecosystem for animal and plants in the upstream and in the coastal environment was reduced, as well as land inundation, and not giving enough space for water to infiltrate to the soil that leads to flood. Another problem is that massive utilization of ground water in urban area will reduce the water table below the ground. The ground water need to be recharged by water through infiltration and absorption so it can maintain its level. If urban area does n'ot have enough open space for water to infiltrate thus the level of ground water can be lower would reduce which can caused water shortage in the urban area. The decreased level of ground water will make the ground become weak and sagging, this condition leads to land subsidence occurrence in urban area.

Comprehensive and suitable urban development concept is needed to deal with those complex problems in Semarang. The issue is not just about the physical development but also the conservation of the ecology. Thus, urban development also needs to should be integrated with conservation concept to keep the sustainability of in the urban area. This is where Green infrastructure can help to deal with those issues could be facilitated. Green Infrastructure is an emerging development concept that integrates development and conservation strategy and it which is suitable to be implemented in Semarang due to its similar addressed issues. Green Infrastructure can be used as an alternative way to deal with development and ecology problem in Semarang. It promotes as a strategic approach for land and water conservation, address the need for community development needs and mapping natural system as a basis for the spatial plan policy in Semarang. Green Infrastructure can could give co-benefits for benefit the environment, society and urban economy.

Furthermore, besides land and water conservation matter, one of Green Infrastructure's benefits is by give more providing space for water absorption and infiltration which can also be integrated in flood risk reduction. It is the idea that This idea will be addressed in this paper. There is an opportunity of integration between Green Infrastructure and Flood Risk Reduction that need to be explored further. This paper will discuss about the implementation of Green Infrastructure concept in mitigating flood hazard optimally using the flood canals in Semarang City as an example. This paper is also supported by GIS based spatial analysis to produce the open space allocation concept.

## **2. Literature Review**

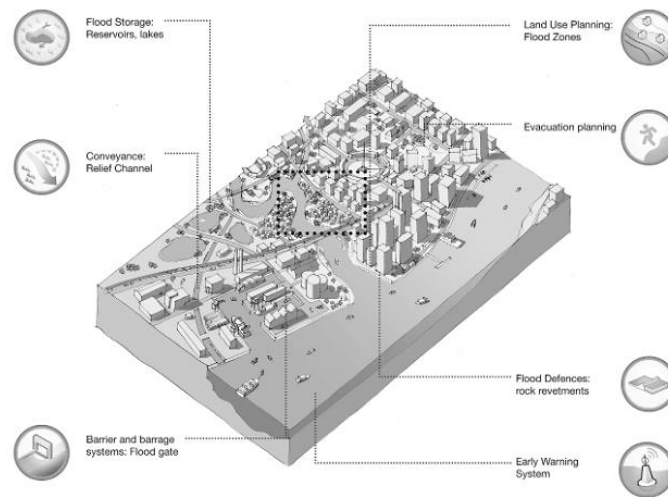
### **2.1. Flood Mitigation Measure in Urban Area**

There are several kinds of mitigation measure. Flood mitigation measures are usually described as structural and non-structural measures. Structural measures aimed at reducing the risk of flood by controlling the flow of water from the outside or from within the urban residence. This action is complementary to the actions of non-structural setting which seeks to ensure that the public safety against flooding with by utilizing planning and management of urban development. Thus, to achieve this ideal, a comprehensive and integrated strategy should be associated with urban planning, and policies and practices beforehand.

Common examples of structural flood mitigation measures in urban area are is making levees. Levees, also called embankments, dykes or stop banks, are the most common form of river control engineering (Starosolszky, 1994) It is also used as protection from flood in many region in the world for decades. Other option is by making conveyance. In the context of flood risk management, the purpose of conveyance is to "provide a route to take potential flood water away from areas at risk. Traditionally this has been seen as a way to remove the problem of flooding from the urban

environment. Such systems often form part of a much broader water management approach including, for example, hydro-electric schemes in which control of excess flows forms a part. In remote areas, rivers may be in a completely natural state; in many parts of the world, rivers have been heavily modified; and in particular contexts, flood conveyance may be achieved by purpose-built artificial channels” (The World Bank and GFDRR, 2012).

Furthermore, flood mitigation measure in urban area need to be integrated with multiple mitigation techniques in order to make it an efficient and effective measure. These techniques include a structural mitigation such as pond, dams, dykes, early warning system, evacuation plan, etc and non-structural mitigation like land use planning as illustrated in figure 1.



**Figure 1 Various Urban Flood Mitigation Technique**  
Source : The World Bank and GFDRR (2012)

Furthermore, flood risk reduction in urban areas need to be considered at a range of region, including the whole river and water catchment as a unity. This is because the source of flooding may be at a distance level from the affected receptor (in this case a town or city). Therefore, one of the options is to tackle the flooding problem before it reaches the urban environment. As the result, flood mitigation would be optimal when it is combined with the flood mitigation measure in the urban area too.

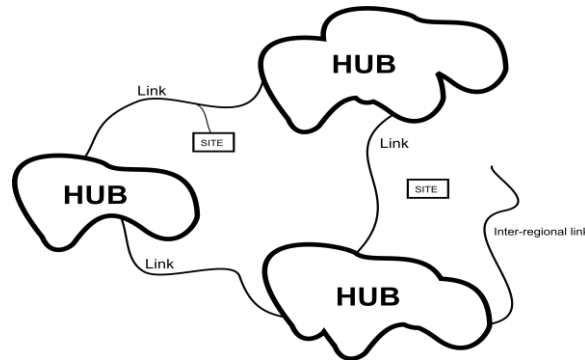
## 2.2. Green Infrastructure Concept

Based on Benedict and McMahon (2006) Green Infrastructure is defined as an “interconnected green space network (including natural areas and features, public and private conservation lands, working lands with conservation values, and other protected open spaces) that is planned and managed for its natural resource values and for the associated benefits in confers to human populations”. From that definition it can be known that green infrastructure emphasizes on the connection or the link within urban open spaces and green areas.

Green infrastructure encompasses a wide variety of natural and restored native ecosystems and landscapes features (greenways, waterways, wetlands, floodplain, parks, etc) (Benedict and McMahon, 2006). Green Infrastructure network connects these landscapes into a system of hubs, links and sites.

Figure 2 gives illustration about green infrastructure network. “Hubs” anchors green infrastructure networks and provide space for native plants and animal communities, as well as origin destination for wildlife, people and ecological processes moving through the system. “Links” is the connections that tie the system together. Example of these connections is greenway, greenbelts, river and stream floodplain, canal, etc. “Sites” also included in green infrastructure network. Sites are smaller than hubs and may not be attached to larger, interconnected community and regional conservation system but contribute important ecological and social values (Benedict and McMahon, 2006).

As cited from Benedict and McMahon (2006), The basic principle of green infrastructure is (1) protecting and linking parks and other green spaces for the benefit of people (recreation, health, aesthetic, urban design) and (2) preserving and linking natural areas to benefit biodiversity and counter habitat fragmentation (protecting native plants, animals, natural processes and ecosystem). An ecosystem preservation and protection functions of green infrastructure is the core idea that can be integrated into flood mitigation measure.



**Figure 2 Green Infrastructure Network**

Source : Benedict and McMahon (2006)

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### 2.3. Infrastructure in Flood Mitigation

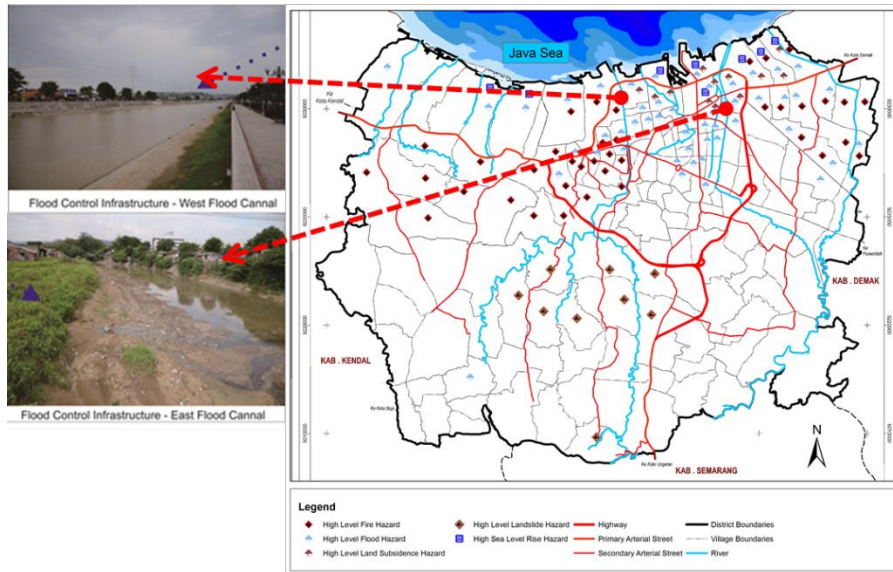
Green infrastructure role in flood risk mitigation is to provide water retention and water catchment area for the rain water. As stated in several institutions, such as American Rivers, Architects American Society of Landscape Architects, Econorthwest & Water Environment Federation (2012), storm water management conventionally focused on removing storm water from a site as quickly as possible to reduce on-site flooding. However, this approach has proven to be devastating to downstream communities because the increasing of streams which often damages municipal and public infrastructure (stream overflows and inundate the land). In addition, frequent flooding in urban streams increases channel and bank erosion, creating an ongoing threat to roads, bridges, and other public infrastructure. Applying Green infrastructure concept in the city development will decrease the degree of flood risk by reducing the excess run of at the source through infiltration, evapotranspiration, and beneficial use of storm water. Green infrastructure technologies can provide the equivalent, or better, control for small-storm flooding events than detention-based storm water management approaches as well as providing enhanced water quality treatment while potentially helping to manage events beyond high-frequency storms (American Rivers, Architects American Society of Landscape Architects, Econorthwest & Water Environment Federation (2012)).

### 3. Methodology

Semarang Municipality has a unique physical setting comprising of coastal area, flat land, and hilly areas. The height of the city is between 0.75 – 348 meter above mean sea level, with description of 1% from total area is coastal area with height 0 – 0.75 meter above sea level, 33% from total area is shallow area with height 0.75 – 5 meter above sea level, and 66% from total area is hilly area with height around 5 – 348 meter above sea level. The hilly area of Semarang is located in the South of the city, including Jatingaleh, Gombel, South Semarang, Gunungpati and Mijen (Semarang Environmental Agency, 2008).

Semarang acts as a capital city of Central Java Province and is a metropolitan area with huge amount of dense population. It is also a central of industries that is very important for of Central Java and contributes to Indonesian economic matters respectively. Thus, Semarang is the flood prone area in Semarang that needs to be mitigated in order to maintain its the city's sustainability. That conditions lead to the choice of Semarang as case study. Furthermore, East Flood Canal (EFC) is used as an example of green infrastructure and flood mitigation integration due to its function and natural open space condition.





**Figure 3 West and East Flood Canals In Semarang**  
Source : The World Bank & The Municipality of Semarang (2013)

Bad drainage and sewer system are the main problem cause that worsening of flood risk in Semarang. There is also a problem with the interconnection among different hierarchy of drainage channels which are often being hampered by city development or poor waste management. Furthermore, another flood control measure that are taken in response to tackling flood in Semarang is West Flood Canal (WFC). The newly established WFC has contributed significantly to reduce the flood impact in Semarang. The WFC under Central Semarang River Basin covers an area of 2,005 Ha. This river basin includes Kripik River, Kreo River and Garang River (Regional Planning and Development Board of Semarang, 2011). WFC also functioned as the main drainage system in the city, which channels the water to Java Sea. WFC has a width of 50 m and the water flows calmly due to the gentle riverbed (Indrosaptono, 2010).

Besides WFC, Semarang also has East Flood Canal (EFC). West Flood Canal has been improved through normalization efforts since 2010 but East Flood Canal (EFC), has not been normalized yet. The sedimentation there is high has been accumulated and therefore some part of the riverbed areas can be seen from the surface. EFC is also developed as countermeasure to reduce flood in Semarang, especially eastern Semarang Area. EFC belongs to the East Semarang Drainage covering 3,705 Ha area, which includes Candi River, Bajak River, Kedungmundu River and Bulu Lor River. EFC has a length of 14.50 km (Regional Planning and Development Board of Semarang, 2011). The high sedimentation rate is due to changes in land use in the river banks. On the embankment of the river, there is a permanent building which functioned as a residential and business.

East Flood Canal's role as a green infrastructure corridor need to be enhanced, in order to be optimally functioned. Ideally, green infrastructure is a system of green network that connects each other. Thus, some segment of East Flood Canal should be used as a green infrastructure representation. This study attempts to explore the potency of green infrastructure implementation for east flood canal in Semarang as an alternative approach in flood mitigation. Descriptive analysis method is taken to address the main objective. A simple calculation using GIS is also taken to support the discussion in this paper. Then, GIS is also used to make a proposed concept of green infrastructure in East Flood Canal Semarang.

West Flood Canal



East Flood Canal



**Figure 4 Existing Condition of Flood Canals in Semarang**

Source: Observation, 2013

## **4. Result and Discussion**

### **4.1. How Can Green Infrastructure serve in flood mitigation?**

With rapid development and complex environment problems, Semarang City needs an integrated development concept that can solve those problems at once. Thus, green infrastructure is a new approach that can be used to cope with those issues. Flood canal in Semarang is a suitable case for green infrastructure implementation, especially The East Flood Canal, but why not The West Flood Canal.? To compare, This is due to the fact that West Flood Canal in Semarang is already a built-up area and functioned as the city's main drainage system. The riverbank is covered with paving block and concrete so it cannot infiltrate and absorb the rain water. On the other hand, East Flood Canals has not been built yet. Eventhough the canals' sedimentation is high, it is still has a lot of spacious open area. The unbuilt condition of East Flood Canal which is still has open space so it still can be used as preservation area but still has the opportunity to be developed. The East Flood Canal was also developed as flood countermeasure in Semarang, so the function is vital in mitigating flood hazard. Vital infrastructure as part of urban physical development (including flood mitigation function) and the potency of conservation area make Green Infrastructure Concept is applicable in East Flood Canal, Semarang.

General Principal of green infrastructure techniques is using soils and vegetation to infiltrate, evapotranspire and absorb the rain water so the runoff can be reduced. Reduced run off can prevent stream to overflow and minimize the inundation in the land. These are the core functions in integrating flood mitigation and green infrastructure. Those functions can be obtained through green area such as parks, fields, floodplains, waterway, greenway, rain garden, ponds, etc.

In Semarang's East Flood Canal case, It has been identified that approximately there is an approximately area of 975.283,95 m<sup>2</sup> as open space. Judging by the aerial view (Googlemaps, 1:2000 scale), it is assumed that the open space is still green (unbuilt, soil and vegetation). This open space that can be utilized is to absorb more rain water and reduce run off. That This area is an asset in Semarang City to be developed efficiently for the Cgreen infrastructure developmentity's need. Therefore a development concept using Green Infrastructure principle is needed for that area.

### **4.2. Proposed Concept of East Flood Canal Green Infrastructure in Semarang**

This part of this paper will explain about proposed Concept of East Flood Canal Green Infrastructure in Semarang based on Green Infrastructure component. First component is the "link". In Semarang context, "link" is defined as the open space along the canal (Approximately 366.635 m<sup>2</sup>/36,7 Ha). Existing condition of this part is the embankment through the length of the East Flood Canal which is

covered by vegetation such as bush plant and grass, including the canal itself. This part forms a corridor from the coast area into the suburban area across the city. There are several possible options that can be done in this part. The first option is by enhancing the stream capacity through canal normalization. As mentioned before, the condition of the canal is highly sedimented. Normalization of the canal will deepen the stream and accelerate the stream flow so the water can be delivered faster to the sea. Next

The second option is, by developing the canal embankment is suitable to be developed as a flood plain. A flood plain is part of the land that proposed as inundation area which will carry exceed water or stream overflow when heavy rain of storm occurred. This is very useful for absorbing the rain water and reducing the run off. Besides serving as inundation area, flood plain also can be used for many activities such as picnic, outdoor activities, playing ground for children, etc during non-rain event. The flood plain does not need to be covered by concrete or other material that can block the water absorption (permeable material such as permeable pavement still can be tolerated). As comparison, the West Flood Canal actually has already had small are for flood plain, but the existing condition of the flood plain is covered by pavement and concrete that makes the water cannot be absorbed by the soil and vegetation. Furthermore, flood plain development in Rhine River can be a good precedence for flood plain development in Semarang (Figure 5).

Buffer is also important to give boundary between flood plain and the built area (buildings, road, houses, etc). The role of buffer is to gives limitation for the physical urban development so the development does not reach the wetland (flood plain). Trees and bush plant are suitable to be put on the buffer area.



**Figure 5. Rhine River Flood Plain in Wageningen.**

Source : Observation, 2014

Second component is the “hub”. In Semarang Green Infrastructure context, “hub” is identified as an open space area apart from the canal but still has connection with the open space area along the canal (Approximately 608.649 m<sup>2</sup>/60,8 Ha). Existing condition of that part is an unbuilt open land covered with vegetation (mostly grass and bush plant). This part is very suitable to develop into parks, city forests and rain gardens or other landscapes that can be functioned as public space and conservation area. Example of landscape in this area is the Goryōkaku Park in Hakodate City, Hokkaido Island, Japan as well as Kambang Iwa Retention Pond in Palembang, Indonesia.

The Goryōkaku park consist of water basin and green area. The water basin can be functioned to be water retention area in rainy season. The water basin can also help to carry excess water from the canal by making artificial channel that connects the canal and the water basin. For Semarang context, a water retention basin can be built as the parts of the parks using Pluit Dam in Jakarta as reference. Pluit Dam dimension is 8 meters deep and 60 hectares wide and can contain almost 17 million cubic of water (Kompas.com, 2013). The “hub” itself has more than 60 hectares open space area that can be utilized. So the “hub” can fits 1 retention pond as big as Pluit Dam and can carry water as much as 17 million cubic. So, this kind of structure will bring many benefits and it is possible to build this kind of structure as urban water reservoir in Semarang City.



**Figure 6. Goryōkaku Park, Japan**

Source : [concordnanae.com](http://concordnanae.com)

Furthermore, the vegetation that covered the park is very useful in reducing water runoff by absorption and evapotranspiration of rain water. The absorption of water also can help recharge the ground water and maintain the water table level, so it can prevent water shortage and land subsidence in urban area. Overall function of this park also brings benefit for the society by giving people a place for socialize and enjoying the beauty of nature. The concept of this park is in line with green infrastructure concept and flood mitigation measure. Therefore, the same concept can be used in the “hub” development of Semarang Green Infrastructure.

The last component is the “site”. In Semarang context, the “site” is identified as the built up area around the canal. Existing condition of this area is settlement area. There is not much option that can be done in this area because it has already been built. The possible intervention that can be taken that in line with green infrastructure concept is by providing water retention area in the settlement. This can be done by making biopores, retention well in the house yard, or maximizing the house garden function. Complete Illustration about the proposed Green Infrastructure concept in East Flood Canal can be seen in Figure 7.





**Figure 7. Proposed Green Infrastructure Concept in East Flood Cannal, Semarang**  
 Source: Analysis Result, 2014

## 5. Conclusion and Recommendation

Semarang has the potential to implement green infrastructure concept to help reducing the flood risk. The green infrastructure applied can bring a number of benefits to the City of Semarang, such as flood risk reduction, ecosystem preservation and open space provision. While the current RTRW shows a little attention on green infrastructure, there is still an opportunity to reconsider the urban development by incorporating green infrastructure concept.

In order to develop a well planned and comprehensive green infrastructure in urban area, integration with local urban plan is mandatory. On the contrary, urban green infrastructure project usually embedded in the city spatial plan because it needs to be overlaid with land use plan. The proposed concept in East Flood Canal Semarang in this study that was described before (ideal concept) needs to be overlaid with Semarang Spatial Plan in order to see the gap within the spatial plan and the concept facts in the field so recommendation can be resulted obtained.

As stated in the Spatial Plan (Semarang Spatial Plan 2011-2031), the area along the canal (link) is planned to be a conservation area. The spatial plan for this area is in line with the green infrastructure concept. Thus, floodplain area is very highly recommended as further the development of this area is in line with due to the similarity of the stated spatial plan and green infrastructure concept.

On the other hand, the unbuilt site (hub) is planned to be settlement area. As explained from in the discussion part before above, this area needs to be a green area through by the development of building parks, garden, city forest, etc. However, there is a gap here between the proposed concept and Semarang Spatial Plan. It can be seen that Semarang Spatial Plan has not fully implemented Green Infrastructure Concept. Therefore, building parks, garden and city forest is very highly recommended as an option for Semarang's physical development especially in relation with green infrastructure implementation.

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**Office:** Jalan Imperial II No. 52 Bandung, West Java, Indonesia 40135  
**Phone:** +622 225 36574 | **Email:** rdi@rdi.or.id | **Website:** www.rdi.or.id