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ADAPTATION STRATEGIES FOR DRAINAGE AND FLOOD MANAGEMENT TAMAN FAIR PARK, IPOH PERAK, MALAYSIA

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ABSTRACT

Flooding has become a significant issue in metropolitan areas, especially Taman Fair Park, Ipoh, Perak, Malaysia. The frequency and intensity of floods have increased due to the increasing rate of urbanization and ever-changing climate. The region is in a very sad state as it is concerned about flooding, which is marked by poor drainage systems and increased flood occurrence due to natural disasters that affect society's day-to-day life and endanger the lives of its people. This study aims to define and examine ways of enhancing flood risk management to maximize the full potential of taking an all-around approach to structural and non- structural issues. By employing all kinds of scope-outs of the phenomena under consideration, the research will focus on directly observing the non-structural, which is sustainable drainage solutions, which include stormwater quantity and quality, use of natural features, and bio-ecological drainage systems have been assessed. It also includes using open drains around the perimeters of areas, higher quality construction of roads and pavements, and heavy work on the drainage system to control runoff effects on the environment. The observation also includes structural measures comprising retention basins, levees, and drainage structures, like levees or retention ponds. These cannot be ruled out when costs concerning flood risks are considered. The findings are based on observation mapping based on the checklist method. Lastly, this study concludes that the integration of advanced flood forecasting and real-time GIS mapping must be applied to improve flooding resilience and

the capability of the people living in Taman Fair Park to deal with flood problems.

Keywords: *Drainage System, Flood Management, Structural, Non-Structural Measure, Urban*

INTRODUCTION

Flooding has become a significant issue in Ipoh, Perak, Malaysia, mainly due to the increasing frequency and intensity of floods. This is driven by rapid urbanization and the unpredictable impacts of climate change, which have strained the area's infrastructure. The region, spanning several hectares of residential, commercial, and green spaces, faces significant flood risks, particularly considering its inadequate drainage systems and increasing vulnerability due to natural disasters. Historical records show recurring flood events, with notable instances in 2024 that disrupted daily life, caused property damage and posed serious risks to public safety. The area's drainage infrastructure is ill-equipped to handle heavy rainfall, and the rising occurrence of floods continues to endanger the lives of its residents Lou et al. (2024). Several studies have argued and concluded that the reality of the strata law has given broad powers to the Management Bodies but has failed to instil good governance. The law introduced does not counsel enforceable standards of good governance (Wong, 2019)Gaps were also found between the management bodies' responsibilities and the residents' roles in ensuring smooth management and maintenance works.

This study explores and enhances flood risk management in Taman Fair Park by adopting a comprehensive approach that integrates structural and non-structural measures. The research will focus on evaluating the current functioning of the drainage system and analyzing the broader impact of flood events by following the National Disaster Management Agency (NADMA), which plays a central role in managing disaster risks, including urban flooding, in Malaysia. It will also consider structural interventions like levees and retention ponds alongside non- structural measures such as land use planning, community engagement, and education. These findings offer valuable insights for designing strategies to enhance urban flood resilience in the face of a changing climate Y. Wang et al. (2024). The study concludes

that a balanced approach, combining infrastructure improvements with community involvement and governance reforms, is crucial for improving the area's resilience to flooding and empowering residents to manage flood risks better.

However, the aim is to define and examine ways of enhancing flood risk management to maximize the full potential of taking an all-around approach to structural and non-structural issues. Physical and social infrastructure are two examples of the specific adaptations that should be implemented along sustainable developments to lessen the vulnerability and increase the resilience of urban settlements. One of the most crucial adaptation strategies to improve our

capacity to adapt is preserving environmental services, known as the Green Infrastructure Approach Liu & Russo. (2021). Implementing adaptation and mitigation programs that provide a variety of co-benefits to communities in terms of poverty reduction, employment, service provision, and quality of life is made much more manageable in cities. These adaptive strategies are crucial to preserve environmental services, which will help drainage and flood management, especially in urban areas. This adaptive drainage and flood management strategy aligns with the SGDs SDG 11, Sustainable Cities and Communities, and SDG 15, Life on Land.

LITERATURE REVIEW

Green Infrastructure Approach

Green infrastructure has emerged as one of the key tactics for achieving sustainable development because it can efficiently combine environmental, social, and economic development Jun Ying et al. (2022). Defined as a "strategically planned network of natural and semi-natural areas". One of the key tactics to attain sustainable development is green infrastructure, which is an efficient way to integrate economic, social, and environmental development Khoshnava et al. (2020). According to Jun Ying et al. (2022), the concept of green infrastructure has been established and developed over time. It is a key component of the research effort of "harmonious coexistence

between humans and nature." Although nature is in a comparatively passive state, the public has already acknowledged the design ideals of "protecting nature" and "respecting nature' Zhou & Weimin (2023). On the other hand, "green infrastructure" places a great deal of emphasis on coordinating the preservation of nature with man- made.

Furthermore, "green infrastructure" promotes the active upkeep, repair, construction, and even reconstruction of green networks Kaskevich et al. (2024). In addition to improving stormwater management capacity, lowering environmental pollution, and mitigating the heat island effect, green infrastructure is crucial for climate change adaptation Rodrigues et al. (2023). This infrastructure creates an ecologically secure basis for developing a sustainable environment. It is the natural life support system of the local environment and lowers pollution levels in the environment Ribbe et al. (2024). This kind of infrastructure creates an ecologically secure basis for developing a sustainable environment and is the natural life support system of the local environment.

Flood-Control Measures (Resistance-based Strategies)

According to Cea & Costabile (2022), urban flooding has become more common in recent years, emphasizing the need for effective flood-mitigation techniques. As a result, flood-risk management, or FRM, is becoming more widely acknowledged as a global issue. Flood-control measures, or resistance-based approaches, have frequently been conventional approaches to flood risk management. Flood-control techniques aim to mitigate flooding using grey infrastructure, including embankments, weirs, dams, and dikes. Even while this strategy can offer significant flood protection, it is now well-acknowledged that risk cannot be controlled exclusively by containing water through a restricted focus on large-scale civil engineering projects Garrote et al. (2019). This awareness has resulted from the shift from structural and extensive flood-defense measures to more integrated flood risk management (FRM) strategies. These strategies are predicated on the idea that complete flood protection is impossible and concentrate on ways to lessen the vulnerability of communities that are vulnerable to flooding by adopting a more comprehensive viewpoint, such as the green infrastructure approach Wang et al. (2022).

Structural Measures for Flood Management

Structural measures for flood management involve engineered solutions to mitigate the impact of flooding by controlling water flow and protecting vulnerable areas. Flood barriers and levees, such as floodwalls, embankments, and dikes, are essential devices that stop rivers from overflowing into surrounding land. Rivers' capacity and flow efficiency are increased via river channel changes such as dredging, straightening, depth, and broadening. Dams and reservoirs are essential for storing floods at peak flows and releasing them gradually to lower the risk of flooding downstream. During intense downpours, stormwater management techniques such as underground storage tanks, retention basins, and detention ponds temporarily retain excessive rainfall in metropolitan areas Russell (2007). Sea walls, breakwaters, and tidal barriers are coastal protection structures that protect from floods driven by storm surges and heights. Furthermore, flood storage areas purposefully absorb floodwaters to mitigate damage, while diversion systems reroute excess water to avoid flood-prone locations Sohn et al. (2020).

Spillways provide regulated water release from dams to avoid overtopping while pumping stations are used in low-lying metropolitan areas to remove excess floodwater. These structural solutions are frequently intended to safeguard agricultural lands, metropolitan areas, and vital infrastructure. Their effectiveness notably increases when combined with non-structural strategies such as public education, floodplain zoning, and early warning systems. Their effectiveness, however, depends on proper design, maintenance, and consideration of environmental impacts to ensure sustainable flood control solutions.

Non-Structural Measures for Flood Management

Non-structural strategies are crucial in minimizing negative environmental effects and the disastrous outcomes of residual risks. Land use regulations, flood forecasting and warning systems, and disaster prevention, preparedness, and response systems are examples of non-structural flood management strategies that have a minimal environmental impact and should be actively explored as viable alternatives, either as stand-alone or in conjunction with other strategies Rosmadi et al. (2022). These steps

will go alongside structural solutions by improving community readiness and tackling the underlying causes of floods. One important approach for restricting development in flood-prone areas, minimizing property loss, and guaranteeing safer land use is floodplain zoning. Communities can take precautionary measures like evacuation or relocating possessions to safer sites when they receive timely signals from flood predictions and early warning systems. Furthermore, flood insurance plans encourage people to take preventative action by compensating for damages and reducing financial damages. According to Bardhan (2022), land use planning incorporates flood risk considerations into urban and rural development consider preventing vital infrastructure and settlements from being in high-risk locations. Afforestation and soil conservation are two aspects of watershed management that lower surface runoff and increase the land's natural absorption capacity. Rehabilitating wetlands and rivers to increase water retention and lower flood peaks is known as natural floodplain restoration.

RESEARCH METHODOLOGY

This research uses a qualitative observation mapping based on the checklist method to analyze and assess flood control measures exercised in Taman Fair Park, Ipoh, Perak, Malaysia. Ipoh was selected for this study due to its historical context of frequent flooding. The qualitative research methodology seeks to capture the details of the structural and non-structural flood management methods. This methodology of approaching the study avoids the general approach of collecting information on natural disasters and flooding. Instead, this focuses on the experiences of the community in case of flooding and the factors that shape resilience in the area.

Figure 1. Plan View of Taman Fair Park, Ipoh Perak
Source: Google Earth (2024)

An observational checklist approach would be used for data collection regarding concerns regarding flood incidents and their management. This checklist will consider the efficiency of existing drainage systems and structural elements like levees and retention ponds. Furthermore, the data was collected from around 3.00 p.m. to 5.00 p.m. on Sunday, 26 November 2024. The literature includes historical records to give us a panoramic view of the trends in flood management over the past few years.

ANALYSIS AND DISCUSSION

The observations made through the checklist would be made on themes related to the efficiency of structural and non-structural measures. Given this, a sampling technique has been used to identify areas of Taman Fair Park prone to floods. Thus, ethical considerations will be given priority while making observations, whereby observation would be done in a respectable way and in a manner that would not disrupt the everyday activities of the residents. As this study is based on the checklist-based observational method, these ideas and solutions, although they offer a systematic point of view for understanding the issues of floods and their management, may also be biased by the observers Nasiri et al. (2016). In conclusion, this method seeks to guide the development of potential solutions for improving the ability to resist flood hazards within urban environments by complementing observational regularity with knowledge of community characteristics.

Figure 2. Type of Drainage at Taman Fair Park Ipoh, Perak

Source: Author

Poor Drainage Performance

Standing water was observed in several parts of the drainage system, especially in congested areas where water flows. Over time, the drains get clogged with debris, sediments, and plants, reducing the efficiency of water flow. This constraint minimizes the general efficiency of the drainage system, especially during floods and rainstorms when water spills over and causes flooding within urban areas.

Maintenance Deficiencies

It can only worsen the already bad situation concerning water stagnation. In many places, minimal cleaning and vegetation maintenance let rubbish, debris, and vegetation overgrowth build up over the years. This lack of maintenance not only decreases the efficiency of drainage systems but also contributes to early infrastructure failure. These barriers are currently on the rise and will expand, hence blocking the capability of the drains to transport water

Design Inefficiency of the Drainage System

These observed curb inlet openings seem a little small to allow for the passage of a massive volume of stormwater during a rainy season. This inefficient design is inconsistent with the Public Works Department (PWD) guidelines as it did not conform to the dimensions and slope recommended for good drainage by the PWD. Unfortunately, it tends to flow onto the roads or grassy areas, creating erosion and extra load on buildings.

Based on current conditions, the lack of adequate flood control laws is a significant problem that leads to problems such as drainage and water standing on roadsides in Taman Fair Park. Malaysia has some laws, including the Land Conservation Act of 1960 and the Street, Drainage, and Building Act of 1974. However, none deal with flood control or prevention. This legal void undermines agencies such as the Department of Irrigation and Drainage (DID) and the National Disaster Management Agency (NADMA), which cannot prevent developments that aggravate drainage problems. The two draining systems with no specific legal framework have not benefitted from a Flood Act or River Law, meaning that large infrastructure design and poor drainage management continue to encourage waterlogged areas

and stagnant water.

However, two critical concerns exist, including the absence of coordination and poor accountability of agencies involved in flood risk management. Unlike other coordinating agencies, the National Disaster Management Agency (NADMA) cannot force federal, state, or local authorities to make relevant decisions, which caused fragmented decision-making and policymakers' poor cooperation. The water is stagnant at Taman Fair Park, where the regulatory concern is typical of governance failure. This shows that other countries' collaborative risk management frameworks could contribute to uniting the stakeholders on sustainable drainage solutions for reduced flood risks.

Finally, funding deficiencies and poor facility management also worsen the Taman Fair Park drainage situation. Flood-related agencies are frequently resource-constrained and cannot fully pursue effective flood risk management solutions. Lack of sufficient appropriation leads to inadequate drainage infrastructure that Creates blockages, sediment build-up, and system failures, while stagnant water is created during rainy seasons. Furthermore, failure to have well-thought-out flood emergency logistics and communication complicates preparedness and intervention. To overcome these challenges, more investment, drainage system maintenance, and improving communication systems are key morale boosters that would lead to better drainage performance Mabahwi et al. (2020).

Figure 3: The Images of Flooding at Taman Fair Park Ipoh, Perak, in 2024
Source: Ipoh Echo (2024)

Taman Fair Park, Ipoh, experienced a recent flooding that exposed different difficulties in managing floods in any region. After nearly three hours of intense rainfall, this flood was realized, leaving 36 people stranded,

several business properties closed, and some vehicles flooded. The accident was blamed on a technical malfunction by a contractor who shut the wrong water gate while carrying out widening works on the Senam River. This mistake stopped the water from reaching the river; instead, it accumulated in the drainage and caused massive floods around the area.

Despite this, it is not only homes that are affected. One source reported drowning in hazardous water as waste disposal was cut during the deluge. When floods began to subside, citizens had issues removing rubble and water and, thus, potential threats to water sources. Authorities are now used to developing long- term measures. As a result, they have been provided RM108.5 million for flood prevention projects to minimize similar disasters in the future by the federal government New Straits Times. (2024). Consequently, there is a need to step up infrastructural development to help enhance proper communication between the contractors and the local governments about upgrading flood control measures within Taman Fair Park and the surrounding region.

The adaptation strategies, referring to Public Works Department PWD and Urban Stormwater Management Manual for Malaysia (MSMA) 2nd Edition guidelines, focus on implementing sustainable and effective drainage solutions to address flood challenges. Based on Table 2, the observations highlight the need for improvements, such as a design strategy that contains Stormwater Quantity Design Criteria, Environmental Considerations, a Comprehensive Framework, Stormwater Quality Control, Integration of Natural Features, and Adaptation Strategies.

Table 2. Results of Finding Design Strategy

Design Strategy				
No	Attribute	Sub Attribute	Observation	Measured
1	Stormwater quantity design criteria	Bio Ecological Drainage System -Road Pavement	Does not meet the requirements of the guidelines	Structural
2	Environmental Considerations	Erosion control measures	None	Structural
3	Comprehensive Framework	Offers a structured approach to urban stormwater management	None	Structural

4	Stormwater Quality Control	Vegetation Swales	Meet the guidelines	Non-Structural
5	Integration of Natural Features	Wetland and Green Spaces	Does not meet the requirements of the guidelines	Non-Structural
6	Adaptation Strategies	Impermeable surfaces that contribute to high runoff	Does not meet the requirements of the guidelines	Structural
7		Roads	Meet the guidelines	Structural
8		Pavement	Meet the guidelines	Structural
9		Building	Does not meet the requirements of the guidelines	Structural

Source: Author

Based on Table 3, which relates to the Public Works Department (PWD) and Stormwater Management Manual for Malaysia (MSMA) 2nd Edition guidelines, the drainage strategy is based on essential characteristics such as perimeter drains and drainage systems. These elements are designed to help integrate management strategies for stormwater runoff, minimize flood hazards, and conform to current regulations. Hence, the guidelines prioritize sustainable practices, including bio- ecological drainage systems, advanced road pavement design, and strong infrastructure to support water flow and reduce environmental effects.

Table 3. Results of Finding Drainage Guidelines

Drainage Guidelines				
No	Attribute	Sub Attribute	Observation	Measured
1	Perimeter Drain	Not more than 600mm	Meet the guidelines	Structural
2	Drainage infrastructure	Durable materials such as HDPE, PVC, and reinforced concrete	Meet the guidelines	Structural

Source: Author

Table 4 clearly shows that effective flood management comprises inspection of drainage systems, routine maintenance of the systems, and flood preparedness measures. These activities include infrastructure management, peak rainfall, inspection of streets, water stagnation, potential location for retention or detention basin, and sediment built up in drainage systems to reduce flood hazards and their impact on communities.

Table 4. Results of Finding Flood Management

Flood Management				
No	Attribute	Sub Attribute	Observation	Measured
1	Regular inspections	Cleaning and repairs of drainage systems to ensure they function	Does not meet the requirements of the guidelines	Non-Structural
2	Flood Management	Water flow during peak rainfall events.	Does not meet the requirements of the guidelines	Structural
3		Inspect streets	Meet the guidelines	Non-Structural
4		water stagnation	Does not meet the requirements of the guidelines	Non-Structural
5		potential locations for retention or detention basins.	Does not meet the requirements of the guidelines	Non-Structural
6		sediment build-up in drainage systems.	Does not meet the requirements of the guidelines	Structural

Source: Author

From the analysis of the results presented in Table 5, therefore, the site information includes the different types of land use, the need to keep drains and other drainage channels clean, the current state of the drainage system, and frequent checkpoints for the sewer system. These elements are essential in evaluating current infrastructure, observing problems, and creating and implementing solutions to enhance drainage capacity and flood resistance.

Table 5. Results of Finding Site Information

Site Information				
No	Attribute	Sub Attribute	Observation	Measured
1	Land Use Types	Natural Areas	Does not meet the requirements of the guidelines	Non-Structural
2	Site Cleanliness: In drainage channels	Free from debris	Does not meet the requirements of the guidelines	Non-Structural
3		Litter	Does not meet the requirements of the guidelines	Non-Structural
4	Drainage Systems Condition	Sediment buildup	Does not meet the requirements of the guidelines	Non-Structural
5	Sewer System Inspection Points	Overflow	Does not meet the requirements of the guidelines	Non-Structural

Source: Author

Structural means in flood control are all those structures that offer a measure of protection against flood occurrence and effects. These include dams, levees, flood walls and drainage systems, and retention basins, which handle water flow and prevent floods. Although these measures help reduce flood risks, some have problems, such as poor structures and maintenance. For instance, insufficient drainage systems cause high-risk situations during periods of intense rainfall.

On the other hand, non-structural measures aim at specific policies and population readiness rather than barriers. These are the flood forecasting systems, land-use planning, and public education programs for community preparedness. Flood management solutions can be improved when structural and non-structural measures are adopted as provided by guidelines such as the Public Works Department (PWD) and Stormwater Management Manual for Malaysia (MSMA) 2nd Edition. Both contribute to ensuring an instantaneous infrastructure safeguard against floods and developing effective community protection measures against possible flood situations.

The adaptation strategies for flood management in Taman Fair Park, based on the Public Works Department (PWD) and Stormwater Management Manual for Malaysia 2nd Edition guidelines, include sustainable drainage solutions, which include stormwater quantity and quality, use of natural features, and bio- ecological drainage system have been assessed. It also includes using open drains around the perimeters of areas, higher quality construction of roads and pavements, and heavy work on the drainage system to control runoff effects on the environment. However, flood management requires constant assessment and treatment, standard inspections, and maintenance and readiness measures. Some structural measures also comprise retention basins, levees, and drainage structures. Other measures, like flood forecasting, land use planning or management, and public awareness, reinforce the structural measures so that infrastructures remain secure from flood situations and the community is equally ready.

Strategy Of Flood Mitigation Urban Landscape Design at Taman Fair Park, Ipoh Perak Malaysia

A few flood mitigation strategies are important for urban areas since climate change and intensive urbanization are the current trends worldwide.

One of them is managing green infrastructure, which includes Rain gardens, green roofs, and permeable pavements. Apart from stormwater control and treatment, these solutions improve urban appearance and support local wildlife. For example, rain gardens are designed to retain runoff, decreasing the amount of water that can cause floods. Consequently, green roofs offer insulation and sequester rainwater, significantly reducing the urban flooding rate during rainfall.

Still, there is a view that, apart from green infrastructure, advanced technologies have significantly contributed to flood control improvements. Geographic Information Systems (GIS) are used to study geographical data and climatic conditions so that the planner can pinpoint the most vulnerable areas and determine how to counter them. Furthermore, other riding technologies, such as artificial intelligence and machine learning, can also use the data accumulated on floods, along with the current bad weather conditions, to enhance the forecast. This predictive capacity is crucial for directing disaster management and prevention and providing necessary information for flood planning and response.

Ultimately, the sustainable approach reflecting the community and design aspects can contribute to strengthening the character of urban environments. Doing this helps cities bring community support for the kind that is locally suitable and acceptable in the efforts towards flood prevention. Also, the construction of multi-purpose spaces that can accommodate excess water, like floodable parks, helps accommodate recreation space for the people. Adapting our cities to climate change and the effects of extreme weather conditions will become key to adopting these integrated approaches to tackling susceptibility to future floods for sustainable cities Fitriyati et al. (2022).

CONCLUSION

This study sought to identify and analyze the factors affecting the status of the flood that are critical for improving flood risk management by integrated structural and non-structural measures. The objectives were to maximize the full potential of an all-around approach to structural and non-structural issues. Some measures assessed include environmentally unprotected

perimeter drains, better roads and pavements, and genuine drainage systems to minimize environmental runoff effects. Other structural options, including retention basins, leaves, and flood barriers, were also compared, even though the study conceded their impact on flood risk management and costs. This reduced risk achievement enabled the study to synthesise and evaluate successful practices concerning structural and non-structural flood hazard interventions. However, this study was able to review and assess structural and non-structural flood interventions systematically, which was accomplished with certain limitations. For example, accurate data on flood distribution is not readily accessible.

In future studies, other diverse technologies that may serve as solutions to flood disasters include innovative flood forecasting systems and geographical information systems (GIS) in real-time flood susceptibility mapping. Future research should also include cost and utility assessments of green infrastructure, the utility of outreach programs to increase community readiness, and more effective policies that support sustainable urban design to prevent future flood occurrences. Therefore, to enhance Taman Fair Park's flood resistance, a few key measures should be implemented, including innovative approaches to drainage and boosting community participation. By adopting these suggestions, the community's ability to face flood challenges can be enhanced in pursuing a protected and more adequate population.

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