



GREEN WATERFRONT CITY, FUTURE PERSPECTIVES FOR SUSTAINABLE CITY IN TIDAL FLOODING PRONE AREA AT NORTHERN SEMARANG

Ivan Muhammad Hanif^{1*}, Purwanti Sri Pudyastuti², Muhammad Isa Sulaiman³, Shafara Aisyah⁴

^{1,2,3,4}Department of Civil Engineering, Faculty of Engineering, Universitas Muhammadiyah Surakarta
Jl. A. Yani Tromol Pos 1 Pabelan, Kartasura, Surakarta, Indonesia, Kode Pos 57102

*Email: d100221327@student.ums.ac.id

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Abstract

Due to their low topography and flat terrain, Semarang's northern coastal areas are vulnerable to tidal flooding. This paper explains the concept of Green Waterfront City for northern coastal areas of Semarang. The concepts include: the design of mangrove forest areas on Semarang's North Coast as a natural, eco-friendly barrier that withstands sea abrasion; the concept of an artificial embankment made of natural materials that collects sediment and turns into a dike to reduce sea abrasion; and amphibious housing, which is a versatile, light-colored, eco-friendly residential area. Should the concept be put into practice, it would create advantages in some aspects such as: a) Socially, people affected by the tidal floods on the north coast of Semarang will be provided with appropriate housing and permitted to go back to where they previously lived; b) Economy: Communities affected by tidal floods on Semarang's north coast will see an increase in their economic worth in the fishing and tourism industries through the introduction of Silvofishery; c) Environment: The development of Green Waterfront City for northern coastal areas of Semarang can mitigate the negative environmental effects of tidal flooding and sea abrasion.

Keywords: *Amphibious Housing, Coastal Area, Mangrove Forest, Tidal Flooding*

1. INTRODUCTION

Semarang is the capital city of Central Java province. Semarang has a coastline on the northern border with a length of 13.6 km and a width of 2.5-10 km. The Northern Coastal Area of Semarang is famous as one of the economic, tourist and densely populated areas in Central Java Province. The existence of Tanjung Mas Port as one of the major ports in Indonesia and several industrial areas around it make the Northern coast of Semarang areas become one of the strategic economic areas in Indonesia that has the potential to be developed. As a strategic economic area, the North Coast of Semarang is also densely populated. The Johar Market area,

the Old City Area, Terboyo Terminal, Tawang Station, and Poncol areas are some areas at the northern coastal of Semarang that are densely populated. Although the Northern Coastal area of Semarang is an economically strategic area, on the other hand the North Coastal area of Semarang also has several problems, especially those related to the natural phenomena of tidal flooding, sedimentation, and land subsidence (Kementrian Energi dan Sumberdaya Mineral Republik Indonesia, 2017; Pemerintah Kota Semarang, 2021).

The Northern coastal areas of Semarang which have flat and low topography causes the areas prone to tidal flooding. Tidal floods are

floods inland in coastal areas during high tides or storm surges. Meanwhile, tidal floods generally occur temporarily and usually occur in a short time during high tide, although in some cases tidal flooding can occur permanently due to land subsidence. Tidal floods can cause significant impacts in everyday life both in the economic and social sectors of society. The impact of the tidal flood greatly disrupted the activities of the people who lived there. This is exacerbated by land subsidence so that some areas are permanently inundated by sea water which has a social impact so that people are required to relocate to places that are not affected. In addition, tidal flooding and groundwater subsidence have disrupted the livelihoods of residents, which has a negative impact on their economy.

This paper will explain a future perspective for sustainable city in a tidal flooding prone area which has land subsidence phenomena in northern coastal area of Semarang based on literatures study.

Land subsidence is the sinking or settling of the land surface caused by natural processes such as soil compaction, erosion, and tectonic activity, as well as human activities such as groundwater pumping, oil and gas extraction, and construction (Chen et al., 2023; Giovanie et al., 2023; Navarro et al., 2023). Moreover, other studies reported that the changes in land use and overuse of groundwater can result in land subsidence (Deltares, 2021; Figueroa-Miranda et al., 2018; Rahmati et al., 2019).

Coastal areas in Indonesia such as Jakarta (the capital city of Indonesia), Semarang, and Palembang are at risk of land subsidence. A study conducted during the period of 1982 – 2010 reported that land subsidence in Jakarta varies spatially and temporally, with rates ranging from 1 to 15 cm per year (Abidin et al., 2011). Subsidence rates of up to 20-28 cm/year have been recorded in a few locations. Land subsidence in the Jakarta basin can be classified into four types: subsidence caused by groundwater extraction, subsidence caused by construction loads, subsidence caused by natural consolidation of alluvial soil, and tectonic subsidence. The spatial and temporal variations of land subsidence were discovered to be dependent on the corresponding variations of groundwater extraction, as well as the

characteristics of sedimentary layers and building loads above it. In general, land subsidence and urban development activities in Jakarta are strongly linked (Abidin et al., 2011).

The economic expansion in recent decades has fueled urbanization and industrialization in Indonesian coastal cities such as Jakarta and Semarang. In light of this economic expansion, Semarang water demands have grown over time (Deltares, 2021). According to Water Dialogue Program (2021), the use of large amounts of water for industrial and other commercial purposes leads to over-extraction of groundwater and an increase in surface load in the areas along the northern coast of Central Java Province, including Demak, Semarang, and Pekalongan. The primary cause of subsidence in the region is anticipated to be groundwater extraction, especially in areas with unconsolidated sediments like the northern section of Semarang (Deltares, 2021). Apart from overexploitation of groundwater, climate change is also causing land subsidence (Ito et al., 2022).

Moreover, a study revealed that the Northern Coast region of Semarang is one of several cities experiencing the phenomenon of high land subsidence rates in the world (Forest Digest, 2022; Wu et al., 2022). A significant area of Semarang has sinking of 20–30 mm/yr LOS (Wu et al., 2022).

Figure 1 shows the line of sight (LOS) velocity map of Semarang (Wu., 2021). According to Wu (2021), the soil type in the area that are subsiding is mostly alluvium which is loose, unconsolidated soil or silt that has been eroded, changed in some way by water, and then redeposited in a nonmarine setting. This condition is a serious and threatening problem in the North Coast of Semarang. In addition, the threat of permanent tidal flooding will cause enormous losses at northern coast area of Semarang which is occupied by industrial areas and also filled with public facilities and densely populated.

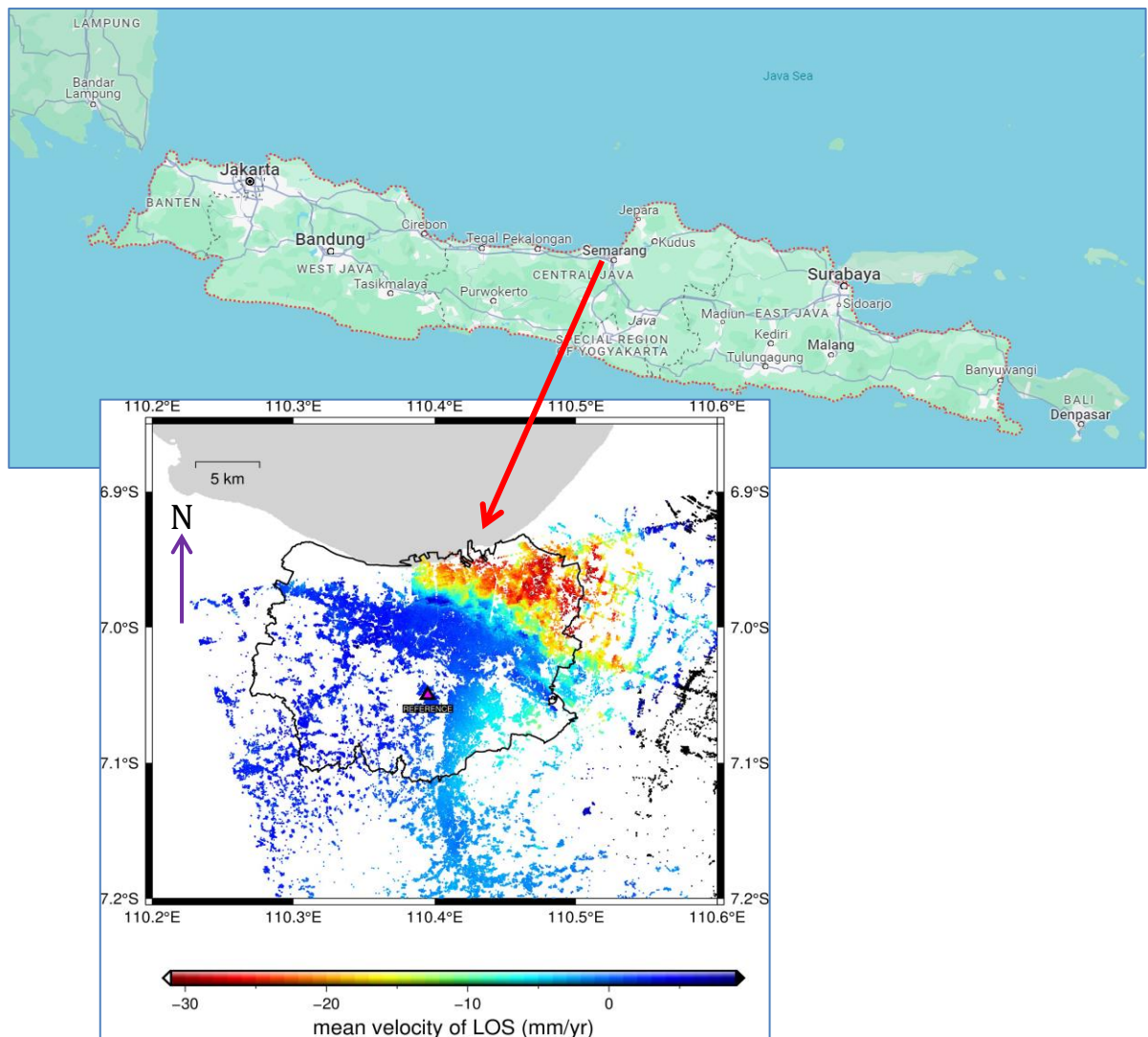


Figure 1. The Line of Sight (LOS) Velocity Map of Semarang (source: Wu., 2021)

A study conducted by Giovanie et al. (2023) reported that land subsidence in Semarang causes water permanent inundation in some areas that trigger physical impact on social, economic, and environmental activities as well as building construction. The community in the areas has made different adaptations based on their individual vulnerability conditions, their knowledge and ability, and their economic situation. The community's economic circumstances are indeed impacted by this situation.

According to Pudyastuti and Isnugroho (2023), Semarang's frequent flood events have had an impact on the city's infrastructures

pertaining to housing, transportation, electricity, and irrigation. Recurrent incidents included the damaged road, the airport and train station being disrupted, and human casualties from flooding. Extreme rainfall, a degraded river system, inadequate solid waste management, degraded drainage infrastructure, coastal flooding in the Northern Coastal Area, and a lack of green open space can all contribute to the flood events in that region (Pudyastuti and Isnugroho, 2023). In order to guarantee the sustainability of the urban system, urban infrastructure sustainability must be attained. However, the flood risk could stop this from occurring. Collaboration between the

government and all stakeholders is necessary for the successful management of flood risk.

Global warming that causes climate change has led countries around the globe to mitigate and create strategies for adaptation to climate change. One of the strategies is to apply and develop green infrastructure. According to Osawa and Nishida (2022), the term "green infrastructure" (GI) refers to the multifunctional ecological networks that are found within, around, and between human residential communities on all spatial scales. These networks can be natural, seminatural, or artificial. A vast range of elements, including intact forests, wetlands, agricultural land, and urbanized green spaces, can be included in this concept. Consequently, GI can be found widely in residential human communities.

Moreover, Osawa and Nishida (2022) explored that the geographic location of natural and seminatural GI essentially controls its implementation potential. For example, in a mountainous or hilly region, coral reef is not applicable GI. A forest cannot be added as GI for the sea. As a result, the natural state of the target area should be taken into consideration when defining the implementation potential of a given GI type (Osawa and Nishida, 2022).

2. METHODOLOGY

THE CONCEPT OF GREEN WATERFRONT CITY FOR NORTHERN COASTAL AREA OF SEMARANG

The concept of Green Waterfront City is a regional development concept that applies a combination concept between Green City and Waterfront City. The Green Waterfront City concept is expected to be able to address economic, social and cultural and environmental problems caused by tidal floods on the North Coast of Semarang so that an area that is economically, socio-culturally and environmentally sustainable is created.

Waterfront City is an urban development concept that is close to water sources such as beaches, lakes, rivers, and there are other natural elements such as the sun, sky, living plants which are considered unique and irreplaceable resources. Meanwhile, Green City is a concept of sustainable and environmentally sound urban development, which is achieved

through a balanced development strategy between social life, economic growth and environmental protection, so that the city becomes a livable place not only for the current generation but also for future generations.

The Green Waterfront City is divided into several concept ideas including:

2.1. The Amphibious Housing.

This is the concept of an adaptive, light, minimalist and environmentally friendly residential area. The housing is adaptable to environmental conditions in coastal areas. It is light because it uses light materials such as metal roofs, and bamboo materials for the walls and the house structures. Bamboo material was chosen because it is easy to obtain and because the price is less expensive. Apart from that, bamboo material also has good structural strength when applied to watery areas. This amphibious housing is a minimalist residential model with as efficient use of space as possible and a shape that is responsive to the influence of the coastal environment. The housing is equipped with rainwater harvesting system and solar panels system that are environmentally friendly and energy efficient.

The rainwater harvesting gives advantages such as provide domestic water supply and reduce flood risk. People in coastal areas typically face a lack of potable water due to high salinity intrusion into surface water and groundwater. As a result, harvested rainwater could be the primary source of drinking water for the coastal region's residents (Rahman et al., 2021). Furthermore, a study conducted by (Palla and Gnecco, 2022) in the Italy-France cross-border coastal area found that domestic rainwater harvesting is effective in supporting urban flood management, by volume and peak reduction indexes greater than 0.2. It implies the realization of storage tanks capable of containing at least 40% of runoff volume generated by the targeted event at the sub-catchment scale (Palla and Gnecco, 2022).

The rainwater storage tanks can be installed at the bottom of the amphibious building floor to utilize the empty space in that section. The housing is also equipped with solar panel system as energy source. The solar panel system is installed with a capacity sufficient to

meet daily needs as a green alternative to electrical energy.

2.2. Silvofishery

Special area arrangement for fish farming areas with the Silvofishery concept which is environmentally friendly and has high economic value. Silvofishery is a concept of reforestation and cultivation of milkfish, tiger prawns and green mussels carried out in mangrove forest areas (SilvoFishery Organisation, n.d.) Implementation of Silvofishery can increase the economic value of the community while preserving the mangrove forests on the North Coast of Semarang.

2.3. Mangrove Barrier

According to Sasmito et al., (2023), Indonesia has the most mangroves in the world. Indonesia has proposed the most ambitious mangrove rehabilitation target in the world (600,000 ha), to be achieved by 2024 in order to support multiple Sustainable Development Goals (SDGs 1-3, 6, 13, and 14). Natural mangroves provide numerous ecosystem services that help to achieve the SDGs both directly and indirectly. Mangrove ecosystems, for example, can be applied for mitigating flood risk, control carbon storage more efficiently than other terrestrial forests (SDG 13), provide habitat for fish and marine organisms (SDG 14), and provide fish products and important fishing grounds for coastal communities (SDG 2) (Kawata, 2022; Sasmito et al., 2023). Conserving remaining mangroves and restoring degraded ones may help mitigate climate change and reduce the effects of climate change on 296 million people living in tropical coastal communities, including Indonesia, the world's largest archipelagic country (Sasmito et al., 2023).

Arranging the mangrove forest area on the North Coast of Semarang as an environmentally friendly natural wall to resist sea abrasion and prevent damage due to

tsunami. Apart from that, mangrove forests are useful in absorbing all types of dangerous metals, making the quality of both water and air in the city of Semarang cleaner. Mangrove forest areas can also be developed as a tourist attraction that can increase economic value.

2.4. Embankment Using Natural Materials

Beaches and coastal areas often experience erosion and abrasion, therefore they need to be protected by building embankments. Litbang Kementrian Pekerjaan Umum dan Perumahan Rakyat Republik Indonesia (2018) has developed an artificial embankment using natural materials to capture sediment and reduce sea abrasion using local materials. In this Green Waterfront City concept, the wave breaker embankment as a regional barrier to prevent incoming waves will be made from local and natural materials such as bamboo.

The wave breaker embankment as a regional barrier to prevent incoming waves is made from local and natural materials such as bamboo. The bamboo material was chosen because bamboo has good structural strength when applied to watery areas. The concept of using bamboo material has a system to capture sedimentation which is characteristic of the North Coast of Semarang and is also suitable for use in coastal areas with light to moderate waves. Apart from that, the use of bamboo material will make bamboo have more economic value, and can be used as a trigger to empower communities whose areas have the potential to be planted with bamboo so that it will also improve the economy of the communities who grow bamboo.

Figure 2 and Figure 3 present the illustration of the Green Waterfront City concept for the northern coastal areas of Semarang.

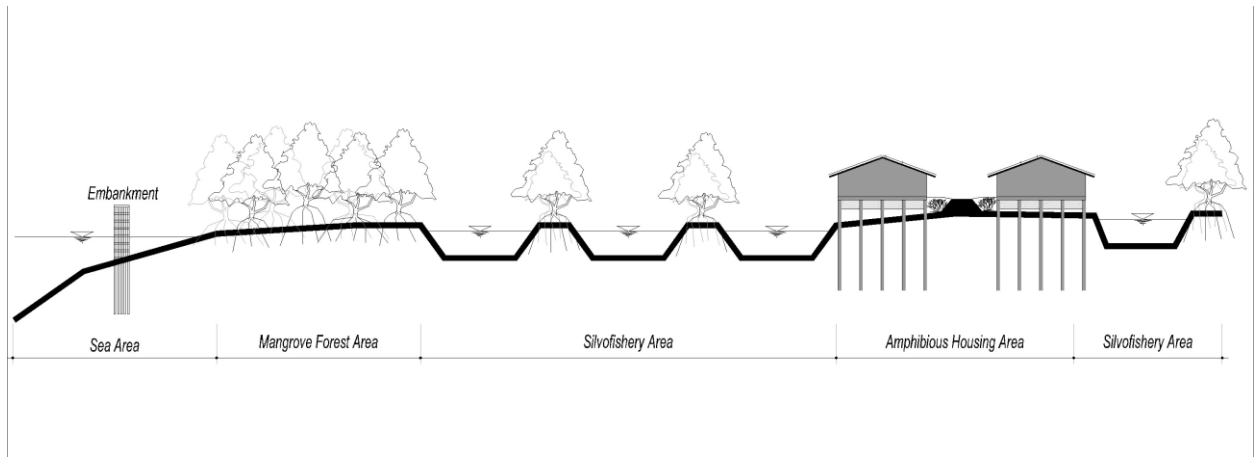


Figure 2. The Design Concept of Green Waterfront City



Figure 3. Amphibious Housing Design Using Light Materials and Adaptable to Floods

3. RESULT AND DISCUSSION

The concept of Green Waterfront City describes how to develop an area that is environmentally friendly, able to adapt to disasters, and sustainable. The idea, which includes fish farming space, embankment and mangrove-protected housing, was created based on the target area's natural state—the northern coastal region of Semarang.

This concept's amphibious housing, which is outfitted with a rainwater harvesting system, not only lowers the risk of inland flooding but also stores potential rainfall-related water sources to meet daily water needs. Additionally, the stilt house style is resilient to coastal flooding.

This concept can be implemented if supported by the following stakeholders:

- a. Bappeda (Regional Planning Agency) of Central Java Province, as policy maker and coordinator who implements, monitors and evaluates programs within the scope of Central Java Province;
- b. Bappeda Semarang City, Central Java, as policy maker and coordinator who implements, monitors and evaluates programs within the scope of Semarang City;
- c. KKP (Ministry of Maritime Affairs and Fisheries) as a partner in socializing programs related to fisheries resource conservation in the form of capital assistance, training and tools;
- d. Ministry of PUPR (Public Works and Public Housing) as a partner that helps in developing residential areas and implementing public infrastructure financing;
- e. The private sector or investors as those in charge of funding the program, managing the area, and developing it;
- f. Semarang's North Coast Coastal Community, as participants who back the program's execution in terms of social, economic, and environmental aspects;
- g. The academics and professionals as sources of guidance and program contributions in the field of science;
- h. NGOs or community groups, as partners in community empowerment so that the program can be sustainable.

The strategic steps that must be taken to realize the idea of a Green Waterfront City consist of several stages including:

3.1 Pre-Implementation

To finalize the concept of the Green Waterfront City, ideas were presented to the Bappeda of Central Java Province and the Bappeda of Semarang City prior to implementation. The next step, if the Green Waterfront City idea is developed and prepared for execution, is to draft program guidelines and a master plan. Finding agencies or investors willing to fund, oversee, and develop the program is the last step in the pre-implementation process.

3.2 Implementation

The process of putting the plans and all the preparations into practice is known as the implementation process. The process of creating the Green Waterfront City area, which includes a wave break embankment, a mangrove forest, a silvofishery, and residential areas with amphibious housing. The implementation process requires collaborative synergy from a variety of stakeholders, including:

- 1) KKP in terms of assistance with the preservation of fisheries resources for the silvofisher region
- 2) Ministry of PUPR in terms of implementing financing for supporting infrastructure and regional development
- 3) Experts or professionals in the field of scientific advice
- 4) In the context of program outreach, NGOs (Non-Governmental Organizations) or community communities, with the North Coast Coastal community of Semarang as participants who support the program's operation.
- 5) Local community organizations that will contribute to or be involved in the Green Waterfront City concept's implementation.

3.3 Monitoring and Evaluation

The monitoring and evaluation stage comes next, following the successful realization of the Green Waterfront City area concept. Studying every shortcoming and issue encountered during the idea implementation process with all relevant parties is the goal of this stage. Throughout the implementation phase, this monitoring and evaluation process is ongoing.

4. CONCLUSIONS

1. The development of Waterfront City with the idea of employing eco-friendly materials is known as the "Green Waterfront City." It is hoped that Green Waterfront City can address the social, cultural, and economic issues brought on by tidal flooding on Semarang's north coast.
2. The Green Waterfront City concepts that have been put into practice include the following: the arrangement of mangrove forest areas on Semarang's North Coast as an environmentally friendly natural wall that resists sea abrasion; the concept of an artificial embankment using natural materials to capture sediment and become a dike to reduce sea abrasion; and amphibious housing, which takes the form of an adaptable, light, minimalist, and environmentally friendly residential area.
3. It is anticipated that the idea could have the following effects if it is put into practice:
 - a) Socially, those impacted by the tidal floods on Semarang's north coast will be given suitable housing and allowed to return to their previous residences.
 - b) Economy: by introducing silvofishery, communities impacted by tidal floods on Semarang's north coast will see an increase in their economic worth in the fishing and tourism industries.
 - c) Environment: By planning the Green Waterfront City-based area on Semarang's north coast, it can lessen the effects of environmental harm brought on by tidal flooding and sea abrasion.

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