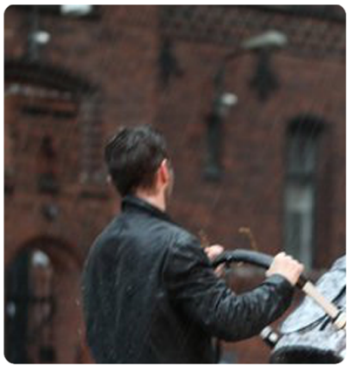
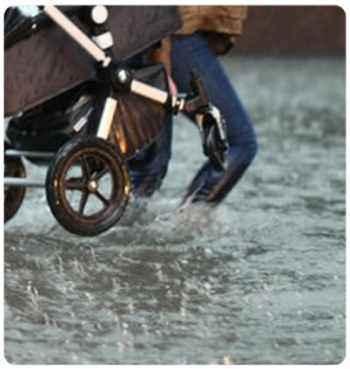


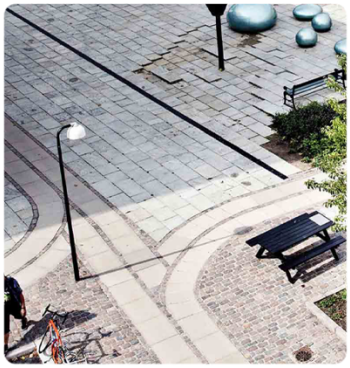
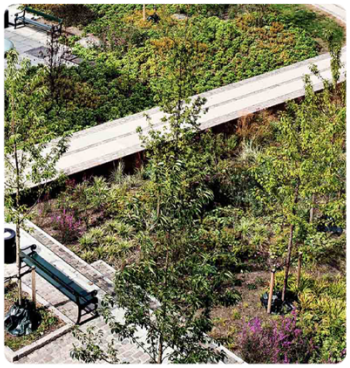
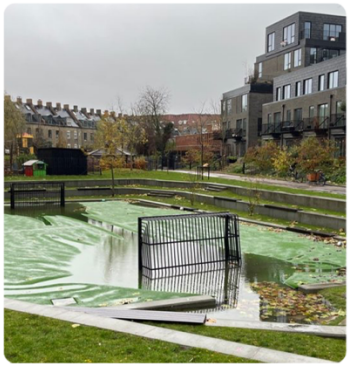
Cloudburst Management Plan

Co-financing with public budget, water tariffs, and private financing in Copenhagen

CLIMATEFIT International best practice factsheet

Case ID: 03



Thomas Machiels

University of Antwerp

CLIMATEFIT

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them.

Summary

Copenhagen was hit by a 1000-year storm (cloudburst) in 2011, creating a sense of urgency and momentum to prepare climate adaptation strategies. The Cloudburst Management Plan (CMP) was developed in 2012 as an offshoot of the city's Climate Adaptation Plan (2011). The CMP includes more than 300 projects, with more than half of them being surface blue-green infrastructure measures, and others being traditional underground grey infrastructure.

The financial model is an innovative co-financing strategy that shares the main financial responsibilities between the municipality and HOFOR, the utility company. A legal change at the national level was lobbied for by the City of Copenhagen to allow utility companies to co-fund multifunctional surface solutions from water tariffs (user fees). Additionally, private property owners are responsible for stormwater management investments on their own properties. The new legal framework allows this co-financing by the utility company under strict conditions:

- Alternative blue-green infrastructure must be proven more cost efficient than traditional (grey infrastructure) solutions.
- Funding from water tariffs can only be used for purposes directly related to the handling of wastewater (stormwater management measures, the drainage system).
- Utilities are not allowed to propose or carry out alternative water projects on their own. They can only provide funding, but the projects must be initiated, in this case, by the municipality.

Although the entire implementation of the plan has been challenged by recent national changes in service level requirements, the CMP has been successful in facilitating a transition from traditional grey infrastructure only to climate adaptation through nature-based solutions. The success is explained by the strong partnerships between various actors, a strong business case that quantifies the cost-efficiency of nature-based solutions and having a long-term reliable funding source with the water tariffs.

Keywords: Co-financing, water tariffs, water charges, Cloudburst Management Plan, Copenhagen

Actors interviewed: (I) Project manager Cloudburst Plan; (II) Copenhagen ambassador, working with other cities on cloudburst management; (III) Senior Researcher Aarhus University, 15 year experience with climate adaptation

Cover photos: Irish construction news (top photo); © GHB Landskabsarkitekter / Steven Achiam (middle photo); © Niels Nielsen from Carlsberg Byen P/S (bottom photo)

Further reading: Cloudburst Management Plan

Suggested citation: Machiels, T. (2024). *Cloudburst Management Plan. Co-financing with public budget, water tariffs, and private financing in Copenhagen*. University of Antwerp for CLIMATEFIT.

Best practice information card

Table 1. Copenhagen Cloudburst Management Plan. Information card

Location	Copenhagen, Denmark
Population size	653,664 (2023)
Project area size	179,8 km² (plan for the entire city)
Area type	Urban, flat and coastal terrain.
Climate challenge	Flooding from increased precipitation due to temperature rise.
Key Community System(s)	Water management, Critical infrastructure, nature-based solutions
Objectives	Make the City of Copenhagen resilient against 100-year storms, protect against flooding.
Climate challenge solution	The Cloudburst Management Plan's core principle of the CMP is to channel water above-ground to areas where it causes no damage and to reduce pressure on the underground sewage system. The plan includes more than 300 projects based on five solution types: Cloudburst boulevards, underground pipes, retention boulevards, central delays, and green roads.
Key benefits	Flood protection and reduced damage from floods, climate adaptation co-benefits (biodiversity, recreational value, improved microclimate), increase in property values and tax, job creation
Implementation status	Since 2011 (Climate Adaptation Plan) and 2012 (Cloudburst Management Pan). Implementation started in 2015 and is ongoing.
Investment volume (€)	€1.9 billion (2024 Euro, 2023 estimate)
Key financing barriers	Lack of public budget within the municipality. Legal framework did not allow utility companies to fund multifunctional surface projects (nature-based solutions)
Financial model	Co-financing with public budgets from taxation, water tariffs from the utility company, and private financing from landowners
Financial sources	Public: local municipalities, publicly owned utilities Private: property owners
Financial instruments	Fees/user charges: stormwater fees (Water tariffs) Public budget from general taxation Direct private investment from property owners Debt: concessional finance (loans with below market rate interests)

Overview and timeline

Copenhagen is the capital of Denmark and is located on flat and coastal terrain, with canals flowing through the old city centre that are connected to the sea. In 2011, the city suffered from a cloudburst equivalent to a 1000-year storm event, causing the city to flood in less than two hours and resulting in about €1.2 billion (2024 Euro) in damage. A 100-year storm already happened in 2010 and occurred again in 2014. 2023 was the wettest year ever recorded in Denmark. **Copenhagen faces increasing risks of flooding due to increased precipitation caused by climate change**. Because Copenhagen is a densely populated and built area, heavy rainfall events can cause costly damages, and **urban heat islands** will increase during long dry summer periods. Following IPCC climate change projections, the Danish Meteorological Institute projects that precipitation during the winter will increase by 25%-55%. While summers are expected to be characterised by longer periods of droughts, summer rainfall will be 30%-40% less. The current cost risk of doing nothing to address cloudburst impacts in Copenhagen is estimated to be €70.4 million (2024 Euro) annually and will rise to €187.41 million (2024 Euro) by 2100. The City Council decreed that the sewer system is required to handle a 10-year rainfall event, making the current sewer system incapable of handling heavier rainfalls that will occur more frequently in the future.

The dramatic 2011 cloudburst put flooding on the political agenda and led to a shared understanding among politicians and Copenhagen citizens that something needed to be done. By 2011, Copenhagen had finished its Climate Adaptation Plan; this was followed by the **Cloudburst Management Plan (CMP) in 2012** for the cities of Copenhagen and Frederiksberg. The CMP embodies a comprehensive restructuring of the drainage system by **combining underground grey infrastructure drainage tunnels with large-scale green-blue infrastructure surface projects, totalling more than 300 projects with a total estimated cost of €1.9 billion (2023 estimates, 2024 Euro) to be implemented over a period of 20 years**. The core principle of the CMP is to channel water above-ground to areas where it causes no damage. It includes measures to turn roads into rivers during heavy rainfall, and water is channelled to outlets and retention basins. This reduces pressure on the underground sewage system. Overall, the plan includes five types of solutions: Cloudburst boulevards to transport water, pipes for underground water transportation, retention boulevards to delay water, central delays for storing water, and green roads to transport and delay water on smaller roads.

The plan and its projects were the result of a rigorous six-step process that includes data collection and investigation, modelling and mapping, 'cost of inaction' analyses, design and qualify ("The Cloudburst Toolkit"), involvement and iteration (public participation), and Cloudburst economics (cost-benefit analysis). **Each year, the City Council decides which projects will be implemented that year**, with the expectation that around 15 projects will be carried out each year. The final list of around 300 adaptation actions and projects was completed and endorsed by the City Council in 2015, which marked the start of implementation until 2035. **The initiatives set out in the CMP will protect the city against extreme rainfall events of an intensity seen only once in a hundred years**. This level of protection is called the service level, which is the performance standard or capacity that a stormwater management system is designed to achieve. The service level can encompass various aspects such as the frequency and intensity of storm events the system can handle, the effectiveness in controlling flood risks, the quality of water discharged, and the overall reliability of the system.

An important **key barrier** had to be overcome in order to start the implementation of the CMP. The City of Copenhagen did not possess the capacity nor the financial resources to implement the Cloudburst Management Plan. The Plan would be implemented within a minimum timeframe of twenty years, each year requiring a selection and prioritisation of individual projects in line with the Copenhagen Climate Adaptation Plan. Even then, municipal resources would be insufficient. The municipality looked towards the water utility company for Greater Copenhagen, HOFOR, to co-finance projects from water tariffs. The barrier here was that **state regulation of the water sector in Denmark prohibited utilities from investing in multifunctional stormwater systems** because these included parts that were not directly related to water provision and treatment, and because the water utility does not own or manage above-ground assets. Simply put, above-ground investments were the responsibility of the municipality, while the water utility company is responsible for the sewer and water treatment systems that are below ground.

The city had to lobby state politicians to change the law. It took several rounds to convince politicians to change legislation, because the national government, specifically the Ministry of Finance, feared that the municipality wanted to change legislation to make the utilities pay for urban improvement and urban maintenance. When the law was eventually changed, it marked a significant transition from traditional grey infrastructure solutions to green infrastructure and nature-based solutions. The water utility is now allowed in Copenhagen to co-finance above-surface projects, but each project includes a strict distinction between project parts that are related to water provision and treatment, and those parts that are not (e.g., parts related to design and aesthetics). **Project delivery and maintenance costs that are related to water management can be financed by the utility company HOFOR from water tariffs. All other costs are carried by the municipality**. The legislation change applies to all Danish municipalities.

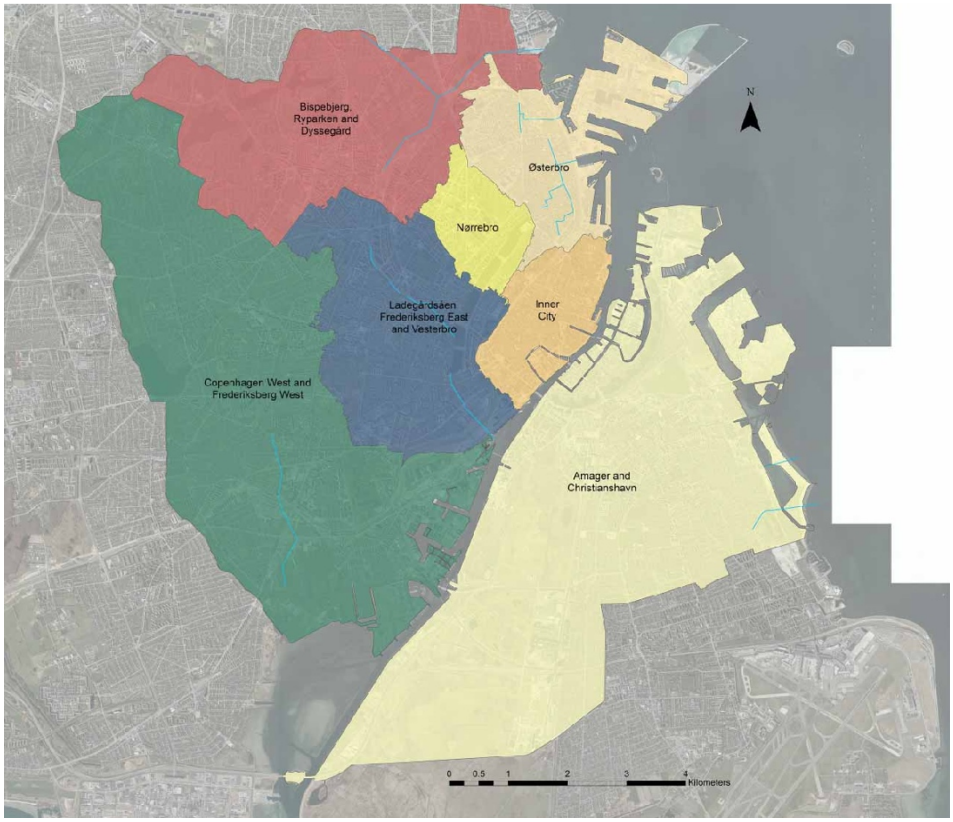


Figure 1. Copenhagen divided in seven hydrological catchments as used in the CMP.[1]

Table 2. Copenhagen Cloudburst Management Plan. Timeline with key moments

Date	Key moment
2011	The City Council approves the Copenhagen Climate Adaptation Plan.
2011	Copenhagen is hit by a cloudburst, a 1000-year storm. The city is flooded in less than two hours, causing $1 billion (US Dollars) of damage.
2012	The City Council approves the Copenhagen Cloudburst Management Plan.
2013-2014	A plan is made for each water catchment area of Copenhagen.
2015	Political decision to start the implementation of the CMP after a final list of more than 300 projects was decided and endorsed by the City Council.
2027	End of implementation under the current service level requirements. National changes require lower service level requirements, making it difficult to implement the CMP that has measures designed for higher service levels.
2035	Planned end date for implementation of the CMP.

Governance and key stakeholders

Figure 2 shows an overview of the **governance and organisational structure of the CMP**. At the top is the **steering committee** with representatives at the CEO and decision-maker level from the municipality and the utility company HOFOR. The steering committee makes main decisions about the programme. The **coordination group** is made up of the Technical and Environmental Administration's management level. The Technical and Environmental Administration is responsible for the city's environmental and climate activities, development of the traffic area, development of new urban areas, and other authoritative functions. The coordination group coordinates the activities of the Centre for Climate Adaptation, which is a municipal group that works in close partnership with HOFOR, the utility company. The **Centre for Climate Adaptation** is responsible for making master plans, preparing and implementing projects, and steering the financial resources from the municipality and the utility company. HOFOR is responsible for co-financing, hydraulic calculations, and traditional pipe construction. The **resource network** represents employees from other

[1] Ziersen, J., Clauson-Kaas, J., & Rasmussen, J. (2017). The role of Greater Copenhagen Utility in implementing the city's Cloudburst Management Plan. *Water Practice and Technology*, 12(2), 338-343.

municipal departments and administrations, to ensure that all relevant sectors are heard and represented in each project and master plan. Private consultants and companies – architects and engineers – are hired to implement the CMP projects.

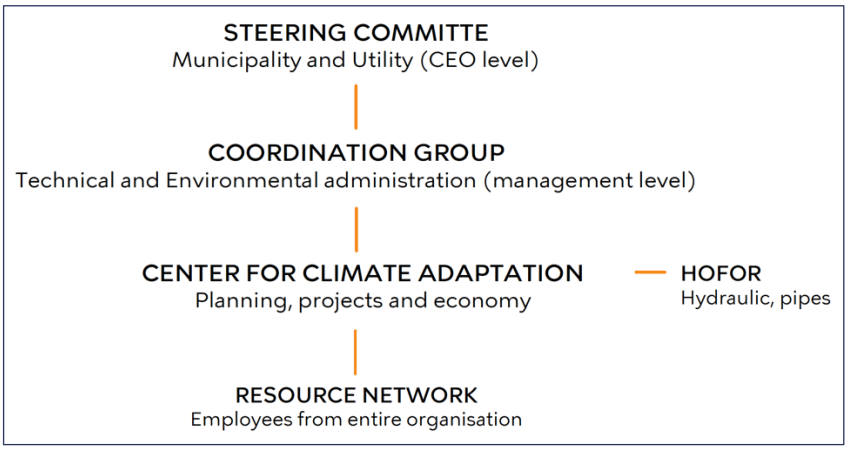


Figure 2. Organisational structure of the Copenhagen Cloudburst Management Plan[2]

Table 3. Copenhagen Cloudburst Management Plan. Key stakeholders and their responsibilities or roles

Stakeholder	Type	Role and responsibilities
City of Copenhagen	Public (municipality)	Lead agency of the CMP that developed the Climate Adaptation Plan and the CMP. Co-finances implementation. The Technical and Environmental Administration is the leading municipal department for this program. Other departments or administrations are involved in individual masterplans and projects if relevant.
HOFOR	Public (utility company)	The utility company is responsible for ensuring drainage systems meet adequate service levels. Shares responsibility for financing and implementing CMP projects. Specifically responsible for hydraulic calculation, sewage system, pipe construction, green roads, financing of rainwater handling
City of Frederiksberg	Public (municipality)	Municipality surrounded by the boundaries of Copenhagen. Co-coordinated the development of the CMP.
Private property owners	Private	Responsible for flood-proofing their properties on private soil. This might involve protecting basements by means of anti-flood backflow valves, ground level adjustments, raising the sides of light wells, basement entrances, etc. Such investments have been included and their costs estimated in the CMP

Business model & financial model

Business model

The CMP's **business model contains three core principles**. First, CMP is an expensive plan, but the future cost of damage is much higher than the investment cost of the CMP. The damage cost of the 2011 cloudburst alone was estimated to be 20%-35% more than the CMP's 2012 estimated cost. Protecting the city now will be less expensive in the long run than regenerating the city after a flood event. Second, the CMP implies a transition towards a mindset and belief in the cost efficiency of blue-green infrastructure combined with traditional grey infrastructure, compared to the traditional use of grey infrastructure only. The appraisal of each project contains a cost-benefit comparison between a blue-green infrastructure and a grey infrastructure solution. The most cost-efficient solution must be implemented, which is often a blue-green infrastructure alternative. The third principle follows from the second. Because blue-green infrastructure projects hold multiple purposes that are not the core task of only one actor, the City of Copenhagen and the utility company HOFOR

[2] City of Copenhagen. (2023). *Climate Adaptation in Copenhagen*. Presentation (received via personal communication; not publicly available).

share the financial responsibility of project delivery and maintenance through co-financing if their interests and responsibilities come together in a project.

The **cost estimate** of the CMP was updated in 2023 to reflect the increase in construction material prices for pipe constructions. **Current cost estimates of the CMP are €1.9 billion (2024 Euro)**. The most significant cost elements of the plan include the surface solutions (31% of the total cost) that are co-financed by the municipality and HOFOR, underground pipe constructions (41%) that are financed by HOFOR, and protection of homes and private properties (19%) that are paid for by property owners. **Cost savings** are expected if solutions can be integrated with other construction projects. Overall, the plan offers a more cost-effective solution to flooding because, in many instances, blue-green infrastructures are more cost-efficient than traditional grey infrastructure. For example, cost estimates of the Sjælør Boulevard project were €131 million for a traditional (grey infrastructure, underground) solution, and only €45 million for a surface solution.

The CMP has multiple values and benefits for the city and its inhabitants. The key value is **protection against future flooding** in the form of flood peak reduction, increased infiltration and water storage, reduction of run-off in general, and run-off to the sewer system. Blue-green infrastructure projects offer various **climate adaptation co-benefits**, including increased biodiversity and improved habitats, reduction of atmospheric pollution, more recreational space that encourages healthier lifestyles, aesthetic values and city attractiveness, rainwater recycling, reduced urban heat island effects, and increased quality and quantity of green and blue infrastructure. There are also multiple **socio-economic and financial values**:

- Property owners benefit from higher real estate and land values as the effect of the proximity of urban green areas like parks and public space improvements.
- Higher real estate values yield increased property taxes for the municipality.
- The construction phase of the CMP projects would create more than 13,000 full-time equivalent jobs, which would generate €270 million (2024 Euro) in tax revenues. The effect for the City of Copenhagen is difficult to calculate because tax revenues from employment accrue to the municipality in which the employee is resident. If the construction of facilities for urban space improvements is additionally included, the number of new full-time equivalents will rise to more than 15,000 and tax revenues to around €350 million (2024 Euro).
- Financial savings because of reduced flood damage.

In 2013, it was calculated that the overall benefits would be €860 million (2024 Euro) in comparison to a situation in which the city does nothing. When considering the cost savings from a combination of traditional grey infrastructure and blue-green infrastructure compared to grey infrastructure only, the total benefits rise to €1.55 billion (2024 Euro). It is unclear if and how avoided damage costs are included in these figures. The City of Copenhagen calculated in 2011 in its Climate Adaptation Plan that, **without climate adaptation measures, the damage cost of a 100-year rain event would be €1 billion (2024 Euro)**. The 2011 floods (1000-year storm) caused €1.2 billion (2024 Euro) in damage costs, which is not much higher than the calculations for a 100-year storm. It shows that adaptation is urgent and more cost-efficient, considering the increasing damage costs and the increased likelihood of extreme weather events. There is no available data about the 2010 and 2014 storms to further compare with.

The **key beneficiaries** of the benefits are the City of Copenhagen and HOFOR (utility company) due to more cost-effective solutions, private property owners, and the citizens due to improved flood protection.

Financial model

The CMP's financial model is based on **co-financing** with from public and private partners. Three **sources** or **instruments** are used, as explained in the CMP:

- **Funding from water tariffs** (58% of the total estimated cost). Most adaptive measures are funded by the utility company HOFOR from water charges.
- **Public financing and funding by taxes** by the municipality (10.5% of the total estimated cost). Adaptive measures carried out at ground level, and combined with green and recreational solutions, must be financed by municipal tax revenues if they exceed the limit imposed by financing via revenues from charges. This means that those parts of surface projects that the utility is not allowed to pay for from water charges must be co-financed by the municipality because these are not directly for flood protection or stormwater management.
- **Private financing from homeowners** (31.5% of the total estimated cost). They pay for flood protection measures; for example, installation of anti-flood backflow valves that block the drain if flood water is pressured back through the service pipe. We did not obtain information about the investment obligations for homeowners.

The plan relies heavily on funding from **water tariffs**, which required a change in legislation (water sector law) that allowed HOFOR to pay for surface measures other than traditional grey infrastructure, mostly underground stormwater infrastructure. It required significant effort to convince state politicians that this was not simply a way to shift financial burdens from the municipality to the utility company. The municipality

nonetheless pushed for this change in the law because it wanted to secure a long-term and reliable funding flow. The municipality succeeded, but conditions were introduced to ensure strict demarcations between the financial responsibilities of utility companies and the municipality.

- Alternative blue-green infrastructure must be proven more cost efficient than traditional (grey infrastructure) solutions.
- Funding from water tariffs can only be used for purposes directly related to the handling of wastewater (stormwater management measures, the drainage system).
- Utilities are not allowed to propose or carry out alternative water projects on their own. They can only provide funding, but the projects must be initiated, in this case, by the municipality.
- After 2015, utility companies are only allowed to co-finance no more than 75%. It is unclear how this affects the ratio set out in the CMP.

Figure 3 is illustrative of these conditions. The green dots on the image represent the elements of a project that HOFOR is allowed to fund because these are stormwater management measures for the city's drainage system and handling wastewater. The purple dots represent project design elements that are not HOFOR's core task, such as tree and green plantings that also serve an aesthetic or public space improvement purpose. These must be paid for by the municipality. These demarcations apply to project delivery and maintenance. As a result, **Figure 3 exemplifies how projects are co-financed by the municipality through taxes and by HOFOR through water charges**.

Figure 3. Co-financing climate adaptation solutions (green dots, HOFOR) and urban space improvements (municipality)[3]

Every project of the CMP has the same **financing and funding structure**. Each year, several projects are selected to be initiated. To finance the projects, the municipality obtains a loan from Kommunekredit, a Danish special-purpose credit institution that provides funding for local growth and green transition in municipalities and regions across Denmark. By pooling the credit demands of municipalities and regions, Kommunekredit can obtain financing on favourable terms in the financial markets, which, in turn, allows it to offer loans at attractive rates to its members, a form of **concessional finance**. The project parts that can be funded by the utility company are then repaid by HOFOR from water tariffs. It is unclear whether project parts funded from municipal tax are also initially financed from a Kommunekredit loan.

The financial model led to an increase in household water tariffs since 2014. From that year onwards, the water tariff is decided annually based on the projects that will start that year. The municipality controls the water tariffs. All project and adaptive measure costs that HOFOR wants to incur on the water tariffs must be approved by the national level. It has been estimated that the water charge of an average household consuming 110 cubic metres of water annually would increase by an average of around €150 (2024 Euro) per year.

Enabling conditions

Different **resources** and expertise were required to gain political and citizen support for the plan, and to secure financing and funding through co-financing. First, **climate modelling** was needed to determine future rainfall intensities and the risk of damage from cloudbursts over the next 100 years. Second, **cost-benefit analyses** were performed to compare the cost efficiency of blue-green infrastructure solutions with traditional grey infrastructure (underground) solutions. This rigorous process required significant resources from the municipality (time, staff, money), but it was necessary to present a business case that proved the cost-efficiency of the CMP compared to traditional solutions and the cost of inaction. The results from this study, in

[3] City of Copenhagen. (2023). *Climate Adaptation in Copenhagen*. Presentation (received via personal communication; not publicly available).

combination with the 2011 cloudburst, created momentum and secured the third important condition: **political buy-in** to change legislation and approve the plan. The business case was convincing because it proved that HOFOR could meet its responsibilities as a utility company at a lower cost, while multifunctional surface projects help the city to offer its growing population more green spaces. Finally, the approval of the CMP required a new way of thinking from all actors involved, including state politicians influenced by local politicians lobbying for legal changes.

An important **legal condition** to implement, finance, and fund the CMP was the legislative change of the water sector law that allows utility companies in Danish municipalities to co-finance surface stormwater management measures for drainage systems from water tariffs. The details and conditions were explained in the previous section ('Financial model').

Outcomes

The CMP included 254 surface projects, 127 pipe projects, and 7 tunnel projects. **As of 2023, 19 (7%) surface projects, 8 (6%) pipe projects, and 3 (43%) large tunnel projects have been completed. 63 (25%) surface projects, 17 (13%) pipe projects, and 4 (57%) tunnel projects have started**. Recently, the national government launched new guidelines to calculate the service level for flood protection programs. These guidelines will apply from 2027 onwards. After 2027, municipalities are only allowed to design and implement projects that meet the new service level calculation guidelines. These are lower than the service level for which the CMP projects are designed. The details of the new calculation method could not be obtained. The cause of this change imposed by the national government was higher construction prices in recent years, leading them to require lower service levels from municipalities than the higher service level envisioned in the CMP. This means that initiatives of the CMP, designed to protect against 100-year storm events (service level), are only allowed to be implemented until 2027. The City of Copenhagen will try to implement as many projects as possible by 2027. The CMP is a comprehensive plan for the entire city, which means that not all areas will have an equally high service level by 2027 if not all projects are implemented. It remains to be seen how this will evolve.

Information could not be obtained about how much has been invested so far.

Some of the implemented surface projects have already proven their **effectiveness**. Recent heavy rainfalls filled a pond in one of the new parks, preventing the surrounding areas from flooding. The municipality is currently developing a monitoring system to monitor how measures perform during cloudbursts.

Although the municipality has not done studies to measure **broader impacts**, some of the first blue-green surface solutions seem to generate increased local and recreational activity around green areas. Other assumed impacts are increased biodiversity, improved microclimates, and in general a more attractive city.

Lessons learned

Successes and limitations

Despite the CMP not being entirely implemented due to unforeseen national changes in service level requirements, it has been successful in causing a shift in the way climate adaptation and stormwater management are approached. According to the interviewees and 'use', an online platform dedicated to promoting sustainable urban development, a key **success factor** is the **many partnerships** that have been established to develop and implement the CMP. Firstly, there is the main partnership between the City of Copenhagen and HOFOR, the utility company. Secondly, the municipality has engaged the local community from the start in the planning and development of individual projects. Community and citizen engagement is important to receive broad support for projects. By presenting the CMP under a banner of 'improved city green space', it stimulated enthusiasm and acceptance among the public. Within the municipality, there is successful horizontal integration of all relevant departments and administrations. Finally, much of the work is also done with input from private party consultants, architects, and engineers.

We can further interpret two other success factors from the enabling conditions. A second success factor has been the **ability to quantify both environmental and socio-economic benefits** following a rigorous analysis using climate change projections, which was important to receive political and public support. Finally, the success also lies in the **financial creativity and the legislative change** that allows for co-financing multifunctional nature-based solutions and blue-green infrastructure projects by multiple public entities, with, most importantly, the water tariffs as a **long-term and reliable financing mechanism**. This is something that public authorities still struggle with in most places because of siloed administrations and financial responsibilities. This case is an example of how, if supported through legislation, the responsibilities of a utility company could be met in a more cost-effective way while channelling funding to nature-based solutions with multiple co-benefits instead of only traditional grey infrastructure solutions.

One **main limitation** of the model in this given context, aside from recent national changes in service level requirements that currently inhibit full implementation of the plan beyond 2027, is that the project **cost-benefit analyses are not allowed to consider other benefits than purely economic ones** based on flood cost and damage. This limitation was stated by the interviewees. Benefits of surface projects such as reducing greenhouse gas emissions, biodiversity, societal impact, recreational value, etc., are not allowed to be included in the cost-effective comparison of alternative and traditional solutions. This is a consequence of the difficult negotiation between the municipality and the state, leading to strict demarcations between the financial responsibilities of utility companies and the municipality.

Jensen et al. (2016, p. 246) attribute this tension to **different priorities between the state and local level**: "National regulators believed that cost efficiency should be pursued by managing wastewater as a discrete infrastructure, independent of the broader processes of urban development and renewal. Whereas urban reconfiguration activities were concerned with developing green liveable cities through place-specific integration of water into the urban fabric, national governance addressed water as an individual consumer good that should be provided in the cheapest possible way." This tension about infrastructure (purple dots, figure 3) versus design (green dots, figure 3) can also lead to difficult negotiations in certain projects between the municipality and the water utility, despite the good partnership. In 2017, Turbudy (2021, p.267) interviewed 23 key stakeholders involved in stormwater management and design in Copenhagen. Most interview respondents, including those most closely involved in the co-financing mechanism, pointed out the **complex and "difficult nature of negotiations (between the local authority and the water utility) over what constitutes necessary infrastructure and what is (urban) design** and the lack of consistency on this point between different projects."

In theory, it could be that a surface solution is overall better than a traditional solution when considering broader societal benefits, but it cannot be selected if it is less cost-effective in economic terms. This may also reflect the **general difficulty of quantifying and valuing wider benefits of nature-based solutions** that could strengthen the business case. Inclusion of such benefits would be possible if more flexible economic costing and appraisal methods were used.

The interviewees furthermore stated that the strict conditions regarding the use of water tariffs also lead to a lot of **bureaucracy and a high administrative workload**. This may explain why, although the water sector law change applies to all municipalities in Denmark, no other Danish municipality is halfway as advanced in planning as Copenhagen because they lack resources (staff, time, money).

Transferability conditions and potential

The co-financing model of the CMP is general and holds the potential to be applied in many other territories and on different scales. The challenge or complexity in transferring this model to other territories lies not in the financial model itself but rather in the legal conditions that must be met considering the dominance of siloed financial responsibilities in public administrations. The use of water charges levied by utility companies holds great potential to be used for nature-based solutions to replace or supplement grey infrastructure, but a **supportive legislative framework** may be needed. It seems from this case that pushing for legal changes requires a lot of effort and convincing of politicians because it is not just a legal change but also a **change in the way of thinking**. At the same time, politicians acting as champions can be important to lobby for changes on a local or higher government level. Grey infrastructure remains the mainstream solution to tackle flooding, while nature-based solutions remain underused but could be more cost-effective and have multiple co-benefits for communities.

Another important condition to develop a plan through co-financing like the CMP is having enough **resources (staff, time, money)** within the public administration. This is exemplified by the fact that Copenhagen, the Danish capital and city with the highest capacity and resources, is to date the only Danish municipality that benefited from the water sector law change. Frederiksberg (105,000), a medium-sized city, was involved, but this was because of geographical reasons. Frederiksberg is surrounded by Copenhagen, and not involving Frederiksberg would create a hole in the hydrological catchment areas.

Related factsheets

Other cases in which water tariffs or water fees are partly used to finance or fund green blue infrastructure or similar projects include the Clean Water Partnership (ID 02), the Flood Buyouts program (ID 10), and the Viveracqua Hydrobond (ID 16). The use of water tariffs for public infrastructure financing and funding generally has a longer tradition in the United States, for example, under the federal Clean Water Act.

References

Brears, R. C. (2022). *Financing Nature-Based Solutions: Exploring Public, Private, and Blended Finance Models and Case Studies*. Palgrave Macmillan.

C40 Cities. (2016). *C40 Good Practice Guides: Copenhagen - Cloudburst Management Plan*. C40 Cities. Last consulted on 11 March 2024. URL

Climate-ADAPT. (2024). *The economics of managing heavy rains and stormwater in Copenhagen – The Cloudburst Management Plan*. Climate-ADAPT. Last consulted on 11 March 2024. URL

Interlace Hub. (2023). *Cloudburst Management Plan – Copenhagen*. Interlace Hub. Last consulted on 11 March 2024. URL

Jensen, J. S., Fratini, C. F., & Cashmore, M. A. (2016). Socio-technical Systems as Place-specific Matters of Concern: The Role of Urban Governance in the Transition of the Wastewater System in Denmark. *Journal of Environmental Policy and Planning*, 18(2), 234-252.

Tubridy, F. (2021). Co-financing green resilient infrastructures in Copenhagen: integrated or superficial design? Landscape Research, 46(2), 261-272.

Whittaker, S., & Jespersen, K. (2022). Stretching or conforming? Financing urban climate change adaptation in Copenhagen. *Buildings and Cities*, 3(1), 974–999.

They City of Copenhagen. (2012). *Cloudburst Management Plan*. The City of Copenhagen. PDF

The City of Copenhagen. (2023). Climate Adaptation in Copenhagen. Presentation (received via personal communication; not publicly available).

Use. (nd). *Climate adaptation and environmental improvements through nature-based solutions*. Use. Last consulted on 11 March 2024. URL

Ziersen, J., Clauson-Kaas, J., & Rasmussen, J. (2017). The role of Greater Copenhagen Utility in implementing the city's Cloudburst Management Plan. *Water Practice and Technology*, 12(2), 338-343.