JIMESE
Journal of Innovation Materials, Energy, and Sustainable Engineering
JIMESE 2(1): 64–78
ISSN 3025-0307

Analysis of the effect of Boezem development as flood control

Pramudya Aridhadinata[1], Agung Dwi Laksono[1], Widia Ade Novita[1], Achmad Faishal Nur Cahyadi[1], Galuh Ismaya Sari[1,*]
[1] *Department of Civil Engineering, Faculty of Civil Engineering and Planning, Institut Teknologi Adhi Tama Surabaya, Surabaya 60117, Indonesia.*
*Correspondence: galuh16.maya@gmail.com

Received Date: June 30, 2024 Revised Date: July 31, 2024 Accepted Date: July 31, 2024

ABSTRACT
Background: Flooding is a frequent problem in Dukuh Kupang, Surabaya, causing material losses and disrupting daily activities. The construction of boezems, which are retention ponds to temporarily store rainwater, is considered a potential solution to control flooding in this area. This study aims to analyze the effect of boezem construction on flood control in Dukuh Kupang with the hope of providing new insights into the effectiveness of boezem as flood control infrastructure and providing recommendations for improved flood management strategies in the future. **Methods:** This study used a descriptive method. Data were collected through questionnaires and scored using a Likert scale. **Finding:** The results revealed that the feasibility score of boezem construction was 60.2%, indicating that boezem construction is considered quite feasible as a flood control solution, but there is still room for improvement. **Conclusion:** Respondents in this study recognized the benefits of boezem construction, but also expressed concerns or factors that are not yet fully supportive. There is a negative stigma among the community regarding the construction of boezems, which is largely due to the lack of socialization and community participation in the development process. **Novelty/Originality of this study:** A study on the effectiveness of booze in Surabaya evaluates technical aspects and considers community perceptions, providing a holistic approach to assessing flood control infrastructure.

KEYWORDS: boezem; community perception; community participation; flood control.

1. Introduction

Natural disasters are inevitable natural phenomena that often have a major impact on human life and the environment. Among the various types of natural disasters, flooding is one of the most common, especially in Indonesia which has a tropical climate with a long rainy season. Floods can be caused by a variety of factors, including heavy rainfall, uncontrolled river flow, and land use changes that reduce the soil's capacity to absorb water (Balahanti et al., 2023).

When flooding occurs, water may overflow from rivers or come from heavy rains, inundating normally dry areas. This phenomenon not only results in damage to infrastructure such as roads and bridges, but also damages agricultural land that is a source of food for many people. In addition, floods can disrupt transportation systems, cut off access and communications, and pose health risks due to contaminated water. The impact of flooding is not only limited to material losses, but also affects the social and psychological

Cite This Article:
Aridhadinata, P., Laksono, A. D., Novita, W. A., Cahyadi, A. F. N., & Sari, G. I. (2024). Analysis of the effect of Boezem development as flood control. *Journal of Innovation Materials, Energy, and Sustainable Engineering, 2*(1), 64-78. https://doi.org/10.61511/jimese.v2i1.2024.978

Copyright: © 2024 by the authors. This article is distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

aspects of society. Flood victims often experience trauma, loss of shelter, and even loss of life (Utomo et al., 2022). Therefore, flood management and prevention are very important, especially in areas that are prone to experiencing this disaster repeatedly.

Disaster mitigation efforts and community education on how to act when flooding occurs are measures that can reduce the negative impacts of this natural disaster. Flooding has become a problem in Indonesia that needs to be addressed through attention or flood prevention and management measures because it causes significant losses to the community, government, and the environment. One of the areas in Indonesia affected by flooding is Surabaya City. Among various preventive efforts in the field of infrastructure such as river normalization and the creation of drainage channels, there is also the creation of artificial lakes or reservoirs called boezems. Boezem itself refers to a pond used to temporarily accommodate rainwater or river runoff in a certain area. (Nawfal et al., 2021). Bozem development was also carried out in the Morocrembangan area of Surabaya and a study was conducted with the title "Bozem Morokrembangan Water Management and Water Tourism Facilities in Surabaya" (Laurencia et al., 2023). This study looks at the management of clean water in Bozem and provides insight to visitors about the water treatment process. The following is the estimated rainfall data in East Java (Fig. 1).

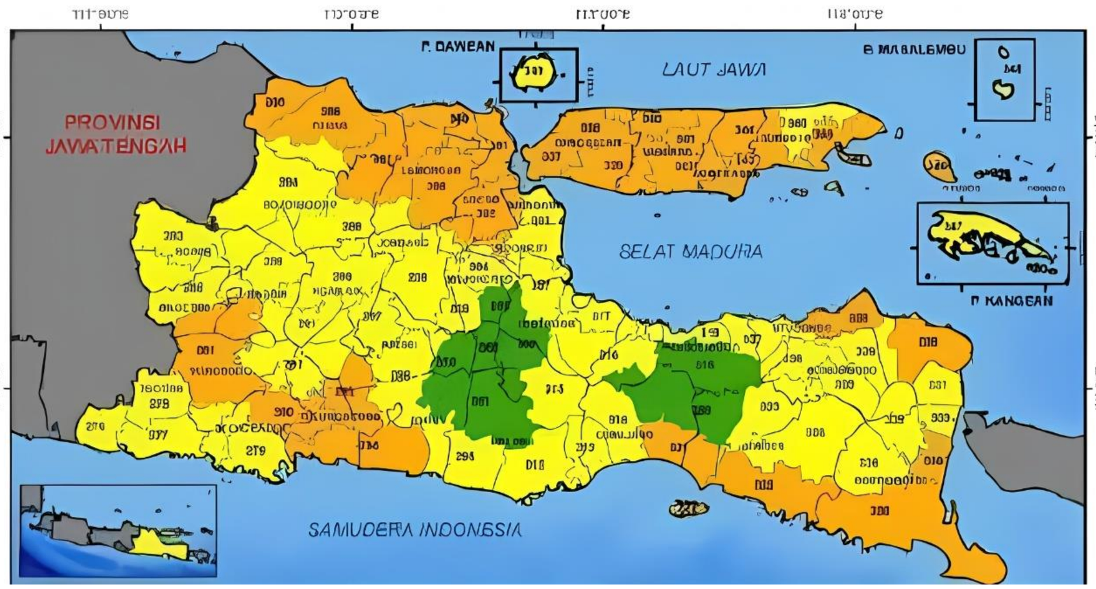

Fig. 1. Rainy season rainfall 2020/2021 season zones in East Java Province

Boezem has been recognized as one of the effective solutions in flood control, especially in urban areas that often experience waterlogging problems. For example, in Balong River, Tandes Sub-district, Surabaya City, boezem is used together with pumps and sluice gates to control flooding. Boezem functions as a retarding basin that accommodates temporary flood discharge runoff before it is discharged to a larger body of water or channeled through a drainage system (Indriyani et al., 2019).

Research conducted by Indriyani in the Journal of Civil Engineering Applications shows that a boezem equipped with a spillway can accommodate a design flood discharge of up to 97.626 m3/second (Hisyam Erwanto et al., 2021). This demonstrates the boezem's capacity to reduce flood risk by accommodating significant volumes of water during periods of intense rainfall. In addition, boezem planning in Pasuruan Regency, East Java Province also shows that the boezem can accommodate water due to rainwater runoff in the 50-year design period of 235.8669 m3/second. This proves that boezem can be an efficient and sustainable alternative to flood management. Thus, boezem plays an important role in overcoming flood problems and is an integral part of the urban water management system. The use of boezems should be considered as part of a comprehensive strategy in future water management and flood control planning.

Boezem air purification is essential to prevent air pollution and jeopardize the health of people who use it. Another study observed that the water quality in the Boezem was contaminated with various pollutants and caused very high levels of air pollution. Due to this contamination, Boezem water cannot be reused. Therefore, the local community must participate in maintaining the cleanliness and water quality of the Boezem for the public good. Community participation in the development of the existing bozem is certainly the purpose of this research, which is to be able to find out the impact and community response to the development of bozem in the Dukuh Kupang area, both negatively and positively. The author has conducted a survey at the bozem location (Fig. 2).

Fig. 2. Boezem location

Dukuh Kupang, Surabaya, is one of the areas experiencing significant flooding problems. Factors contributing to this problem include increased rainfall, reduced green open spaces, and uncontrolled development that often blocks waterways. Previous research has tried to implement an ecodrainage system through the creation of biopore infiltration to solve the flooding problem in this area (Faradilah, 2021). However, a more comprehensive solution is still needed to effectively control flooding. This research is urgent because the flooding that occurs in Dukuh Kupang not only causes material losses but also affects the quality of life of residents. By understanding the influence of boezem development, the government and stakeholders can plan and implement more effective flood control strategies. In addition, this research can provide new insights into the application of flood control technology in densely populated urban areas.

2. Methods

This research adopts a survey method with a quantitative descriptive approach to explore facts in the field related to the construction of Bozem as a flood control effort. The main objective of this research is to identify and analyze data objectively through a series of interviews, measurements, and direct observations conducted by the researcher. The data collection methods used involved observations of the physical condition of the Bozem and interactions with visitors and surrounding communities to gain their perspectives on the effectiveness of the Bozem in controlling flooding. Interviews were conducted to obtain in-depth information from respondents who have direct experience with the flooding phenomenon in the area.

Data analysis was conducted using the scoring method, which allows researchers to classify and assess data based on a specific scale. This helps in measuring the success rate of the Bozem in reducing flood risks and impacts. Primary data collected through direct observation by the researcher was enriched with secondary data from respondents, consisting of 20 randomly selected individuals. The use of quantitative measurement tools administered to the local community allowed this study to generate data that can be quantified and analyzed statistically. As such, this research aims to provide evidence-based recommendations to improve flood control strategies in Dukuh Kupang, Surabaya. The measurement tool in this study is a questionnaire, which is a tool for measuring and recording observations of social or natural phenomena. According to Sugiyono (2009), this tool is important for obtaining accurate data. The Likert scale is used as a standard in this study to determine the interval between points in the questionnaire, which enables quantitative data collection. Sugiyono (2014) states that the Likert scale is an assessment method used to evaluate the reactions, opinions, and views of individuals or groups towards certain social situations. Each question in an instrument that utilizes this scale has a range of answers, ranging from strongly agree to strongly disagree, which are then quantified into certain numerical values.

Table 1. Likert scale

Statement	Score
Strongly Agree (SA)	5
Agree (A)	4
Neutral (N)	3
Disagree (D)	2
Strongly Disagree (SD)	1

(Sugiyono, 2014)

3. Results and Discussion

From the results of data collection with structured questionnaires distributed using google form, 20 respondents were obtained. The data obtained has been verified before and to remove invalid data that will affect the results of the research data analysis. The profile of respondents in this study was observed to give an idea of what the sample of this study looks like. Respondents are categorized by several groups based on gender, age, occupation, and education of respondents.

3.1 Respondent profile

Of the total respondents, there were more women with 12 people or 60%, while male respondents amounted to 8 people or 40%. Although there is a difference of 4 people or 20% between the two genders, the proportion between male and female respondents can still be considered quite balanced in this study (Fig. 3).

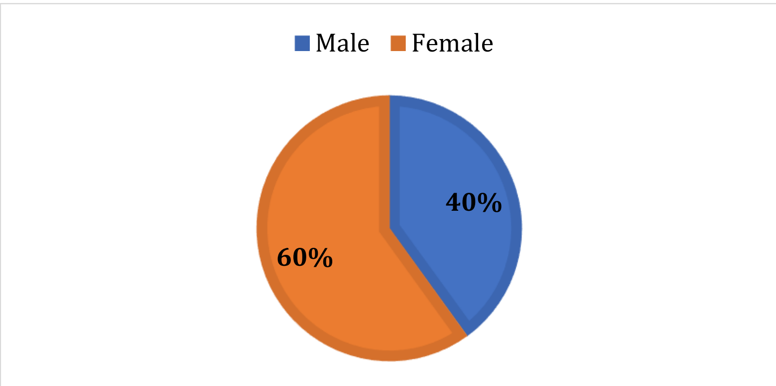

Fig. 3. Gender

Based on the results of data collection that the author conducted, data on the age respondents were obtained where the age group 20-25 years dominated with a total of 9 respondents (45%), then respondents with the age group 26-31 years 3 respondents (15%), respondents with the age group 32-37 years with a total of 4 respondents (20%), and the age group 38-45 years as many as 4 respondents (20%) (Fig. 4).

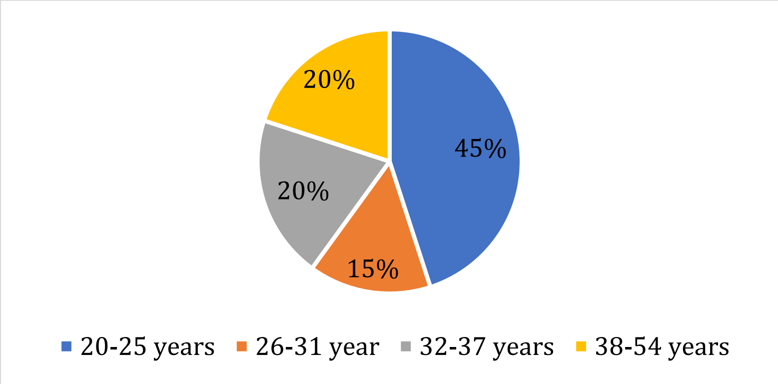

Fig. 4. Age of respondents

By occupational group, the questionnaire data revealed that 80% (16 people) of the total respondents were self-employed, followed by the civil servant occupational group with a total of 10% (2 people) and another 2 people (10%) as housewives (Fig. 5).

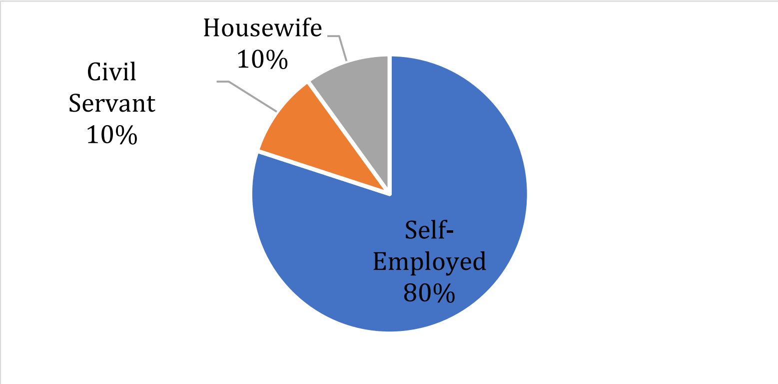

Fig. 5. Occupational of respondent

From the available data, the education level of the respondents was obtained, including 12 people with high school education (60%), followed by 5 respondents with undergraduate degree education (25%), and 3 people with associate's degree education (15%) (Fig. 6).

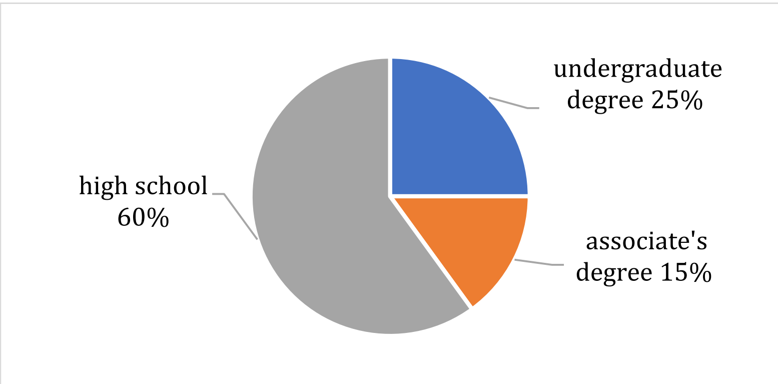

Fig. 6. Respondents' education level

3.2 Questionnaire results

Based on the questionnaire data obtained, it turns out that there are still many negative stigmas among the community about the construction of the Boezem. Upon further review, it turns out that this is due to the lack of socialization and community participation regarding the construction of Boezems around residential areas. This can be seen in questionnaire question point 9 where 14 participants (70%) unanimously answered that they were never involved in the planning and construction of Boezem around their 160 settlements.

Table 2. Survey on community perceptions regarding the construction and impact of Boezem in Dukuh Kupang

No	Questions	Total Respondents					Total
		SD	D	N	A	SA	
1	In the process of building this bozem, does it have any impacts experienced by the residents?	2	2	5	10	1	20
2	In the impact of the government, is there a solution related to that?	8	2	6	3	1	20
3	Before the construction of the bozem, were there any problems during the rainy season?	2	4	4	3	7	20
4	Are there any health impacts on the construction process?	2	4	11	1	2	20
5	Have you experienced any difficulties in mobilization during construction?	1	2	5	4	8	20
6	How effective do you think the construction of the boezem is in controlling flooding in Dukuh Kupang?	1	1	14	2	2	20
7	Do you think the construction of the boezem has affected the economic activities of the local community?	1	3	7	4	5	20
8	Do you agree that boezem is a long-term solution to the flood problem in Dukuh Kupang?	1	2	14	1	2	20
9	Do you feel involved in the planning and construction process of the boezem in Dukuh Kupang?	14	2	3	1	0	20
10	What do you think about the quality of construction and design of the boezem that has been built?	1	2	13	1	3	20

The total observation score is calculated by summing the scores of each statement item that has been observed, which is then multiplied by the weighted score according to the Likert scale. The highest score that can be achieved is the result of multiplying the top score on the Likert scale by the total number of items, which is 5 times 10, resulting in 50. The expected total score is obtained by multiplying this maximum score by the number of people who respond, so 20 times 50, giving a result of 1000.

Table 3. Community perception on the construction and impact of the Boezem in Dukuh Kupang

No	Questions	Total Respondents				
		SD	D	N	A	SA
1	In the process of building this reservoir, does it have any impact on the residents?	2	4	15	40	5
2	In this regard, is there a solution from the government?	8	4	18	12	5
3	Before the construction of the bozem, were there any obstacles during the rainy season?	2	8	12	12	35
4	Are there any health impacts on the construction process?	2	8	33	4	10
5	Have you experienced any difficulties in mobilization during construction?	1	4	15	16	40
6	How effective do you think the construction of the boezem is in controlling flooding in Dukuh Kupang?	1	2	42	8	10
7	Do you think the development of the bozem has affected the economic activities of the local community?	1	6	21	16	25

8	Do you agree that boezem is a long-term solution to the flood problem in Dukuh Kupang?	1	4	42	4	10
9	Do you feel involved in the planning and construction process of the boezem in Dukuh Kupang?	14	4	9	4	0
10	What do you think about the quality of construction and design of the boezem that has been built?	1	4	39	4	15
Total score		33	48	246	120	155

$$\sum \textit{observation score} = (\textit{total x score SA}) + (\textit{total x score SA}) + (\textit{total x score SA}) + (\textit{total x score SA}) + (\textit{total x score SA})$$

$$\sum \textit{observation score} = 33 + 48 + 246 + 120 + 155$$

$$\sum \textit{observation score} = 602 \quad \text{(Eq. 1)}$$

Meanwhile, the feasibility percentage is calculated using the following formula.

$$\textit{Percentage of feasibility} = \frac{\textit{observation score}}{\textit{expected score}} \textit{ x 100\%}$$

$$\textit{Percentage of feasibility} = \frac{602}{1000} \textit{ x 100}$$

$$\textit{Percentage of feasibility} = 60.2\% \quad \text{(Eq. 2)}$$

From the scores that have been obtained based on the data from the questionnaires that have been distributed to 20 respondents, a feasibility percentage of 60.2% is obtained, which shows that although there is recognition of the potential of the boezem in controlling floods, there are still significant doubts. Respondents may recognize that the construction of boezem is considered quite feasible as a flood control solution.

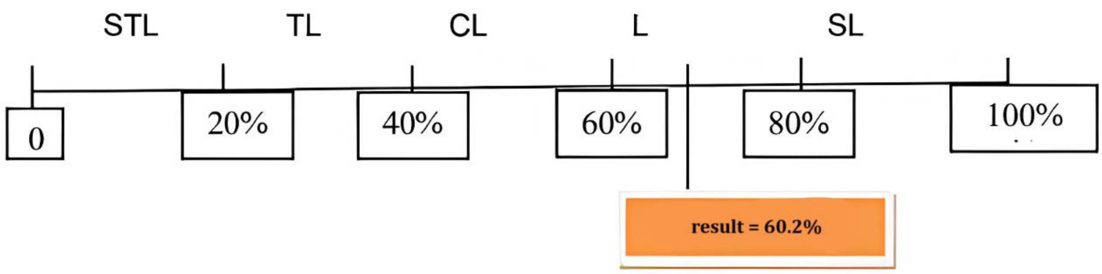

Fig. 7. Scale of eligibility categories

The assessment of the feasibility of boezem construction in Dukuh Kupang is categorized into five levels: Very Inappropriate (STL), Not Feasible (TL), Feasible Enough (CL), Feasible (L), and Very Decent (SL). These classifications help in understanding the overall evaluation of the project based on various parameters, including technical, environmental, economic, and social aspects. A Very Inappropriate (STL) rating indicates that the project is not suitable for implementation due to significant constraints, such as high environmental risks, substantial financial burdens, or strong opposition from the local community. Meanwhile, a Not Feasible (TL) classification suggests that while the project may have some potential benefits, it still faces major challenges that hinder its viability.

On the other hand, a Feasible Enough (CL) rating implies that the project has moderate feasibility, meaning that while it meets some necessary requirements, further improvements and adjustments are needed to ensure successful implementation. A Feasible (L) rating suggests that the project is generally viable, with manageable challenges and a clear pathway toward successful construction and operation. Finally, a Very Decent (SL) classification signifies that the boezem construction is highly suitable, with strong potential for long-term sustainability, minimal risks, and broad support from stakeholders. Achieving this level of feasibility requires comprehensive planning, stakeholder engagement, and the adoption of innovative and environmentally friendly technologies.

The construction of a boezem as flood control in Dukuh Kupang Surabaya has received a feasibility score of 60.2%, reflecting the view that while there are potential benefits, there are also significant concerns that need to be addressed. Boezems, as hydraulic infrastructure, can indeed play an important role in reducing flood risk, but questions about long-term effectiveness and environmental impacts remain relevant and need to be addressed.Concerns over the cost of boezem construction and maintenance point to the need for careful financial planning and the search for sustainable funding sources. Socioeconomic impacts on local communities cannot be ignored; boezem development must consider the welfare and sustainability of local livelihoods. Environmental risks, such as changes in water flow and potential pollution, require comprehensive environmental impact studies and effective mitigation plans. To improve the feasibility score, a holistic approach involving all stakeholders is necessary. Dialogue with local communities can pave the way for community participation in the boezem construction and maintenance process. Exploration of innovative technological solutions, such as the use of eco-friendly materials or automation systems for operational efficiency, can also improve project feasibility. Thus, boezem construction will not only be a technical solution for flood control but also a sustainable project that is accepted by the community. This will ensure that the benefits of the boezem development can be maximally felt by the residents of Dukuh Kupang Surabaya while maintaining the ecological and socio-economic balance of the area.

3.3 Integration of green infrastructure in flood control

The integration of green infrastructure in flood control represents a paradigm shift from traditional gray infrastructure approaches, such as concrete drainage systems and levees, to more sustainable, ecologically friendly solutions. Green infrastructure utilizes natural processes to manage stormwater, reduce flooding, and enhance urban resilience against climate change. Commonly adopted solutions include retention ponds, bioswales, green roofs, urban wetlands, and permeable pavements. These solutions provide multiple co-benefits, including improved water quality, enhanced biodiversity, and increased urban aesthetics.

One of the fundamental principles of green infrastructure is its ability to mimic the natural hydrological cycle. By incorporating vegetation and permeable surfaces, green infrastructure facilitates water infiltration, evapotranspiration, and groundwater recharge, which significantly reduces surface runoff and mitigates the risk of urban flooding. This is particularly crucial in densely populated cities, where impervious surfaces such as roads and buildings limit natural water absorption, leading to increased flood vulnerability. Numerous studies highlight the efficacy of green infrastructure in urban flood management. Zhang et al. (2021) demonstrated that cities integrating green stormwater infrastructure experienced notable reductions in peak flood levels and enhanced groundwater recharge rates. By incorporating green solutions, cities can manage stormwater more efficiently, reducing the burden on conventional drainage systems and mitigating flood risks.

For instance, retention ponds and constructed wetlands act as temporary water storage areas, capturing excess stormwater during heavy rainfall events and gradually releasing it into drainage systems or natural waterways. This process helps regulate water flow, preventing sudden surges that could lead to urban flooding. Similarly, bioswales—landscape elements designed with vegetation and engineered soils—play a crucial role in absorbing and filtering runoff before it enters larger water bodies. These structures reduce pollutant loads and improve overall water quality while contributing to flood resilience. Another effective measure is the implementation of permeable pavements in urban areas. Unlike traditional concrete or asphalt surfaces, permeable pavements allow rainwater to seep through and infiltrate the underlying soil. This reduces the volume of surface runoff and helps in groundwater recharge, thereby minimizing the risk of localized flooding. Green roofs also contribute to flood mitigation by capturing rainfall, reducing runoff, and enhancing urban cooling effects.

The integration of green infrastructure is particularly relevant in the development of boezems—water retention and storage areas designed to regulate floodwaters. In Dukuh Kupang, the implementation of green infrastructure principles can enhance the environmental sustainability of boezem development while ensuring hydrological balance. By incorporating retention ponds, bioswales, and green corridors within the area, the boezem can function not only as a flood control mechanism but also as an ecological habitat and recreational space. Research indicates that well-designed boezems can significantly alleviate urban flooding by temporarily storing excess rainwater and gradually releasing it into downstream channels. The presence of vegetation within and around the boezem improves water infiltration and reduces erosion, contributing to long-term flood resilience. Furthermore, integrating urban wetlands into boezem areas enhances biodiversity, supports local ecosystems, and provides aesthetic and recreational benefits for the surrounding community.

Despite its benefits, the integration of green infrastructure in flood control poses certain challenges. One of the primary concerns is the high initial investment required for implementation and maintenance. While green infrastructure solutions often lead to long-term cost savings by reducing damage from floods and minimizing stormwater treatment costs, securing funding and public support for such projects remains a challenge. Additionally, urban planning constraints and land availability can limit the widespread adoption of green infrastructure. Many cities face difficulties in retrofitting existing infrastructure to accommodate green solutions, especially in highly urbanized areas with limited open space. Effective policy frameworks and stakeholder collaboration are essential to overcoming these barriers and ensuring successful implementation. Public awareness and community engagement also play a crucial role in the sustainability of green infrastructure projects. Educating local communities about the benefits of green infrastructure and involving them in maintenance efforts can enhance the long-term effectiveness of flood control strategies. Moreover, interdisciplinary collaboration between urban planners, hydrologists, ecologists, and policymakers is necessary to develop holistic, adaptive solutions that address both flood mitigation and environmental sustainability.

The integration of green infrastructure in flood control presents a viable and sustainable approach to managing stormwater, reducing urban flooding, and enhancing climate resilience. Solutions such as retention ponds, bioswales, permeable pavements, and green roofs offer multiple environmental, social, and economic benefits. By incorporating these strategies into urban planning, cities can achieve more effective flood management while improving overall environmental quality. The case of boezem development in Dukuh Kupang highlights the potential for green infrastructure to enhance flood control mechanisms while maintaining ecological balance. However, challenges such as financial constraints, land availability, and policy implementation must be addressed to ensure the successful integration of green solutions. Moving forward, a collaborative, interdisciplinary approach will be key to maximizing the benefits of green infrastructure in flood mitigation efforts.

3.4 Application of the 'sponge city' concept

The 'Sponge City' concept focuses on enhancing the urban landscape's ability to absorb and store rainwater through integrated green infrastructure, permeable surfaces, and wetland systems. This approach allows cities to manage stormwater efficiently, reducing the risk of floods while promoting environmental sustainability. Various cities have successfully implemented this concept to mitigate stormwater-related disasters. By utilizing natural and engineered solutions, the Sponge City model enhances water retention, increases groundwater recharge, and improves overall urban resilience to climate change.

One notable example is China's nationwide adoption of the Sponge City concept, which has significantly reduced urban flood risks. Research by Zhao et al. (2021) highlights that city applying Sponge City principles have experienced reduced flood vulnerability while benefiting from enhanced urban sustainability. Measures such as green roofs, rain gardens, artificial wetlands, and bioswales have been widely implemented to manage excess rainwater and restore natural hydrological processes. By prioritizing permeable infrastructure and water-sensitive urban design, these cities have successfully mitigated stormwater runoff, improved water quality, and enhanced urban biodiversity.

In the context of Dukuh Kupang, adopting Sponge City strategies could provide significant advantages for flood control and environmental sustainability. The integration of green spaces, permeable pavements, and retention ponds can help manage rainwater more effectively while reducing pressure on existing drainage systems. Furthermore, developing urban wetlands and bioswales within the region can promote biodiversity, improve water absorption capacity, and create aesthetically appealing public spaces. Implementing Sponge City principles in Dukuh Kupang would not only enhance flood resilience but also contribute to long-term urban sustainability, ensuring a more livable and climate-resilient environment for residents.

Despite its promising benefits, the implementation of Sponge City strategies presents challenges, including high initial investment costs, land use constraints, and the need for interdisciplinary collaboration. Cities aiming to adopt this concept must establish comprehensive policies, secure funding for green infrastructure projects, and engage local communities in sustainable water management practices. Overcoming these challenges requires coordinated efforts between policymakers, urban planners, environmental engineers, and local stakeholders. By fostering a multi-disciplinary approach and prioritizing nature-based solutions, the successful implementation of Sponge City principles can lead to a more resilient and adaptive urban landscape in Dukuh Kupang.

3.5 Utilization of flood-resistant materials and innovative construction techniques

The selection of construction materials and techniques significantly impacts the long-term performance and durability of flood control infrastructure. Utilizing flood-resistant materials such as water-repellent concrete additives, corrosion-resistant steel, and hydrophobic coatings can enhance the resilience of boezem structures. These materials help prevent water infiltration, reduce structural degradation, and improve the overall longevity of flood mitigation systems.

In addition to material selection, innovative construction techniques can further optimize flood resilience. Waterproofing strategies, including membrane coatings, sealants, and geotextile layers, provide additional protection against moisture damage. Moreover, advanced construction methods such as prefabrication and modular assembly can improve efficiency, reduce waste, and ensure precise structural integrity. These approaches not only enhance flood resilience but also minimize environmental impact by reducing carbon emissions and construction-related disruptions. By integrating flood-resistant materials and modern construction techniques, Dukuh Kupang can develop more robust and sustainable flood control infrastructure, ensuring long-term protection against extreme weather conditions and climate change-induced flooding.

3.6 Implementation of sustainable drainage systems (SuDS)

The successful implementation of Sustainable Drainage Systems (SuDS) requires a multi-faceted approach that integrates engineering, environmental, and social considerations. In urban areas, SuDS are designed to enhance natural hydrological processes by promoting infiltration and reducing the volume and velocity of stormwater runoff. Research by Woods-Ballard et al. (2015) emphasizes that SuDS can be effectively implemented through green infrastructure solutions such as permeable pavements, rain gardens, and bioswales. These components facilitate water absorption and filtration, preventing pollutants from entering water bodies and mitigating urban flooding.

One of the key benefits of SuDS is their ability to improve water quality by filtering out contaminants before they reach larger water systems. Studies by Zhang et al. (2021) highlight that SuDS features, such as constructed wetlands and vegetative swales, act as natural biofilters that remove heavy metals, nutrients, and suspended solids from stormwater. This function is particularly beneficial in densely populated areas like Dukuh Kupang, where urban runoff is often laden with pollutants from roadways and industrial activities. Implementing these features within the boezem design can significantly enhance the self-purification capacity of water bodies, contributing to a healthier urban ecosystem.

Another important aspect of SuDS is its role in promoting biodiversity and ecological balance. Research by Kazemi et al. (2009) suggests that incorporating vegetated SuDS elements in urban landscapes fosters the development of microhabitats that support various flora and fauna. In the context of Dukuh Kupang, green infrastructure solutions such as wetland restoration and green roofs can serve as refuges for local wildlife, improving ecological connectivity and urban resilience. Additionally, these features provide aesthetic and recreational value to urban spaces, enhancing community engagement and well-being.

The integration of SuDS into existing flood management strategies requires careful planning and policy support. According to Berland et al. (2017), successful implementation hinges on stakeholder collaboration, clear regulatory frameworks, and adequate funding. Municipal governments and urban planners must work together to incorporate SuDS into zoning regulations and building codes, ensuring their widespread adoption. In Dukuh Kupang, a participatory approach involving local communities, researchers, and policymakers can facilitate knowledge sharing and encourage the adoption of best practices in sustainable water management.

Despite its numerous advantages, the implementation of SuDS also faces challenges. Studies by Ashley et al. (2013) indicate that land availability, maintenance requirements, and public perception can hinder the widespread adoption of SuDS. In high-density urban areas, limited space for green infrastructure can restrict the feasibility of certain SuDS components. Moreover, the long-term maintenance of SuDS features, such as sediment removal in wetlands and vegetation management in bioswales, requires ongoing financial and institutional support. Addressing these challenges requires innovative solutions, such as retrofitting existing urban spaces with SuDS-compatible designs and integrating smart water management technologies.

Overall, incorporating SuDS into the boezem design of Dukuh Kupang presents a sustainable approach to flood management, water quality improvement, and ecological conservation. By leveraging scientific research and interdisciplinary collaboration, urban planners can optimize the benefits of SuDS while addressing potential challenges. Future studies should explore cost-benefit analyses and pilot projects to assess the effectiveness of various SuDS configurations in different urban contexts, further strengthening the case for their implementation.

3.7 Case study: Boezem development in Surabaya

Surabaya has identified boezem development as a flood control strategy and an enhancement of water catchment areas. However, many existing boezems serve merely as water reservoirs without being optimally utilized. Ideally, the city should be capable of managing water resources productively, creating a livable environment, and ensuring flood resilience. An evaluation of Surabaya's flood control projects by Rahman et al. (2019) emphasizes the need for multi-functional boezems that integrate recreational spaces, wetland ecosystems, and community engagement initiatives. Implementing these recommendations in Dukuh Kupang can maximize flood management efficiency while promoting socio-environmental benefits.

4. Conclusions

The conclusion of the research on the construction of boezem as a flood control in Dukuh Kupang Surabaya shows that there is a negative stigma among the community, which is mostly caused by the lack of socialization and community participation in the development process. This can be seen from the questionnaire results where the majority of respondents indicated that they were not involved in the planning and construction of the boezem. The feasibility score obtained was 60.2%, reflecting recognition of the potential of the boezem in controlling flooding but also significant doubts regarding its long-term effectiveness and environmental impacts.

To overcome the negative stigma and increase community involvement in boezem development in Dukuh Kupang Surabaya, it is recommended to increase socialization efforts. This can be done by holding community meetings, workshops and information campaigns that explain the benefits and process of boezem development in a transparent manner. It is also important to facilitate the active participation of the community in planning and decision-making, so that they feel ownership and responsibility for the project.

In addition, there is a need for improved communication between the government, developers and communities to build trust and ensure that their concerns are taken seriously. The application of innovative and environmentally friendly technologies can help increase positive perceptions of the project. Finally, comprehensive environmental impact studies should be conducted periodically to monitor the effectiveness of the boezem and identify areas of improvement to ensure the long-term sustainability of the project.

Acknowledgement

This award is dedicated to all those who have provided important support and contributions to the research on the construction of a boezem as a flood control in Dukuh Kupang Surabaya. We express our sincere gratitude to the respondents who took the time to fill out the questionnaire and provided valuable insights. Appreciation also goes to the research team and field assistants who have worked with great dedication in data collection and analysis.

We would also like to recognize the support of the local government, nongovernmental organizations, and the Dukuh Kupang community for providing the necessary access and resources for this research. Finally, we are grateful to our educational and research institutions for providing facilities and an environment conducive to the successful completion of this research.

Author Contribution

The research on the construction of a boezem as flood control in Dukuh Kupang Surabaya is the result of group work by the authors who have made significant contributions in every aspect of the research. The authors designed the study, conducted field data collection, analyzed questionnaire data, and wrote and revised the manuscript. In addition, the author was also responsible for methodology design, statistical analysis, interpretation of results, and drafting of conclusions. The author coordinated community socialization and participation, collected feedback from respondents, and contributed to the environmental impact study and mitigation plan development. The author provided technical support and knowledge on hydraulic infrastructure development. The author has approved the final version of the manuscript and is responsible for all aspects of the work in ensuring that questions regarding the accuracy or integrity of any part of the work are appropriately resolved.

Funding

This research received no external funding.

Ethical Review Board Statement
Not available.

Informed Consent Statement
Not available.

Data Availability Statement
Not available.

Conflicts of Interest
The authors declare no conflict of interest.

Open Access
©2024. The author(s). This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made. The images or other third-party material in this article are included in the article's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this license, visit: http://creativecommons.org/licenses/by/4.0/

References
Ashley, R., Gersonius, B., & Digman, C. (2013). Adaptation of urban drainage to climate change: Addressing barriers to implementation. *Urban Water Journal, 10*(3), 181-190. https://doi.org/10.1080/1573062X.2013.767344

Balahanti, R., Mononimbar, W., & Gosal, P. H. (2023). Analisis Tingkat Kerentanan Banjir Di Kecamatan Singkil Kota Manado. Jurnal Spasial, 11, 69–79. https://ejournal.unsrat.ac.id/index.php/spasial/article/view/51447

Berland, A., Shiflett, S. A., Shuster, W. D., Garmestani, A. S., Goddard, H. C., Herrmann, D. L., & Hopton, M. E. (2017). The role of trees in urban stormwater management. *Landscape and Urban Planning, 162*, 167-177. https://doi.org/10.1016/j.landurbplan.2017.02.017

Hisyam Erwanto, N., Yulianti, E., & Surbakti, S. (2021). Perencanaan Boezem Dan Pompa Dalam Penangan Banjir Di Kabupaten Pasuruan Jawa Timur. *Sondir*, *5*(2), 1–9. https://doi.org/10.36040/sondir.v5i2.4194

Indriyani, D., Aziz, S. K., & Mubarok, P. M. (2019). Boezem, Pompa, dan Pintu Air sebagai Pengendali Banjir di Kali Balong Kecamatan Tandes Kota Surabaya. *Jurnal Aplikasi Teknik Sipil*, *17*(2), 43. https://doi.org/10.12962/j2579-891x.v17i2.5293

Kazemi, F., Beecham, S., & Gibbs, J. (2009). Streetscape biodiversity and the role of bioretention swales in an Australian urban environment. *Landscape and Urban Planning, 92*(3-4), 187-197. https://doi.org/10.1016/j.landurbplan.2009.04.001

Rahman, M., Ningsheng, C., Islam, M. M., Dewan, A., Iqbal, J., Washakh, R. M. A., & Shufeng, T. (2019). Flood susceptibility assessment in Bangladesh using machine learning and multi-criteria decision analysis. *Earth Systems and Environment*, *3*, 585-601. https://doi.org/10.1007/s41748-019-00123-y

Saves, F. (2021). Penerapan Ecodrainage Melalui Biopori Di Jalan Dukuh Kupang Surabaya. Pawon: Jurnal Arsitektur, 5(2), 185–200. https://doi.org/10.36040/pawon.v5i2.3468

Utomo, D. D., & Marta, F. Y. D. (2022). Dampak Bencana Alam Terhadap Perekonomian Masyarakat di Kabupaten Tanah Datar. Jurnal Terapan Pemerintahan Minangkabau, 2(1), 92–97. https://doi.org/10.33701/jtpm.v2i1.2395

Woods-Ballard, B., Kellagher, R., Martin, P., Jefferies, C., Bray, R., & Shaffer, P. (2015). *The SuDS manual*. CIRIA.

Zhang, K., Hwang, Y., & Sweeney, J. (2021). Performance assessment of constructed wetlands for urban stormwater runoff treatment. *Water Research, 191*, 116809. https://doi.org/10.1016/j.watres.2020.116809

Zhang, S., Lin, Z., Zhang, S., & Ge, D. (2021). Stormwater retention and detention performance of green roofs with different substrates: Observational data and hydrological simulations. *Journal of Environmental Management*, *291*, 112682. https://doi.org/10.1016/j.jenvman.2021.112682

Zhou, H., Li, H., Zhao, X., & Ding, Y. (2021). Emergy ecological model for sponge cities: A case study of China. *Journal of Cleaner Production*, *296*, 126530. https://doi.org/10.1016/j.jclepro.2021.126530

Biographies of Authors

Pramudya Aridhadinata, Department of Civil Engineering, Faculty of Civil Engineering and Planning, Institut Teknologi Adhi Tama Surabaya, Surabaya 60117, Indonesia.

- Email: galuh16.maya@gmail.com
- ORCID: N/A
- Web of Science ResearcherID: N/A
- Scopus Author ID: N/A
- Homepage: N/A

Agung Dwi Laksono, Department of Civil Engineering, Faculty of Civil Engineering and Planning, Institut Teknologi Adhi Tama Surabaya, Surabaya 60117, Indonesia.

- Email: galuh16.maya@gmail.com
- ORCID: N/A
- Web of Science ResearcherID: N/A
- Scopus Author ID: N/A
- Homepage: N/A

Widia Ade Novita, Department of Civil Engineering, Faculty of Civil Engineering and Planning, Institut Teknologi Adhi Tama Surabaya, Surabaya 60117, Indonesia.

- Email: galuh16.maya@gmail.com
- ORCID: N/A
- Web of Science ResearcherID: N/A
- Scopus Author ID: N/A
- Homepage: N/A

Achmad Faishal Nur Cahyadi, Department of Civil Engineering, Faculty of Civil Engineering and Planning, Institut Teknologi Adhi Tama Surabaya, Surabaya 60117, Indonesia.

- Email: afaishalnc@gmail.com
- ORCID: N/A
- Web of Science ResearcherID: N/A
- Scopus Author ID: N/A
- Homepage: N/A

Galuh Ismaya Sari, Department of Civil Engineering, Faculty of Civil Engineering and Planning, Institut Teknologi Adhi Tama Surabaya, Surabaya 60117, Indonesia.

- Email: galuh16.maya@gmail.com
- ORCID: N/A
- Web of Science ResearcherID: N/A
- Scopus Author ID: N/A
- Homepage: N/A