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GREEN INFRASTRUCTURE IMPLEMENTATION TO INCREASE SUSTAINABILITY IN THE CITY OF SURABAYA (CASE STUDY: FLORA PARK)

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ABSTRACT

The rapid development of cities not only has an impact on the improvement of economic aspects, but also brings quite serious problems, especially the decline in environmental quality. To ensure that the condition of the urban environment is maintained, regulations are implemented, one of which regulates the availability of green open space. This regulation comes under the aim of limiting the built-up areas in urban areas so that open spaces can be used for planting and can be made available to the public for social and recreational activities.

Objectives: The objective of this study was to identify the application of green infrastructure as part of the green open space in Surabaya.

Methodology and results: The method used in this research is descriptive qualitative by collecting data directly through field observation or indirectly through literature study. The location taken for this research was Flora Park in Surabaya. The results of the observations show that the park implements well the green infrastructure concept such as the use of environmental paving block, perforated pipes, xeriscaping, rainwater harvesting, tree canopy, reservoir, and supportive waste management system.

Conclusion, significance and impact study: It is important to pay attention to the maintenance of the park so that it remains align with its function and use.

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- Sustainable City

1. INTRODUCTION

Currently, cities are experiencing rapid development, changing the shape of space, population, economy, and the built environment [1]. Many people are urbanizing, moving from rural to urban areas, for various reasons, such as the availability of job opportunities, ease of access to services,

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and other factors [2]. However, the increasing population in urban areas has several impacts, especially concerning environmental issues. This also worsens the initial conditions in Indonesia, which is a disaster-prone area, including disasters related to climate change [3]. Urban areas with dense built environments often experience problems related to high temperatures compared to rural areas [4]–[6]. Buildings, roads, bridges, and other infrastructure capture and store heat, resulting in a phenomenon known as the urban heat island (UHI) effect [5]. As cities grow larger, the UHI also gets higher because more land is converted into developed areas, and the energy requirements for cooling processes are getting bigger [7], [8].

The transformation of the built-up regions into urban areas, which affects the increasing UHI and is exacerbated by global warming, requires implementing comprehensive policies as a solution for sustainable urban infrastructure planning [9], [10]. In recent years, various efforts have been made to implement greener, environmentally friendly infrastructure planning [11]. Green infrastructure is considered a strategy to ensure the future sustainability of cities [12].

The density of residential areas due to rapid population movement is also one of the causes of high temperatures in urban areas. Residential areas, which should be a comfortable environment, have now lost their function and quality due to very high-density levels. Based on studies in the field of urban planning, livable settlements are an essential aspect to ensure the comfort and safety of their residents. Several criteria are used as benchmarks for settlements that are said to be livable, namely: quality of houses, coverage and quality of environmental roads, availability of drinking water and clean water, ecological drainage, waste and waste management, availability of public transportation, affordability of living costs, the legality of land ownership rights, and availability of green open space [13].

Surabaya is Indonesia's second-largest metropolitan city [14] and is also not free from the problem of residential density [15]. The Surabaya City Government is currently sustainable urban development by paying attention to environmental aspects [16]. Implementing green infrastructure in cities is urgent to ensure ecological sustainability and comfort those living there. Law No. 26 of 2007 concerning Spatial Planning also states that green open space in urban areas is at least 30% of the city area, with a proportion of 20% for public green open space and 10% for private green open space. One of the reasons for the limited area of green open space is the rapid growth of the urban regions in recent decades [17]. Often, irregular urban development sacrifices park areas for commercial and residential projects [18]. However, due to public

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awareness about the importance of a healthy, comfortable, and sustainable environment, the development of parks as part of urban green infrastructure is increasing [19].

Parks, as an example of Green Open Space, function to help preserve the environment by providing places for recreation and physical activities [20]. Parks can act as conservators of biodiversity [21], absorb carbon, reduce air pollution, and reduce hot temperatures in cities caused by the urban heat island phenomenon [22]. Parks also positively impact social aspects of society [23], creating space for social interaction, strengthening community ties, and providing a place for cultural and artistic activities. Previous research has studied the urgency of providing parks as part of green infrastructure. However, it is essential to examine the existing conditions of parks as part of implementing green infrastructure in Surabaya.

2. RESEARCH METHODOLOGY

This research was conducted to describe the implementation of green infrastructure in Flora Park. This research is a type of qualitative descriptive research where qualitative data is described in detail to explain the results of the research that has been carried out. The data sources in this research were obtained directly through field observations and indirectly through literature review. The observations were conducted to see the physical condition of the park, such as using eco pavers, perforated pipes, xeriscaping, rainwater harvesting, tree canopy, reservoir, and supportive waste management system. The literature review is used to expand the theoretical framework related to implementing green infrastructure in urban areas, especially green open spaces. Interviews were also conducted to extract data regarding the community's opinions as users and beneficiaries of the facilities provided in green open spaces. The location of this research is the Flora Park of Surabaya. The location of this park was chosen considering the representation of parks in the city of Surabaya, which are often visited and used by the wider community, not only for recreation but also frequently for children’s educational programs.

3. RESULTS AND DISCUSSION

Flora Park has improved the environmental quality and positively influences the economic and social conditions of the community. From an environmental aspect, Flora Park makes the air around the park cooler. Flora Park has hundreds of plant species and large trees that can supply clean oxygen to the environment. Apart from that, Flora Park also positively impacts people's

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mental quality by making them calmer when visiting the park. This aligns with the theory that humans cannot be separated from nature. Humans will have better mental health when they are close to nature.

3.1 Existing Condition

Flora Park is in Gubeng District, Surabaya. As the name suggests, this park has a complete collection of plants ranging from various flowers and herbal plants to giant trees. In its operations, Flora Park has implemented several types of green infrastructure. This significantly impacts the environment, especially in reducing pollution levels and protecting the sustainability or existence of various flora in the park. Several types of green infrastructure implemented in Flora Park include perforated pipes, rainwater harvesting, xeriscaping, and tree canopies.

Following its function, the perforated pipes found in Flora Park are used for water absorption, especially during the rainy season, when rainwater intensity is relatively high. To reduce waterlogging, perforated pipes placed in the grass area will help channel water to irrigation or water channels. Apart from that, the garden area is also dominated by paving blocks. This aims to facilitate water absorption into the soil to minimize the occurrence of puddles, which can disturb the aesthetics and comfort of the garden area.

Fig 1. The use of paving blocks

Fig 2. Rain harvesting

Another example of implementing green infrastructure is rainwater harvesting. The method used in Flora Park to harvest rainwater is by providing several water tanks at several points in the park to collect rainwater that falls. This water tank is used to wash the hands of park visitors. When it is the dry season, and there is no rain, this tank will be filled with water by the

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relevant agencies to continue meeting visitors' hand-washing needs.

Xeriscaping can also be found in Flora Park. Xeriscaping is one application of green infrastructure, which involves grouping plants with the exact needs. This grouping aims to save water used for watering plants. Planting medicinal or herbal plants in Flora Park is done by xeriscaping. To maintain the comfort of visitors when doing activities in the park, there is a tree canopy expansion, which provides shade for park visitors who will spend time there. This tree expansion canopy is on almost every pedestrian path, so visitors do not feel too hot from the sun. This tree canopy also makes the road next to Flora Park shadier, making road users comfortable.

In Flora Park, there is also an artificial reservoir. This artificial reservoir collects rainwater and acts as a water catchment to prevent puddles from occurring when the rainy season arrives. However, it is regrettable because the artificial reservoir in Flora Park is currently poorly maintained and filled with dry leaves on top. This gives the impression of being dirty, and if it is not cleaned, the standing water in the artificial reservoir can become a breeding ground for mosquitoes, which has the potential to endanger park visitors. It is also feared that the leaves in the artificial reservoir will settle to the bottom and hinder water absorption into the soil.

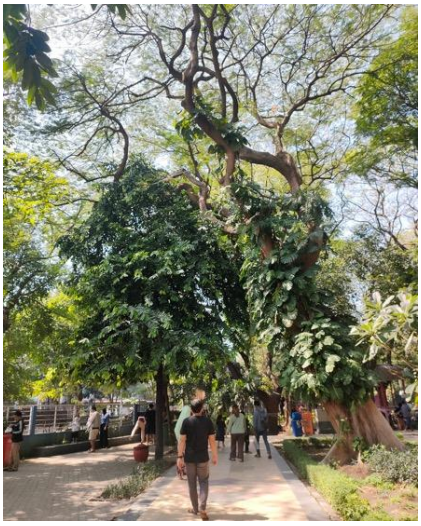

Fig 3. Tree canopy expansion

Fig 4. Artificial reservoir

3.2 Match Between Function and Utilization

Green open space is significant in maintaining environmental balance in urban areas. Flora Park is a non-natural green open space area in Surabaya that was deliberately built by the government

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to serve as a public place for socialization, recreation, and children's play areas. With various types of well-maintained vegetation, Flora Park can improve air quality because it can absorb pollution from exhaust emissions and vehicles passing around the park. Extensive vegetation can also provide coolness and function as shade for visitors inside the park and motorized vehicle users outside the park.

Fig 5. Playground area

3.3 Supporting Facilities

Various supporting facilities can be found in Flora Park, one of which is effective waste management to minimize the negative impact of waste on the surrounding environment. There are a lot of visitors to Flora Park, especially on weekends. This certainly affects the volume of waste generated. If waste management is not carried out properly, it will reduce the level of cleanliness and aesthetics of the park. The waste in Flora Park is managed by separating organic and non-organic. Trash cans with various colors according to their type of waste are placed at several points and can be easily reached by park visitors. There is also a temporary storage area for waste, which will later be transported to the final disposal site. Several barrels for composters can also be found at several points in the park. The compost produced from the composter can be used to fertilize plants and improve the quality of the soil by enriching its nutrient content.

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Fig 6. Composter

Fig 7. Waste management

3.4 Accessibility

Flora Park is well-designed and easy to access, one of which is used as a communication medium for the city community. In this case, the community can use the park to hold social gatherings, cultural festivals, and even children's learning activities outside of school. This activity can create better social ties between communities and build positive community communication. Taman Flora also provides facilities for people with disabilities to create an inclusive environment where everyone feels welcome and participates in community activities. The provision of disability-friendly facilities includes pedestrian areas and children's play areas.

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Fig 8. Disability pedestrian area

Fig 9. Children's play area

3.5 Maintenance

Flora Park is maintained to sustain its cleanliness and beauty. This maintenance is mainly in plant care, such as applying fertilizer, usually done at the beginning of the planting process. This aims to ensure the vegetation maintains its fertility and gets an adequate supply of natural nutrients to support its growth. Plant watering is also carried out regularly, especially during the dry season and no rain falls. This watering aims to keep the plants alive and maintain humidity. Vegetation that continues to grow requires maintenance and pruning to keep its shape neat and not endanger park visitors. In addition, plants that have died or are damaged must be immediately replaced by replanting with plant seeds that are in better condition. This aims to minimize the spread of plant diseases, and it is feared that it will harm the overall vegetation in the park. Apart from maintaining plants, supervision is also essential to maintaining the garden's sustainability. Security is carried out by officers going around the park and supported by CCTV cameras scattered in several corners to ensure that conditions are controlled safely.

4. CONCLUSION

Green open space is essential in ensuring that the city becomes a suitable place to live. Flora Park, one of the Green Open Spaces in the City of Surabaya, has implemented various green

infrastructure to maintain environmental sustainability in the park area. Green infrastructure applications found in Flora Park include perforated pipes, paving blocks, rainwater harvesting, xeriscaping, and tree canopies. Perforated pipes prevent puddles in garden areas because falling rainwater will be transferred to water channels. Paving blocks in the Flora Park area are used to accelerate the absorption of rainwater into the soil. To collect rainwater so it is not wasted, Flora Park uses the rainwater harvesting method for further water use, such as watering plants and washing hands. Xeriscaping in Flora Park aims to group medicinal or herbal plants to save more water when watering plants. Apart from that, to maintain the comfort of visitors when doing activities in the park, there is a tree canopy expansion, which provides shade for park visitors and road users around Flora Park. This park not only contributes to environmental issues but also to the increase of society's mental health. This aligns with the theory that humans cannot be far from nature. Although cities have grown with many buildings and skyscrapers, humans still need something green.

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