The Sustainable Urban Water Management Transition: Case study of Gladsaxe Municipality.

Title Page

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Student Report

I. Acknowledgements

This thesis is the culmination of my two-year Sustainable Cities Master's degree at Aalborg University. This is the first time I worked alone on any project. There were obstacles along the way, but the conclusion demonstrated that the effort was worthwhile. So, I am thankful.

I would like to thank my thesis advisor, Birgitte Hoffman, for her consistent aid and encouragement during the whole process. In this sense, her supervision was invaluable since her suggestions and recommendations about this project kept me focused on the objectives.

Also, I would like to express my gratitude to my family and friends, whose constant encouragement and moral support always proved helpful.

II. Abstract

There are serious implications associated with human-inflicted climate change, which is defining the current era. Changes in weather patterns that impede food production, increasing sea levels, and excessive precipitation that may lead to catastrophic flooding are just a few of the repercussions of climate change. The scope of the issue expands dramatically when climate change, urbanization, and a growing population are considered altogether, and the repercussions may be catastrophic. Unless immediate and dramatic action is taken now, it will be more difficult and more expensive to deal with these consequences in the future. With a focus on water management and climate adaptation characteristics, this project analyses the history of Gladsaxe Municipality in order to assess the development of urban water management systems. This project discovers that the municipality exhibits the majority of the characteristics of a Water Cycle City as defined in the Urban Water Management Framework by Brown et al. (2009). This research also incorporates the multi-level perspective by Geels (2002), which makes it possible to conclude that the old state of water management permitted the shift to SUWM due to changing climate. The final stage of this project involves a discussion on how the lessons learned from Gladsaxe Municipality can be applied to similar projects so that we can depart from the traditional trajectories that we have followed in the past.

III. Table of Content

IV. List of Tables

IV. List of Figures

VI. Glossary

GAA	Gladsaxe Almennyttige Andelsboligforening
GHG	Greenhouse gas
IPCC	Intergovernmental Panel on Climate Change
SDGs	Sustainable Development Goals
SuDS	Sustainable Drainage Systems
SUDS	Sustainable Urban Drainage Systems
SUWM	Sustainable Urban Water Management
LAR	Local area drainage and recycling
UN	United Nations
UWMT	Urban Water Management Transition
WSC	Water Sensitive City
WSUD	Water Sensitive Urban Design
WWTP	Wastewater Treatment Plant

1 Introduction:

It is anticipated that as a consequence of increased urbanization on a global scale, cities would become more alert in the fight against climate change. UN-Habitat reports that cities consume more than 78 percent of all global energy and produce more than 60 percent of greenhouse gases (United Nations, n.d.). This situation is expected to aggravate in the future since urban areas are disproportionately responsible for climate change and account for less than 2 percent of the planet's surface (United Nations, n.d.). According to "World Urbanization Prospects 2018: Highlights" 68% of the world's population will live in urban areas by 2030 (United Nations, et al., 2019, p. 1). Cities are major contributor to climate change as well as they are also in the list of victims. Due to these impacts, such as rising sea levels and severe weather, metropolitan areas are directly threatened by climate change impacts such as cloudbursts, flash floods, drought, etc.

While water is of the utmost importance to life on earth, it is often overused and depleted as a valuable and irreplaceable resource (Purushottam, 2021). The three most significant factors influencing water cycle frequency are water availability, use trends, and urbanization.
The management of water, including both its sources and infrastructure for storage, distribution, and treatment (Purushottam, 2021). To cope up with the current climate change situation cities need to rethink their water management and the solutions needs to be sustainable as well. Sustainable Urban Water Management (SUWM) is being pursued by many cities around the globe as a way to become climate-conscious by integrating water management with climate change adaptation measures. But achieving sustainability within water management sector is not an easy task, as the concept of sustainability is complex. As the name implies, sustainable development is a type of development that allows us to meet the needs of the present without compromising the capacity of future generations to meet their own needs in the future (Sustainable Development Commission , n.d.). For the water management sector to grow in a sustainable manner, it is necessary to make efficient use of available resources, to invest prudently, and to advance technologically. Additionally, this whole procedure requires several adjustments to regular practices.

It is necessary to know how much and what kind of water is available in order to address water scarcity in cities. This is since cities are expanding, which increases the demand on water supply (State of Green, n.d.). Additionally, it is essential to keep in mind that as the population increases, so does the volume of wastewater that wastewater treatment facilities must process. Wastewater collection and treatment systems are essential to the growth of a city's population because they facilitate water-related activities, which increases cities liveability (State of Green, n.d.).

There are many available solutions (SuDS, SUDS, NBS) that can help cities to help develop SUWM to be resilient and safe from present and future climate change by ensuring the harmony between environment and living beings. As well as researchers also created many frameworks for the establishment and examination of the SUWM. Sustainable Development Goals by UN, Urban Water Management Transition (UWMT) are two examples of widely used frameworks for the transition towards SUWM. In this thesis UWMT was utilized to examine the Gladsaxe Municipality of Denmark to understand the different phases of transition inside SUWM.

Research conducted in this study will provide a viewpoint that can serve as an understanding of actors' activity in domains involved in sustainable transitions of water management. The following chapters describe the research issue to be addressed in this research and the methodology used to collect data.

2 Climate change consequences on Urban Water Cycle:

The following sections will describe relation between hydrologic cycle, urbanization, population growth with the changing climate.

2.1.1 Environmental Effects Due to Climate Change

It is common knowledge that climate change is a long-term change in temperatures and weather patterns that may result from natural causes, such as variations in the solar cycle. However, since the 1800's human activities have been responsible for climate change, primarily by burning fossil fuels, such as coal, oil, and gas. Due to the greenhouse gas emissions not only the precipitation pattern is interrupted, but also the temperature and sea level is rising, but also the number of extreme weather events like floods, cloudbursts, storms, cyclones, droughts are rising at alarming level (United Nations, n.d.). It is well known that international organizations and governments are trying to mitigate and adapt to climate change with adaptation and mitigation measures, yet the effects are already appearing (Talley, 2019).

2.1.2 How Climate Change, Hydrologic Cycle, Urbanization and Population Growth is affecting each other?

The water in the hydrosphere is constantly in motion between the ocean, the atmosphere, and the continents, and the process that describes its movement is called the hydrological cycle. Part of the infiltrated water is evaporated into the atmosphere directly from the upper part of the ground. The part of the infiltrated water which is not returned to the atmosphere seeks its way through the ground and ends up emptying into the underground water reservoirs, and part returns to the waterways which eventually flow into the oceans (Lindh, 1972). Figure 1 represnts different stages of hydrologic cycle. The hydrologic cycle is the basis of life on planet earth, and it is also intricately connected to the Carbon Cycle and the Nitrogen cycle which pretty much forms the environment around us.

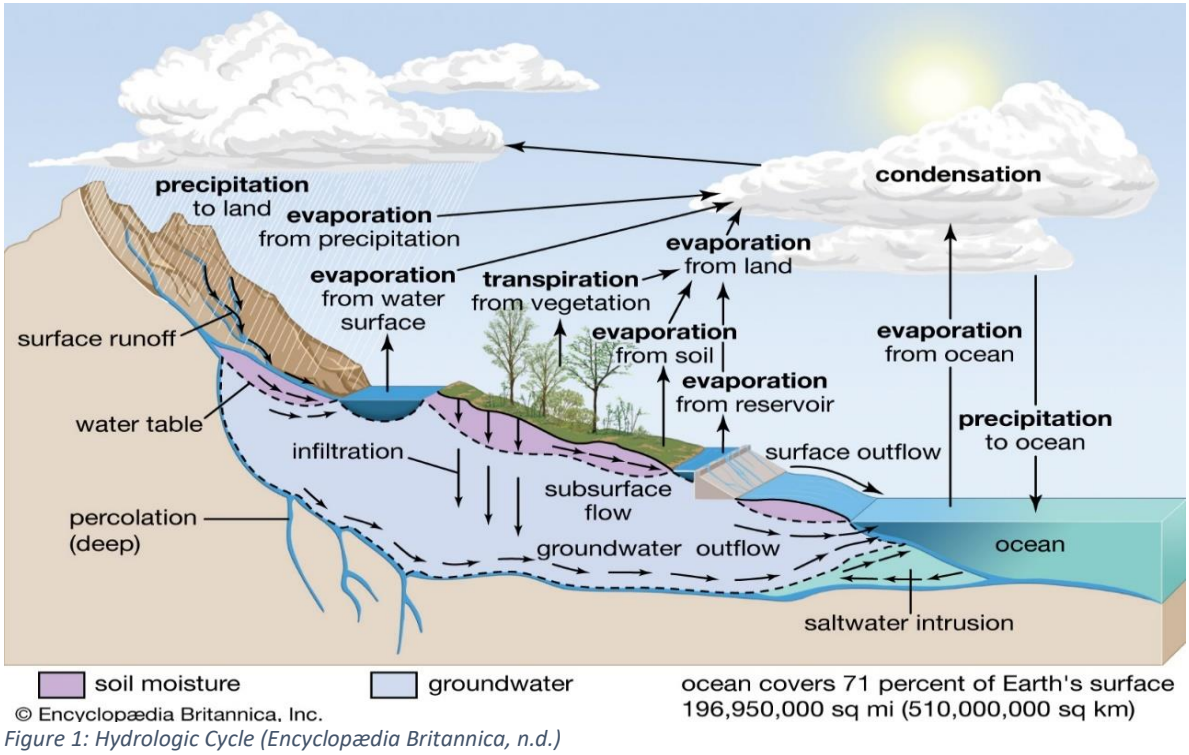

Figure 1: Hydrologic Cycle (Encyclopædia Britannica, n.d.)

Urbanization is the process of transforming once rural regions into urban communities and redistributing a population from rural to urban areas. It entails alterations in dominating vocations, lifestyle, culture, and behaviour, and modifies the demographic and social structure of both urban and rural regions. Urbanization increases the number, size, and land area of urban settlements and the number and percentage of urban inhabitants relative to rural dwellers. (United Nations, 2019, p. 10).

The world's urban population nearly quadrupled between 1950 and 2018, from 0.8 to 4.2 billion people. In this period, the average yearly change in the urban population was 2.54 percent, more than 50 percent higher than that of the world population (1.62 percent). As a result, global urbanization accelerated between 1950 and 2018, to the point where urban dwellers grew from 30 to 55 percent. The urban population reached its first billion in 1959, then reached its second billion in 1985, three billion in 2002, and four billion in 2015. Global urban populations are projected to reach 5 billion by 2028 and 6 billion by 2041 due to continued growth in urban areas. (United Nations, 2019, pp. 9-10) . Figure 2 represents the Urban populations worldwide, developed, and developing regions.

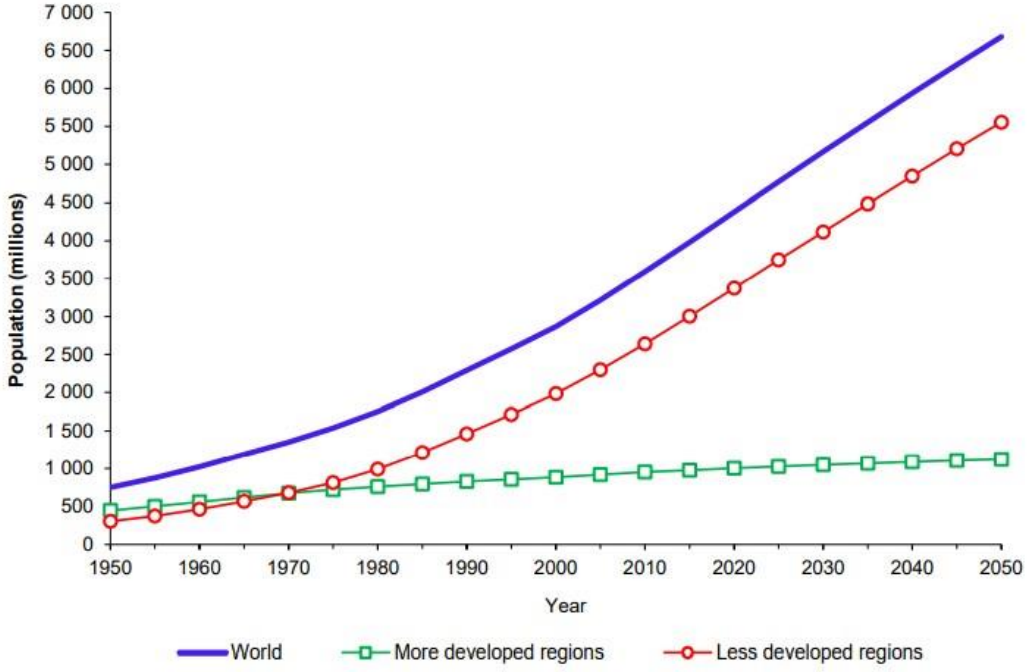

Figure 2: Urban populations worldwide, developed, and developing regions, 1950-2050 (United Nations, 2019, p. 13).

There are several problems associated with urbanization from a hydrologic perspective. For example, the increased demand for water for municipal, industrial, and recreational purposes, changes in the physical environment that alter the natural water balance, and the disposal of waste that may contaminate streams and underground aquifers, etc (Lindh, 1972).

Climate change has enormous effects on all elements of our planet's environment, including the hydrologic cycle. A variety of things have been directly affected by the continuous increase in global temperatures at the quickest pace in millions of years due to climate change. Water vapor concentration depends on multiple significant factors directly connected with the hydrologic cycle, such as precipitation patterns, clouds, streamflow patterns, etc. and each has a substantial influence on the water cycle. Increasing global temperatures cause a rise in water evaporation into the atmosphere, which intensifies the cycle of rain and snowstorms. In

addition to a larger water vapor concentration, warmer air may cause more violent rainstorms, which can cause serious flooding in coastal regions (The Climate Reality Project, 2016).

Climate change poses a distinct threat to cities. High temperatures, sea-level rise, and extreme weather events are all increasingly noticeable in urban areas due to their construction on concrete, having no capacity to absorb either solar radiation or rain, thereby making the effects of heatwaves and flooding more acute (Lombraña & Dodge, 2021). As a result of these changes all the living beings, and our ecosystem faces a dangerous threat in terms of freshwater availability and water management.

2.1.3 Climate Change in Denmark

The impact that climate change is already posing in Denmark will be discussed in this section.

As global warming is underway, the rise in temperature closely follows the development of the global average temperature in Denmark. From the mid-20th century, the temperature increased by 1.5º C, and according to the climate models it is expected to continue increasing towards 2100 (Olesen, 2022). There is no doubt that the annual precipitation in Denmark is increasing, which is an indicator of climate change. It is expected that Denmark's weather will become more extreme over the coming decades with wetter winters and heavier showers during the summer, which may result in flooding. In 1870, precipitation amounted to only 650 millimetres, but today it is 750 millimetres, an increase of nearly 15 percent (Olesen, 2020).In general, the primary cause of the rise in water levels is the increase in global temperatures, which is causing oceans to expand and glaciers to melt in places such as Greenland, Antarctica, and other parts of the planet. Since 1900, the sea level around Denmark has risen approximately 2 millimetres per year. This trend is upward and will very likely continue around Denmark and around the globe (Olesen , 2021).

2.1.4 Climate Change Adaptation in Denmark

This section shades light on Denmark's climate change adaptation measures over the years. Denmark presented its first national climate adaptation strategy in 2008, the "Danish Strategy for Adaptation to a Changing Climate", which sought to put climate adaptation on the agenda at the national and local levels (The Danish Government, 2008). As per the new climate target for 2030, the country must reduce its greenhouse gas emissions by 70 percent when compared to 1990 levels (Klimarådet, 2020, p. 8). By determining a percentage target and long-term target for climate neutrality by 2050, this is the first time Denmark sets target for total Danish emissions by law, and the targets mark a new direction for Danish climate policy (Klimarådet, 2020, p. 8). Over the next 10 years, Denmark will complete almost half of the work that has reduced emissions by around 38% since 1990. Due to this, a large reduction effort in Denmark is expected to affect most of the society within the next decade (Klimarådet, 2020, p. 8).

It is clear from the description above that Denmark aspires to be a green leader capable of inspiring the rest of the world and demonstrating that the green transition is compatible with economic prosperity.

2.1.5 Gladsaxe Municipality and climate change adaptation:

This section will provide an insight of the area and climate change adaptation in Gladsaxe Municipality.

Gladsaxe Municipality is located in the eastern part of North Zealand and is characterized by its hilly terrain, clayey soil and high-water content. Gladsaxe Municipality is away from the coast, but it has plenty of waterbodies surrounding it. Bagsvaerd Lake and Lyngby Lake are adjacent to the municipality and Utterslev Mose is a large lake area (Scharling & Cappelen, 2017, p. 57). Figure 3 presents the map of Gladsaxe Municipality.

Figure 3: Gladsaxe Municiaplity (Gladsaxe Webkort, n.d.)

In 2018, Gladsaxe officially included the Sustainable Development Goals (SDGs) in its municipal policy as one of the first municipality in Denmark, known as Gladsaxe-strategy. Gladsaxe is also working on their wastewater management for a quite some time. In December 1984, the first wastewater plan for Gladsaxe Municipality was prepared, until now the municipality prepared and implemented several wastewater plans after regular interval (Gladsaxe Kommune, 2011). In May 2021, the City Council adopted the Wastewater Plan 2021, which sets the framework for Gladsaxe Municipality and the utility company Novafos to work together on the development of the drainage system over the next decade (Gladsaxe Kommune, 2021). Gladsaxe municipality have several other plans, but Gladsaxe Strategy and Wastewater Plan 2021 is the most present and in the implementation stage. Because they point out the present and future objectives about climate change adaptation of Gladsaxe Municipality.

Gladsaxe Strategy:

The Gladsaxe Strategy provides a blueprint for planning and managing the municipality's environment, social well-being, and sustainable development. The Gladsaxe strategy includes

six objectives, which all contribute towards one or more of the UN17 goals (Gladsaxe Municipality, 2018). The objectives and connection with UN17 goals as represented in Table 1.

Objectives of Gladsaxe Strategy	**Incorporated UN17 Goals**
Children shaping the future	Goal 4: Quality Education, Goal 17: Partnership for Goals
Business-friendly city with job growth	Goal 8: Decent Work and Economic Growth, Goal 12: Responsible Consumption and Production, Goal 17: Partnership for Goals
Equal opportunities to succeed	Goal 3: Good Health and Well-Being, Goal 4: Quality Education, Goal 8: Decent Work and Economic Growth, Goal 17: Partnership for Goals
Green and vibrant city	Goal 11: Sustainable Cities and Communities Goal 17: Partnership for Goals
Lifelong health and well-being	Goal 3: Good Health and Well-Being, Goal 17: Partnership for Goals
Climate-conscious city	Goal 12: Responsible Consumption and Production, Goal 13: Climate Action Goal 17: Partnership for Goals

Table 1: Objectives of Gladsaxe Strategy and relation with the UN17 Goals (Gladsaxe Municipality, 2018) (United Nations, n.d.).

Now it is clear that Goal 17 (partnership for goals) links to all objectives, while Goal 3 (good health and well-being), Goal 12 (responsible consumption and production) are linked with two objectives. In addition, it is evident that the aims of the Gladsaxe Strategy are unrelated to ten other UN17 Goals, including Goal 6 (clean water and sanitation), popularly known as the water goal (United Nations, n.d.).

Wastewater Plan 2021:

The Wastewater Plan 2021 lays the foundation for Gladsaxe Municipality and Novafos (utility company) to extend the drainage system over the next ten years. Gladsaxe Municipality and Novafos (utility company) are striving to help foster the development of a sustainable city in accordance with Gladsaxe Municipality's overarching strategy for sustainable development, called The Gladsaxe strategy (Gladsaxe Kommune, n.d.). Table 2 represents the objectives and strategies of the Wastewater Plan 2021.

Objectives of Wastewater Plan 2021	**Strategies to reach the objectives**
1. Health-wise wastewater management **2.** Contribute to a better environment **3.** Resilience to future climate change **4.** Contribute to a sustainable city together with city's parties	**1.** Sustainable rainwater management **2.** Cloudburst Solutions **3.** Collaboration support and partnerships **4.** Renovate the drainage system and optimize operations

Table 2: The objectives and strategies of the Wastewater Plan 2021 (Gladsaxe Kommune, 2021).

2.2 Problem Statement:

Our time is characterized by an anthropogenic climate change, a problem whose stakes are high. There are a wide range of climate change effects, ranging from changing weather patterns impairing food production to rising sea levels or extreme rainfall that can cause catastrophic flooding, all of which are global in scope and unparalleled in size. Without immediate and dramatic action now, coping with these consequences will be more difficult and more expensive in the future (United Nations, n.d.).

Keeping this in mind, the purpose of this study is to investigate the urban development of the Gladsaxe Municipality in Copenhagen. This research examines the history of Gladsaxe Municipality to evaluate the evolution of urban water management techniques, with a concentration on water management and climate adaption features. As part of this research, lessons learnt from the development process will be explored so that future comparable initiatives may avoid potential impediments. Considering all these, this report attempts to address the following research questions and sub-questions.

2.3 Research Question:

How has urban water management evolved in Gladsaxe Municipality, and what was and is the current trajectory of the transition towards sustainable urban water management?

- How is the present urban water management in Gladsaxe Kommune characterized using the Urban Water Management Transition Framework and the Multi-Level Perspective theory, and from what has it evolved?
- How might the lessons learnt from Gladsaxe Municipality be used to similar initiatives in order to transcend conventional paths.

2.4 Research Design:

The research project focuses on the Danish municipality of Gladsaxe's urban developments. It examines changes in the urban water management techniques in the Gladsaxe Municipality. The project has two objectives:

I. According to the Urban Water Management Transition (UWMT) Framework, describe the current status of the transition to sustainable urban water management in Gladsaxe Municipality.
II. Examine how Gladsaxe's understanding of planning might assist SUWM in overcoming typical planning approaches.

The preliminary research questions were addressed with two analyses that build upon each other and contribute to each other's results to address the question. This analysis is framed by several document analyses, semi structured qualitative interviews, and theoretical considerations. In addition to presenting the results of the multidimensional analysis and commenting on them, the study concludes with a response to the research question and a discussion of the results. Figure 4 illustrates the project design which was followed during the project work.

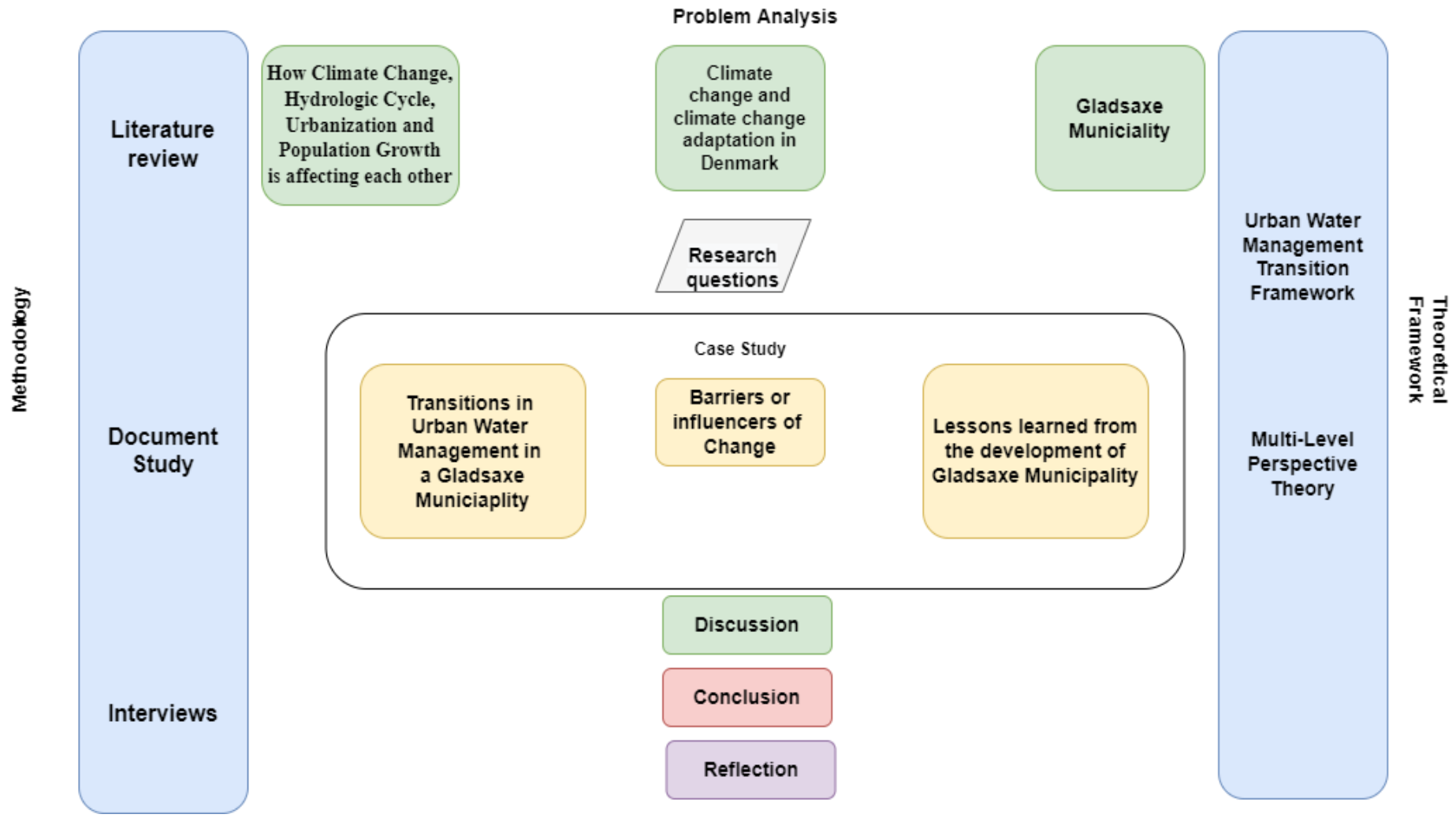

Figure 4: Illustration of Project Design.

3 Theoretical Framework

This project uses the theoretical framework as an underlying foundation for the analysis. The theories offer a deeper understanding of the system in which the issue arises. In the following sections, the researched theories and their intended implementations will be discussed.

3.1 Urban Water Management Transition (UWMT) Framework:

At Australia, there were three social research programs conducted between 2002 and 2008, that led to the development of the Urban Water Management Framework. The purpose of these research programs was to investigate the institutionalization of urban water management in a variety of Australian cities to facilitate the development of policies and benchmarking at the macro scale for urban water transitions. The research that was conducted during these programs included detailed historical, current, and future research, figure 5 represents the six transition stages of Urban Water Management Transition Framework and (Brown, et al., 2009).

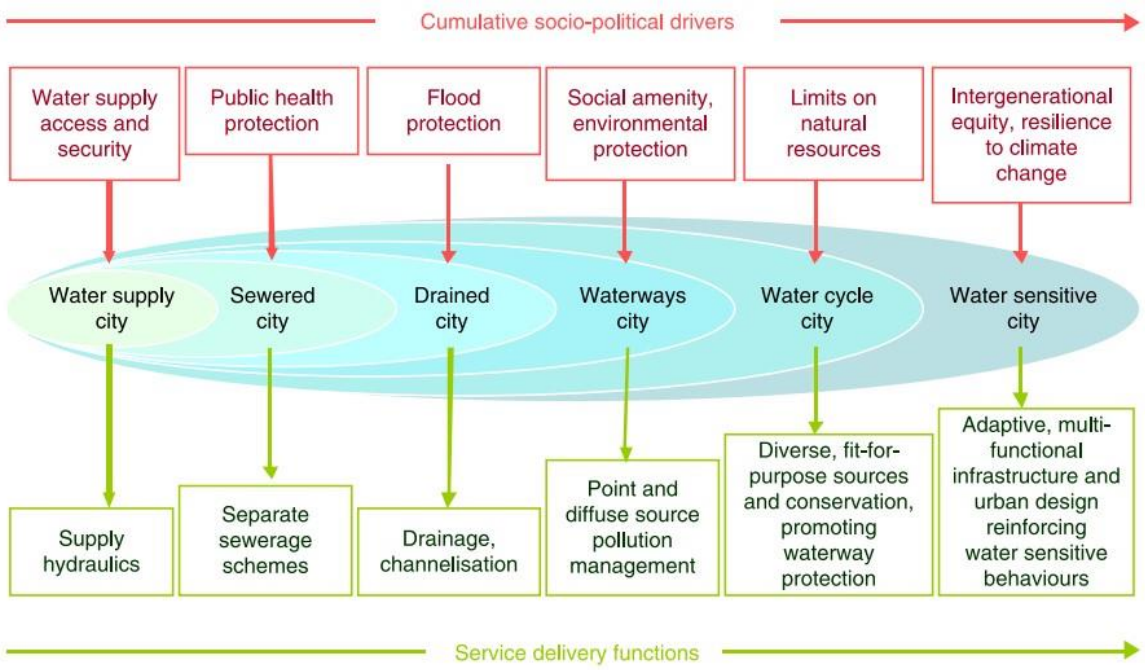

Figure 5: Urban Water Management Transition Framework (Brown et al. 2009, p. 850)

The first three transition stages, the "Water Supply City," the "Sewered City," and the "Drained City," all originated from the historical research phase and the "Waterways City" and part of the "Water Cycle City" evolved from the second research period. The remaining transition phases of 'Water Cycle City' and 'Water Sensitive City' emerged as a result of the study conducted on the future (Brown, et al., 2009).

The purpose of the present project is to analyze the transition of the water regime in Gladsaxe Municipality towards SUWM through time using the UWMT Framework in order to determine which of the city-states Gladsaxe Municipality belongs to, through the analysis of the water regime through time. More information about the six city-states will be found in the following sections.

3.1.1 Water Supply City:

The Water Supply City is the first modern urban water city state in Australia, representing the early 1800s European colonization of the continent. The normative foundation at the time was the efficient supply of safe and secure water supplies for a burgeoning urban population, as well as centralised provision for the elite, where the social movement of cleanliness was closely tied to social position (Brown, et al., 2009). The majority of the cognitive abilities utilized to handle these standards were imported from the British hydraulic engineering profession, with important engineers being recruited to Australia from the United Kingdom (Brown, et al., 2009).

This influenced the design, construction, and administration of centralised municipal water supply schemes, including the extraction of enormous volumes of water (from what was thought to be a benign environment) through the construction of dams and pipe networks to deliver vast quantities of water. After such systems were developed, a strong normative development emerged stating that 'unlimited fresh water' should be a public right granted by governments (such as the United Kingdom) at very low costs to ensure equitable access to disadvantaged groups and the poor.

This marks the beginning of the first official hydro-social contract in Australian cities, which was established with the development of regional governments (often municipal and subsequently metropolitan water boards) that raised a centralized tax system to pay for water infrastructure and service (Brown, et al., 2009). In some places, this took the form of a flat property tax, whereas in others, a particular water tax was levied. The hydro-social contract implicitly guaranteed the supply of a safe, inexpensive, and virtually endless quantity of water from a hospitable environment to a rapidly expanding metropolitan population (Brown, et al., 2009).

3.1.2 Sewered City:

The Sewered City state emerged between the mid and late 1800s, depending on the particular city within Australia (Brown, et al., 2009). By this time there are well established cognitive ‘engineering communities between the UK and Australia, and public health concerns around epidemic outbreaks of cholera and typhoid across European cities were at the top of the political agenda in the UK (Brown, et al., 2009). There were also outbreaks across Australia, but not at the same scale. With the discovery that people were becoming ill through pathogen infection of water supplies from wastes, sewage and industrial effluents, the combined sewerage system was innovated in London (Brown, et al., 2009). The construction of a reticulated sewage system required the disposal of wastewater outside of cities, and often to a receiving stream that was deemed ecologically sound (Brown, et al., 2009).

This development influenced the cognitive processes in Australia, with Sydney starting the construction of a combined sewerage and stormwater drainage system in 1850 (Brown, et al., 2009). By 1890, it was clear that the Australian rainfall conditions were more intense and stochastic than the British and the larger infrastructure required was deemed too costly. Along with some of the newly developing American cities, from the late 1800s Australian cities invested in separate sewerage systems (Brown, et al., 2009). Many cities also invested in on-site septic systems due to the perceived prohibitive cost of providing this infrastructure. The new regulative regime often involved the evolution of new water boards that were responsible for water supply and sewage through raising a levy in addition to property taxes (Brown, et al., 2009).

A rapidly expanding urban population was implicitly protected by the hydro-social contract through the provision of sewage services which directed waste flows into ecologically benign receiving waterways to ensure public health protection (Brown, et al., 2009). Due to the natural development of the addition of sewage services to the water supply services of the preceding city-state, the hydro-social contract remained essentially the same (Brown, et al., 2009).

3.1.3 Drained City

As Australian cities emerged from a recession, government investment in infrastructure and welfare soared, which prompted the Drained City state to emerge after WWII (Brown, et al., 2009). Australian culture adopted the global ideal of materialism as its normative standard manifested in the new fantasy of owning a house, a spacious lawn, and a family car for everyone. Due to the automobile, individuals were willing to live further away from city centres, resulting in the rapid development of medium to low density housing (Brown, et al., 2009).

In addition, flooding and property damage intensified and Australian engineers were able to generate local cognitive capital by combining local rainfall data with drainage design guidelines (Brown, et al., 2009). In the 1960s, urban hydrology arose globally, and Australia was a significant inventor, inventing methods, and models for moving rainwater quickly to receiving waterways (Brown, et al., 2009). To facilitate additional urban development in floodplain zones, numerous rivers were piped underground, and river systems were channelized. Most homes were built away from rivers, which were regarded as rubbish dumps, not treasured features of the city (Brown, et al., 2009).

Hydro-social contracts implicitly guaranteed cost-effective flood control by efficiently transporting rainwater to neutral environments to allow rapid urban expansion and resources were provided by local governments and centralized water and sewerage management authorities (Brown, et al., 2009). As centralized authorities expanded their service delivery functions, the hydro-social contract remained unchanged. However, local governments gradually became involved as new urban areas were built, resulting in a complex contract involving multiple providers (and fragmented) (Brown, et al., 2009).

3.1.4 Waterways City:

While previous city states expanded their hydro-social contracts, Waterways City challenges the services previously accepted by city states (Brown, et al., 2009). Although progress has been made, Waterways City was not mainstream in any Australian city. The previous convention of not accounting for environmental services in the hydro-social contract has led to excessive water extraction and contamination (Brown, et al., 2009). This reinforced the previous convention that the environment is benign and is not as significant as economics. An influential worldwide movement known as 'environmentalism' began systematically questioning this premise and promoting ecological conservation as a normative aim in the late 1960s (Brown, et al., 2009).

It has been a concern of Australians since the 1970s that local waterways were damaged by trash, gross pollutants, hydrocarbons, algal blooms, and beach closures (Brown, et al., 2009). In earlier decades, tremendous urban growth led to communities seeking more amenities and green spaces. Aside from integrating water into planning functions as a visual and recreational component for communities, measures were taken to reduce the input of pollutants into waterways. Among those measures were regulation of wastewater treatment plant discharges and industrial processes as well as the replacement of septic tanks with centralized sewerage systems (Brown, et al., 2009). Increasing amounts of diffuse-source stormwater pollution led

academics and practitioners to design novel solutions such as combined nature-based solutions, wetlands and biofilters to combat this situation (Brown, et al., 2009).

This city state gained prominence through cognitive tools such as industry standards and capacity development programs (Brown, et al., 2009). The prior hydro-social contract couldn't manage stormwater pollution because it was dispersed. Even though decentralized technologies were promising, little was known about how they operate under distributed accountability and continuous administration (Brown, et al., 2009). Present issues had been compounded by the absence of a specific funding stream modelled after the hydro-social contract of the Drained City. As a result, roles and responsibilities have changed dramatically, with new stakeholders participating actively, including community and environmental organizations (Brown, et al., 2009). Normally, this causes friction between experts and politicians concerned with conventional ideals regarding water supply, sewerage, and drainage as well as those attempting to embrace new environmental methods (Brown, et al., 2009).

3.1.5 Water Cycle City:

Water Cycle City is an innovative solution to the limitations of conventional water sources in supplying urban populations and growing cities, as well as pays attention to the streams ability to digest pollutants. In addition to the growing acceptance of social, economic, and environmental sustainability, it represents an effort to reconcile issues between Waterways City and previous city states through intellectual and policy jargon (Brown, et al., 2009).

An integrated or total water cycle approach was explored by researchers and practitioners that involves water conservation and the development of fit-for-purpose water supplies (derived from sources of varying quality - rainwater, storm water, sewage, seawater) that are also sensitive to energy and nutrient cycles (Brown, et al., 2009). In an environment where water resources were nearing their maximum capacity for sustainable usage, such a strategy combined supply security and waterway conservation, but it is in direct conflict with earlier hydro-social contracts which guaranteed risk-free water supply services implicitly (Brown, et al., 2009).

As part of the Water Cycle City, businesses, communities, and governments worked together to manage the water cycle, with risks shared and diversified via private and public instruments and through multidisciplinary, multistakeholder learning, adaptive solutions were developed (Brown, et al., 2009). The stated attributes of a Water Cycle City were endorsed rhetorically, but controversial issues such as centralization and decentralization of recycling remained (Brown, et al., 2009). Rather than supporting the coexistence of centralised and decentralised systems and creative forms of co-management with the community and private sector considering the current extended drought, the government largely expanded centralised systems with implicit controls and promises to communities derived from the old hydro-social contract (Brown, et al., 2009). Therefore, the hydro-social contracts were effective during the time of the Water Supply City and the Sewer City. In contrast, alternate water supplies were provided by decentralized and diffuse technology, similar to concepts proposed for controlling diffuse pollution sources in Waterways City (Brown, et al., 2009).

If Waterways City has enough time to stabilize, the hydro-social contract may facilitate a simpler transition to Water Cycle City. As a result of the Waterways City's links to environmental conservation, supply chain security, public health protection, and flood management, the Water cycle City's ideas are likely to be more widely adopted (Brown, et al., 2009).

3.1.6 Water Sensitive City:

Although there is currently no Water Sensitive City, scientists and practitioners interested in sustainable water management are evaluating this notion. To be successful as Water Sensitive City, it needs to undergo a substantial socio-technical transition, since water-sensitive cities would likely have significantly different hydro-social contracts than conventional urban water systems (Brown, et al., 2009).

To be effective, a Water Sensitive City would need to construct a hydro social contract that incorporates normative values including as environmental restoration and preservation, supply security, flood control, public health, amenity, liveability, and economic sustainability. This would incentivize communities to maintain natural resources and ecological integrity for future generations and to be resilient to climate change (Brown, et al., 2009).

It has been argued that a smart and engaged community would promote a sustainable lifestyle, and as a result, water experts and practitioners will be able to develop and manage water resources in a more sustainable and efficient way (Brown, et al., 2009). As a result, technology, infrastructure, and urban design would be diverse and adaptive, leading to a growth in social capital and sustainable habits. In a Water Sensitive City, there would be a flexible institutional framework and hydro social contract (Brown, et al., 2009).

3.2 Transitions in a multi-level perspective:

According to the multi-level perspective (MLP), transitions are nonlinear processes resulting from the interaction of numerous developments at three levels: niches, socio-technical regimes, and exogenous socio-technical landscapes (Geels, 2002; Geels, 2012, p. 472; Rip & Kemp, 1998). In this sense, the 'levels' indicate diverse configurations of increasing stability, Figure 6 illustrates how the hierarchical structure with regimes embedded in landscapes and niches inside and outside of those regimes (Geels, 2012, p. 472).

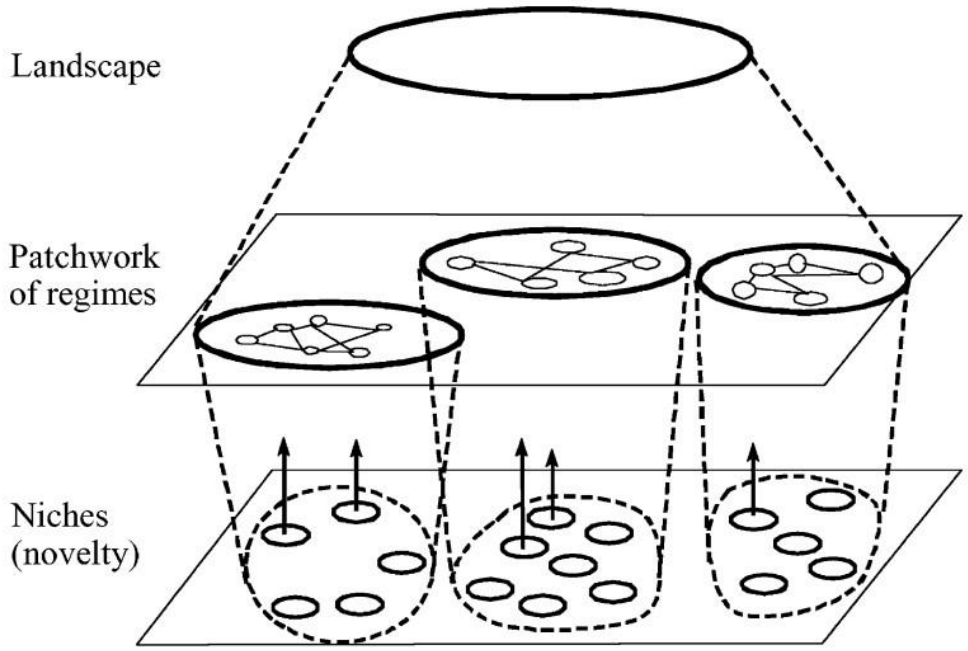

Figure 6: Hierarchical structure with multiple levels (Geels, 2002, p. 1261).

In this study, MLP will be utilized to determine how socio-technical transitions take place into socio-technical regimes in response to socio-technical landscape pressures, as well as how niche innovation affects the socio-technical regime at that moment.

3.2.1 Niche:

Within the MLP, innovations originate in niches, which are "protected areas" such as research and development laboratories, subsidized demonstration projects, or tiny market niches that are ready to support new inventions (Geels, 2012, p. 472). Rather than relying on current frameworks, niche actors develop radical innovations that deviate from them, and they anticipate their innovative ideas will eventually be integrated into the system or even replaced (Geels, 2012, p. 472). Even though niches are crucial for transitions because they provide the seeds for systemic transformation, it is difficult to do so because the current system is sustained by several lock-in mechanisms (Geels, 2012, p. 472).

On the other hand, it is common to support niches through experimental or demonstration initiatives, which allow niche actors to learn about advances in the actual world (Geels, 2012). Niches gain momentum if visions (and expectations) become increasingly specific and widely accepted, if several learning processes are aligned, if social networks grow, and if multiple learning processes are aligned in a stable configuration (dominant design) (Geels, 2012).

3.2.2 Socio-Technical Regimes:

Geels (2004) addresses that an existing socio-technical system has a socio-technical regime that rules in actual actions within local practices, while rules also configure actors (Geels, 2004). There are a variety of regime norms, including cognitive routines and common ideas, skills and competencies, lifestyles and user patterns, beneficial institutional structures and laws, and legally enforceable contracts (Geels, 2011). Innovation occurs gradually under established regimes because of lock-in, and minor adjustments add up to steady growth (Geels, 2011). As well as being a part of the technological sphere, these trajectories can also be found in the cultural, political, scientific, commercial, and industrial realms (Geels, 2011).

3.2.3 Socio-Technical Landscape:

A landscape is an external framework or setting for actor interactions and a variety of factors contribute to the socio-technical landscape, including oil prices, economic growth, wars, emigration, large political coalitions, cultural norms, and environmental concerns (Geels, 2002, p. 1260). Socio-technical landscapes refer to the external technology elements, whereas regimes refer to laws governing activities within communities. The socio-technical landscape context is even less susceptible to change than the regime context, resulting in landscapes change much more slowly than regimes (Geels, 2002, p. 1260).

3.2.4 Socio-technical Transition:

The socio-technical transition refers to the progression of a specific set of activities through successive stages characterized by distinct causal mechanisms (Geels, 2020). Figure 7 presents the Multi-level perspective dynamics. According to the multi-level perspective Geels & Schot, (2007), expresses that, transitions are characterized by interactions between processes at these levels:

(a) “niche-innovations build up internal momentum, through learning processes, price/performance improvements, and support from powerful groups,

(b) changes at the landscape level create pressure on the regime

(c) destabilisation of the regime creates windows of opportunity for niche innovations". (Geels & Schot, 2007, p. 400)

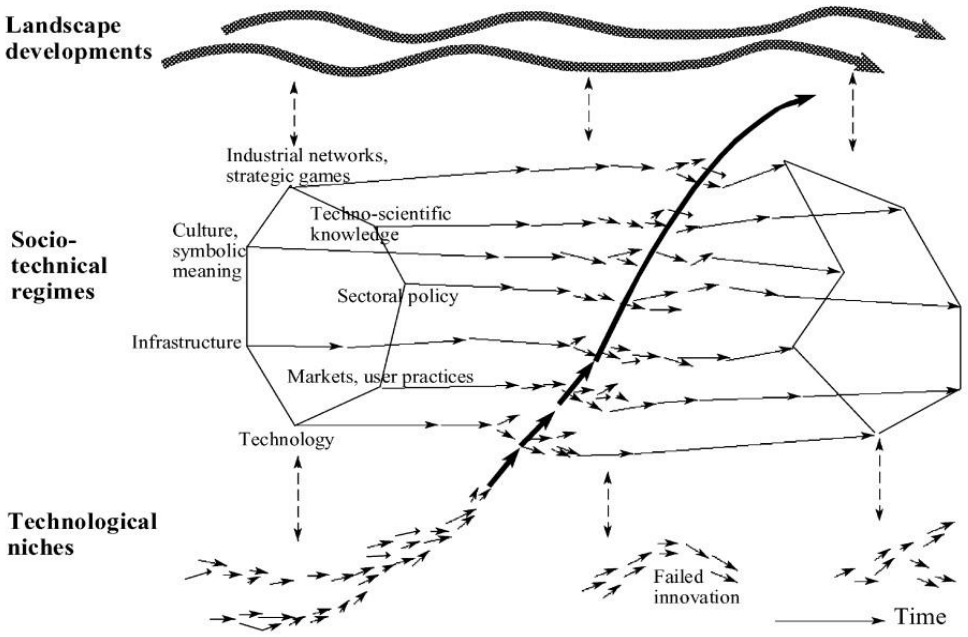

Figure 7: Multi-level perspective dynamics (Geels, 2002, p. 1263).

It is in the interest of the synchronization of these processes that innovation can be introduced into mainstream markets, where it will be competing with the existing regime.

In this project, the objective is to analyse the selected case study in light of socio-technical transitions in the field of water management. The components of the landscape, the regime, and the niche will be identified, explained, and analysed to determine the relationships between them to accomplish this. As a result, previous transitions will be identified as well as scenarios for possible future transitions toward SUWM will be described.

4 Methodological Approach

The following section provides the reasoning behind the research approach carried out in this project. The research approach consists of four different methods; a case study, literature reviews, document studies, and qualitative interviews, each of which have individually contributed to the gathering of data and information needed to conduct the analyses. In the following, the four methods are described and their contribution and relevance for the project is clarified.

4.1 Case Study:

Case studies have generally been seen as deficient in rigor and impartiality in comparison to other social research approaches and this is one of the primary reasons why study design and execution must be articulated with great care. Case studies are commonly employed because they may provide insights that cannot be obtained via other methods. Case studies have often been seen as a beneficial instrument for the basic, exploratory phase of a research project, as a foundation for the construction of the "more structured" instruments required in surveys and experiments. According to Rowley (2002) "case studies are useful in providing answers to 'How?' and 'Why?' questions, and in this role can be used for exploratory, descriptive, or explanatory research" (Rowley, 2002, p. 16).

One of the potential outcomes of this research project is an in-depth analysis of urban water management in Gladsaxe Municipality. Therefore, Gladsaxe Municipality's current water management measures will be examined as part of the case study. Inspired by Urban Water Management Transition by Brown et al. (2009), the objective of the research is to identify the current state of water sensitivity in the district. Using a theoretical perspective, the objective of this case study is to learn about and define how urban water management has transitioned as well as to investigate the urban water-related transition exercise.

The development process of Gladsaxe Municipality is interesting from different angles. The collaboration between the city council and the utility company Novafos to manage water is really strong and made the way of sustainable transition well-ordered for Gladsaxe Municipality. Some of the many fundamental aspects that define the case of the urban growth of Gladsaxe Municipality include strong local governmental backing, financial incentives, and public participation. These are only few of the many crucial factors which made the development process more holistic in Gladsaxe.

For purposes of conducting a comprehensive examination of SUWM, the municipality of Gladsaxe was selected based on the aforementioned considerations and reasons. An investigation has been conducted to identify transition-facilitating components for urban water management to facilitate transitions. It was also intended to assess whether the municipality is a world-leading example whose ideas and approaches may be replicated by other urban development entities.

4.2 Literature Review:

Literature reviews are a comprehensive examination of scholarly publications on a certain topic that have been published in recent years. They provide a comprehensive summary of the most recent information available concerning the subject under investigation and illustrate how previously held beliefs are complemented by new information. In order to identify relevant research theories, methods, and potential gaps in existing knowledge, a literature review is frequently conducted. As a result, this procedure is utilized in the formation of the foundation

for new research, as it provides insight into topics that are not yet part of the research area and support for existing ones (McCombes, 2019).

An extensive literature review was conducted as part of this project to acquire the necessary background data to formulate the problem statement and research question as well as to conduct formulative research. In the initial phase of the literature review, the research focused on the effects of climate change, urbanization, and population growth on the urban water cycle and climate change consequences in Denmark. After the initial phase, the scope of the evaluation focused on Gladsaxe Municipality and urban water management in the specific municipality.

4.3 Document Study:

This study's empirical data gathering relied heavily on selected papers, book chapters, and city planning documents presented in table 3. Most of these documents are published in Danish, Google Translator was used to translate them into English.

Name of the document	**Contribution**
Rammer for Udvikling-almene boligbebyggelsers bevaringsværdier by Bendsen (2017)	This document gives information about public housing in Gladsaxe municipalty, which reveals how it became a suburban city.
Spildevandsplan: Gladsaxe Kommune 2011-2014 by Gladsaxe Kommune (2011)	These three documents provided necessary information about how sustainable transition took place in Gladsaxe and how climate change adaptation became connected with water management.
Spildevandsplan 2021 by Gladsaxe Kommune (2021)	
Spildevandsplan 2015 by Gladsaxe Kommune, (2015)	
Gladsaxe Kommunes Spildevandsplan 2021 – Milojørapport by Ramboll (2020)	This environmental report revealed current environmental state of Gladsaxe and what matters-initiated adoption of Wastewater Plan 2021.
Vandforsyningsplan 2012-2024 by Gladsaxe Kommune (2012)	This document provided information about recent planning and background of water supply history of drinking water in Gladsaxe Municipality.
Gladsaxe Strategy: Sustainable growth and welfare, 2018-2022 by Gladsaxe Municipality (2018)	This document uncovers how SDG goals were incorporated into municipal plan by Gladsaxe Municipality.

Table 3: Document study overview.

4.4 Interviews:

Two semi-structured, qualitative interviews have been conducted in an attempt to obtain additional information about the Gladsaxe Municipality case study. The semi-structured interviews have provided a variety of viewpoints on water management in the metropolitan region and how various sectors and actors cooperate altogether.

Semi-structured interviews are a form of data collection that involves asking questions within a defined theme framework but are neither arranged nor phrased in any particular order (George, 2022). Semi-structured interviews in research are often qualitative in nature. A variety of disciplines use them as exploratory tools. A particular use for these methods occurs in field research involving multiple interviewers, as they enable all interviewers to examine different aspects of the research issue while maintaining the same theoretical framework (George, 2022).Table 4 provides an overview of the conducted interviews.

Interviewee	Interview focus points	Organization
Bo Brøndum Pedersen	The SDGs, nature-based solutions, water management, climate change adaptation, lessons learned	BOVAK
Mathias Elle	Relation between Novafos and Gladsaxe, nature-based solutions, water management, climate change adaptation	Novafos

Table 4: List of conducted interviews, transcriptions are found in Appendices 1 & 2.

5 Transitions Toward Sustainable Urban Water Management

Following is an in-depth assessment of what is required to ensure a sustainable transition in urban water management and to attain water sensitivity in Gladsaxe Municipality. The study has two goals: to determine the present level of sustainable urban water management (SUWM) and to investigate the existing variables that might either facilitate or impede the transition to water sensitivity.

5.1 Background Information About Gladsaxe Municipalities Urban Development

This section is to describe the housing and urban development of Gladsaxe Municipality since the establishment of the municipality. To become urbanized, Gladsaxe Municipality had to undergo a series of urban development steps. Gladsaxe-Herlev Sognekommune was established in December 1841 and until 1900 they were known as rural municipality (Gladsaxe Kommune, n.d.). From there, Gladsaxe had to go through several transition stages to become today's suburban business district. In the 1960s, Danes continued a migration that began in the 1940s and 1950s to the city's outskirts (Bendsen, 2017). In response to the increase in passenger automobiles, transportation patterns and cities developed. New residential zones were planned around all the important Danish provincial towns as well as the capital region, from which one could travel between home and employment in the old towns or newly constructed suburbs 21 (Bendsen, 2017). Søndergård Park was built during 1949 to 1951, the settlement consists of 69 terraced houses on one floor with utilized roofs, 60 staggered terraced houses on one floor, and 69 single-family houses on one floor (Bendsen, 2017, p. 211). In 1951, Høje Søborg was constructed, which is composed of two buildings: Høje Søborg I and Høje Søborg II, which are located near Søborg Torv by Søborg Hovedgade. The development consists of 133 apartment units as well as commercial tenants (Bendsen, 2017, p. 287). During the period of 1962 to 1968, Høje Gladsaxe was constructed. The buildings consist of 17 apartment blocks, a school, a church, a center with shops and collective functions, in addition to various facilities such as a heating plant. In this development, there are more than 2,000 apartments in a small square that is surrounded by the school, the church, and the community center (Bendsen, 2017, p. 393).

This section clarifies how Gladsaxe Municipality transformed into a business district from largely known as industrial district. The first urban-planned industrial region in Denmark was the Gladsaxe industrial district, which was developed beginning in the mid-1930s (Dansk Bygningsarv A / S, 2010, p. 22). Although Danish industry was undergoing considerable reorganization following World War II and owing to unfavorable conditions regarding lending and finance, industrial development did not commence in earnest until after the war (Dansk Bygningsarv A / S, 2010, p. 22). Gladsaxe municipality exerted much effort to become a prominent business district. In the 1950s, there was a significant number of industries, and in the 1960s. For Gladsaxe's redevelopment, numerous older structures were demolished in 1982. As part of Gladsaxe's public housing development between 1983 and 1987, many units of public housing were built (Gladsaxe Lokalhistoriske Forening, n.d.)(Molin & Wendel-Hansen, 2018). Since the early 1990s, when the previous name "industrial district" was replaced by "business district" as a logical result of the growth with fewer factories and more office firms, attempts to improve bike routes, improve public transportation links, and modernize the business districts have operated concurrently. As part of the shift from industry to business, the Gladsaxe municipality's oldest industrial district had a substantial cleanup and disposal of polluted soil in 1996 (Gladsaxe Kommune, n.d.).

This section provides information about population growth and present housing situation in Gladsaxe Municipality. In 1901, the population of Gladsaxe municipality was 1,754 and, from 1940 to 1970, the population grew significantly, reaching a high of 74,808 individuals (Rømer, 2018). From 1970 until 1990, the population of the municipality declined, but since then it has been on the rise (Rømer, 2018). In 2020 there were 69,262 residents living in Gladsaxe Municipality and population forecasts for 2020-2035 indicate that the population will increase by 6,772 citizens until 2035 when there are expected to be 76,034 citizens in the municipality (Mortensen & Jensen, 2022). Within Gladsaxe, there are 31,542 houses, divided between multistorey, terraced, and detached houses, and 36 percent of these houses are owned by non-profit housing associations (Gladsaxe Kommune, n.d.).

5.2 Water Management in Gladsaxe Municipality:

In Gladsaxe and eight other municipalities Novafos is the municipal water utility company, previously known as Nordvand. In 2009, the municipally owned water company was established and is responsible for managing drinking water, rainwater, and wastewater for the municipalities (Gladsaxe Kommune, 2012) (Novafos, n.d.). Groundwater is pumped from underground by Novafos to produce drinking water and Søborg Vandværk, Bagsværd Vandværk receive drinking water from four source sites located throughout the municipality (Gladsaxe Kommune, 2021, p. 45).

As part of the Gladsaxe Municipality's drainage system, there are approximately 300 kilometers of main drainage pipes along with approximately 80 kilometers of associated pipes up to the municipal boundary, approximately 7,000 downpipes, 32 pump stations for rainwater and wastewater, and 26 basins that reduce the risk of flooding and overflows of water (Gladsaxe Kommune, 2021, p. 53). It may be noted that the drainage system is hydraulically divided into seven catchments, (Utterslev Moses opland, Gyngemosens opland, Kagsåens opland, Bagsværd søs opland, Værebro Ås opland, Bagsværdrendens opland, Hollandsrendens opland) all around the municipality (Gladsaxe Kommune, 2021).

In Gladsaxe Municipality, there is no wastewater treatment facility, wastewater is distributed to three treatment plants through shared municipal infrastructure. A majority of wastewater from the southern part of the municipality is discharged to Renseanlaeg Lynetten and Renseanlæg Damhusåen, both of which are operated by BIOFOS and situated in Copenhagen. In the north, the wastewater is directed to the Mølleåværket power plant in Lyngby-Taarbæk Municipality. BIOFOS and Mølleåværket are public limited companies in which Gladsaxe Municipality is a shareholder (Gladsaxe Kommune, 2021, pp. 55-56).

5.3 The Transition of Urban Water Management in Gladsaxe Municipality

The present study makes use of the terminology and framework of the Urban Water Management Transition framework proposed by Brown et al. (2009) as a basis for understanding the current SUWM and water sensitivity of the Gladsaxe Municipality. Table 5 presents the Urban Water Management Transition in Gladsaxe.

City State	***Reasons for Transition***	***Indicator***
Water Supply City	Water supply rapidly became a concern as more and more wells were drilled on private plots, resulting in	Gladsaxe Vandforsyning was formed by the construction of the Søborg Waterworks and Vandtrnsvej water tower on Gladsaxevej and the required water was collected from Søborg Mose (Jensen, n.d.) (Gladsaxe Kommune, 2012, p. 23). In 1914, the Søborg Waterworks was upgraded to a larger

	insufficient water for everyone. (Jensen, n.d.).	capacity water and Bagsværd Waterworks was established as the second waterworks in 1921 (Gladsaxe Kommune, 2012, p. 23).
Sewered City	A comprehensive water and wastewater system is necessary in order to reduce water-borne infections, and the sewage system needs to be expanded (Brown, et al., 2009).	Gladsaxe began developing a combined sewer system in 1900 (Gladsaxe Kommune, 2021, p. 54). In the 20th century, Denmark created a publicly run infrastructure of waterworks, distribution infrastructures, and sewage systems and the construction of piped below-ground infrastructure was largely spurred by hygiene and public health concerns in the early twentieth century (Jensen, et al., 2016, p. 241)
Drained City	A hydro-social contract implicitly guaranteed flood control by transporting rainwater efficiently to neutral environments, allowing rapid urban expansion and local governments and centralized water and sewerage management authorities provided resources (Brown, et al., 2009).	The Gladsaxe Municipality indicated that half of the municipality is situated within an intervention-required catchment area, with a total of thirteen areas in risk. Several climate change adaptation projects were implemented such as Separate sewerage in Kagsåkvarter East and West, Separate sewerage in Sandkrogen, the rainwater basins at Gladsaxe Idrætscenter, Rainwater management / climate adaptation on Kong Hans Allé and in Kong Hans Have etc (Gladsaxe Kommune, 2021, p. 71). Novafos (previously known as Nordvand) was established in 2009 as Gladsaxe's municipal water company for managing drinking water, rainwater, and wastewater (Gladsaxe Kommune, 2012) (Novafos, n.d.). Prior to their establishment the municipality was the responsible entity to manage water in Gladsaxe.
The Waterways City	In 1952, Copenhagen harbour public baths were closed because of deteriorating water quality (Sørensen, et al., 2016). It was the late 1960s the influential worldwide movement of 'environmentalism' began (Brown, et al., 2009). Expansion with increasing wastewater management requirements.	Water pollution was a big concern for Denmark. In the 1970s, Denmark's newly formed Ministry of the Environment formalized environmental consciousness. The ministry took an active interest in the effects of wastewater on aquatic ecosystems. Thus, in the 1980s and 1990s, substantial investments were made in modern wastewater treatment facilities throughout the country (Jensen, et al., 2016, p. 241). Roughly half of the sewer system of Gladsaxe Municipality was constructed between 1920 and 1960 and approximately 90 km of lines have been renovated in the last 30 years, primarily through sliplining (Gladsaxe Kommune, 2021, p. 54). Action Plan for the Aquatic Environment on 10 June 1987 (Conley, et al., 2002). For recreational swimming, a permanent public harbour bath was inaugurated in 2002 (Jensen, et al., 2016, p. 243).

The Water Cycle City	Innovative solutions took place to resolve the difficulties emerged by the previous city states.	Few examples of Gladsaxe being Water Cycle City: • Høje Gladsaxe Park – rainwater lakes and extension of attenuation basin. • Gladsaxe Sports Centre – handling and attenuation of rainwater. • Marielyst cooperative association – diversion of rainwater. • Vandledningsstien in Gladsaxe Municipality landscape. • A climate-protected residential area Gedvad. • Local drainage of rainwater (LAR) and recycling.
The Water Sensitive City	Holistic and integrated water cycle management increases liveability, protection of health of receiving water bodies, green public spaces to retain and detain water, flexible design (Brown, et al., 2009). .	Examples of Gladsaxe being Water Sensitive City: • Gladsaxe Sports Centre – handling and attenuation of rainwater. • Vandledningsstien in Gladsaxe Municipality landscape. • A climate-protected residential area Gedvad. *Not yet fully achieved.

Table 5: The transition in urban water management in Gladsaxe is based on the framework proposed by Brown et al. (2009).

As seen in Table 5, Gladsaxe Municipality has several attributes of the Water Cycle City state. This urban district has a number of large-scale rainwater detention and retention systems as Water Cycle City state such as: Høje Gladsaxe Parken is a public recreational park and nature area that has a stream and two lakes that can accommodate approximately 6,900 m3 of rainwater, Vandledningsstien has a number of water basins capable of holding 3,500 m3 of water, and Gladsaxe Sportscenter is an open sports and folk park with ponds and canal systems for capturing and diverting rainwater between the sports halls and along the side-lines of the football fields (Gladsaxe Kommune, n.d.).

The Gladsaxe Strategy, which incorporates UN Sustainable Development Goals into the municipality's development planning process, is a highly valued aspect of the Water Cycle City State, providing a unique opportunity for the municipality to combine diverse sectors, bodies of knowledge, and actors.

As the municipal water utility, Novafos manages the drinking water, sewage, and rainwater within Gladsaxe Municipality. As Novafos is the sole provider of these services in Gladsaxe Municipality, it holds a dominant position in water management. Gladsaxe citizens are also able to take part in LAR's water management program. It is necessary for citizens to obtain a seepage permit to facilitate this activity as the geology and groundwater conditions in Gladsaxe Municipality vary greatly (Gladsaxe Kommune, 2021, p. 25). This way water is also being co-managed by the community which is a major attribute of Water Cycle City state.

In terms of waste management Gladsaxe is also implementing wide set of actions. In 2020, the Gladsaxe Municipality collected 26,000 tonnes of garbage from homes and public buildings, of which about 13,500 tonnes were recycled (Gladsaxe Kommune, n.d.). The Gladsaxe Strategy aims to improve residential recycling rates to 50 percent by 2022 and in 2020, the rate was 39.1% (Gladsaxe Kommune, n.d.). This objective may be achieved by collecting food waste and optimizing current programs and the food waste system is anticipated to be implemented in all homes by the end of 2022 (Gladsaxe Kommune, n.d.). Since mid-May 2019, the food waste service has been offered to detached and terraced homes and, In the spring of 2020, the program was also implemented in multi-story buildings and by significant housing corporations (Gladsaxe Kommune, n.d.). Concern about waste management, recycling and actions about it in the Gladsaxe Municipality establishes the attributes of Water Cycle City state.

In climate adaptation projects like The Water Park and Gladsaxe Sports Centre, drainage systems relate to recreational areas, which create new opportunities for outdoor activities. Additionally, there was a focus on how to include elderly people, girls in 7th and 8th grade from the nearby school in activities surrounding the football fields, and elderly people from the neighbourhood, this way young girls and older individuals had the opportunity to contribute to the project by presenting their ideas (Bennetsen, n.d.). Finally it is evident that the city's climate adaptation projects are not just functional, but also allow residents to use urban and recreational spaces in various ways (Bennetsen, n.d.). These activities bring Gladsaxe Municipality closer to becoming a water-sensitive city state, however Water Sensitive City state is more complex and in-depth which is explained in the Chapter 3.1.6.

The majority of Gladsaxe Municipality is sewered communally, although certain parts are sewered separately (Gladsaxe Kommune, 2021, p. 54). Except for not having a completely separated sewage system, Gladsaxe Municipality meets the requirements for a Water Cycle City.

5.4 Motivator of Change:

According to the multi-level perspective approach, the following section analyses urban water management in Gladsaxe Municipality. In this section the climate change is considered as the landscape, the water management in Gladsaxe Municipality as regime and innovative solutions to manage rainwater and wastewater like Local drainage of rainwater (LAR), nature-based solutions as niche.

5.5 Change In The Landscape:

As explained in the problem analysis chapter that the climate change is visible in Denmark and in future this pattern will continue. It is common for Denmark to experience flooding from the sea, as it is closely related to floods, but several heavy rainfall events over the last decade have raised awareness of the danger of flooding caused by precipitation (CliCNord, n.d.). The insurance industry estimates that the cloudburst event in Copenhagen on July 2, 2011, caused damage of six billion Danish Krone (Naturstyrelsen, 2013, p. 3). At that moment the climate adaptation and emergency preparation were not enough to handle the huge amount of rainwater.

As a result, the government had to take steps to adapt with the changed climate. Danish government published an action plan on climate protection at the end of 2012, a key component of the action plan is that everyone is responsible for adapting to the changing climate, including municipalities as well (Lund, 2013). To comply with that, the government entered into an agreement with the National Association of Local Authorities to invest 2.5

billion DKK in climate adaptation during 2013 (Naturstyrelsen, 2013). Municipalities were required to prepare a climate adaptation plan by the end of 2013, maps of areas at risk of flooding needed to be included in these plans, as well as a description of the steps needed to counter violent cloudbursts that are likely to become more frequent as climate change progresses (Lund, 2013, p. 5) . This action opened a new horizon towards climate change adaptation in Denmark, the municipalities came up with their very own climate adaptation plan with the objective to solve their own climate problems within the given guideline.

5.6 Interaction Between Regime and Niche:

Innovation occurs gradually under established regimes as a result of lock-in, and incremental changes result in steady growth (Geels, 2011). Conversely, niches are often promoted through experimental or demonstration efforts, enabling niche players to become familiar with genuine world advancements (Geels, 2012).

Gladsaxe Municipalities water regime was locked in with the traditional pipe based common sewer system for a long time. Bo Brøndum Pedersen from BOVAK, he was a project manager at Novafos from 2010 to 2014, discusses the water management regime at Novafos during his tenure:

"The water management was pipe based. And in a lot of the areas that was having one pipe for both the sewers a black and a blue in the same suit. And they had some areas where if there was a big flow it was going out in nature" (Appendix 1- Bo Brøndum Pedersen).

They knew that they must separate their sewer system as they did in 70s and 80s. Mathias Elle a project manager of Novafos acknowledges:

"...Some of the system is already separated like this as they were built in the 70 and 80s. They knew it was the way forward" (Appendix 2- Mathias Elle).

According to Wastewater Plan 2011, in Gladsaxe Municipality, there was approximately 250 kilometers of main sewers and 150 kilometers of connecting pipes to the municipal boundary (Gladsaxe Kommune, 2011, p. 25). To separate such a huge drainage network is matter of long time, so Gladsaxe focused on experimental niche innovation such as LAR and other nature-based solutions. To answer the question why Gladsaxe chose to adopt nature-based solutions, Mathias Elle a project manager of Novafos answers:

"I think, at least in the past, the recreational value has been the key driver" (Appendix 2- Mathias Elle).

After the establishment of Nordvand (now Novafos) in 2009, it was easier for Gladsaxe municipality to promote Local drainage of rainwater (LAR) and other NBS. On this matter Bo Brøndum Pedersen expresses his opinion:

"When the people from the environment part of Gladsaxe Kommune saw an opportunity to do something together with us who was working with the sewage, we thought if we can do something combined then it would be a good thing" (Appendix 1- Bo Brøndum Pedersen).

Communication was the key between the citizens, the municipality and Novafos, Bo Brøndum Pedersen acknowledges:

"I think they had some employees who was very active in the nature department and also talked a language that other people could understand" (Appendix 1- Bo Brøndum Pedersen).

During 2010, the municipality established that residents who ensured seepage (LAR) on their own property would receive a partial refund of the connection fee paid to the wastewater system (Miljøministeriet / Miljøstyrelsen, 2020). This was a stepping point of promoting niche innovation I Gladsaxe Municipality promote Local drainage of rainwater (LAR). In order to niches to gain momentum, visions (and expectations) need to be explicit and widely accepted, numerous learning processes need to be aligned, social networks should expand, and multiple learning processes need to be coordinated in a stable configuration (dominant design) (Geels, 2012). According to Wastewater Plan 2011 there was a municipal target that "*in 2014, there will be a total of 1000 citizens who are expected to handle rainwater on their own land*" (Gladsaxe Kommune, 2011, p. 15).

Prior to the landscape pressures on the existing water regime, Gladsaxe Municipality already focused on climate change adaptation. Gladsaxe Municipality began climate adaptation several years before the government and KL agreement in 2012 that all municipalities should identify flood risks, create an adaptation strategy, and prioritize measures (Miljøministeriet / Miljøstyrelsen, 2020).The cloudburst that occurred over Copenhagen on July 2, 2011, boosted mapping efforts, and local officials pushed for an ambitious plan (Miljøministeriet / Miljøstyrelsen, 2020). Bo Brøndum Pedersen states how Gladsaxe and Novafos handled the pressure from the landscape:

"We had to make a climate change plan, we had to incorporate that in all the projects we had, so that was that was important. That made it legal to say, we can do more for the same money if we change the way of things" (Appendix 1- Bo Brøndum Pedersen).

The evolution of Wastewater Plan goals is presented in Table 6. Wastewater Plan 2011 was published prior to the landscape pressure and the other two wastewater plans were published afterwards.

	Wastewater Plan 2011
Goals	• "The wastewater must be transported away so that it takes place safely and in the most optimal way in relation to operation and energy consumption. • The natural circulation of the water must be restored as far as possible, which will help to minimize the risk of future floods when it rains heavily. • The discharge of mixed rainwater and wastewater must be reduced as much as possible to avoid a burden on the aquatic environment and so that goals and requirements in the state's future water plans can be met. • The drainage system must be renovated to an extent so the value of it is preserved".
	Wastewater Plan 2015
	• Maintain an efficient and safe discharge of wastewater • Meet the requirements of the water plans • Interaction with climate adaptation
	Wastewater Plan 2021
	• The goal is that with a separate sewer system to ensure good hygienic and health conditions in connection with the management of wastewater, especially in connection with the major rain events. • The goal is that with the management of rainwater and wastewater to reduce the discharge of pollutants to watercourses, lakes and the sea, to have a better water environment and the national requirements in the water area plans are met. • The goal is that with the future expansion of the drainage system to handle both daily rain and the major rain events. • The goal is that with the solutions for managing rainwater and wastewater, to contribute to the development of a sustainable city in social, environmental and economic balance.

Table 6: Wastewater Plan goals since 2011 (Gladsaxe Kommune, 2011, p. 9) (Gladsaxe Kommune, 2015, p. 3) (Gladsaxe Kommune, 2021, p. 13).

Using hydraulic Mike models, a consulting firm mapped out the entire municipality and assessed its infrastructure and assets for the first time (Miljøministeriet / Miljøstyrelsen, 2020). The Gladsaxe Municipality conducted a comprehensive groundwater mapping in 2014, resulting in people not being able to seep on their own property (Miljøministeriet / Miljøstyrelsen, 2020). Based on the groundwater mapping, fifty percent of Gladsaxe Municipality is located within catchment areas that require intervention. For a total of thirteen locations, the risk was evaluated by integrating the possibility of water being present on the terrain, the value of the affected regions, and damage expenses incurred from floods (Miljøministeriet / Miljøstyrelsen, 2020).A project group with Gladsaxe Municipality as the lead was formed to assess the need for mapping and the project group was composed of Nordvand and several municipalities' organizations and sectors, including the town planning department, the nature department, the road department, and the team responsible for climate adaptation and wastewater (Miljøministeriet / Miljøstyrelsen, 2020). This is an example of the initiation of sectoral integration. Project group participants served as ambassadors for the project group within the administrations from which they come and previously, initially the project group made mapping decisions, afterwards the group advised policymakers on climate adaptation issues (Miljøministeriet / Miljøstyrelsen, 2020).

In addition to criteria such as cost-effectiveness, natural conditions, traffic hubs, green spaces, and a plan for the physical transformation of the region, the planned projects of the water company were deemed crucial variables while prioritizing the 13 risk areas. Additionally, climate change adaptation opportunities and the need to adapt were considered as significant factors (Miljøministeriet / Miljøstyrelsen, 2020). Ten of the thirteen risk zones were residential, while the other three were commercial. In the specified residential zones, climate adaption facilities were built in accordance with the areas' priority and a climate adaptation approach has been incorporated into the urban change of Gladsaxe and Bagsværd business districts (Miljøministeriet / Miljøstyrelsen, 2020).

This section will highlight what was done in the last decade in Gladsaxe Municipality in terms of climate change adaptation and water management. The exact number of implemented LAR solutions was not found, but according to Bo Brøndum Pedersen:

"They have worked a lot about handling water locally, it's better because then they didn't need to upgrade all the sewers" (Appendix 1- Bo Brøndum Pedersen).

In the center of Kong Hans Allé, and close to Buddinge Station, is the Kong Hans Have public park. Prior to 2014, this site was used primarily as a flat baseball field. Since the garden was inaugurated in 2018, it has been surrounded by mountains with depressions and a lake into which water can flow during storms (Gladsaxe Kommune, n.d.).

Demonstrationshaverne i Bagsværd were inaugurated in 2015 and demonstrate effective rainwater management in small gardens. The five gardens were selected based upon visibility from the road, design, and size as well as balancing solution costs with supply connection costs. By combining rain beds, ditches, and depressions, the gardens illustrate the ability to meet building and boundary distance requirements (Gladsaxe Kommune, n.d.).

Høje Gladsaxe Parken is a public park and natural area. In 2014, a stream and two lakes were constructed that can store approximately 6,900 m3 of rainfall. As part of the project, untreated wastewater discharges into the Fortress Canal were reduced (Gladsaxe Kommune, n.d.). Its facilities are responsible for managing rainwater and cloudburst water from the 1900 residents within Gladsaxe Park and Gladsaxe Sportscenter (Gladsaxe Kommune, n.d.). Plants and animals can benefit from the lakes, which are designed to replicate natural lakes. Gladsaxe Sportscenter, Marileyst district and Vandledningsstein are part of this mega climate adaptation project.

Since the Gladsaxe Sportscenter underwent climate adaptation measures in 2014, it has transformed into a sports and folk park that uses rainfall to facilitate impromptu activities in a visible manner. In order to collect and reroute rainfall, ponds and canals are located between the sports buildings and around the edges of the football fields (Gladsaxe Kommune, n.d.). Figure 8,9,10, and 11 represents the rainwater detention and retention facilities in Gladsaxe Sportscenter.

Figure 8: Rainwater management in Gladsaxe SportsCenter (own Figure by author)

Figure 9: Skate Park with detention basin function in Gladsaxe sportscenter (own Figure by author)

Figure 10: Detention Basin in Gladsaxe SportsCenter (own Figure by author)

Figure 11: Retention Basin in Gladsaxe sportscenter (own Figure by author)

Marielyst, part of Gladsaxe Almennyttige Andelsboligforening (GAA), received a major boost in 2014 when it received a substantial climate adaptation project, which included the infiltration of rainwater. Rainwater from roofs and solid surfaces seeps into rainwater beds, ditches, and depressions on the housing association's property. As a result, the management of rainwater is evident from the surface, along with elements that encourage retention, detention, and mobility (Gladsaxe Kommune, n.d.). Figure 12 represents the use of raingardens in Marielyst.

Figure 12: Rainwater flows directly towards ranwater basin in Marielyst (own Figure by author)

Vandledningsstien in Gladsaxe was developed by Nordvand in 2013 which connects Høje Gladsaxevej and Vandtrnsvej / Tinghjvej by interconnecting rainwater basins. The basins have a capacity of 3,500 m3, and their top eight basins, known as the 'Meadows,' are equipped with wooden and earthen sides and collect rainfall at the basin's base. There are eight basins in the lowest part of the site, known as the Cascades, which have wooden sides and a constant water surface throughout the basin (Gladsaxe Kommune, n.d.). Figure 13 presents the Vandledningsstien in Gladsaxe.

Figure 13: Vandledningsstien in Gladsaxe (own figure by author)

Initially, Gladsaxe municipality relied on niche innovations in response to a changing climate. Niche innovations gained momentum from it and pushed through within the existing regime and became integral to water management. Climate change and other water management issues still putting pressure on the Water management regime. For example, it is estimated that 17 outlets in Gladsaxe Municipality discharge sewage overflow water (Novafos, 2021, p. 24). The following figure 14 illustrates the total number and volume of sewage overflows in the municipality.

År	Antal udløb	Antal overløb	Udledt vandmængde
2017	17	322	136.000 m^3
2018	17	200	45.000 m^3
2019	17	346	182.000 m^3
2020	17	225	154.000 m^3

Figure 14: Overview of number of outlets, number of overflows and discharged water volume in Gladsaxe (Novafos, 2021, p. 25).

This problem has been addressed by the Wastewater Plan 2021, which incorporated the decision that the entire municipality must be sewered separately. Over the next 35-40 years, a separate rainwater system is to be established throughout the municipality according to Wastewater Plan 2021 (Gladsaxe Kommune, 2021, p. 13).

It does not mean that Gladsaxe Municipality is done with climate change adaptation as it is a continuous process. The Svanemøllen Skybrudstunnel is a joint venture between HOFOR, Novafos, Gladsaxe, Gentofte and Copenhagen Municipalities to construct a new tunnel that would improve the drainage of rainwater and prevent sewers from overflowing during periods of heavy rainfall (Miljøstyrelsen, n.d.). It is anticipated that the cloudburst tunnel will consist of two tunnel branches: the Lygten tunnel, which will cross Ryparken and Svanemølle Barracks, will reach Svanemøllebugten, and the Nordkanalen tunnel, which will cross Dyssegrdsparken and Sholmslund to reach Svanemøllens Barracks, where it will reach Svanemøllebugten (Miljøstyrelsen, n.d.). The Svanemøllen cloudburst tunnel (SST) is the backbone of the cloudburst plan for the City of Copenhagen. The tunnel allows for the transmission of precipitation from Gladsaxe Municipality cloudbursts into the Sound. For several years, the tunnel will be able to serve as a retention tank for Gladsaxe's sewage until it is transported to treatment facilities. This will result in less sewage overflows into Utterslev bog and the Nordkanalen, resulting in improved water quality (Gladsaxe Kommune, n.d.).

So, it can be acknowledged that the cloudburst event was an agitating factor for the transition to SUWM in Gladsaxe, it created a window of opportunity as the landscape did put pressure on the regime that it was handled by niche innovations. As they have advanced into the next phase to climate change adaptation and due to the emergence of new problems, Gladsaxe is concerned with both environmental planning and climate adaptation. According to their activities in the past decade it is clear that they are determined that they will not wait for a new disaster to change the conventional approach to managing water.

6 Discussion

As a result of the earlier assessments of this report, presented in the preceding chapters, this chapter examines and comments upon those assessments. This project attempts to take a stance on the preceding analytical work and focuses mostly on describing the thoughts that emerged while performing the process.

6.1 Lessons Learned from Gladsaxe

Since, Gladsaxe is acknowledged as an example of innovative, sustainable urban development, it is interesting to analyse the lessons learned that may be applicable to similar initiatives and developments. In the next sections lessons learned from this case study on Gladsaxe Municipality about sustainable urban development will be discussed.

6.1.1 How Good is Gladsaxe In terms of Sustainable Urban Development?

There is a strong political desire for Gladsaxe to thrive and grow, which leads to the city's focus on climate adaptation. The objective of the municipality is to achieve a harmonious balance between urban expansion and wellbeing, as well as social and environmental equilibrium (Miljøministeriet / Miljøstyrelsen, 2020). Considering these factors, the municipality's ambitious climate adaptation activities are closely linked to its overarching political objectives (Miljøministeriet / Miljøstyrelsen, 2020). To answer whether Gladsaxe can be introduced as a leading example of sustainable Urban Development, Mathis Elle expressed:

"In a Danish context, they are one of the front runners" (Appendix 2- Mathias Elle).

To answer the same question Bo Brøndum Pedersen expressed his opinion by saying: *"It's in top five in Denmark" (Appendix 1- Bo Brøndum Pedersen).*

It has been the focus of Gladsaxe Municipality to deal with climate change-related issues for more than a decade. Gladsaxe Municipality takes the lead on climate and environmental issues as a public enterprise; however, they also rely on their residents and businesses to make climate-friendly decisions in the face of global challenges (Miljøministeriet / Miljøstyrelsen, 2020).

6.1.2 How Gladsaxe Became a Frontrunner in Climate Change Adaptation

This section will describe how Gladsaxe attained their current position as a frontrunner in terms of climate change adaptation. Throughout the many years that climate adaptation has been an ongoing issue for Gladsaxe City Council, and the municipality has consistently shown a deep commitment towards it (Miljøministeriet / Miljøstyrelsen, 2020). Although it is challenging to say when they first started using LAR and nature-based solutions for climate change adaptation, it is evident that they started quite early. This was the first steppingstone for Gladsaxe to become climate friendly.

Over the past decade, Gladsaxe Municipality has elected new mayors, but the focus has not shifted from adaptation to climate change and those who are responsible for the administration believe that this has been one of the significant factors contributing to the municipality's success in adapting to changing environmental conditions (Miljøministeriet / Miljøstyrelsen, 2020). Gladsaxe Municipality is striving to become a more sustainable city day by day. It is evident from the city's Wastewater Plan and the participation in ongoing climate change adaptation projects that this is the case (Miljøministeriet / Miljøstyrelsen, 2020).

Glasaxe Municipality and Novafos have collaborated on a variety of climate change adaptation projects in the past. From the projects that have been completed, it is evident that they have been working well together and are still doing so. However, finding the best solution was not an easy feat in this case. They were involved in innovative projects in the complex topographical area of Gladsaxe Municipality. There were many interrelated issues to be considered by Novafos and Gladsaxe Municipality. Mathias Elle said:

"When you make these solutions. There's a lot of things which you need to agree on. Who is responsible for what kind of service and maintenance. Where it's when you just make traditional piping it's very clear it's like you have done that for ages" (Appendix 2- Mathias Elle).

Novafos and Gladsaxe Municipality are both committed to addressing climate change. Bo Brøndum Pedersen shared his experience:

"It was great as everyone trusted each other so they were willing to take a little risk because they were believing in each other" (Appendix 1- Bo Brøndum Pedersen).

Public participation is significant issue in Gladsaxe for climate change adaptation, as it spreads awareness towards the citizens about climate change and the selected solution (Miljøministeriet / Miljøstyrelsen, 2020). Several successful climate adaptation projects have been implemented by Gladsaxe Municipality in conjunction with non-profit housing associations, with local enthusiasts acting as ambassadors (Miljøministeriet / Miljøstyrelsen, 2020). The ambassadors were bringing in fresh information and passing it on to others at the same time. This way people felt more closer to the projects and expressed their thoughts and problems (Miljøministeriet / Miljøstyrelsen, 2020). Bo Brøndum Pedersen acknowledged:

"Instead of talking with the public, then we were talking with their representatives, and they were talking with their neighbors and in in some way it's like they trust their neighbor more than they trust the policy so, but it works. By doing this they took the ownership of what's going on" (Appendix 1- Bo Brøndum Pedersen).

Almost of the projects in Gladsaxe required public participation and it was done intentionally. To establish LAR the municipality had to communicate a lot with the citizens, it's because of the nature of the solution was different and new and required public involvement to be fruitful. Bo Brøndum Pedersen stated:

"They also have an approach where they're talking a lot with the public. Because yes, these two goes together. Where we can look at the Copenhagen, it's that they make it big tunnels under the city and then they don't need to talk to people. So that's two different kinds of approach" (Appendix 1- Bo Brøndum Pedersen).

Although Gladsaxe Municipality is the co-owner of Novafos, Climate change adaptation in Gladsaxe is a combined effort between Novafos and Gladsaxe Municipality. Mathias Elle explained by saying:

"When I say they have done a lot, it's of course a collaboration because. It is our duty as a utility company to make these projects. But they have worked a lot on trying to make smarter solutions" (Appendix 2- Mathias Elle).

As the water utility company Novafos carries the burden of planning the climate change adaptation projects according to the municipal plans. Their goal is to find cost effective and service level solutions while working with the municipality, which is a challenging task to work

with. Mathias Elle also Expressed his thought on working with municipal plan and real-life situations:

"I don't think the plan in itself does anything which we cannot do so it's the interpretation of the plan in terms of the legislation. Even if the municipal plan say it needs to be green, they cannot dictate the solution we need to choose in practice, but we need to consider if is it cost efficient. That's where the collaboration begins" (Appendix 2- Mathias Elle).

It's a logical question that how finance works in the municipality. Gladsaxe has quite a few large-scale projects The financing of these climate change adaption infrastructures is also a big concern. Gladsaxe Municipality collects water tariffs to support a significant amount of climate adaptation programs currently in progress. To determine the amount of investment, the municipal finance department contributes to the process because the same residents are responsible for paying both the rate and the tax. Therefore, ensuring that an adequate amount of investment is made is essential. In addition, some of the initiatives are sponsored by a variety of partners, including housing organizations that don't seek financial profit. Mathias Elle Explained how it works between Novafos and Gladsaxe Municipality:

"You pay for the drinking water and when you pay for the drinking water, you also pay for the wastewater and rainwater. So, the tariff for the drinking water is the way to build all water management infrastructure and of course also the clean water infrastructure" (Appendix 2- Mathias Elle).

The municipality was required to pay 25 percent of the co-financing projects when the climate change adaptation plan 2014 was finally approved (Miljøministeriet / Miljøstyrelsen, 2020). Taking this information into consideration, the city council decided to finance its portion of the expenditures through an allocation of 25 million Danish krone spread over 25 years. The 25 million kroner budget was not spent, despite the numerous climate change adaptation projects (Miljøministeriet / Miljøstyrelsen, 2020). That's because of the water tariff, which provided sufficient coverage, in addition to additional sources of income from partners and Novafos was financing the climate change adaptation projects. Mathias Elle stated:

"The very ambitious projects in the past have been totally financed by the utility company" (Appendix 2- Mathias Elle).

So, it is clear that due to the climate change adaptation projects Gladsaxe Municipality never suffered financially and they have enough budget to implement on future climate change adaptation projects.

As a strategy for adapting to the changing climate, Gladsaxe Municipality relies on the collaboration of third parties and the involvement of all appropriate administrations as part of its adaptive strategy (Miljøministeriet / Miljøstyrelsen, 2020). Diverse initiatives can only be developed if multiple stakeholders contribute their time and expertise, facilitating the development of diverse initiatives. The team responsible for flood risk zone mapping was combined with Nordvand, several organizations and sectors of the municipality, the city planning department, the nature department, the traffic department, and the team responsible for climate adaptation and wastewater (Miljøministeriet / Miljøstyrelsen, 2020). As they had to work with different entities, the knowledge grew, and it reflected in the implementation stage. As it can be seen in the Gladsaxe Strategy that all six objectives relate to the SDG Goal 17 (partnership for goals). Gladsaxe has taken part in several projects with neighbouring municipalities like Gentofte, Herlev, Copenhagen municipality. They also worked collaboratively with many organizations such as Biofos, Hofor, Rambol etc.

The planning system of Gladsaxe Municipality is through and holistic. As they publish a new environmental plan it can be expected that it relates to the other existing plans which are related to environment. The new plan can be identified as the continuation of previous plan with set of new objectives, but the new plan will not be obstructive to any existing plans in any way. For example, Wastewater plans are part of the statutory planning hierarchy, which ensures that state, regional and municipal plans do not conflict with each other (Gladsaxe Kommune, 2021, p. 42). Gladsaxe Strategy, State area water plan, Municipal plan 2017, Water supply plan 2012-2024 and Action plans for groundwater protection are some of the existing plans that were incorporated in Wastewater Plan 2021.

An important part of sustainable synergy is to evaluate, assimilate, and make effective use of all aspects. This requires a coordinated effort among stakeholders, a synchronized approach to political activities, as well as appropriate technology use. As Gladsaxe has developed synergy between different sectors for different projects multiple time, so it can be stated that Gladsaxe is on the path towards sustainability and becoming a sustainable city. But the job is not done yet, Gladsaxe can be more than just a sustainable city. The next section will describe how and what kind of activities are suitable for Gladsaxe itself and other cities who can and want to follow the path of sustainability.

6.1.3 What Can Gladsaxe do now:

Taking on the role of a frontrunner in climate change adaptation and sustainable urban development, Gladsaxe has some new obligations to fulfil. By sharing their methods, experiences, and lessons learned with other municipalities and cities in other countries, they can inspire other municipalities. As a result of the large number of diverse competences and levels involved in Gladsaxe Municipality's responsibility, information exchange occurs both internally and externally. By participating in a project centred on the housing properties of a housing association, for example, a full housing association may be able to acquire knowledge about climate adaptation. By doing this Gladsaxe is targeting the population of a focused area, which is working for them, but they can always do more. On this note Bo Brøndum Pedersen stated:

"There are some silos that are sometimes difficult to find out who is handling what. Like What is a groundwater, what is rainwater. That's two different things. But when it's inside the ground, it's the same. I think that the next thing they should do was using their position as one of the top five and help changing the laws, they maybe should use a little bit more time and money on evaluating the project so they could tell others about good ideas" (Appendix 1- Bo Brøndum Pedersen).

It's true that large amount of Climate adaptation information can be found on the website of Gladsaxe Municipality. But all those information are in Danish, and this makes harder for someone from outside world to access required information. This way the flow of information becomes obstructed, and this issue can be solved rather easily by publishing plans and other documents in English.

6.1.4 SDGs as a framework:

In 2015, all United Nations Member States adopted the 2030 Agenda for Sustainable Development as a framework for peace and prosperity for people and the planet (United Nations, n.d.). A global partnership between nations, both developed and developing, is required to achieve the 17 Sustainable Development Goals (SDGs), which serve as a call to action (United Nations, n.d.). In addition to eradicating poverty and other deprivations, the goals are equally committed to promoting health and education, reducing inequality, and stimulating economic development, all while combating climate change and protecting our

oceans and forests (United Nations, n.d.). As described before that Gladsaxe Municipality incorporated SDG goals into its municipal plan. So, a question can be asked that how good SDGs as a framework is. According to Mathias Elle:

"It's a good framework to represent the green agenda and it's known by people and it's easier to explain" (Appendix 2- Mathias Elle).

Bo Brøndum Pedersen also expressed his thought on how SDGs work in real life, and what is the perspective of the professionals who works with them:

"If we want to plan a solution, we would do it as the same before. But now we are putting a number like number 9 or 17. Yeah, but that's only for communication for the outside. The arguments are the same as we had before. The only thing is just SDG goals help us as we now have a frame to explain it to people because all the engineers and the biologist we agreed in and made with ours. We need it for explaining it to others. So, it's only a framework for communication" (Appendix 1- Bo Brøndum Pedersen).

Finally, it clear that SDGs is a great framework for a holistic approach to climate change adaptation. But SDGs does not produce the solutions for the problems rather than showing a pathway towards sustainable transition and helps professionals to knowledge of sustainability.

6.2 What can Dhaka city learn from Gladsaxe:

At present, Bangladesh is a developing nation having just celebrated its 50th anniversary of independence in 2021 and Dhaka is the capital city where majority of development efforts are concentrated. The region has 23,234 inhabitants per square kilometre in an area of 300 square kilometres, making it one of the most densely populated regions in the world (World Population Review, 2022). There are more than 18 million people living in Dhaka and the surrounding municipalities, which are growing at an annual rate of over 4.2% each year (World Population Review, 2022). However, the rapid growth of development activities is causing considerable difficulties for local residents due to uncontrolled rapid development activities (JPZ-FCEA-SARM, 2016).

Dhaka is vulnerable to a variety of climate-related threats, such as temperature fluctuations, excessive and unpredictable precipitation, flooding, cyclones, and heat waves (Rabbani, et al., 2011). It is estimated that these natural disasters affect city life and livelihoods almost every year, which may intensify if non-climatic variables, such as population density, poverty, rural-urban migration, illiteracy, unplanned urbanization, and lack of public amenities and services, combine to intensify the impact. It is imperative for Dhaka to take immediate steps to mitigate climate-induced risks to ensure its long-term viability (Rabbani, et al., 2011). Moreover, enough low ground was available around the city, providing a water retention area citywide, in which surplus water could be stored temporarily and due to growing urbanization and unplanned construction, the water retention areas have been filled in, which has significantly reduced natural drainage capacities (JPZ-FCEA-SARM, 2016, p. xix).

Presently, Dhaka City's internal drainage system consists of storm sewer lines, surface drainage, and open channels (locally known as Khals) that carry rainwater and a portion of the city's wastewater to nearby rivers. In urban areas, many open channels play a crucial role in providing stormwater drainage (JPZ-FCEA-SARM, 2016, p. xix). In total, there are 45 natural khals within the open channel system, which span approximately 142 kilometres (JPZ-FCEA-SARM, 2016, p. xix). Apart from the open waterways and lakes, the Dhaka stormwater system is composed of around 380 km of storm sewer lines spanning approximately 140 square

kilometres. There are 8.75 km of box culverts under DWASA covering 40 percent of the city's area (JPZ-FCEA-SARM, 2016, p. xix).

A variety of stormwater drainage problems and obstacles are now confronting Dhaka, such as indiscriminate land development, ineffective political support, lack of public awareness, etc (JPZ-FCEA-SARM, 2016, p. 43). However, as the first lesson from Gladsaxe Municipality, Dhaka should focus on regular planning about different agendas.

Gladsaxe Municipality's city council developed, updated, and implemented several plans that were instrumental in guiding the municipality's development. On the other hand, In 1959, the first Master Plan for Dhaka was established and it expired in 1981 (JPZ-FCEA-SARM, 2016, p. 63).The city of Dhaka had virtually no proper plan until 2010, and as a result of the absence of a city's master plan in the last 30 years and the weak monitoring system of the development authority, Dhaka grew haphazardly during this period of intense growth pressure, filling in approximately 270 square kilometres of wetlands in and around the city (JPZ-FCEA-SARM, 2016, p. 63). At present days, there has been a significant backlash to this whole issue caused by indiscriminate land development and city planning. So, Dhaka's urbanization-related problems can therefore be attributed to a lack of proper planning and regular planning. Providing frequent planning, updating existing plans, and proper execution is the only way for Dhaka to avoid slipping into a dangerous position.

Since Novafos is responsible for water management in Gladsaxe Municipality, it is evident that it has always achieved its full potential as the sole provider of stormwater and drinking water services. In addition to the Dhaka Water and Sewerage Authority (Dhaka WASA), other institutions cannot be ignored in managing stormwater drainage in the city and other agencies involved in drainage concerns in the DMP area include DCC, RAJUK, BWDB, and Cantonment Board (JPZ-FCEA-SARM, 2016, p. 49). Multiple actors present a challenge in terms of synchronizing their efforts across various projects and creates silos as who is responsible for what. The Gladsaxe Municipality has a strong political and administrative commitment to climate adaptation integration and water management. In contrast, even though the solution to the drainage problem of Dhaka city is extremely important to its residents, it has been unable to capture the attention of policymakers since the city was established (JPZ-FCEA-SARM, 2016, p. 51). The adoption and implementation of drainage legislation require political support, and in order to strengthen their support of development efforts, it is necessary to unite political leaders and organizations (for example, Dhaka WASA, DCC, RAJUK, BWDB, etc.) under a single banner (JPZ-FCEA-SARM, 2016, p. 51). It is, therefore, possible for political leaders at the highest level to inspire them by taking the initiative.

People in Dhaka often dispose of their garbage in neighbouring drains, clogging the entrance, and preventing rainwater from reaching the main drain (JPZ-FCEA-SARM, 2016, p. 53). Similarly, to how solid trash is disposed of, building materials are disposed of in a manner that causes severe blockage of inlets, resulting in regular flooding of city streets and this is a clear indication for lack of public awareness (JPZ-FCEA-SARM, 2016, p. 53). So, it can be expressed that Gladsaxe is far ahead from Dhaka in terms of building public awareness. During the implementation of any project, Gladsaxe establishes clear communication between public representatives, municipality and the actors connected with the project. It makes a level playing field for everyone and creates smooth flow of information towards the citizens, this process makes the plan implementation more fluent and uninterrupted. Therefore, it can be affirmed that the establishment of an efficient drainage system in the city of Dhaka necessitates social awareness since they have fallen far behind.

From the above discussion it is not fair to compare between Gladsaxe Municipality and Dhaka City. Gladsaxe started early and they are way ahead now, their success depended on multiple sectoral integration which created a holistic approach towards sustainability. Dhaka can follow the footsteps of Gladsaxe as have done a lot to adapt with the changed climate and their activities are clearly inspiring so Dhaka can be inspired and start with something, may be small scale. As Bo Brøndum Pedersen expressed his opinion on this matter:

"You can always do something. By sum just if you talk together about when you are working on the roads, you can talk about if you take some water out, use it for something else. Our normal system saved us for 100 years. So, we are going to change one percent. So, let's do it in a smart way, just we must make it a normal thing" (Appendix 1- Bo Brøndum Pedersen).

7 Conclusion:

As described in the beginning of the project the water is the basis of life on planet earth, thus water management is a highly significant matter. When the water management sector goes through sustainable transition to restore the balance in the natural hydrological cycle then it becomes rather complicated. During the sustainable transition of urban water management, a wide set of actors such as government, utility company, citizens, different organizations take part in the process. It has been observed that the transition process becomes more intricate as the actor network grows. A sustainable transition requires wise utilization of resources, prudent investments, technological advancement, as well as several adjustments to regular practices to overcome its complexity. Therefore, it also represents other aspects of sustainability that relate to water management. In this thesis, the main objective is to identify what is the current phase of urban water management in Gladsaxe Municipality, what was the previous phase and why the transition occurred. The answers were found by analysing Gladsaxe's water management according to Urban Water Management Framework by Brown et al. (2009) and multi-level perspective by Geels (2002).

According to Brown et al. (2009), Gladsaxe Municipality possesses most of the attributes of a Water Cycle City state, as well as a few attributes of a Water Sensitive City state. Geels (2002)'s multilevel perspective led to the discovery of a niche innovation (LAR, NBS) that was being implemented within an existing regime (water management) in Gladsaxe Municipality. Ultimately, as landscape (climate change) did put pressure on the existing regime of (water management) for transition, the niche (LAR, NBS) gained momentum and became a part of the regime due to widespread application.

In the end, this case study revealed a riveting picture of Gladsaxe Municipality's SUWM program. In the past decade, Gladsaxe Municipality have been able to achieve sustainable development through climate change adaptation in different parts of Gladsaxe. Their environmental goal, sector integration, and ambitious projects have allowed them to be a pioneer in climate change adaptation in Denmark. This is a result of their unwavering focus on climate change adaptation, and not being sceptical about innovation. This should serve as an example to other cities as climatic changes require us to adapt our way of thinking as well.

8 Reflections

In this section, thoughts and assessments are presented regarding the project's work process and outcome, leading to viewpoints that could be utilized for future research.

8.1 Initial Process

The project centred on sustainable urban development in terms of instituting sustainable urban water management on a city scale. The Gladsaxe Municipality's climate change adaptation effort in Denmark is well-known. This was the primary reason for concentrating on Gladsaxe to comprehend the concept of sustainable urban development in a Danish context. As with every other effort, this initiative also encountered obstacles. The biggest problem was the failure to establish contact with the municipality, after several attempts it resulted unanswered emails, referral, and refusal to engage in interviews. Several planning documents produced by Gladsaxe Municipality were examined to overcome this difficulty and get the viewpoint of the municipality. As the majority of the papers are written in Danish, Google Translate was used to convert them to English. This method was time-consuming, and the translator did not always provide the desired output. In the end, interviews with a current and a former employee of Novafos greatly reduced the knowledge gap about sustainable urban development in Gladsaxe.

8.2 Further Research

The geography of Gladsaxe Municipality varies from location to location, and half of the municipality has been designated as flood-risk zones. Using a mix of LAR and nature-based solutions, Gladsaxe developed many pilot projects to comply with the essential climate change adaptation and water management. It would be fascinating to know, via site-specific research, how these solutions were embraced and how they are performing in terms of projected outcomes. The aim of this project was the whole municipality. As other municipalities, such as Copenhagen and Frederiksberg, are also participating in climate change adaptation, this project's methodology may be used to comprehend their views and the rationale for their efforts to adapt to climate change.

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