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Porous Structural Model for the Coastal City of Da Nang in the New Context - Vision 2045

Bao An Phan and Thi Kim Anh Le

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Porous structural model for the coastal city of Da Nang in the new context - vision 2045

1st Phan Bao An
Civil Engineering Department
The University of Technology and Education, Danang University
Danang City, Vietnam
pban@ute.udn.vn

2nd Le Thi Kim Anh
Civil Engineering Department
The University of Technology and Education, Danang University
Danang City, Vietnam
ltkanh@ute.udn.vn

***Abstract*—** The tourist city of Da Nang will become even more livable when harsh weather conditions and natural disasters are minimized to as good as possible. For a city with high porosity to natural conditions, cultural tourism, socio-economic factors, infrastructure, and landscape architecture, such as Da Nang, adverse weather has had a significant impact on watershed planning solutions in urban design for tourism purposes in Da Nang. Watershed planning plays the most crucial role among the factors contributing to the formation of urban sprawl.

Keywords— Porous Structural Model, watershed planning, the Coastal City, harsh weather phenomenon, urban designing for tourism.

***Tóm tắt* —** Thành phố du lịch Đà Nẵng trở nên tốt hơn nếu kiểm soát tốt các hiện tượng thời tiết cực đoan, thiên tai. Đối với đô thị có tính xốp cao về điều kiện tự nhiên, du lịch văn hoá, kinh tế- xã hội, cơ sở hạ tầng, kiến trúc cảnh quan như thành phố Đà Nẵng, thời tiết tiêu cực đã gây ảnh hưởng nghiêm trọng đến giải pháp quy hoạch lưu vực trong thiết kế đô thị phục vụ du lịch tại Đà Nẵng. Trong khi đó, quy hoạch lưu vực đóng vai trò là yếu tố quan trọng nhất trong các yếu tố mà tạo thành cấu trúc đô thị xốp.

***Keywords*—**cấu trúc đô thị xốp, quy hoạch lưu vực, thành phố du lịch biển, hiện tượng thời tiết cực đoan, thiết kế đô thị phục vụ du lịch.

I. INTRODUCTION

Da Nang is a city located in the Central region of Vietnam, with a diverse range of natural resources including the sea, rivers, mountains, and a favorable geographical location for travel both to the South and the North. The city of Da Nang has been designated to take tourism as a key economic sector in the direction of developing the Central region's economy [1], especially beach tourism.

However, the biggest challenge that Da Nang faces every year is harsh weather phenomenon and natural disasters, especially floods. This has had serious consequences for the lives of local residents as well as the quality of tourist services in the city. In addition, the urbanization process increases the number of people dependent on the environment, leading to the generation of waste and the consumption of resources at an ever-increasing pace[2]. The tourist city of Da Nang is not an exception when it comes to an increasing number of urban areas experiencing terrifying floods due to climate change bringing about larger amounts of rainfall and an escalating flood risk. The historic flood in 2022 in Da Nang is the clearest evidence[3].

Therefore, the "sponge" urban structure has gradually taken shape in some cities worldwide that are vulnerable to flooding and natural disasters, such as Berlin, Germany, New York, USA, etc. This model is described for watershed planning solutions in urban areas with coastal or complex river systems or natural-based solutions to address climate shocks. This means adding more parks, greenery, and urban green spaces or utilizing natural drainage systems to improve the climate of the city.

The analyses above demonstrate that solutions for watershed planning of the porous urban structure model for the coastal tourist city of Da Nang in the new context, envisioning 2045, have become necessary and urgent.

II. SCIENTIFIC BASIS

A. *An Overview of Coastal Urban Areas in Da Nang City*

1) Climate Conditions:

Da Nang is located in a tropical monsoon climate region, characterized by high temperatures and minimal fluctuations. There are two distinct seasons each year: the dry season from January to September and the rainy season from October to December.

The average annual temperature is around 25°C, with the highest temperatures occurring in June, July, and August, averaging between 28°C and 30°C. The lowest temperatures are in December, January, and February, averaging between 18°C and 23°C. Occasionally, there are cold spells, but they are not prolonged.

The average air humidity is 83.4%, with the highest occurring in October and November, averaging between 85.67% and 87.67%. The lowest humidity is in June and July, averaging from 76.67% to 77.33% [2].

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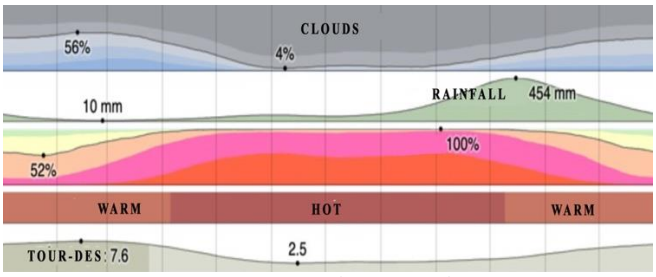


Figure 1. Climate chart for the city of Da Nang

2) Geographical Location and Landscape:

Da Nang is located in the Central region of Vietnam, where you can find unique and captivating natural landscapes. The combination of beaches, mountains, and architectural elements creates a distinctive coastal scenery, referred to as one of the most beautiful beaches on the planet, attracting tourists every year.

- Beaches: Da Nang is renowned for its stunning beaches with fine white sand, such as Bai Bac, Bai Nam, Bai O beach, which are enticing for tourists. Among them, My Khe Beach is ranked among the world's most beautiful beaches and stands out as one of Da Nang's notable attractions

- Unique Mountain-Sea Range: The coastal area of Da Nang features a unique combination of mountains and the sea. The famous mountain peaks, known as Ngũ Hành Sơn (Marble Mountains) and Sơn Trà (Monkey Mountain), create a unique landscape where you can enjoy breathtaking views from above of the sea and the city

- Thuan Phuoc Bridge and Dragon Bridge: Two famous bridges in Da Nang, Thuan Phuoc Bridge and Dragon Bridge, enhance the coastal landscape. Dragon Bridge, with its impressive design that can expand and carry the image of a Vietnamese dragon, creates a spectacular scene at night.

- The Paracel Islands *(Hoàng Sa)* and the Spratly Islands *(Trường Sa)*: play a crucial role in creating the majestic coastal landscape of Da Nang with symbols and memorials related to the protection of Vietnam's island sovereignty. [2, 4].


Figure 2. Coastal landscape in the city of Da Nang

3) Infrastructure:

The coastal infrastructure in Da Nang has been significantly developed to ensure convenience, safety, and comfort for both residents and tourists.

- Transportation: The transportation network is growing, encompassing roads and highways connecting the city with neighboring regions. Access routes to beaches and coastal attractions have also been improved for convenient coastal travel.

- The Da Nang International Airport is an important gateway connecting the city to international and domestic destinations. This airport has been upgraded and expanded to accommodate the increasing annual passenger traffic.

- Pedestrian Walkways and Beach Areas: Da Nang offers a network of pedestrian walkways and coastal roads, allowing residents and tourists to enjoy the seaside view and natural landscapes. Beaches and coastal areas have been equipped with resting huts, benches, and other amenities to create a relaxing environment.

- Coastal Construction Projects: There are numerous works and tourism development projects along the coast that include apartments, villas, and luxury resorts, creating a high-end and convenient living environment. In addition, the coastal area of Da Nang is equipped with public facilities such as schools, hospitals, healthcare facilities, shopping centers, stores, golf courses, along with recreational activities such as yachting, surfing, kayaking, and entertainment services. Maximizing the harmony between architectural structures and urban landscapes creates an attractive destination for coastal areas.

- Water and electricity supply system: developed to ensure a stable source of energy and necessary resources for residents and tourists.

4) Economic potential:

- The coastal urban area of Da Nang is an attractive investment destination, offering numerous business opportunities in tourism, real estate, services, and various other industries. The development of coastal urban projects has created opportunities for investors and businesses to capitalize on.

- Creating economic revenue: The tourism sector generates income for accommodation, entertainment, cuisine, and shopping services. Meanwhile, the tourism economy plays a significant role in creating employment opportunities and local economic development. Furthermore, the government can utilize this tax revenue to invest in infrastructure and other public services as coastal tourism develops, enhancing the tourist experience, and improving the quality of life for local residents.

- Property Development: Increasing demand for real estate projects, including resorts, apartments, villas, and hotels, creating investment opportunities for investors and businesses in the real estate sector

- Promotion of culture and exchange: Coastal tourism creates opportunities for cultural exchange, enabling local residents to interact with tourists and fostering a diverse and enriching environment. This environment provides opportunities to showcase the local identity and the city's tourism brand, thereby attracting more visitors and investments. [2, 4].

B. *Concept of a porous urban area*

The concept of a "Porous City" is created by the elements having diverse functions in the expanded ability with multi-dimensional way, including socie-econo, population, architectural space, urban function, etc. The concept of a "porous city" can be understood as the intricate, multidimensional transformation of diverse elements and functions within an interactive urban environment, where each component undergoes dynamic changes while maintaining a tightly integrated connection, fundamentally embodying a strong cohesion within their interlinkages. This means that these distinct characteristic elements can blend together in various ways in terms of form, structure, aspects, etc., while still creating soft spaces like urban voids, variations in urban watersheds, and even the adaptability of urban infrastructure. The capacity to integrate multiple components, and diverse functions (with a flexible functional nature) within the same urban area generates greater diversity in combining functionalities. The integration of manufacturing, housing, and service facilities is increasingly dependent on the advancements in the information technology [5].

There are several features affecting the resilience of urban areas. In terms of the urban planning field, there are three main areas that influence the porosity of urban areas as follows:

1) Urban Porosity:

The phenomenon of high population concentration in major cities and the resulting high building density lead to the fragmentation of public spaces and a decline in the quality of urban residents' lives as well as the quality of tourism. This implies that the social porosity has affected the spatial porosity…

2) Porosity in transportation:

In larger urban areas, there is increasing pressure on the rigid, hierarchical transportation system that contrasts with the porous, non-hierarchical nature of the functional structure entities. The 'porous' structure requires a network-like transportation system, emphasizing multidirectional connections rather than being constrained by specific frames, circular routes, and predetermined radial patterns. This leads to the expansion of arterial routes becoming costly and time-pressured due to traffic congestion resulting from increased traffic influx into the main axes.

3) Porosity of watershed planning:

The ability of the watershed planning system to respond to changes and adapt flexibly to environmental, social, and economic factors, while minimizing the negative impacts of surrounding elements. In the context of a porous urban structure, the porosity within the watershed planning holds the utmost significance among the factors. This ensures that the watershed planning system not only meets the fundamental drainage needs but also supports urban development in a sustainable manner [5].

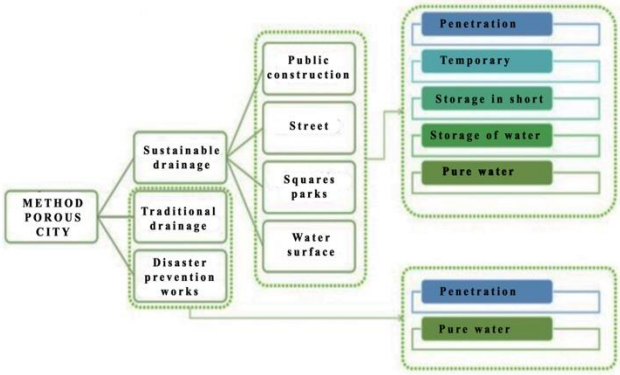


Figure 3. Urban drainage escape solutions group according to the Sponge City model (Peter Nicholson, 2020).

In another interpretation of the concept of a porous urban structure, the notion of "Bubble City" is considered a useful version that responds to coping with the increasingly heightened climate change, leading to the consequences of extreme weather events and natural disasters. In this version, watershed planning is identified as playing a role that is even more crucial and distinct. [6]

C. *Experience in applying lightweight urban models worldwide.*

1) Germany

To address the two consequences of climate change, Berlin is mitigating flooding and severe storms within the city. This is achieved by allowing a portion of rainfall to permeate into the ground, while the remaining portion (due to urbanization and a reduction in greenery) is directed through drainage systems into reservoirs for retention and cooling purposes during the summer. The operational mechanism of this solution is as straightforward as a permeable 'sponge'. Furthermore, Berlin consistently incorporates additional greenery, covering rooftops with grass and moss, painting buildings with bright colors, applying thermal insulation layers along streets to prevent asphalt from melting during hot weather, and planning water storage areas. The key point here is to avoid being "locked" in a landscape dominated by concrete and asphalt, transforming any area into permeable surfaces, such as parking lots and medians, that can allow water to seep into the ground [7].

2) Thailand

Voraakhom Park - located in Bangkok and affiliated with Chuallongkom University - has been transformed into a lush green oasis, offering expansive recreational spaces, playgrounds, and even a small-scale museum. Since its opening in March 2017, the park has garnered the attention of numerous students and residents. In addition to its other important functions, the 4.5-hectare area serves a crucial role for this flood-prone city in its ability to collect and manage rainfall during storm seasons, thereby mitigating the urban heat generated by high temperatures influenced by human activities in the summer. This park can hold up to nearly 1 million gallons of water (about 4 million liters) during severe flooding events through its design for controlled inundation. [8].

III. RESULTS

A. The perspective of urban planning for sustainable development adapting to the harsh weather phenomenon in Da Nang City

1) Orientation for sustainable tourism development::

- Sustainable tourism economic development: Tight management of tourism infrastructure construction and development, investment in green infrastructure such as parks, eco-friendly green spaces, promotion of public transportation usage, cycling, and walking to reduce emissions. Furthermore, it is essential to manage excessive tourism growth to prevent situations of overloading that can adversely impact the environment and local community. This can be achieved by restricting both the quantity and types of tourists visiting attractions, with a focus on providing high-quality experiential opportunities.

- Promote sustainable tourism activities that are closely integrated with environmental conservation efforts. This implies that tourists should be encouraged to engage in nature-experience activities with environmental awareness, while also receiving the transmission of local cultural significance and values. This aids in the preservation and development of Da Nang's cultural heritage.

- Ensure a balanced benefit between the tourism industry and the local community. Tourism businesses should create employment opportunities for the residents while promoting local products.

- Collaboration and Cross-disciplinary Management: Establishing a collaborative model among local authorities, tourism businesses, and communities to ensure the management of sustainable tourism development that benefits all stakeholders involved. This helps to build a positive image of Da Nang and attract more tourists.

2) Watershed Planning

- Enhancing Waterlogging and Flood Resistance Capability: The watershed planning system is designed to have the capacity to efficiently collect and process rainfall, thereby minimizing the risk of waterlogging and urban flooding.

- Developing a natural drainage system: Incorporating porousness into the watershed plan involves safeguarding and generating green spaces, natural river systems, permeable land areas, parks, and green zones to enhance natural water drainage capacity.

- Functional diversification: The watershed planning system in a porous urban area must possess the capability to diversify the functions of land usage, ranging from residential zones to commercial, industrial, and recreational zones. This fosters flexibility in land utilization and adaptation to the urban environment's changes.

- Designing a network to connect urban drainage systems: The watershed planning system needs to be consistently integrated with other elements of the porous city, such as transportation, infrastructure, and urban residential areas.

- Sustainable Management: Resilience in watershed planning ensures sustainable management of water resources and the environment, encompassing activities from rainwater collection to wastewater treatment, as well as water source preservation."

B. Watershed planning within the context of porous urban structures

1) The Coastal Structural Characteristics of Da Nang City

The formation of natural currents along the coastal sandy shores leads to erosion of the coastal structures throughout the seasons. Additionally, during the rainy and stormy seasons at the coastline of Da Nang, high tides and waves cause the sea level to rise, affecting the coastline, roads, and coastal structures. Furthermore, the natural flow along the coastline of Da Nang plays a crucial role in generating the movement of sand and gravel within the area. This flow can push sand and rock particles in various directions, leading to erosion phenomena in coastal regions, resulting in the formation of lower-lying areas and providing conditions for high tides and inundation to occur in these areas. The consequences of these phenomena are detrimental to the coastal structures and the shoreline infrastructure.

The impact of tropical storms is a crucial factor influencing the coastal structure of Da Nang, particularly in areas with rocky slopes such as Son Tra Peninsula, Hon Chao Island, Bai Sung Co Beach, and Black Rock Beach. This phenomenon is explained by the strong influence of high winds, tall waves, and heavy rainfall during storms, which can lead to severe erosion and even significant alterations to the coastal structure and surrounding environment. Furthermore, the coastal structure of Da Nang is also influenced by the construction of coastal facilities and transportation infrastructure such as roads, bridges, urban areas, resorts, etc. Therefore, altering the coastal structure can lead to changes in water currents, reduced permeability, and shoreline stability.

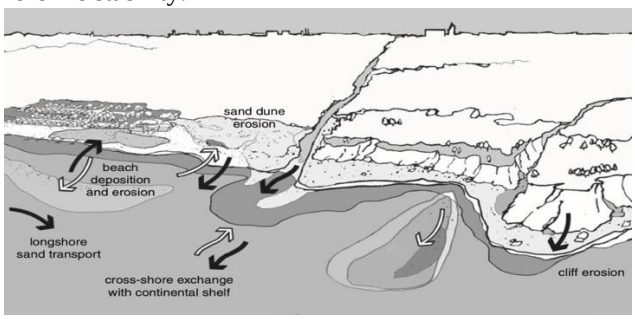


Figure 4. Structure of Danang coast

2) Proposed Solution

Rainfall and tidal intensity are weather factors that contribute to the occurrence of flooding and high tides in the city. Heavy rainfall can lead to flooding, while tidal intensity (the increase in seawater level) can affect coastal areas. Therefore, the design of water flow regulation, also known as watershed management, can employ technical solutions to control water flow in cases of heavy rain or high tides. This is achieved through the design of drainage systems, water reservoirs, rainwater drainage systems, and other relevant infrastructure to ensure efficient water circulation.

Furthermore, to cope with extreme weather phenomena, including abnormal climate situations such as heavy rain, storms, high tides, and severe droughts, watershed planning needs to be integrated with urban infrastructure to ensure safety and sustainability for residents. This is because Da Nang is a coastal city with a unique geographical position closely tied to frequent occurrences of extreme weather events each year.

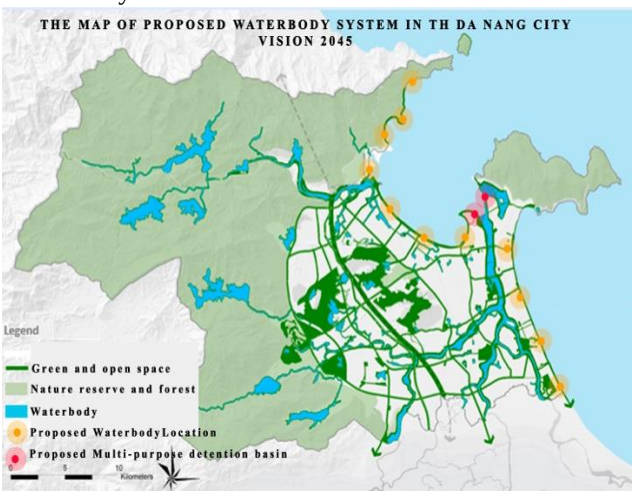
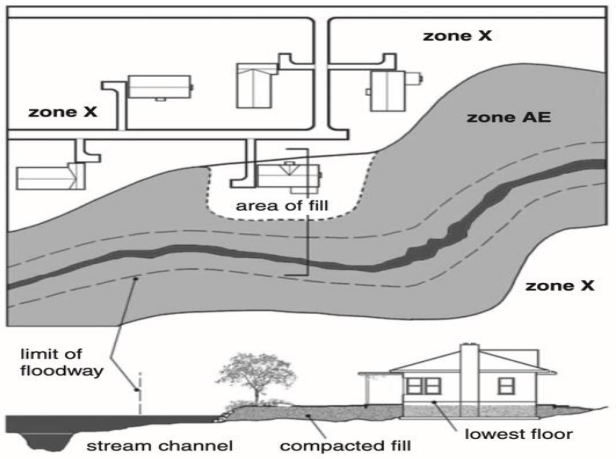


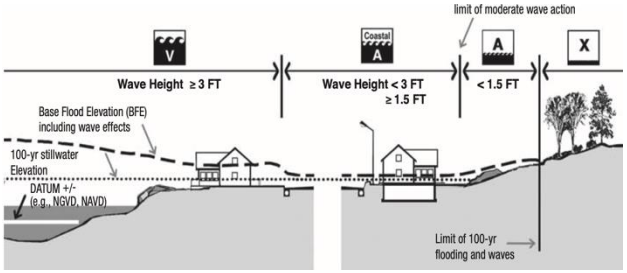
Figure 5. Proposed Map of Multi-functional Infiltration Position in Watershed Planning.

Based on the watershed planning map in the city of Da Nang, determining the locations for setting up water collection points and storage along the coastal road plays a crucial role in watershed planning.



Hình 6. Elevation based on fill. A site and building could be elevated out of an AE zone by approved fill.

In this context, the author has identified several potential danger points (a total of 11 points) where significant erosion events could occur. The purpose of identifying these points is to establish a water collection and storage system, aiming to minimize the risk of flooding in coastal areas and inhabited regions that are exposed to these danger points [9].



Hình 7. House constructed before NFIP provision

"A special case that is mentioned involves a location situated on both sides of the Thuận Phước Bridge, where the boundary between the sea area and the river intersects. Notably, this location is also considered a vital wind funnel of the Son Tra Peninsula. In this context, the author has proposed the construction of a versatile container structure, which holds particular significance and importance compared to other storage structures. The purpose of this structure may be related to regulating water flow, safeguarding coastal areas against flooding, and simultaneously capitalizing on the opportunity to create an efficient interaction between freshwater and saltwater systems [9]

In watershed planning, identifying potential hazardous points and implementing water storage and regulation solutions a crucial components to ensure the safety and sustainability of the environmental system and population within the context of changing weather patterns and the current situation in the city of Da Nang [9].

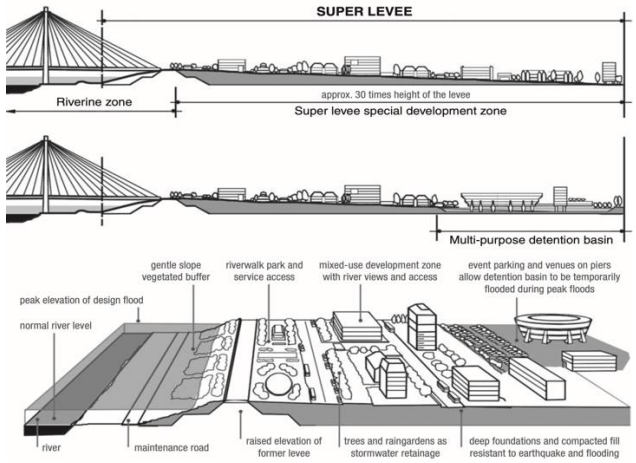


Figure 8. Super levees and multipurpose retarding basins (temporary flood detention areas) are part of flood control, river enhancement, and urban reinvestment zone initiatives.

IV. CONCLUSION

Coastal urban areas in the city of Da Nang have strong potential for robust development due to their unique geographical location, comprehensive infrastructure, attractive investment and business opportunities, along the ability to create an appealing living environment.

However, to achieve this, managing the development concurrently with environmental protection is of utmost importance, to leverage the strengths of coastal tourism in the city of Da Nang and maintain the value of this coastal urban region in the future. In the context of this study, the article aims to address the sustainable development criteria of a highly vulnerable urban area like Da Nang. Within these criteria, watershed planning is considered the most crucial factor. Therefore, based on analyses of favorable geographical location, robust infrastructure, appealing living environment, and the backdrop of extreme weather conditions along the coastal area of Da Nang, the author proposes several solutions to contribute to the construction and development of a tourism-oriented urban landscape, similar to that of Da Nang.

Danang, 11th November 2022

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