ICFM 10
Adapting to Global Change:
Innovative Approaches to Flood Management and Resilience
May 20-22, 2026 | Western University, London, Ontario, Canada

Resilient City-Oriented Flood Control and Waterlogging Prevention Planning for the Beijing Municipal Administrative Center

Zhengyao Fu[1]
Beijing Municipal Institute of City Planning and Design, Beijing, 101117, China[1]
E-mail: Fuzhengyao@foxmail.com

ABSTRACT

Against the backdrop of the Beijing Municipal Administrative Center (BMAC) undertaking the historic mission of relieving non-capital functions and advancing high-quality development, this study addresses the prominent challenges of flood control and waterlogging prevention in the BMAC, including the natural vulnerability of "the lower reaches of nine rivers", the mismatch between low-standard existing drainage systems and high-standard construction requirements in the new era, and the transition from human-water alienation to city-water integration. Based on the goal of building a millennium city with integrated water and city, resilient safety, and sponge city features, this paper proposes five core strategies: establishing the "Tongzhou Weir" flood control system with the concept of "upper storage, middle diversion, and lower drainage", creating ecological and water-friendly riverside spaces, implementing zone-specific waterlogging prevention measures, integrating green and gray infrastructure to upgrade pipe and river networks, and advancing sponge city construction to enhance rainwater control and utilization. Furthermore, four recommendations for overall coordination are put forward: improving the coordination of flood and waterlogging encounter scenarios, strengthening urban space planning coordination, enhancing the connection between new and existing infrastructure, and improving emergency management coordination. This research provides a systematic planning framework for the BMAC to achieve the 100-year flood control standard and high-standard waterlogging prevention capacity, and offers a valuable reference for the construction of flood safety patterns in other similar cities under the new development philosophy. Keywords: Beijing Municipal Administrative Center (BMAC); flood control and waterlogging prevention; planning strategy; resilient city; sponge city; water-city integration

KEYWORDS: Beijing Municipal Administrative Center (BMAC); flood control and waterlogging prevention; water-city integration; resilient city; sponge city

1 INTRODUCTION

As one of the two core pillars of Beijing's planning and development in the new era, the Beijing Municipal Administrative Center (BMAC) is a landmark project of historic significance. It is tasked with relieving Beijing of non-capital functions and advancing the coordinated development of the Beijing-Tianjin-Hebei (BTH) region, representing a century-long endeavor and a millennium-scale initiative. In recent years, the BMAC has undergone rapid construction and development in line with the overall urban layout of "one core, one sub-center, two axes, and multiple nodes" outlined in the Beijing Master Plan (2016–2035). Since the relocation of municipal organs and enterprises kicked off in 2019, the center is projected to accommodate 400,000 to 500,000 permanent residents relocating from the central urban area by 2035 (People's Government of Beijing Municipality, 2017). However, the original Tongzhou New Town, which undertakes this historic mission, is endowed with unfavorable natural conditions. Its hydrological and geographical setting renders it highly susceptible to both external flooding and internal waterlogging. Meanwhile, the existing urban municipal infrastructure, though still inadequate, must be upgraded expeditiously to meet world-class standards. Therefore, adhering to the strategic orientation of

high-quality development, establishing a benchmark for people-centered projects in the capital in the new era, and safeguarding flood safety in the BMAC are critical initiatives pivotal to national welfare and people's livelihood.

This paper elaborates on the problems and challenges encountered in constructing the flood control and waterlogging prevention framework of the BMAC, summarizes key planning strategies and priorities, and puts forward insights and recommendations. It aims to fully leverage the exemplary role of the BMAC's planning and construction, thereby providing a reference for gradually shaping a new paradigm of high-quality urban development under the new era and new development philosophy.

2 CURRENT SITUATION AND CHALLENGES

The BMAC is situated in the northern part of Tongzhou District, Beijing, covering an administrative area of roughly 155 square kilometers. It lies in the alluvial plain of the Yongding and Chaobai Rivers, boasting a warm temperate continental semi-humid monsoon climate. The multi-year average rainfall stands at 541.3 mm (1956 – 2015), with precipitation hitting 775.6 mm in 2021 (Compilation Committee of Tongzhou District Local Chronicles, 2023). Pursuant to the Beijing Master Plan (2016 – 2035), the original Tongzhou New Town was redesignated as the BMAC, which mandates high-standard planning and construction to exemplify and facilitate the alleviation of non-capital functions. By 2035, it is anticipated to initially evolve into an internationally renowned, harmonious, livable, and modern urban area. In December 2018, the CPC Central Committee and the State Council, in their approval of the Regulatory Detailed Plan for the Beijing Municipal Administrative Center (2016 – 2035), required the construction of a green, forested, sponge, smart, humanistic, and livable city, positioning the BMAC as a new landmark of the capital. To further implement urban planning arrangements, constructing a robust flood control and waterlogging prevention safety framework for the BMAC confronts three major challenges.

2.1 The Natural Context of "the Lower Reaches of Nine Rivers" and the Assurance of 100-Year Flood Control Safety

The BMAC is a confluence of numerous rivers, historically known as "the lower reaches of nine rivers". It encompasses 24 rivers, including the North Canal, Wenyu River, Xiaozhong River, Yunchao Flood Diversion River, Tonghui River, Liangshui River, and Yudai River, with a total length of around 106 kilometers and a total water area of approximately 1,850 hectares. All these water bodies fall under the Chaobai River and North Canal systems within the Haihe River Basin. The BMAC has a long history of frequent flood disasters, which have inflicted heavy losses on people's lives and property. Statistical data on flood disasters over 255 years (from 1736, the first year of the Qianlong reign, to 1990) indicate that years with moderate to severe waterlogging account for roughly 20%. After the founding of the People's Republic of China, flood disasters were mainly concentrated in the 1950s. Since 1958, the construction of water conservancy projects in the upper reaches, such as the Huairou Reservoir and Miyun Reservoir, coupled with the reinforcement of dikes, dredging of rivers, and excavation of artificial flood diversion channels, has significantly enhanced flood detention and discharge capacity, thus minimizing the occurrence of major flood disasters in recent decades.

The BMAC is located in the lower reaches of the main streams of the Wenyu River and North Canal. The main stream of the North Canal assumes the responsibility of draining rainwater from Beijing's central urban area and multiple districts along its course. In recent years, rapid urbanization has brought about significant changes in the basin's underlying surface and an increase in the surface runoff coefficient, leading to greater runoff generation and accelerated confluence. This has intensified the flood control pressure on the main streams of the Wenyu River and North Canal. Rough calculations reveal that the peak flood discharge of different frequencies in the current Lingoukou – Beiguan Barrage section of the Wenyu River main stream has increased by 25% to 48% compared with the original design (Beijing

Municipal Institute of City Planning and Design, 2018). Meanwhile, the accelerated construction of the BMAC has driven the continuous expansion of urban planned construction land (according to the Tongzhou New Town Plan (2005–2020), the planned urban construction land area was 86 square kilometers; according to the Regulatory Detailed Plan for the Beijing Municipal Administrative Center (2016–2035), the construction land scale of the center is controlled at approximately 110 square kilometers) (People's Government of Beijing Municipality, 2018). Some original farmland drainage ditches have been converted into urban drainage rivers or rainwater pipelines, reducing natural water storage and infiltration space. Consequently, this has caused regional drainage difficulties and underscored the risks of external flooding and internal waterlogging.

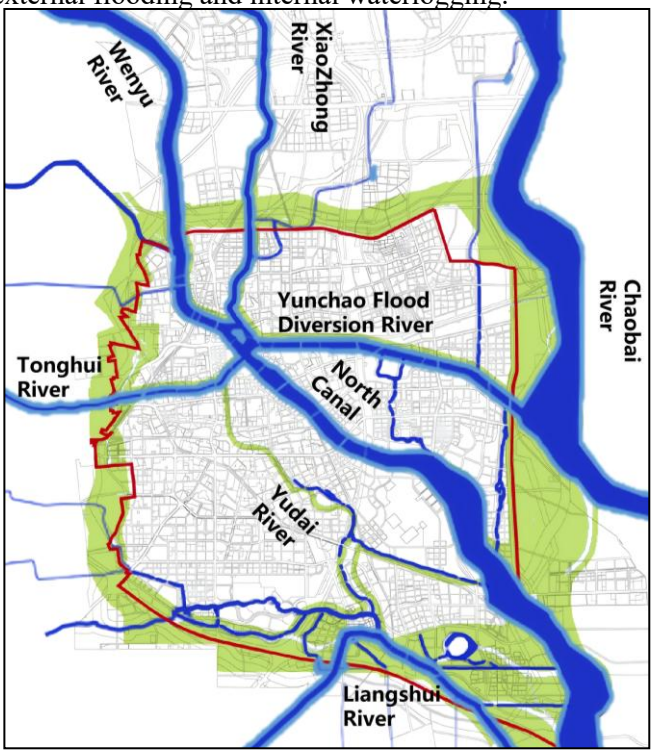

Figure 1: River system of Beijing Municipal Administrative Center

2.2 The Existing Low-Standard Drainage System and the Construction of a High-Standard Waterlogging Prevention System in the New Era

According to statistics as of 2016, the BMAC houses approximately 58 existing rainwater pipeline systems, with a total length of about 173 kilometers and pipe diameters ranging from Φ300 mm to □ 4000×2600 mm. A dynamic coupled model integrating pipelines, river networks, and two-dimensional ground surfaces was established using Mike software for evaluation, and InfoWorks software was employed for simulation comparison and verification. The results indicate that roughly 113 kilometers (67%) of the existing rainwater pipelines in the BMAC have a design standard lower than a 1-year recurrence interval, and about 37 kilometers (22%) have a standard lower than a 2-year recurrence interval. Analysis of pipe network survey data reveals that most existing rainwater pipelines and canals were constructed decades ago, and their design standards are no longer compatible with current requirements.

In addition to its dense river network, the BMAC has constructed numerous large-scale transportation facilities in tandem with urban development, which have altered the natural rainwater drainage basins. These facilities mainly include the Beijing-Qinhuangdao Railway, Beijing-Chengde

Railway, and Tongsan Railway, as well as the Beijing-Tianjin Expressway, Tongyan Expressway, East Sixth Ring Road, and Beijing-Harbin Expressway. Their intersections with other urban roads have formed concave overpasses. As of 2016, there were 20 existing rainwater pumping stations at these concave bridges, most of which have a low design standard of 5 to 10-year recurrence intervals. In the event of heavy rainfall, these stations are prone to malfunction, resulting in road traffic disruptions.

2.3 The Past of Human-Water Alienation and the Future of City-Water Integration

The BMAC is characterized by a low-lying and flat natural terrain, slightly higher in the northwest and lower in the southeast, with a ground elevation ranging from 28.5 meters to 14.3 meters and an average terrain slope of approximately 0.955%. The North Canal runs through the BMAC from northwest to southeast and assumes the primary responsibility for flood control and waterlogging prevention. Its planned water level for a 50-year recurrence interval is roughly 21.8 meters to 18.57 meters, and for a 100-year recurrence interval, it is about 21.9 meters to 18.90 meters. Therefore, under the dual impacts of backwater from high external flood levels and the low-lying, waterlogging-prone terrain, rational vertical zoning and control of the BMAC are of utmost importance. Due to insufficient attention to urban vertical planning in the early construction stages, the ground elevation and slope direction of some existing roads and residential communities are improperly designed, leading to water accumulation and internal waterlogging during heavy rainfall events. For instance, during the "8.8" heavy rainfall event in 2018 (with a maximum hourly rainfall of 78.2 mm), among the 74 waterlogging points, 29 were low-lying communities and 36 were low-lying roads.

There are still 78 kilometers of substandard dikes along the main rivers in the BMAC, such as the North Canal, Chaobai River, and Wenyu River. The most prominent issue is the absence of dikes on the left bank of the North Canal. The 100-year flood level of this section is higher than the elevation of surrounding roads and ground. Currently, the riverbank and beach in this section are occupied by the Canal Square and Olympic Sports Park, making it challenging to implement the original dike construction plan and posing significant flood control safety hazards. Therefore, on the basis of respecting the natural context, current conditions, and the demands of urban residents, it is an important challenge to gradually address the insufficient attention to water safety in the development process, systematically enhance urban flood safety, and transition from human-water alienation to city-water integration.

3 STRATEGIES FOR CONSTRUCTING A FLOOD SAFETY PATTERN

To further implement General Secretary Xi Jinping's important instructions on the planning and construction of the Beijing Municipal Administrative Center (BMAC), comprehensively improve the flood control and waterlogging prevention capacity of the BMAC, ensure the safety of people's lives and property as well as urban operation, and build the BMAC into a millennium city that carries Chinese wisdom, integrates water and city, and is safe and livable, the BMAC has proposed three main strategies and five key points: constructing a flood control pattern integrating water and city, building a resilient and safe waterlogging prevention system, and systematically advancing sponge city construction.

3.1 Intelligent Water Management and Establishment of the "Tongzhou Weir" Series of Flood Control System

In accordance with the concepts of water regulation, water governance, and water-friendly development, and drawing on the ancient wisdom of using "weirs" to divert water, a series of flood control system featuring "upper storage, middle diversion, and lower drainage" has been constructed to reduce flood pressure in the BMAC, effectively detain and store rainwater and floods, and achieve the 100-year flood control standard. Specifically, upper storage involves building 2 new reservoirs and 48 flood storage and detention areas in the upper reaches to store and control mountain floods; middle diversion includes digging the new Wenchao Flood Diversion River and dredging the Yunchao Flood

Diversion River to divert floods to the Chaobai River; lower drainage focuses on renovating key rivers such as the Wenyu River and North Canal to ensure unimpeded drainage; a circular green recreational belt is reserved on the periphery of the BMAC, serving both flood regulation and storage and optimizing the spatial ecological pattern. These measures together form the overall flood control water system pattern of Tongzhou District, characterized by "three horizontal and two vertical lines for external flood defense, multiple points for rainwater and flood storage and detention, one circular belt around the city, and nine rivers integrating harmoniously".

3.2 Creating Dynamic Water-Nurturing and Attractive Water-Friendly Riverside Spaces

Through micro-topography treatment and optimization of construction design, and by adopting a mode of integrating green spaces, buildings and dikes, the 3-kilometer dike-less section of the North Canal, which was previously difficult to construct, will be built into an ecological dike shoreline. This will comprehensively meet the needs of flood control, landscape, and water-friendly activities, forming a demonstration riverside space. The Wenchao Flood Diversion River and its adjacent riverside spaces will be planned and constructed to divert 440 cubic meters per second of floodwater from the Wenyu River under the 100-year flood scenario, ensuring the flood control safety of the BMAC without raising the existing dikes. An open green space at the junction of Shunyi and Tongzhou Districts will be constructed to connect the Wenyu River-Chaobai River ecological corridor, forming a shared, safe, and pleasant riverside space.

3.3 Zone-Specific Measures, Customized Waterlogging Prevention Zoning and Refined Governance Strategies

In line with the high-standard waterlogging prevention requirements of the 50-year to 100-year flood recurrence interval, the BMAC coordinates rivers, lakes, rainwater pipelines, and pumping station system, and delineates hierarchical waterlogging prevention zones integrating storage, drainage, and elevation raising based on local conditions. Under the comprehensive consideration of safety, ecology, water-friendly features, and landscape conditions, zone-specific waterlogging prevention strategies are formulated ("one zone, one policy"), with a focus on ensuring the safety of high-risk areas such as depressed overpasses, existing low-lying communities, and built-up low-lying areas. For urban construction areas with favorable topographical conditions, gravity flow self-drainage or elevation drainage is prioritized; for local low-lying areas, measures such as local external water interception and high-lift pumping stations are appropriately adopted to meet waterlogging prevention requirements; for regional low-lying areas, the final plan is determined by comparing and selecting between the flood storage and drainage scheme using rivers or flood storage areas and the high-lift drainage scheme by constructing regional pumping stations. In accordance with the planning idea of integrating "self-drainage, high-lift drainage, storage-drainage, and elevation drainage", the BMAC plans to construct and reconstruct more than 60 various rainwater storage and drainage facilities, including depressed overpass pumping stations, community rainwater pumping stations, and flood drainage pumping stations.

3.4 Integration of Green and Gray Infrastructure, High-Standard Construction of Pipe Network and River Network Systems, and Scientific Support for Vertical Planning Compilation

It is planned to construct, renovate, and expand 282 kilometers of main rainwater pipelines, raising the recurrence interval to 3 to 10 years. Ecological treatment will be carried out on 17 flood drainage rivers with a total length of approximately 117 kilometers to ensure unimpeded drainage in the lower reaches. Six dual-purpose flood storage and detention areas (for both normal and emergency use) will be built, with a total storage capacity of 2.67 million cubic meters for storing and detaining floodwater in the rainy season and serving as urban public recreational spaces for residents in the dry season. In addition, based on the simulation results of hydrological numerical models, the risk of waterlogging within 50 to 100 years is evaluated, and vertical adjustments are optimized for 23 road sections to mitigate

waterlogging risks. A total of 46 rainwater regulation and storage areas with a total capacity of 26,000 cubic meters will be set up by comprehensively utilizing green spaces, squares, and stadiums.

Figure 2: Jing River of Beijing Municipal Administrative Center

3.5 Implementing Sponge City Construction Requirements and Proposing Planning and Design Key Points for Rainwater Control and Utilization

Adhering to the core concept of sponge cities of "natural storage and natural infiltration", technical guidelines for planning and design are provided for permeable building communities, self-purifying road squares, and rainwater-harvesting green spaces and parks to implement the sponge city concept and promote the planned construction of sponge cities in the BMAC in an orderly manner. Taking the Urban Green Heart as an example, the surface runoff storage mode is widely adopted to replace the traditional rapid drainage mode of rainwater pipelines, giving full play to the role of ecosystems such as buildings, roads, green spaces, and water systems in absorbing, retaining, infiltrating, and slowly releasing rainwater (Fu, Zhang, et al. 2022). Overall, a large storage-type sponge dominated by old canal courses and flood storage areas is constructed, and small permeable sponges dominated by rain gardens, grass swales, and bioretention facilities are created in detail. This will enable 91.7% of rainwater to be absorbed and utilized on-site, with the annual total runoff control rate reaching over 90%.

Figure 3: The Urban Green Heart of Beijing Municipal Administrative Center

4 CONCLUSION AND RECOMMENDATION

Urban flood control and waterlogging prevention systems are important components of municipal infrastructure. With the frequent occurrence of extreme climates, the demand for urban development and construction, and the further upgrading of the resilient city concept in recent years, the importance of urban flood safety has become increasingly prominent. Under the new era and new development philosophy, constructing an urban flood control and waterlogging prevention pattern that ensures the safety of people's lives and property, maintains stable urban operation, improves the water ecological environment, and promotes the improvement of the whole-basin flood control system is of great significance. Drawing on the experience of constructing the flood control and waterlogging prevention pattern in the BMAC, the following four aspects of overall coordination work are recommended:

4.1 Improve Coordination of Flood and Waterlogging Encounter Scenarios

Flood and waterlogging disaster risks often occur simultaneously. The "23 • 7" catastrophic basin-wide flood in the Haihe River Basin caused severe losses in Fangshan, Mentougou and other districts of Beijing, and one of the important reasons was the concurrent occurrence of floods and the superposition of flood peaks. Taking the BMAC as an example, due to the large drainage area of the North Canal and the 50-year flood process that can last for about 3 days, the calculated waterlogging area in the urban area differs by twice under two working conditions: simultaneous rainfall in the entire North Canal basin, and local rainfall superimposed with external flood peaks. Therefore, in areas with low-lying natural terrain and prominent external flood and internal waterlogging problems, special attention should be paid to coordinating the risks brought by the superposition of floods and waterlogging. Special research should be carried out, and refined drainage and waterlogging prevention models should be used to simulate multiple encounter scenarios and operating conditions, so as to scientifically and reasonably determine the encounter conditions of external floods and internal waterlogging, pipeline flow processes, the operating conditions of waterlogging prevention pumping stations and gates, and the relationship with the scale of waterlogging prevention pumping stations.

4.2 Strengthen Coordination of Urban Public Space Planning

With urban development and construction, changes in underlying surface conditions have led to a gradual increase in urban runoff, while the original flood storage space has been continuously reduced. Relying solely on source sponge measures and small rainwater pumping stations is inevitably insufficient to cope with the risks posed by flood and waterlogging. To align urban flood safety with urban development positioning, in the planning stage, it is necessary to reserve "leeway" in urban public space, coordinate the relationship between water area land and construction land, and focus on the reservation and management of flood storage and detention areas; at the design stage, on the premise of ensuring safety, flexible technical means should be adopted to coordinate the landscape effects on and off the banks, creating riverside spaces integrating blue and green areas and combining water and forests; in the construction stage, along with urban construction and renewal, synchronous progress should be made in river dredging and renovation as well as the construction of supporting drainage and waterlogging prevention facilities, proactively plan the construction of major flood control and waterlogging prevention facilities, and dynamically eliminate annual flood season waterlogging points.

4.3 Enhance Coordination of New and Existing Infrastructure Connection

To meet the needs of urban development, the planning and design standards for flood control and waterlogging prevention have been gradually improved. However, the existing built-up areas have low drainage and waterlogging prevention standards, and the construction of new surrounding projects may further exacerbate the waterlogging risk in the existing built-up areas. Therefore, in the process of new project construction and renewal and reconstruction, the regional waterlogging prevention safety should be systematically improved from the perspective of basin-wide comprehensive coordination. Taking the BMAC Comprehensive Transportation Hub as an example, the project plan comprehensively coordinates the drainage and waterlogging prevention planning and design conditions of key projects such as the transportation hub, the Sixth Ring Road High Line Park, and the undergrounding of the Sixth Ring Road Expressway. It has carried out research and impact analysis on multiple system schemes such as pumping station drainage, linear project regulation and storage, and park green space regulation and storage. While meeting the requirements of the above key projects, it has simultaneously solved the historical waterlogging problems of surrounding existing low-lying communities such as Ziyunnanli Community, greatly improving the drainage and waterlogging prevention level of the basin.

4.4 Improve Coordination of Emergency Management

In recent years, disasters caused by extreme climates have become increasingly frequent worldwide. Relying solely on gray infrastructure construction to resist excessive flood threats can no longer meet the city's safety guarantee requirements. Promoting the in-depth integration of resilient city construction with modern urban operation and management has become a key task under the new development philosophy. In July 2022, Beijing took the lead in organizing the compilation and release of the Beijing Urban Waterlogging Risk Distribution Map, which shows the distribution of potential waterlogging risk points to the public and provides corresponding evacuation measures and prevention guidelines. To further refine the support for scientific decision-making by government departments, urban planning units have superimposed important urban elements such as key infrastructure, buildings, transportation, and population on this basis, and compiled the Beijing Central Urban Area and Municipal Administrative Center Waterlogging Risk Impact Analysis Map with "one point, one map". This map is used to quantitatively analyze not only the direct impact of waterlogging but also the indirect impacts on social functions, crowd activities, and transportation. The analysis results will be incorporated into the annual physical examination and evaluation of territorial space planning, providing technical support for implementing the deployment of resilient city construction, promoting the orderly development of urban waterlogging control work, and improving the level of emergency management.

REFERENCES

People's Government of Beijing Municipality. Beijing Master Plan (2016–2035) [Z]. Beijing: People's Government of Beijing Municipality, 2017.

Compilation Committee of Tongzhou District Local Chronicles. Beijing Tongzhou Yearbook 2022 [M]. Beijing: People's Government of Tongzhou District, 2023.

Beijing Municipal Institute of City Planning and Design. Flood Control and Waterlogging Prevention Plan for the Beijing Municipal Administrative Center [R]. Beijing: Beijing Municipal Commission of Planning and Natural Resources, 2019.

People's Government of Beijing Municipality. Regulatory Detailed Plan for the Beijing Municipal Administrative Center (2016–2035) [Z]. Beijing: People's Government of Beijing Municipality, 2018.

Zhengyao Fu, Wenyong Zhang, et al. Practicing the Concept of Ecological Civilization and Creating a Model of Harmonious Coexistence — Exploration and Practice of Municipal Infrastructure Planning for the Urban Green Heart in the Municipal Administrative Center [J]. Beijing: Beijing City Planning & Construction Review, 2022.