Beijing Copenhagen

Joint Article on Climate Adaptation and Sponge City

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Beijing Municipal Commission of Planning and Land Resources

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1 Introduction

1.1 Climate Change – the Background for the Collaboration

Climate change is a global challenge that, especially for the world's major cities, is crucial to be able to deal with in a sustainable way as urban growth is expected to increase in the future. At the same time as climate change is a major challenge, it also offers great opportunities for new areas of urban water management and the development of urban spaces and green areas.

Although there is a very big difference in the size of the cities, the challenges and the solutions are often the same. Most solutions can be scaled and adapted to the needs and requirements of the different cities for functionality, architecture etc.

No city has the complete solution to the great challenges posed by climate change, but through cooperation and exchange of experience, the challenges can be solved and contribute to the development of the climate-resilient cities of the future. We feel confident that the solutions can give a big boost to the city's development in terms of improved urban spaces, liveability, better use of rainwater, more growth, and last but not least increased cooperation with other cities in the development of innovative solutions.

This joint article serves as a city-to-city collaboration between Beijing-Copenhagen on climate adaptation and sponge city construction. Sponge City and cloudburst as concepts were applied in Beijing and Copenhagen respectively both in the initial design and masterplan implementation. The best practice of demonstration projects was highlighted, especially the Green Valley project in Beijing, which is also as the result of collaboration between Beijing and Copenhagen. The aim of the article is not only to introduce Beijing-Copenhagen collaboration on climate adaptation, but also to provide references and possibilities for city governors, researchers and planners to adapt climate change and build better cities.

1.2 Setting the Scene – Beijing Copenhagen Collaboration

The collaboration between the two cities was formally launched with the conclusion of a Memorandum of Understanding on the Establishment of a Working Group on Sustainability in Planning and Construction in 2012. This initiative was further strengthened by the Strategic Sector Cooperation (SSC) Project between Beijing and Copenhagen on Sustainable Urban Development in 2018. A joint 3-year workplan was signed between the City of Copenhagen and Beijing Municipal Commission of Planning and Land Resources in May 2018. Thus the collaboration on climate adaptation started in 2018 with the focus on experience exchange on rainwater management, including planning, recycling and purification, together with green solutions development and citizen involvement. The Technical and Environmental Administration of the City of Copenhagen and Beijing Institute of City Planning and Design are responsible for the tasks.

The two cities are facing the same challenges on more frequent cloudbursts in the future and more dry conditions at the period time. In Beijing, it is a challenge that there is a need to increase groundwater recharge in view of an increasing need for drinking water. This challenge is included in proposals for climate adaptation solutions in Beijing. Rainwater treatment is a common challenge that the two cities exchange experience on so that rainwater can be reused and discharged to water areas without harming the aquatic environment. Moreover, opportunities for citizen involvement in the solutions implementation has been discussed.

1.3 Introduction to Beijing and Copenhagen

Beijing

Beijing is located in Northern China and is the political, economic, cultural and transportation center of China, with high density of population and wealth. Beijing has 14 municipal districts, 129 streets, 142 towns and 43 townships. According to official data the permanent population in Beijing in 2019 was 21.53 million.

There is a continental climate in Beijing with cold, dry winters and hot, rainy summers. The average annual precipitation is 595mm. The rainfall in flood season from June to September accounts for 75%-84% of the annual precipitation.

Beijing has five flood control rivers, 4 main drainage rivers, and more than 30 large drainage channels. In addition, there are 26 lakes in Beijing central area, responsible for water regulation and storage during flood season.

Historically, Beijing experienced many serious flood disasters, which caused a threat to life and properties. Among them, the "721" rainfall on July 21, 2012, lasted nearly 16 hours, with an average rainfall of 215mm in the urban area. The direct economic loss caused by this rainfall was estimated about 16.2 billion RMB. In response, with increased awareness of the importance of systematic construction and demand for urban development, Sponge City concept has been developed and adopted as a solution for flash flooding.

Copenhagen

Copenhagen is located in the eastern coast of the island of Zealand. The city (municipality) has 600,000 inhabitants and the Greater Copenhagen Area has around 3.5 million inhabitants.

There is a coastal climate in Copenhagen with moderate precipitation in the whole year. The rainfall is higher from July to September. The average annual precipitation is 728 mm. and the rainfall is expected to increase due to climate change. The city developed a climate adaptation plan that was politically approved in 2011.

On July 2nd, 2011, Copenhagen experienced a cloudburst event in which they received almost 150 mm of rain within a 2-hour duration causing nearly US$1 billion worth of damages. In the wake of this event, it became evident that Copenhagen needed a better way to manage stormwater that inundated the city during extreme precipitation events.

In response, Copenhagen issued a "Cloudburst Management Plan" in 2012, which set forth a strategy to utilize a mix of grey and green systems to absorb and convey stormwater from these heavy rainfall events. Currently, Copenhagen is working towards implementation of 300 projects that aim to work as a networking for conveying stormwater and better managing flooding.

2 Climate Change Adaptation in Beijing

2.1 Sponge City as a Concept

With the continuous expansion of urban scale and the continuous improvement of urban construction density, in recent years, the problems of urban waterlogging, polluted and smelly water, groundwater level decline, etc. have become increasingly prominent.

The grey infrastructure as drainage pipeline, pumping station, sewage treatment plant, etc. corresponding to the traditional concept of rapid removal and terminal treatment of stormwater cannot deal with the problems effectively. Combined with climate change that can lead to more heavy rains, which becomes a challenge for Beijing as well as many other cities in China.

This is not just an issue in China, and as a result, the solution of water problems in global cities over the past 25 years has gradually turned to ecology, system and sustainability such as LID in the United States, SUDs in the United Kingdom, WSUD in Australia and ABC in Singapore. All of these are described as Nature Based Solutions (NBS) relying more on surface management of stormwater and the integration of stormwater management in urban designs. Correspondingly, China puts forward the Sponge City as the core concept to strengthen the management of urban planning and construction.

The Sponge City concept takes into consideration the full water circle in cities, giving full play to the role of buildings, roads, green spaces, water systems and other ecosystems in absorbing, storing and releasing rainwater, and effectively control run-off by natural accumulation, infiltration and purification.

The concept of Sponge City is developing over time. This is mainly because the importance of a systematic approach to construction and the demand for new

urban development has made it clear that the concept needs to be flexible to follow the changing needs in cities.

One of the changes has been the expansion of integrated stormwater management of grey-green combination. Up to now, it has gradually developed into a systematic and comprehensive construction concept including water safety, water environment, water ecology, water resources and other water related specialties.

In December 2013, President Xi Jinping emphasized improving the city drainage systems should priority the limited stormwater resources and natural methods to construct sponge city with natural accumulation, natural infiltration, and natural purification.

There is a guide for this approach: 'The technical guide for sponge city construction - Construction of rainwater system for low impact development' which gives the definition of sponge city. Cities can be designed as sponge-cities to be resilient by being able to adapt to environmental changes and natural disasters. Sponge cities can absorb, store and purify water when it rains, and then release and reuse the water when necessary – for example during dry periods. By using this approach cities will be able to improve the function of the urban ecosystem and reduce the urban flooding.

2.2 Development of Sponge City Concept

Beijing as the first city in China has carried out urban stormwater utilization research and application. Before 2015, sponge city construction in Beijing was mainly carried out in form of stormwater control and utilization.

There are several stages of the development of the Sponge City Concept in Beijing[①]:

Scientific research stage (1989-2000)

In the early 1990s, the National Natural Science Foundation of China (NSFC) carried out Research on Rain Flood Utilization, one of Key Issues in the Development and Utilization of Water Resources in Beijing, and through this the concept of stormwater utilization was first proposed. This led to a new study in Beijing "Research and Demonstration of Urban Stormwater Control and Utilization Technology in Beijing" that was carried out in 2000. After this study the actual implementation of demonstration projects on urban stormwater control and utilization was started.

① **Reference:** Beijing Sponge City Construction Evaluation Report, Beijing Sponge City Construction Joint Conference Office, March 2022.

The experiment and demonstration stage (2000-2012)

After the research phase, the concept of sponge cities was transformed into technology integration and demonstration. By 2006, 10 stormwater projects were constructed – covering 154.43 million square meters. These projects made it possible to utilize up to 3 million cubic meters of stormwater. This was done through integrating technologies allowing to infiltrate, collect, regulate and discharge stormwater.

For the 2008 Olympics the city built the Olympic Park and Olympic venues with integrated facilities for stormwater runoff control and reuse, fulfilling the commitment of "science and technology Olympics, people's Olympics, Green Olympics". And following the Olympics in 2009 the city went on to include the utilization ratio of stormwater and flood was in the "Technical Guidelines for Soil and Water Conservation Schemes of Construction Projects in Beijing" as the precondition for EIA approval.

Development and promotion stage (2012-2015)

During the next stage, the technologies of stormwater control and utilization were comprehensively promoted. The Municipal Planning Commission printed and issued the "Technical points for stormwater management and utilization of new construction projects (Provisional)", which clearly outlines the planning and design requirements the construction of stormwater management projects. In this phase one of the key focus points was resource utilisation and turning harm into benefit.

In 2013, the "Water impact assessment" system was fully implemented as the pre-condition for the approval of construction projects, and the stormwater drainage management and utilization of construction projects were strictly controlled as a result of this work.

In 2015, the general office of the State Council issued "Guidance on promoting the Sponge City Construction" and Beijing entered the stage of comprehensive construction of sponge city.

Construction of Sponge city stage

In 2016, Tongzhou district of Beijing was selected as the second batch of national sponge city construction pilot. In 2017, the general office of the municipal

government issued “Implementation Opinions on Promoting the Sponge City Construction”.

In September 2017, “Master Plan of Beijing” (2016- 2035)” was officially approved by the CPC Central Committee and the State Council.

Following the plan an Implementation zoning control strategy for sponge city construction was proposed. The plan would dramatically increase the capacity of the city to utilize stormwater. As a result of the plan more than 20% of the urban area would absorb and utilize 70% of annual rainfall in 2020. The aim is to keep expanding so that more than 80% of the urban area will be part of the work in 2035.

"1 + 16 + N" Masterplan

Beijing is very committed to lead the development of the city through planning and therefore Beijing has actively explored and established "1 + 16 + N" sponge city planning system in combination with “Master Plan of Beijing (2016- 2035)”.

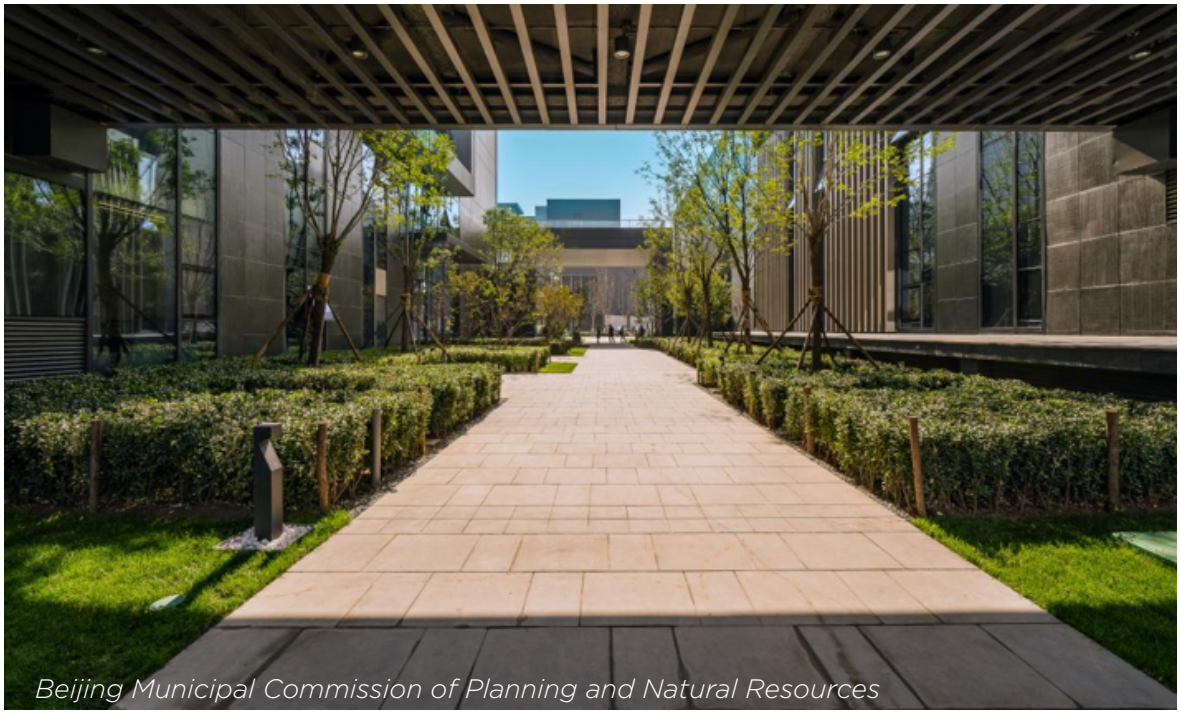
The number "1" stands for Sponge City Special Planning of Beijing, the number "16" refers to the special plans on implementing the sponge city concept in 16 districts, and the letter “N" refers to a number of key areas where sponge city special planning will be taking place.

What is really important is that the special planning of sponge city is synchronized with other planning areas such as drainage and waterlogging prevention, and infrastructure and green space planning. The Sponge City Special Planning of Beijing has been recognized by experts from the Ministry of Housing and Urban Rural Development Commission (MoHURD), who believe that "the concept of urban-district two-level control and pollution control based on the river basin system has exemplary significance for sponge city planning and construction in mega cities".

For the smooth progress of sponge city construction, Beijing has established the guarantee system and formulated good coordination mechanism at urban-district level. Beijing Sponge City Office has been established to promote sponge city construction and implementation in both city level and district levels. Besides the establishment of sponge city office, Beijing has formulated regulations and policies on sponge city construction to strengthen specifications.

2.3 Results of Beijing's Sponge City Approach

Beijing has achieved significant results from the sponge city approach. The city has finished 5237 sponge city projects until 2020. Among them, there are 39.7 square kilometres of permeable pavement, 54.6 square kilometres of concave green space, and 3.3 million cubic meters of rainwater storage volume.



Beijing Municipal Commission of Planning and Natural Resources

2.3.1 Increased flood control

The city has different standards for flood control. In the inner city it is 1 in 200 years, 1-100 for sub-center and 1 in 50-100 in new cities. The system works with a flood and drainage control system utilizing both rivers, pumping station, storage tanks etc. to control the flooding. The flood control system also secures that important traffic roads such as ring road, trunk road and radial line will remain unblocked in the event of 10-year rainfall.

Wenyuhe Park

Green Heart of Urban Sub-center Park

2.3.2 Ecological restauration of water bodies

Through the dedicated effort to improve water quality in the rivers and lakes in the city and as a result the water ecology of Beijing has continuously improved with increased quality in both rivers and reservoirs, and also increasing the landscaping of the water system.

As an example, Beijing promoted the ecological management of Yongding River by implementing the so called "open road with water, guide the way with water" to explore ecological methods to drive ecological management. As a result, the ecological condition of the river course has improved significantly.

Jinghe River

2.3.3 Sewage treatment

During "the 13th Five Year Plan" period, focusing on improving the quality of urban and rural water environment, Beijing continued to build or expand 28 WWTPs and upgraded 12 WWTPs. The sewage treatment capacity reached 6.9 million cubic meters per day and 3562 kilometers new sewage pipelines and 544 kilometers new reclaimed water pipelines are built. Beijing sewage treatment rate has increased from 90% in 2016 to 95% in 2020. The urban areas of Beijing have basically achieved all sewage collection, coverage and treatment. In accordance with the governance principle of "one river, one policy", 142 black and odorous water bodies with a total length of 669 kilometers were comprehensively renovated.

Liangshuihe River

3 Climate Change Adaptation in Copenhagen

3.1 Cloudburst Adaptation as a Concept in Copenhagen

The Municipality of Copenhagen is committed to see the need for climate adaptation as an opportunity to make Copenhagen an even greener, more sustainable and robust city for the future everyday lives of the people living in Copenhagen (The Cloudburst Plan). To meet this goal, it is necessary to work with integrated city planning, where climate adaptation is one of many perspectives, when solving the challenge of uncontrolled flooding due to heavy rain/cloudbursts and more stormwater. The other perspectives that are needed for a successful project is improving the characteristic of the city, developing the uniqueness of the city, creating new green public spaces and improving flora and fauna, while strengthening the public life. This is the declared goal for The Municipality of Copenhagen: to make the public spaces better, also when it is not raining.

To do this it is necessary to involve the surrounding stakeholders. When does, the local boards and citizens engage themselves in developing the city the municipality share their considerations about the project at an early stage? This is an opportunity to both becomes challenged by outsiders view on priorities and considerations and the possibility for capacity building for the engaged people through a thorough dialogue. This dialogue often leads to new solutions, adjusted priorities and even more know-how to the Copenhageners about developing the city with responsibility and to a diverse set of needs and goals. In the end, it is a political decision how the project will be developed.

Improving the characteristics of the city is about acknowledging, respecting and strengthening the quality and structure of the city. Uniqueness of the city is made by many different local areas and connections that reflects history, use and people, that defines the identity of the area and the local needs that must be taken into consideration.

Tåsinge Square **photo by Troels Heinen**

Skt. Kjelds Square **photo by Troels Heinen**

Creating new green public spaces is about turning gray into green and create new green connections. Improving flora and fauna is about making new habitats and more variation in the habitats that we already have and connecting them better. This effort should reflect increase experiences, connections throughout the city and local life.

3.2 Climate Adaptation Plan for Copenhagen

In 2009 the city decided to start working on a climate adaptation plan to prepare for a future with a warmer, wetter climate with an increase in extreme weather events. The plan mapped the risks that the city could expect to be facing given the various climate scenarios, and sets the strategy for the work that has to be carried out over the next 30-50 years to make sure that Copenhagen despite the changing climate continues to be a great place to live, work and invest in.

The basic philosophy behind the Climate Adaptation Plan is to make adaptation a precondition in the future for urban development in the city. Resilience must be a part of all the work that will be undertaken – and not just from a negative, problem fixated point of view. The idea is to look for synergies and possibilities and develop solutions that will improve the recreative qualities of the city – and the quality of life for the Copenhageners.

In the climate adaptation plan, the main challenges for Copenhagen were identified to be:

1: 30% more rainfall in the next 100 years and more frequently cloudbursts in the summer period

2: Up to 1 meter higher sea level and thus increasing risk of storm surge

As the risk of damage during cloudbursts was already found to be high, it was decided to start work immediately to reduce this risk. The risk of the city being hit by a severe storm surge is not great today, but will increase in line with the rise in sea level. This challenge will be addressed over many years by incorporating solutions in urban development.

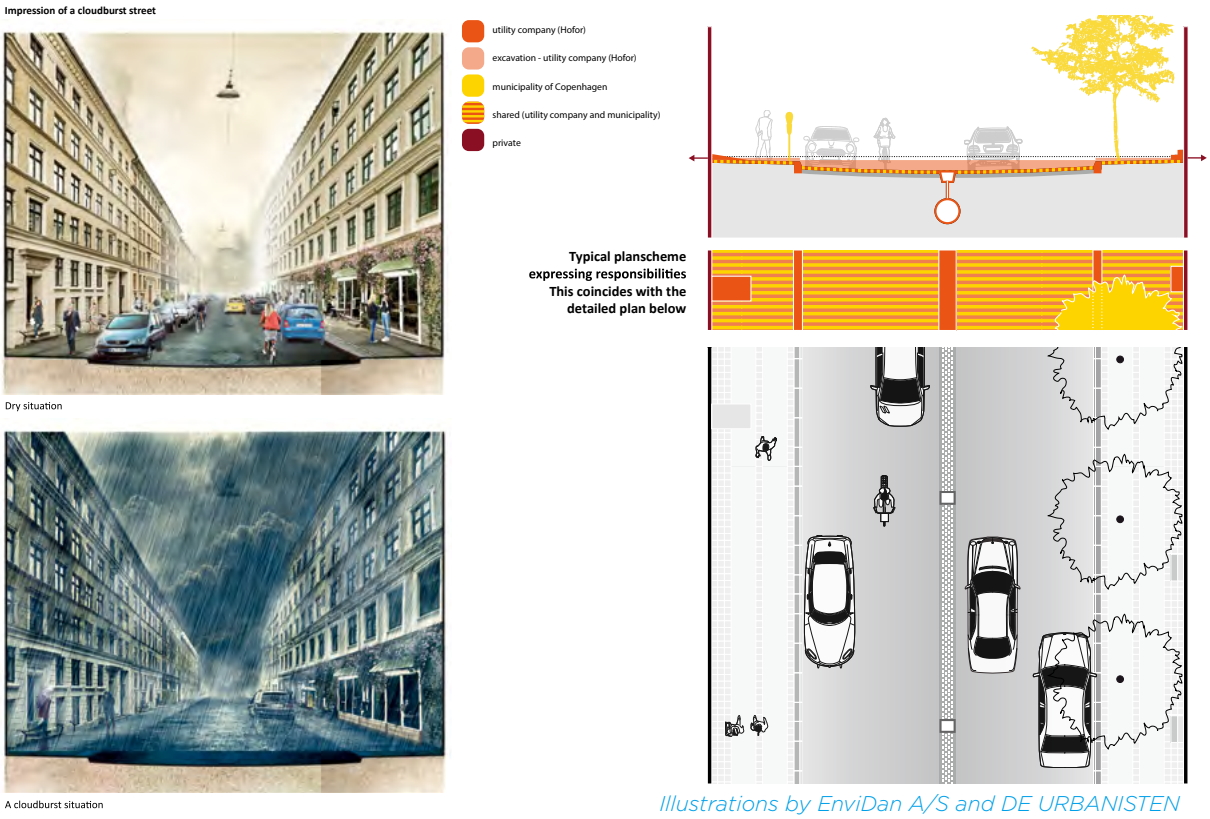
In order to be able to prepare a coherent cloudburst plan for the entire city, there was a need to develop solution typologies that at a general level describe ways of handling rainwater. There are developed five typologies in the Copenhagen cloudburst adaptation.

- Cloudburst Road
- Delay Path
- Delay Square
- Green Roads
- Pipes and Tunnels

Together these five typologies define how the rainfall is managed in a responsible and city-integrated way.

3.2.1 Cloudburst Road

The cloudburst road transports the rainwater on the surface in a controlled system that secures that the water will run naturally and with no obstacles on the way to a designated recipient, magazine or tunnel. Here you can see an example of a typical cloudburst road and how the expenses between the municipality and the water supply are typically divided.

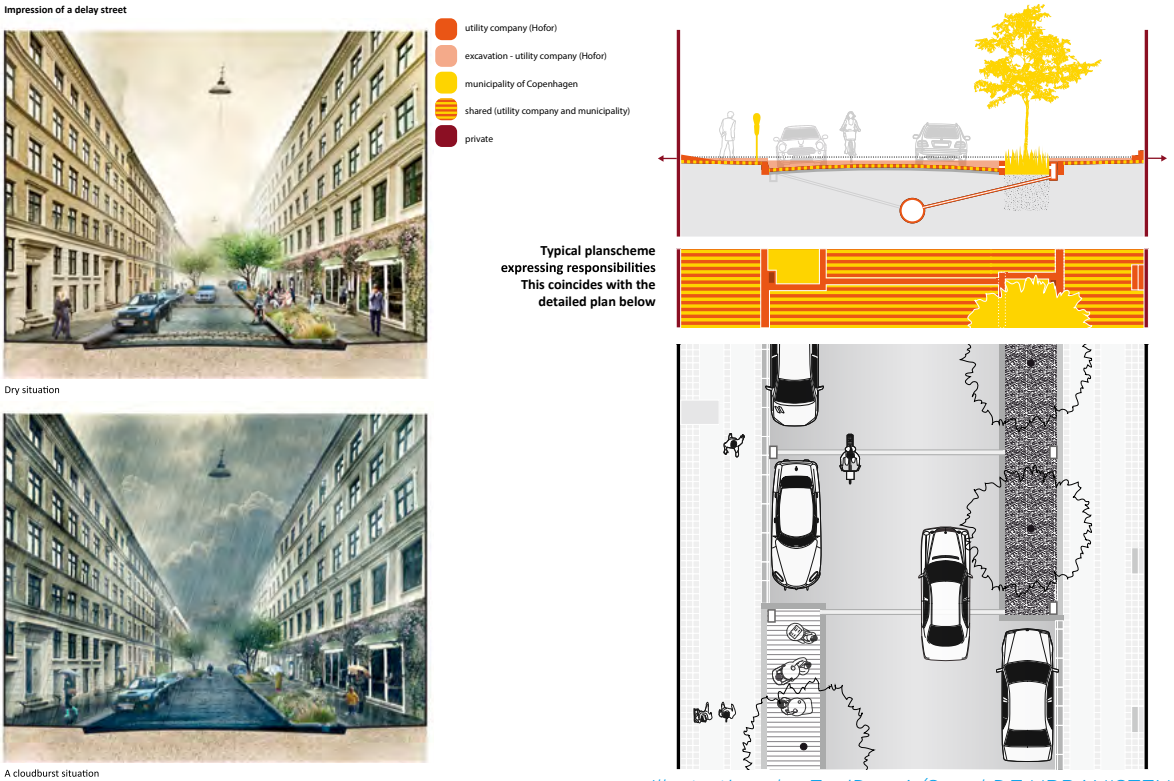


Illustrations by EnviDan A/S and DE URBANISTEN

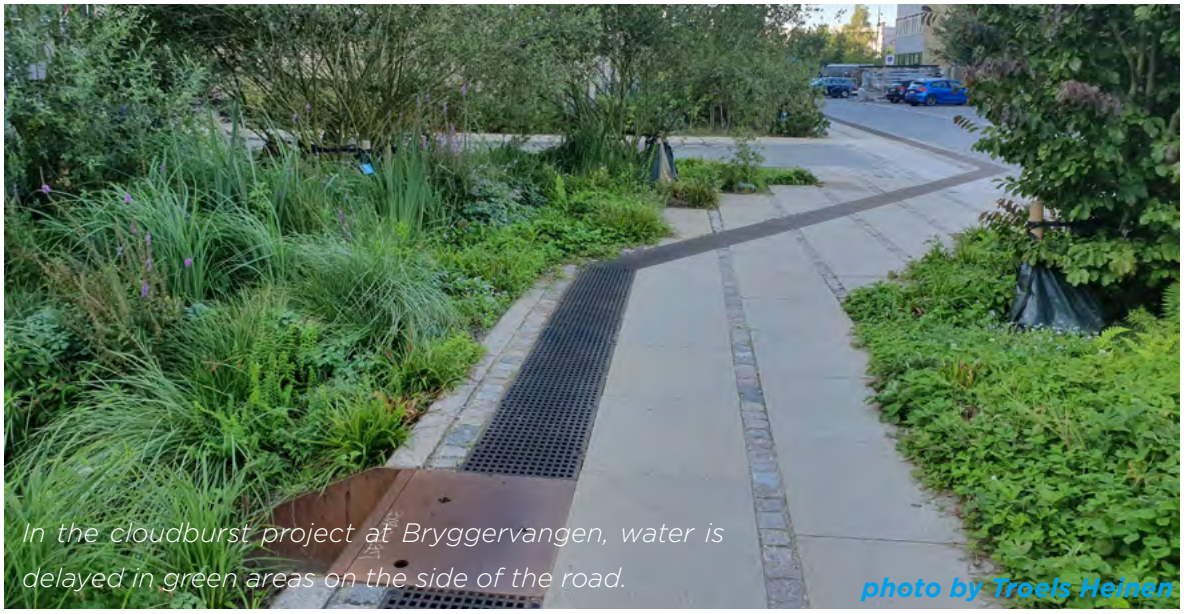
Example of cloudburst road at Bryggervangen.

3.2.2 Delay Path

The delay path is a designated place that has room for naturally to hold back rainwater from the sewage or final recipient. The design of the delay path controls and directs the water in a controlled way. Where it is possible the rainwater can also be percolated. Here you can see an example of a delay path and how the expenses between the municipality and the water supply are typically divided.



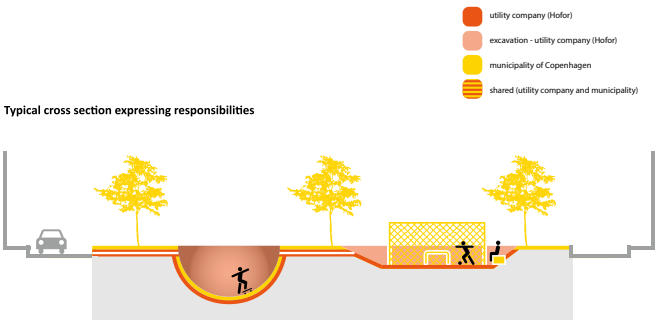
Illustrations by EnviDan A/S and DE URBANISTEN

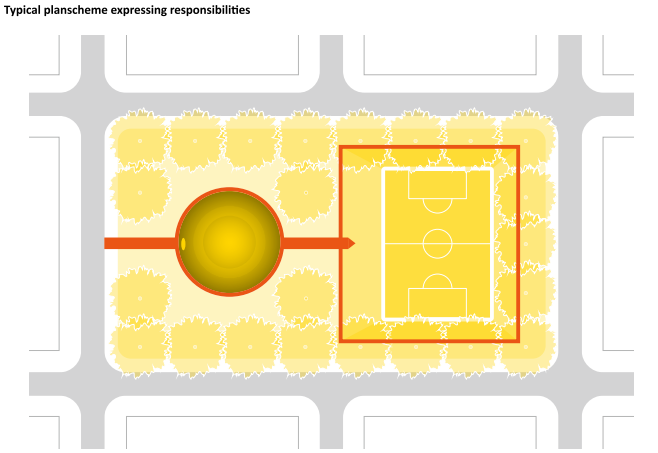


In the cloudburst project at Bryggervangen, water is delayed in green areas on the side of the road.

photo by Troels Heinen

3.2.3 Delay Square





Illustrations by EnviDan A/S and DE URBANISTEN

The delay square is a designated place where rainwater can be collected. Here the water can be hold back from the sewage or recipient for a shorter or longer periods of time. The design of the delay square is often a leveled pocket either in the landscape or in the public space, where water can be gathered. When there is room in the sewage or recipient the water can be led away from the delay square in a controlled way. It is important that the delay squares can handle big amounts of water, are easy to clean and maintain. Here you can see an example of a delay square and how the expenses between the municipality and the water supply are typically divided.

In this project at Scandiagade, eight delay squares have been built. The eight basins have a total capacity of 1500m^3.

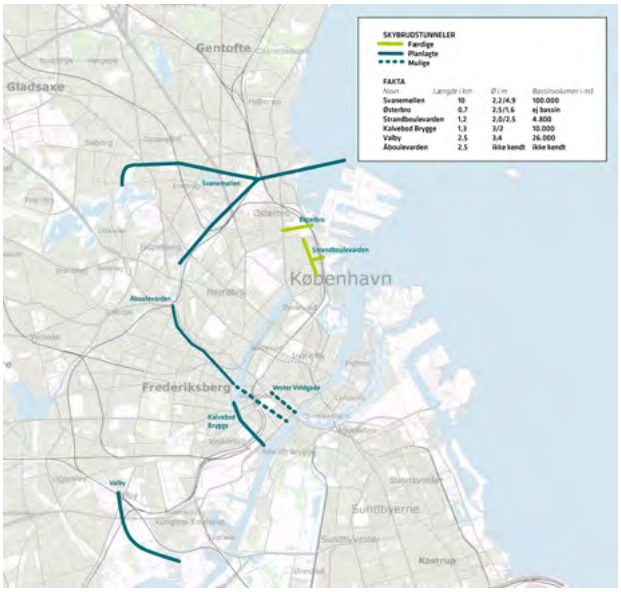
3.2.4 Green Roads

The green roads are a way to handle rainwater locally. Their function is to delay and detach the daily rain from the combined sewer. In case of cloudburst, their function is to delay water to avoid flooding. In most cases, green roads will create extra value in the shape of a green and blue urban space.

Green road

3.2.5 Pipes and Tunnels

Pipes and tunnels are the last of the five typologies. These are built and maintained by the utility company. Their function is to effectively transport large quantities of rainwater in case of a cloudburst. This typology does not add any extra value to the urban area, but is an vital part of the blue infrastructure in the city.



Map showing the cloudburst tunnels planned in Copenhagen

The cloudburst tunnel at Strandboulevarden being consructed

3.3 Implementations in Copenhagen

Through these five typologies it is possible to integrate climate adaptation in the existing structure of the city and here through contribute to a green and well-maintained city. It takes a careful understanding of the place and use and often also more money than what is only needed for handling the rainwater on the surface, but often still cheaper than expanding the existing sewage system of the city. The possibilities of meeting several political goals and local needs, through a close analysis of place and use, is available when handling water on the surface, but it is not self-fulfilling. It takes a broad perspective on the place and

project and includes thorough analysis, citizen involvement, a sustainability approach and high-quality advisers. This work can of cause be done on several levels, which is an important initial consideration to make and revisit through your project.

The new Enghaveparken after the renewal of the park in combination with the cloudburst project. **photo by Troels Heinen**

3.3.1 Description of the planning and implementation system in Copenhagen

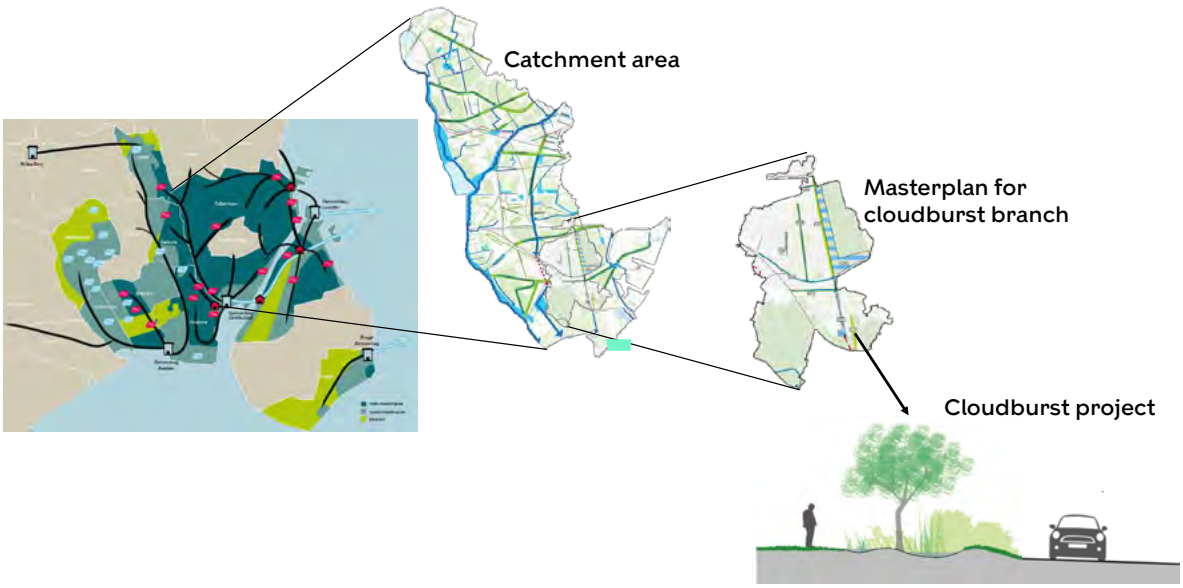
Climate adaptation in Copenhagen is based on its Climate Adaptation Plan and the Cloud Burst Plan, which shows the challenges that the city is facing now and in the future, and describes several solutions for rainwater handling. Based on the Cloud Burst plan, Copenhagen has been divided into seven larger water catchment areas, 60 smaller catchment areas, and finally 300 cloudburst projects. The plan has been politically approved by the local government back in 2015, and The Technical and Environmental Administration is responsible for implementing the plan within a 20-year timeframe.

Even though it is the responsibility of The Technical and Environmental Administration to implement the plan, cloudburst protection and climate adaptation in Copenhagen is done in very close cooperation between the municipal government and the utility company, HOFOR. The reason for this joint effort is that HOFOR is in charge of handling

stormwater, but now that a large part of the rainwater is handled on the surface, it is the responsibility of the municipal government as the solutions become a part of the urban spaces. Some of the 300 projects are pure Copenhagen Municipality projects, some are purely HOFOR and some are joint projects both on the surface and underground.

Masterplan

A masterplan is a screening and analysis of a specific smaller catchment area, including several cloudburst projects which are hydraulically connected. The masterplan also analyses urban space, city nature, regulatory requirements, conservation etc. Every couple of years, the masterplan has to be re-visited, so to make sure that it is up to date with the changes in the city.



Besides the 300 projects, HOFOR is responsible for constructing seven larger cloudburst pipes around the city, which can channel large amounts of water into the harbor.

The first couple of years has shown, that realizing the plan and its 300 projects is easier said than done. In 2018 Copenhagen Municipality therefor, together with HOFOR, initiated the work on 60 'masterplans'. Before a cloudburst project can be started it has to be part of a finish masterplan, to make sure that it fulfills its role in connection to the other cloudburst projects, traffic, urban development etc. in the area, as very few cloudburst projects can work on its own.

All in all, the implementation of the climate adaptation plan involves and requires many different actors to work together to succeed.

3.3.2 Experiences with citizen involvement

It is challenging to work with citizen involvement in climate adaptation projects, as in all other complex projects. The planning is done on many levels over many years from the strategic plan to building the concrete project. During this period of time the framework of the project can change a lot, which will influence the economics and scale of the project. The citizen involvement is robust if it takes this needed flexibility into consideration and focus more on values and local needs, without promising how the local needs can be met, before there is an overview of both the economy and framework for the project.

When this is said it is even more necessary to start early, and have an ongoing dialogue with stakeholders throughout the development and construction of the project. This dialogue is important because it is in these early phases that the framework of the projects is clarified. Here the local needs are just some out of many demands that must be met. The other demands are the political goals, the budget of the project, legal circumstances and the technical reviews and specialist proposals of the project. This is a fine cocktail to balance.

Another important aspect in citizen involvement is clear communication. The most common questions are: which topics can the involvement influence? Which are already political decided? How is our contribution taken care of? How can we see our influence in the final project?

These are all difficult questions to answer. What always should be explained is what can be influenced - use of the place, identity/atmosphere or target group and what is already decided politically or through an earlier dialogue. It is just as important to explain how the inputs are used from here on and when the stakeholders can expect to see a result/ next phase of the project/dialogue. The most important message to deliver is that the final design or solution will always be based on a professional assessment and in the end it will always be the politicians, who will be responsible for the final project and therefore often has the last word in how priorities are made.

3.3.3 Dialogue that led to participation

The climate adaptation project Skt. Jørgens Lake is at this moment still at a strategic level.

The Lakes of Copenhagen.

It concerns the iconic and protected lakes of Copenhagen. The lakes of Copenhagen are an important part of the structure and landscape of the city. They are connecting the south to the north through a recreational space and dividing the retail city from the surrounding city where more people live. At the time of the dialogue three on-surface-scenarios was presented, at site, through a week, to have a discussion with the users of the place what the pros and cons of the scenarios where. The dialogue was facilitated with posters, models. 3d experiences and eager professional from the municipality. This dialogue led to a debate about if other options where possible. Due to this debate a fourth below-ground-scenario was included in the ongoing development of the project.

Citizens involved in a workshop regarding the lakes in Copenhagen.

A new method using 3d glasses were used to visualize the concept of the project.

3.3.4 Participation

At Ranzausgade, not far from the lakes, but further away from the city center, another climate adaptation project is taking place. The project was initially started as a traffic safety project and then combined with the goals of the cloudburst plan when the funding and the concrete development of the project started. This project is placed within the area based renewal program of Nørrebro, which is a five year long program that through local participation works with strengthening both the social, cultural and physical aspects of the area. The climate adaptation program therefore had a local collaborator that had had a thorough dialogue with all users of the street -both the ones passing through, doing business and living there. Here the dialogue mostly concerned the future traffic structure and which use the street should initiate and thereby who it should attract. The climate adaption was here used as supporting the new and slower traffic structure and a more green public space, that was not only for cafes, but also attractive and accessible for people that didn't want to pay for sitting at a café. This vision was formulated through a close and long dialogue with the local users of the street through various methods from big scale tests of new design and traffic solutions to meetings and workshops.

These two examples show that the citizen involvement is a dynamic and diverse part of the project development. The most important part is, as municipality, to listen to the conclusions of the dialogue. It is not always possible to redirect the project, but it is always needed to take the involvement serious and give feedback and explanations to the engaged collaborators, when the project is further developed after a local dialogue.

4 Joint Projects between Beijing and Copenhagen

The climate adaptation area 'Green Valley' in Tongzhou, the sub-district in Beijing is one of the projects under Beijing-Copenhagen collaboration on Sustainable Urban Development. In October 2019, Danish delegations from the City of Copenhagen, Danish Embassy, HOFOR visited Tongzhou District in Beijing and discussed Green Valley Cooperation Project. The inspiration for Green Valley originates from experts from Beijing Municipal Institute of City Planning & Design, HOFOR and the Technical and Environmental Administration, City of Copenhagen.

The Implementation scheme of Sponge City, is located in Old South Road, Tongzhou District, in southeast of the office area in Beijing, which is in area for relocation Housing for Employee in Beijing MC (Beijing Municipal Administrative Center)

4.1 Project Area in Tongzhou, Beijing (Green Valley)

The project areas 10.66ha, which is trapezoidal. The green Valley Park in the middle divides the area into two groups, A-1 and A-2.

The project is on vacant land, with no available rainwater regulation and storage facilities. The type of groundwater in the project area are phreatic water and confined water. The phreatic water level is 5.80-10.90m, and the confined water level is 10.00-13.60m.

The natural dynamic types of phreatic water in the project area are infiltration-runoff and evaporation. And phreatic water is mainly supplied by rainfall infiltration and lateral runoff, and are discharged by lateral groundwater runoff and evaporation. The annual change of water level is generally less than 1-3m.

The natural dynamic type of confined water in the project area is infiltration-runoff. And confined water is mainly supplied by the lateral runoff and transfluence of groundwater, and are mainly discharged by the lateral runoff and artificial exploitation of groundwater. The natural terrain of the project area is basically flat.

The rainstorm in Tongzhou district mainly concentrates in July to August in the flood season, mostly from late July to early August, and the interannual variation of rainstorm is great. The occurrence time of flood is consistent with the time of rainstorm, and is often concentrated in July and August. The river system floods in the region mainly comes from the rainstorm and flood in the upstream of flood season and the waterlogging in the region, especially the heavy rainstorm and continuous rainstorm, which often causes the flood disaster in the region.

4.2 Design Objectives

According to the "Objective Specification of Sponge City Construction project in Tongzhou District of Beijing", the design objectives of the project are as follows: the annual runoff control rate is 85%, the annual SS control rate is 42.5%, the rainwater resource utilization rate is 5%, the sunken green space rate is 50%, and the permeable pavement rate is 70%.

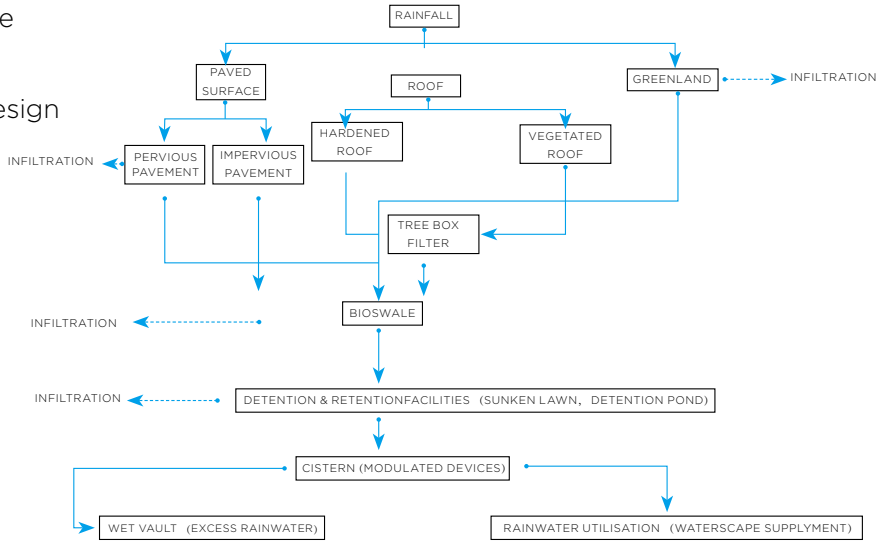
4.3 Design Principles

The basic design principles of sponge city include system control, governance coordination, protective development, adjust measures to local conditions, cost control and so on.

The residential area is the focus of source control, and comprehensive management of rainwater includes infiltration, stagnation, storage, purification, utilization and drainage. The detailed implementation measures cover roof rainwater to green space, green roof, permeable pavement, rainwater storage tank , grass ditch, etc., which can improve the rainwater storage and retention capacity of the residential area. It is recommended to use permeable pavement in non-motorized driveway, sidewalk, parking lot and yard light areas with permeable conditions rainwater and sewage diversion, control initial rain pollution and scientifically arrange stormwater regulation and storage facilities.

4.4 Engineering Design

- Technical Route
- Overview of Design



The project scheme design will be guided by sponge city, combined with Beijing climate conditions, suitable selection of runoff coefficient. And runoff pollution control storage facilities of efficiency significantly are designed in the project, which can be well integrated with the landscape. The technical measures suitable for this project include rainwater regulation and storage facilities, permeable pavement, vegetation grass ditch, interception type purification and overflow facilities, rainwater collection and reuse facilities, road attached rainwater retention and storage purification facilities, drainage pipe network and municipal regulation and storage system facilities, etc. During the selection and layout of technical facilities, the project preliminary set the layout scope of permeable pavement, vegetation grass ditch, seepage channel and diversion channel and scale of rainwater collection and recycling facilities. The roof greening is set according to the landscape design demands, the remaining storage volume is calculated according to the design target. Finally, the storage facilities, the scale of sunken green space, rainwater garden and so on are set to achieve the control goal of sponge city.

For the collection and utilization of rainwater, the rainwater falling on the roof first enters into the stilling basin through the rain pipe, and then flows into the front pond through the diversion channel. After the preliminary treatment, it flows through the gutter under the road surface to the sunken green space or rainwater garden. If rainwater falls on the road, the runoff can be purified and collected by means of permeable pavement, sunken green space and permeable pipe trench and other facilities. Rainwater exceeding the standard can be discharged into the rainwater pipe nearby. At the gutter inlet, sewage hanging basket, swirling flow and sediment facility can be set up to collect pollutants. Part of the treated rainwater can be seeped or discharged into rainwater pipes for indirect use, while the other part enters rainwater storage tank for regulation and storage. After filtration and disinfection, the rainwater can be distributed in a centralized way for green irrigation and road flushing.

4.5 Typical Facility Node Design

4.5.1 Sunken Green Space

Roof rainwater is transferred through the rain pipe and drained into the sunken green space. At the same time, the road adopts the form of flat curb. The road rainwater directly flows into the sunken green space for infiltration and filtration, and the rainwater in the sunken green space is discharged to the rainwater pipe through the infiltration outlet overflow.

Sunken Green Space

4.5.2 Rainwater Garden

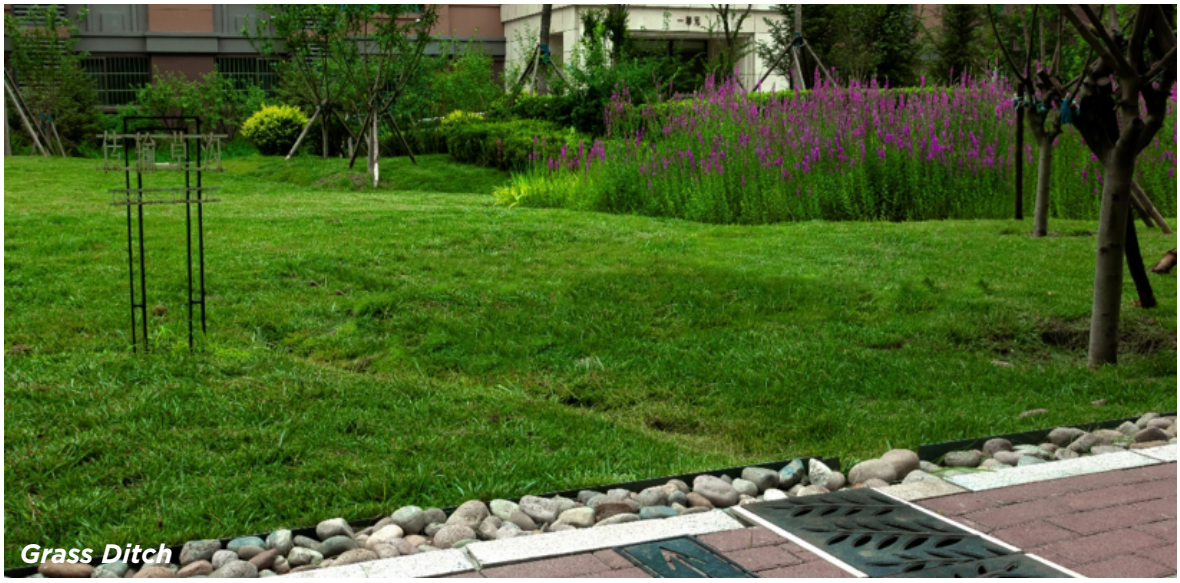
4.5.3 Permeable Pavement

In the project, permeable pavement mainly adopts three forms: permeable brick, permeable concrete and gravel. Rainwater in pedestrian areas can be directly infiltrated through permeable pavement, and excess rainwater will be discharged into the surrounding sunken green space.

Permeable Pavement

4.5.4 Grass Ditch

Grass ditch is set outside the pavement in the community to collect rainwater from the pedestrian areas. Grass ditches are set on both sides of the vehicular road to collect road surface rainwater and transfer the rainwater to the surrounding sunken green space or rainwater garden.



Grass Ditch

4.5.5 Crossing Ditches and Diversion Channels

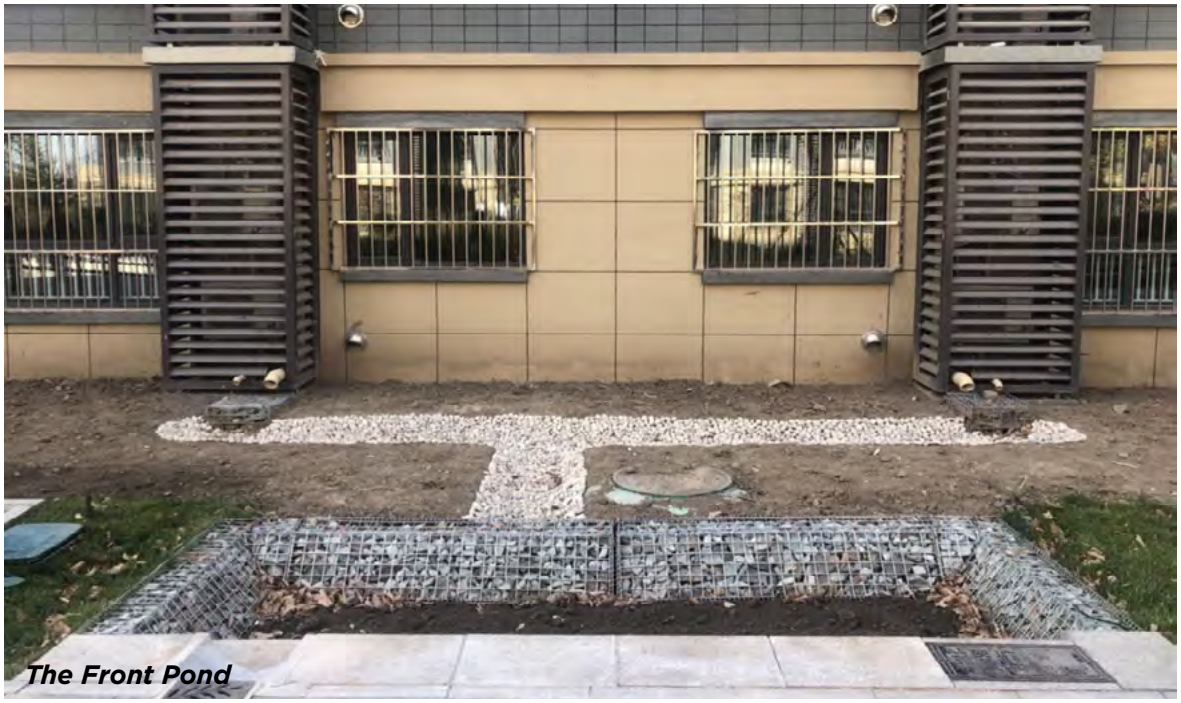
In this project, infiltration channels, crossing channels and diversion channels are set around the green space according to the transfer needs, in order to collect, transport and discharge runoff and rainwater and reduce runoff.

Crossing Ditches

Diversion Channels

4.5.6 The Front Pond

The pond is located near the raindrop pipe to collect the rainwater on the roof. After the rainwater is pretreated, the pond enters the sunken green space or rainwater garden through the gully.



The Front Pond

4.5.7 Rainwater Storage Tank

Rainwater storage tank is a collection, storage and utilization facility with rainwater storage function, and also has the function of reducing peak flow. In this project, a rainwater storage tank is built at the end of the rainwater pipe network, and the rainwater of the rainwater storage tank can be recycled and used for road flushing, green space irrigation, etc.

Rainwater Storage Tank

4.6 The Analysis of Sponge City Achievements

The technical measures for the sponge city design of this project include sunken green space, grass ditch, rainwater garden, front pond, permeable pavement and rainwater storage tank. After calculation, the annual total runoff control rate is 86%, the annual SS total removal rate is 55.2%, the rainwater resource utilization rate is 8.3%, the sinking green land rate is 50%, and the permeable pavement rate is 77%, all of which meet the target requirements of sponge city construction.

This project makes full use of the vertical conditions of the terrain, reasonably direct rainwater, increases the infiltration of rainwater through the storage and infiltration of plants and soil, reduces the pollution of rainwater, and establishes a rainwater reuse system, comprehensively realizing multiple benefits such as safety of drainage, groundwater conservation and rainwater resource utilization. In addition, the sponge city of this project has a rich variety of facilities, which are integrated into the landscape of the park, creating a beautiful ecological environment and improving the effect of the residential landscape of the community.

5 Outro

Climate adaptation is a global challenge that especially requires action in big cities to ensure human lives and values. The challenge is new to many cities and requires rapid development to keep pace with climate change. Although there is a big difference in the size of the cities, the vast majority of solutions are scalable and can be adapted to the special needs of the individual cities in relation to e.g. architecture and traditions.

The planning of urban drainage has to be future proof, taking the entire urban water cycle, demographic processes and climate change effects into account. Our cities must be able to adapt to different return periods of rainfall to prevent flood disasters, rationally use rainwater, and maintain a good hydrological and ecological environment i.e. combine discharge and harvesting.

The collaboration between Beijing and Copenhagen has shown that exchange of experience and dialogue is the way forward if we are to succeed in climate adapting the cities so that they are also attractive to live and invest in in the future.

Graphic Designer, Jian Shan

Photo Credit: The City of Copenhagen, Beijing Institute of City Planning and Design

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