Duri Kosambi Sponge Park: The application of Sponge City concept on green open space in reducing flood intensity in Jakarta

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Abstract. Flood in Jakarta has been a big issue nowadays. It soaked a thousand hundred hectares of resident area. There are many factors generating flood in that area, such as the dysfunctional of green open space as flood control. Furthermore, the large of provided green open space has not been complied the requirement, as only 9.9% of pre-requrement large of 30% of large area. Sponge City Concept is on of ideas in the form water controlling succeeded to be applied in China having 4 main concepts, which are water ecology, water safety, water environment, and water resources. Therefore, this article takes green open space Duri Kosambi as the specific research object by redesigning it into Duri Kosambi Sponge Park. This paper utilizes 3 (three) steps in redesigning green open space Duri Kosambi, pre-design, design, and post-design. The result of this paper Duri Kosambi Sponge Park design consisting of a plan-layout design, an aesthetic bioswale, a multifunction “O’Area”, and an absorption poll visualized in 3D picture. Additionally, a plan and analysis of Duri Kosambi implementation are discussed in this paper. By stating this idea, it is expected to be able to give the positive effect for environment, economics, and social culture in the society.

1. Introduction
Flooding in Jakarta has been a big issue recently. It soaked 1,397 neighbourhoods with a total population of 454,158 people and 114,305.69 ha of drown area [1]. The Meteorology, Climatology, and Geophysics Council (BMKG) stated that the flood in Jakarta in 2021 is generated by extreme weather, impacting the increase of rain cloud growth and rainfall intensity [2]. Besides, the land subsidence in Jakarta occurring every year impacts the increase of risk of being flooded by high tide and flood. The Directorate General of Water Resources Ministry of Public Works and Housing (PUPR) [3] stated that the land in Jakarta undergo subsidence with the range 0-12 cm/year due to the escalation of groundwater usage for household consumption and industry. The decrease of the soil is caused by the widespread of ground water for household consumption and industry in Jakarta. Pratiwi, et.al [4] also stated that Jakarta area is a downstream area located under the sea level. Therefore, if the overflow of water on the surface occurs, the flood will occur.

Flood occurring in Jakarta is the annual duty for government of Jakarta. On 2021, government collaborating with Regional People's Representative Assembly (DPRD) of Jakarta have been allocated
the fund by IDR 1.5 trillion for solving the flood [5]. The fund has been allocated for revitalisation of pump house, river normalization, and even for alerting Public Facilities and Infrastructure Handling workers [5,6]. However, that have not been able to reduce flood intensity coming annually.

In fact, the existing green open space has been unable to resist high puddles. It is only planted with trees without any water absorption into the soil before being channelled to the river concept. This condition worse with the fact that the total amount of green open space in Jakarta is only 9.9% of 30% of pre-requirement [7].

The concept of flood control in urban areas has been developed recently, one of them is the “Sponge City Concept”. It is an idea discussing ecological rain management developed in China [8]. It is also applied in some countries in the world before with different terms as shown by Figure 1.

For instance, Best Management Practices (BMPs) in America, Sustainable Urban Drainage System (SuDS) in England, and Water Sensitive Urban Design (WSUD) in Australia succeeded in being implemented [6]. There are 4 (four) main principles in planning and implementation of the sponge city concept, such as: water ecology; water safety; water environment; and water resources [10]. However, the application of the concept has not been applied massively in Jakarta, especially in the green open space area. The government only focuses on the addition of biopore holes around the street [11,12] and less attention regarding the value of green open space as the media to reduce the flood. Based on the explanation, the writer has the idea in the form of green open space implementing sponge city concept to reduce flood intensity, especially in Jakarta.

2. Methods
The methods used in designing Duri Kosambi Sponge Park shown as Figure 2.

2.1. Pre-design stage
Pre-design is conducted by collecting the data required in designing Duri Kosambi Sponge Park in the form of secondary data. The data is obtained by reviewing numerous literature sources, including from books, news articles, national and international journals related to the discussed topic.

2.2. Design stage
The collected data is processed and presented into systematic results later. This stage is undergone by creating the preliminary design of Duri Kosambi Sponge Park using AutoCAD, SketchUp, and Lumion. Afterwards, the design is deliberated with experts to get constructive inputs, suggestions, and final design.
2.3. Post design stage
Later, the approved final design will be analyzed regarding the steps of implementation the design and how the effect if the design is implemented. The result is shown in the form of the chart and table.

3. Results and discussion

3.1. Duri Kosambi sponge park layout plan
The concept of Duri Kosambi Sponge Park is shown Figure 3. The layout setting is supposed to form an artistic, appropriate, and multifunction design of the planned element. The layout design of this park is divided into 4 (four) zones (Figure 4), including:

- Zone 1 is an absorption pool area.
- Zone 2 is a playground area.
- Zone 3 is a Multifunction O'Area.
- Zone 4 is a Tree Canopy Expansion by adding the variety of trees in the garden.

![Figure 3. The existing condition of green open space of Duri Kosambi](image1)

![Figure 4. Layout plan of “Duri Kosambi Sponge Park”](image2)

The road area plan is designed by utilizing paving blocks with raw material and mix compositions which can absorb rainwater (porous concrete). It is expected to accelerate rainwater into the soil. Putri et al. [13] revealed that porous concrete has rapid infiltration acceleration at a rate of 2,804.71 inches/hour. There are two paving blocks employed in the road area. They are rectangle shape (conventional) and hollow shape. Its combination will also add to the aesthetics of the garden.
3.1.1. Aesthetic bioswale

The next design is providing a building aesthetic bioswale in the median and garden roadside as revealed by Figure 5. Bioswale is one of the engineering design infrastructures ensuring that the water flow is directed to a reservoir [14]. The Aesthetic bioswale design is in the form of elongated basin with a certain depth and it is planted with ornamental plants vegetation.

![Aesthetic Bioswale design](image)

**Figure 5.** Aesthetic Bioswale design

Bioswale has a simple system in contributing water absorption into the soil. Later, the road runoff water getting into bioswale, then filtered and deposited by the variety of plants and rocks. Furthermore, the water is infused into the soil sequentially through the hollow pipes shown in the Figure 6.

![The Detail of Aesthetic Bioswale](image)

**Figure 6.** The Detail of Aesthetic Bioswale

The production of bioswale brings a lot of benefits, such as being able to reduce the content of mud, heavy metals, and rainwater pollutants; enhancing the ability of water absorption into the soil; and being able to add aesthetics and recreation for the local community [15]. It has been proven in study conducted by Xiao, et.al. [16] identifying the existence of nitrogen, phosphate, and total organic loading by 99.1%, 99.5%, and 99.4% and surface runoff by 99.4% decrease, compared to the after bioswale construction control. Herein in Purvis, et.al. [17] also identified the existence of enterococci concentration, fecal coliform concentration, and total suspended sediment decrease by 55%, 75%, and 10% to bioswale overflow and by 59%, 65%, and 88% to underdrain bioswale.
3.1.2. Multifunction O’area

Multifunction O’Area is an additional facility in the form of outdoor seating in the middle of Duri Kosambi Sponge Park. It is designed as multilevel design with a grass layer cushion, as being shown in Figure 7. It is integrated with an absorption well (Figure 8), functioning as rainwater reservoir falling to the Multifunction O’Area. Rina, et al. [18] stated that the existence of the absorption well can lower flood rate surface up to 0.01020 m³/s of 0.02211 m³/s flood rate without water reservoir. Putri and Sudarmadji [19] identified that there is the effectiveness of absorption well construction by 18.7% up to 26.1% in ability to let the rainfall be absorbed into the soil. Taufik and Anggraeni [20] also identified the effectiveness of absorption well construction by 34.408% up to 99.96% in reducing water rate. Therefore, it can be concluded that the absorption well construction has some advantages, such as [21]: to fulfil soil pores resisting the land degradation occurs; to increase the amount of water entering the soils; and to reduce surface runoff which can prevent flooding.

![Figure 7. Multifunction O’Area design](image)

Figure 7. Multifunction O’Area design

![Figure 8. The detail of absorption well system](image)

Figure 8. The detail of absorption well system

3.1.3. Water absorption pool

Water absorption pool or retention pool is a pool made for accommodating water runoff surface water that is reabsorbed later into the soil [14]. It is designed as multilevel design by utilizing the cut and fill process for land surface formation as shown by Figure 9. The existence of an absorption pool can add the aesthetic value of Duri Kosambi Sponge Park through multilevel water absorption contour. Besila [14] stated that the existence of the absorption pool is more effective in accommodating and absorbing runoff water than a sloping runoff niche.
3.2. The stages of Duri Kosambi Sponge Park implementation

The stages of Duri Kosambi Sponge Park implementation can be seen on Figure 10 and explained below.

- **Socialization.** This step is supposed to educate the local community of Duri Kosambi regarding the flood, the effect, and how to overcome with flood. This activity also discusses the grand design of Duri Kosambi Sponge Park built in Duri Kosambi green open space.
- **Land study.** In this step, there will be land study supposing to implement the first design of Duri Kosambi Sponge Park in the whole of green open space area.
- **Permission.** This step is done to get the permission regarding the construction of Duri Kosambi Sponge Park from the related agencies.
- **Agreement.** This step is done by making an agreement by signing **Memorandum of Understanding (MoU)** done by green open space manager, related agencies, and the local community regarding the use and the management of green open space area together.
- **The DED (Detailed Engineering Design) making** is a shop drawing of design component of Duri Kosambi Sponge Park. It is done by project tender system referring the Presidential Regulation No. 16 Year 2008 about The Government Procurement of Goods/Services [22].
- **Inauguration.** This step is the last step of Duri Kosambi Sponge Park implementation. It is undergone symbolically by green open space manager, related agency, and the local community.

![ absorption pool](image)

**Figure 9.** The water absorption pool design (self-made by the authors)

![ absorption pool](image)

**Figure 10.** The Duri Kosambi Sponge Park implementation stages
3.3. The analysis of effect from implementing Duri Kosambi Sponge Park

Every construction conducted in a region let the society get the impact. Its impact of conducting a construction may be positive or even negative. Moreover, there are three fields having a strong impact caused by construction, such as environment, economics, and social culture [23]. The analysis of effect from Duri Kosambi Sponge Park construction towards those three aspects is shown by Table 1.

Table 1. The Analysis of Effect from Implementing Duri Kosambi Sponge Park

| No | Impacted Area   | Explanation                                                                                                                                 |
|----|----------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| 1  | Environment    | The environment becomes more beautiful, cozy, neat, and comfortable due to the increase of plant variety. In addition to that, the water goes to a water reservoir and absorption first before flowing to drainage. |
| 2  | Economics      | The employment opportunity and business in the community increases, impacting the increase and acceleration of the community’s income.          |
| 3  | Social Culture | The corporation among the local community increases through some activities, such as taking care of the facilities and joint activities, like exercise and community service done in Duri Kosambi Sponge Park. |

4. Conclusion

To sum up, flood occurring in Jakarta is a natural disaster that can be anticipated by conducting some infrastructure engineering, which one of them done by maximizing the function of green open space as flood control. Duri Kosambi Sponge Park is one of the alternatives taken by the Jakarta government in preventing floods by implementing the sponge city concept. Furthermore, the construction of Duri Kosambi Sponge Park is designed to require 4 (four) principles including water ecology; water safety; water environment; and water resources. Besides, the implementation of the design is believed to have positive effects for the environment, economics, and social culture.

5. References

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