Models for Green Stormwater Management as the driver force for a districtwide sustainable development.

Comparative case study research of Water Sensitive Zomerhof / Agniese (Rotterdam) and Augustenborg (Malmo) Eco-districts.

Abstract:

Over the coming decades, climate change will be a strong threat on our planet. This threat, caused by urban density and human consumption, means greenhouse emission, floods, and desertification, etc. Many planners and urban designers develop urban strategies to build stronger cities, which can cope with future disasters and can provide greater capacity for resilience. One of the several issues affecting cities is the change in flood pattern. This is influenced by natural and socio-economic trends as well. This paper focuses on the special part of sustainable development practices that through the collaboration of community members and design leaders create innovative solutions for social and ecological issues in Eco-districts. In these cases, participation plays a vital role in raising awareness against climate risks. Green stormwater management in Eco-districts is one of the resilient solutions to increase districtwide green sustainable performance. Consequently, managing stormwater will have a positive effect on biodiversity by growing vegetation around small canals and watercourses in the urban landscape of the neighborhoods. The aim of the research is to investigate the strategy of stormwater management at the neighborhood scale and to compare the two identified case studies in two different cities in Europe Rotterdam and Malmo. It reveals how they use similar green strategies and how they are different in mitigating the flood effect. Moreover, it examines the positive impacts of social infrastructure in the two projects. Obviously, both Eco districts are regarded as sustainable design projects that conserve and reuse potable water and provide relief for stormwater runoff through natural drainage systems. Meanwhile, they differ in project objectives as well as final outcomes. The method of the research is to make comparative analysis of the two projects and the measures of positive impacts on social resilience is used as well. The conclusion of the paper is to provide recommendations for cities and neighborhoods, that are willing to implement Eco districts and achieve sustainability within their communities.

Key words: Eco-district, Resilience, Biodiversity, green stormwater management

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1.Introduction

How can the city be climate proof?

The answer to the question can be found when taking attention to how human body is always resilience to the external environments. The city functions like human body. Buildings act like the organs of our body. The green areas and paths act like lungs by its important rule to cleaning the city environment and providing oxygen. While the roads act like veins and arteries that control the traffic for people and goods movement. the body have senses which tell the body what happen in our environment and inform him how to get the body to adapt when whether is hot or cold. "*Perhaps the first person to do so was Karl Marx, who as early as the 19th century was employing this term to describe how humans were extracting materials and altering natural landscapes in unprecedented ways. Marx observed that humans were in the process of colonizing nature and rapidly "metabolizing" its resources*". *"Urban metabolism is not only a powerful metaphor for better understanding our urban systems, but also the fundamental framework we need for accelerating the transition to sustainable cities*." [1]. These thoughts lead planners, researchers, and city leaders to "*create more ecological opportunities for the city population and helping out the country with its commitment to cleaning and restoring its environment and diminishing its global environmental footprint*" [2]. As a result, it's important to take the responsibility to act like the senses to our cities to support the economic and social co-benefit for climate adaptation.

This scientific literature reviews the basic background about the sustainability concept and its relation to the climate change. Then introduce one of the urban climate change solutions that is called Eco-district. The concept, goals and implementation of the Eco-district tools is explained with two case studies, one of them is ZOHO district in Rotterdam city, Netherland and the other is Augustenburg neighborhood in Malmo, Sweden. The two case studies are analyzed in terms of the process of development, public spaces and the social infrastructures and green storm water management implementation. These two projects are used as case studies subject due to its important role in helping their countries to clean and restore their environment. Not to mention the promotion of these two districts into an attractive beautiful place for inhabitants. A final set of discussion in the conclusion will summarize and compare the positive impact between the two study cases.

1.1 Sustainability and changing climate over review:

Sustainability has a historical background in term that started from the 21st century. "*The name sustainability is derived from the Latin sustinere (tenere, to hold; sub, under). Sustain can mean "maintain," "support," "uphold," or "endure*" [3]. Sustainability is not a term, but also is an idea that theorist in urban design and planning associated with the city needs "*From the beginning of the sustainable concept by the world's great theorists and authors in ecological city design and planning Richard Register. the first coined the term "ecocity" in his 1987 book Ecocity Berkeley: Building Cities for a Healthy Future*" [4] to "*2020 book The Galápagos Islands: Evolution's Lessons for Cities of the Future. sustainability has the capacity to endure or continue and has to do with preserving or maintaining resources* "[5]. The reason behind the sustainability concept, which was adopted by the advocators, is to increase the level of pollution in cities. Not only the

cities, but also the whole world is globally affected with the increase of industrial consumption and higher density of population.

Now, what is the link between the climate change and sustainable development? This question was answered by Christiana Figueres - UNFCCC Interview 3rd February UNRIC *"they one in the same, you can't have development that is sustainable in the long term. If they work consistently be affrighted by natural disaster, that could wipe out to 3%GDP that already seen last year. You can peruse development that sticks unless you address the climate change and begin to mitigate that. She also summarized that ''they are actually about the same process and they are moving in the direction of society that we actually need''.* [6].

Global example that happened in Europe over the past 150 year caused change population due to the flood affects. The result of the study represents that "*Between 1870 and 2016, Europe experienced substantial growth in population (130%), urban area (more than 1000%), and wealth (more than 2000% constant prices). However, there has been large variability in patterns of development between regions. In 8% of European regions (NUTS 3), the total population in 2016 was lower than in 1870. Rural population across the continent declined, and fixed assets in agriculture barely changed in contrast with large increases in wealth in the housing, industry, and services sectors*" (Supplementary Fig. 1).[7].

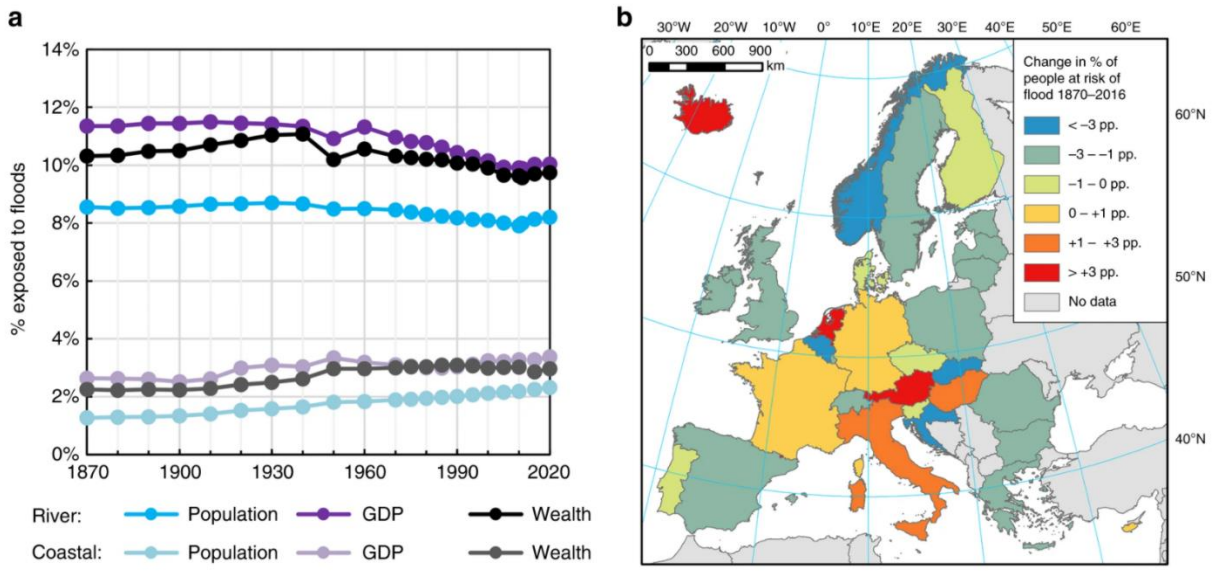

Figure 1/Trends in flood losses in Europe over the past 150 years/https://www.nature.com/articles/s41467-018-04253-1/figures/1

Percent of the population exposed to the 100-year river and coastal flood in Europe

(a) change in population exposed to floods from 1870-2020
(b) in percentage points, to the 100-year flood (either river or coastal) in each country (1870–2016).

1.2 Eco-district definition:

To illustrate the starting point of the Eco-district concept, it is important to mention that the Eco-district focuses on the community interaction beside climate adaptation planning strategy at the neighborhood scale. The other meaning of Eco-district is "*a neologism associating the terms "district" and "eco" as an abbreviation of ecological. It designates an urban planning aiming to integrate objectives of sustainable development and social equity and reduce the ecological footprint of a neighborhood, urban area, or region. This notion insists on the consideration of the whole environmental issues by way of a collaborative process"* [8]. As a result, the community will take the ownership to drive the neighborhood future vision in a better way. This shows us that the Eco-district is not just a concept but also a development practice. To clarify the importance of social interaction the famous American- Canadian journalist Jene Jacobs "As a mother and a writer who criticized experts in the male-dominated field of urban planning," [9]. She has been inspiring healthy and thriving cities in neighborhoods. in one of her books mentioned "*cities have the capability of providing something for everybody, only when they are created by everybody*" [10]. Eco-district has an emphasize on equity, it's distinguished form other sustainability ideas. The way people live together, sharing, participation, and collaboration, etc.

Another definition can be described as neighborhoods or inhabitant that have plans of both physical benefits like social collaboration, as well as community requirements such as foods, energy, water. Meanwhile the terms can be explained as" *district and neighborhood are used interchangeably. Both refer to a scale that is the planning unit of modern cities with spatially or community-defined geography. Boundaries may include neighborhood or business association boundaries, urban renewal areas, local and business improvement districts, major redevelopment sites, watersheds or geographic demarcations, as appropriate*".[11]

Many studies and practices have been used to identify the goal of an Eco-District. Which is to translate the updating version of traditional sustainable concept through community members, institutions, city leaders, and socialist experts, etc. Consequently, the city will establish social resilience that can live in sustainable living conditions. Beside this, these adapting strategies could build affectively vibrant neighborhood, smart cities, and healthy environment.

Other studies and articles tried to investigate the main idea of its protocols. Eco-district has significant rule in urban sustainable performance. "*The Portland Sustainability Institute (PoSI) launched Eco-Districts in 2009 as an initiative to help cities remove these implementation barriers and create an enabling strategy to accelerate neighborhood-scale sustainability*". *Success requires a comprehensive approach that includes active community participation, assessment, new forms of capital and public policy support. District-scale projects, such as district energy, green streets, smart grid, demand management and resource sharing, are well known. However, the*

widespread deployment of these strategies has been slow to develop due to a lack of comprehensive policy or implementation frameworks at the municipal level .

Eco-district protocol referred in" *2009 formerly Portland sustainability institute established as a beginning to help cities remove these implementation barriers and create an enabling strategy to accelerate neighborhood scale sustainability. Success requires a comprehensive approach that includes active community participation, assessment, new forms of capital and public policy support*".[12]

In brief, Eco-district as a definition has various sorts of thinking to update sustainable and social association toward the city requirements. As a result, the city can be capable to be resilience against unexpected natural threats. It's the right scale to simulate the city improvement. Moreover, to innovate enough in considerable impacts for current situation and for the new vision of the cites.

1.3 How the green stormwater management are climate mitigation strategies for districts?

To answer this question. It is worth to mention the initial of Eco district elements that respond to the local needs for sustainable neighborhood development." *The substance of your Eco district plan can be broken down into various focus areas that match your community's particular needs. The focus areas of your plan should ultimately address improving quality of life in your community. They can be decided on at a community meeting, after collecting data about what community members most value, in collaboration with community members and professionals during the initial planning phase. They serve as concepts that will be further broken down into more specific goals, targets, and actions" [13].*

The most important elements among Eco-district elements can be summarized by the following see figure (2):

- **Equity**: this type of development concern on general inhabitants demands by education improvement, affordable housing, health and wellness, and equity in development.

- **Habitant**: as an implementation of development strategy to improve the biodiversity and landscaping.to attain the intensity of green environment.

- **Energy:** this kind of strategy fucuses on the reducing the total energy by using the renewable energy consumption. Thus, it leads to mitigate the effect of greenhouse emission, and reaches the efficient district energy system.

- **Transportation:** this sort of strategy is to decrease the co2 emission form vehicle energy impact on environment. Through encouraging walking, biking, ride sharing.

- **Stormwater and water:** they are an important implementation system for adapting strategy to prevent the natural threats like flood, heavy rainfall season .By using local materials and smart technologies to conserve the recycled water from rainfall season, creating artificial lakes, splitting the sewage system, and applying the drainage system to water the plants.

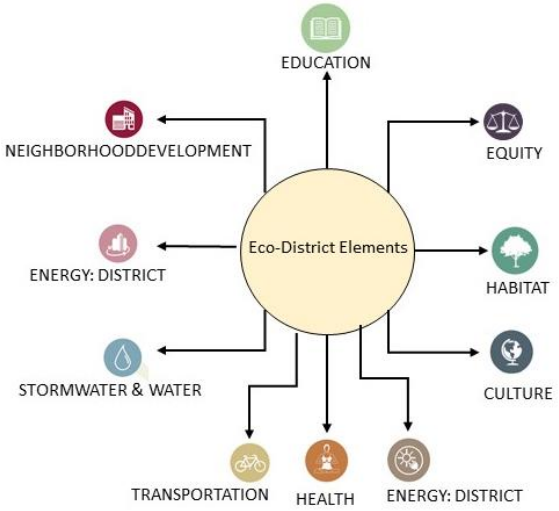

Figure 2/ Eco-district elements made by author. Based on https://ecodistricts.org/wp-content/uploads/2013/03/EcoDdistricts_Protocol_Executive_Summary_ISSUE_6.242.pdf

In fact, stormwater management is considered as one of the efficient strategies that diminish the climate change threats. Since many cities have suffered from flood threat due to the geographical positions. Several practices from different cities adopted green water management. They realized the noticeable reduction of their environment, and they have made robust system, greening the environment, and to create attractive social activity. Some examples can be as an important evidence, like the pictures below:

Figure 5Green Alleyway Project- Detroit, MI/Source: livinglabdetroit.com

Figure 4Wetland-Greenworks Philadelphia, PA/Source: Green Infrastructure: A Landscape Approach

Figure 3Rain Barrel-Lancaster, PA/Source: lancasterconservancy.org

2. Case studies

Chapter one:

2.1 Water Sensitive Zomerhof / Agniese district (Rotterdam)

Figure 6/Rotterdam allotment garden © Amar Sjauw EWa/https://www.urbangreenbluegrids.com/projects/water-sensitive-rotterdam/

project background:

Before describing the project development as a primary flood protection, it's worth to mention that the flood issue in Rotterdam city generally has occurred during the rainfall season. Rotterdam traditionally focused on flood protections, by building bikes.

"*Before the Middle Ages, when people started building dikes, it was common practice in low-lying areas to build on man-made mounds or on ground that was naturally higher than the surroundings. Yet when people began to intensively use and build on lowlands as well, the switch was made to use dikes as primary flood protection. Exceptions to this are the harbor areas found in many historic towns, which lie outside the dike walls and are raised in their entirety*" [14]. A report that is written by(Dirk van Peijpe) in Apr. 16, 2018 on strategies of open spaces and urban adaptation page (59-66) illustrated that "*In 2013 De Urbanisten were invited to support the city of Rotterdam to develop their Rotterdam Climate Adaptation Strategy. Rotterdam is situated in the Dutch delta. The city has a long tradition of continuous adaptation of the city to new hydrological circumstances. This resulted in a robust system that keeps the delta city dry and safe. The maintenance and improvement of this system of dikes, open water and sewers is the starting point for a climate proof Rotterdam*" [15].

The map below, figure (4) represent the geographical position that is situated at the mouth of Nieuwe Mass channel leading to the Rhine-Meuse-Scheldt delta at the North Sea.

Figure 7/vector map of the city of Rotterdam, in South Holland, Netherland https://www.123rf.com/photo_97451130_stock-vector-vector-map-of-the-city-of-rotterdam-in-south-holland-netherlands.html

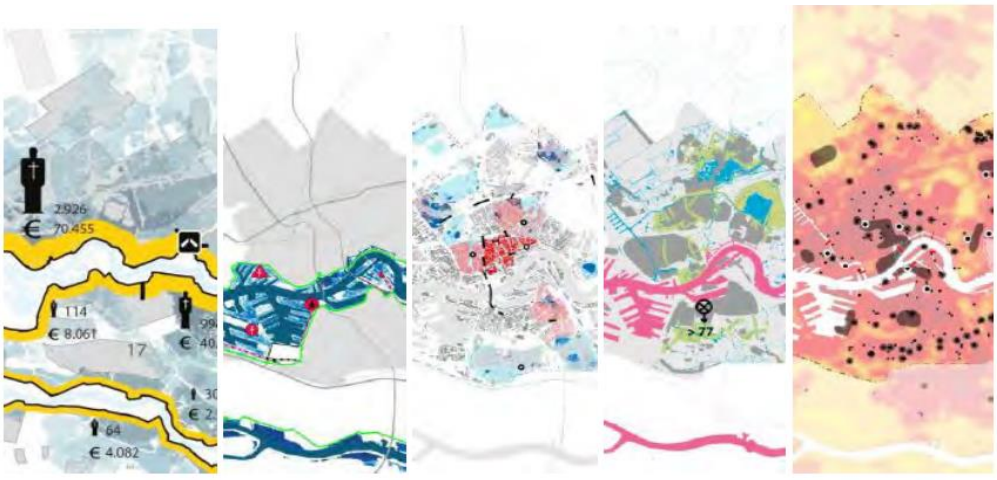

Figure 8 / RiskRotterdam_©DeUrbanisten source: http://www.freiraum.or.at/gisa/download/Publication%20Urban%20Densification%202018

The figure (8) represent Rotterdam city risks that influenced by the flood.

The project has long term vision from 2001 and it's currently ongoing. Most of the introduced planning strategies by participating the teamwork DE URBANISTEN are implemented. The district is mainly situated in Rotterdam, NL. The client of the project is the Municipality of Rotterdam that related to knowledge of portal, Spatial Adaptation (Ministry of infrastructure and Environment) Valorization program Delta technology. Regarding the elaboration of the comprehensive idea of ZOHO climate change adaptation strategy. "*As a delta city, Rotterdam is vulnerable to climate change. Rainfall intensity, river drainage and sea level are changing. This in combination with continuing growth and city density increases the risks. This calls not only for new measures but above all a different vision of water management. In this respect Rotterdam has been in transition for 15 years now. A wide range of plans and programs reflect this development: starting with the first Water Plan (2001), the Water City 2035 Vision (2005), the transformation to the second integrated Water Plan (2007), the Rotterdam Climate Proof Program (2008), the Rotterdam Adaptation Strategy (2013), the recently-launched Resilience Program(2014) and the Water Sensitive Rotterdam Program (2015) completes the journey*" [www.resilientrotterdam.nl/en/] [16].

The figure below, shows the comprehensive scheme of water management and flood system protection. All the engaged stockholders improved the system which goes back to the previous centuries, by implementing smart technologies. To ensure, the inhabitant can depend on this promote system in the current days and in future.

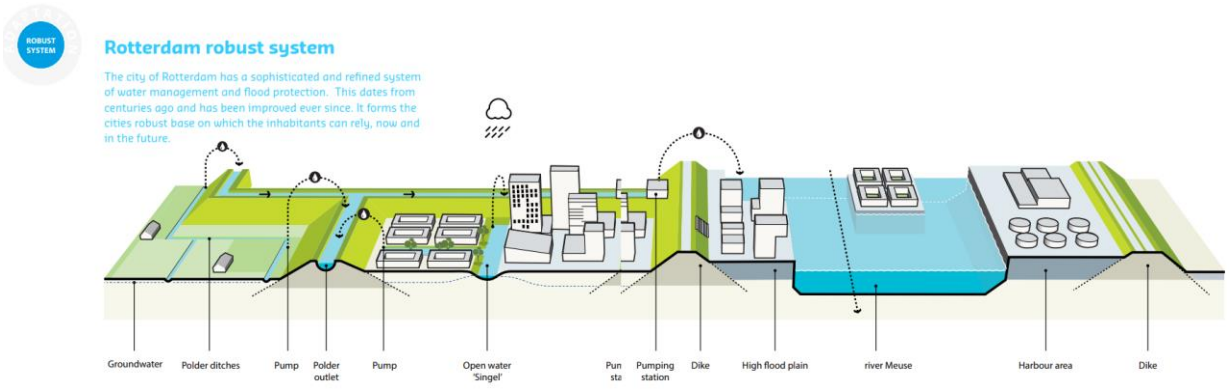

Figure 9/comprehensive strategy Scheme showing the robust system of water management and flood protection in Rotterdam

The project objectives:

Since the Around Molennar the chief resiliency officer by becoming the partner in the prestigious 100 Resilient Cities network. The city of Rotterdam has different objectives to continue this ambition. Creating experiment places, sharing knowledge on climate adaptation, and using the up to date technology to make the life smart and easy to face the technical problems.
"*Water Sensitive Zomerhof / Agniese district is a collective name for several simultaneous projects within the districts Agniesebuurt and Zomerhofkwartier in Rotterdam. They compose a complete*

strategic vision on How to make the district 'water sensitive' and focusses on two concrete themes. On one hand they seek for fruitful combinations of public space redesign of the street network and an overall sewage renewal. On the other hand, they seek for successfully combining urban renewal of private domain and climate adaptation of one large housing corporation, within three different urban block typologies that can be found in the district" [16].

"*In altogether of its plans and projects, the objective of Water Sensitive Rotterdam is to make the city a better place to live and to promote social cohesion in addition to climate adaptation. For example, WSR contributes to the resilient city. The central question for Water Sensitive Rotterdam is therefore how the various municipal services can be motivated so that in every urban plan and project, water management and climate adaptation is considered. WSR tries to introduce the principles of climate policy in every plan while remaining flexible*" [17].

Three urban block typologies are:

1. A complete circular water system for the district:

> "*When examining the large scale of the entire city one can see that water scarcity and abundance are two sides of the same coin. The district has good infiltration conditions and could therefor store water when there is too much and reuse it when there is too little. We define a strategy in which the district holds 100% of its rainwater locally. To do so a series of interventions must be done that can be executed in time and connect to each other in different ways. First a water sensitive public space framework must be laid out in which water can be collected, retained, and stored locally. Secondly the private domain must hold -and preferably reuse- a substantial amount of its own water. And thirdly some special case must be implemented to connect the large underground system to the open water and to the public domain. The water square Benthemplein be the first showcases in this strategy*" [18].

2.Water sensitive streets:

> *Between 2016 and 2018 the municipality of Rotterdam plans a complete renewal of its sewer system in the district. This is a -not to be missed- opportunity to combine this with a smart water sensitive redesign of its street network. We developed a toolbox of water sensitive measures that can be combined in reprofiling streets, so that it makes a storm water sewage system superfluous. The sewer system then only needs to be used for the transportation of black water from the buildings, meaning it can be smaller and does not have to transport large amounts of rain to a storage location when a peak event occurs. Reprofiling streets into water sensitive streets then equals:*
>
> • *Storing all rain water locally, including peak events*
> • *Being cost effective and even cheaper than placing new subterranean sewage pipes*
> • *A chance to upgrade and improve public space quality*
> • *Greening the district substantially*

• *Creating a climate adaptive solution at the same time (cooling the stony urban fabric)* [19]

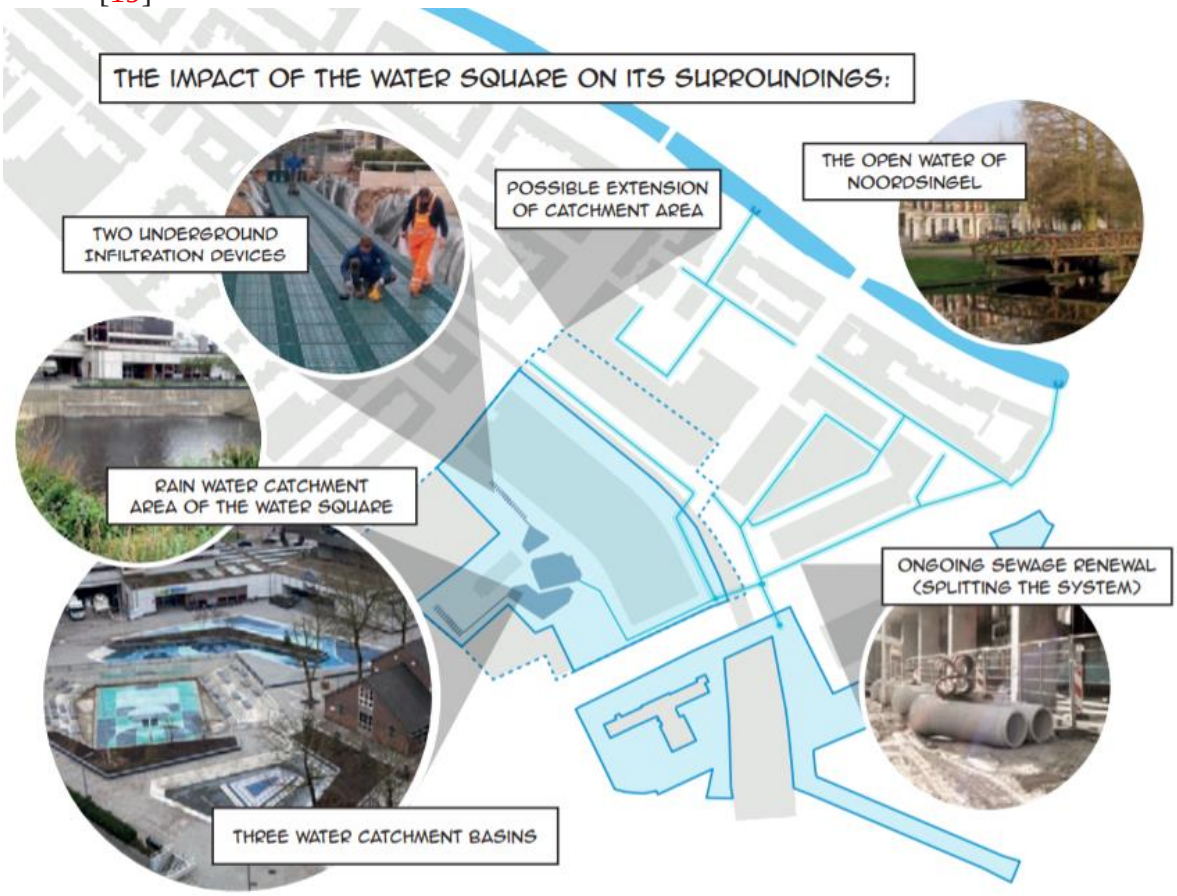

Figure 10/ map represent the water square impacts on the surroundings/book of Rotterdam adaptation strategy

Increase buffer capacity:

"*Heavy rain events are a serious problem in the city of Rotterdam and especially in the city center and in prewar districts. This applies to the entire ZOHO district. With the realization of the water square, a substantial part of the overall temporary peak storage has been taken care of. On a more local scale though, many places in this district have very little infiltration capacity and open water is situated too far away to be of immediate relief for buffering peak rain events. The existing mixed sewerage system also has limited capacity. This system currently is being replaced in large parts of the district by an improved split sewerage system. This will create the opportunity to combine precise adjustments in public space with new underground works. Decreasing the large number of impervious surfaces is a generic ambition that can be elaborated further in ZOHO. Overall, we aim for a more complete water management system that stimulates a rich diversity in public, semi-public and private spaces at the same time* ". As the below fig.

Figure 11/ Present situation of permeability and rain proofing ZOHO/www.urbanisten.nl/wp/?page_id=508

Decrease effects of drought:

"In between the extreme water. When exposed to air for long periods of time, they will start to rot and lose their constructive rain events, longer periods of drought occur. This happens in summer and in wintertime and causes a serious threat to the wooden foundations of 19th century buildings along Noordsingel and in the Agniese district. These wooden poles must be permanently under function causing serious threats for the future safety of the inhabitants of the buildings that rely on these foundations. Also, many species of trees and plants will suffer from longer periods of drought and lower ground water levels. Keeping rainwater that falls within the area and preventing it to be pumped out or drained away is one immediate measure that can be taken to keep ground water levels at pace and decrease the immediate effects of longer periods of drought"[19].

Figure 13/plans shows the drought mitigation diagrams /book Rotterdam- Climate Change Adaptation Strategy / http://www.urbanisten.nl/wp/?page_id=508

Fighting heat stress:

"*Most cities have a lot of hard surfaces in between buildings that have the tendency to heat up fast when the sun shines and temperatures rise. Because the heat is captured in these spaces, a cumulative effect occurs, causing health problems for vulnerable groups like elderly and sick people and productivity loss in the working population. The presence of shady places, sheltered water, soft surfaces and trees have proven to be effective remedies. Furthermore, it is important to prevent the use of air conditioning in buildings because these tend to heat up public spaces substantially during hot days, causing even more heat stress to the city*".

Figure 14/fighting heat stress management plans strategy / book Rotterdam- Climate Change Adaptation Strategy/ http://www.urbanisten.nl/wp/?page_id=508

Softening the surface, decreasing car dominance:

"*One immediate measure that can be taken in order to effectively decrease the negative effects of all three previously mentioned climate challenges, is to replace hard impervious spaces for more soft and green spaces. We call this 'depaving'. This will increase the infiltration capacity and make a positive contribution to keeping ground water levels at pace, cooling public space, and increasing storm water buffering capacity. The possibility to depave the area is an important key to success. Especially in the southern part of the ZOHO-district an abundance of underused hard surfaces can be found. Space for parking cars dominates the public realm while repeated counts show that less than 50% of the parking places on average is being occupied. Changing car parking into pedestrian parks will be a leading principle for climate proofing the district*'s.

Figure 15/Figure 11/Overview of all parking spaces and their occupation rates/http://www.urbanisten.nl/wp/?page_id=508

A great place to experiment with slow urbanism:

"*One of the main drivers for the changing use of public space is the slow urbanism movement in ZOHO. A new way of city making takes place here, with a focus on re-programming the existing urban fabric and a bottom up approach to planning. Instead of workers coming by car disappearing into anonymous office buildings, the place is being populated by a diverse group of urban users that mainly come by bike and inhabit the urban space as lingering pedestrians. There is a lot of creative energy in the area with great potential to experiment on all different levels. Currently, almost every week there is something to do in or around the Yellow building* "

Figure 16 / the result of new bublic space/ www.urbanisten.nl/wp/?page_id=508

Figure 17/ view of water squares after implementation/ photo by :pallesh + azarfane

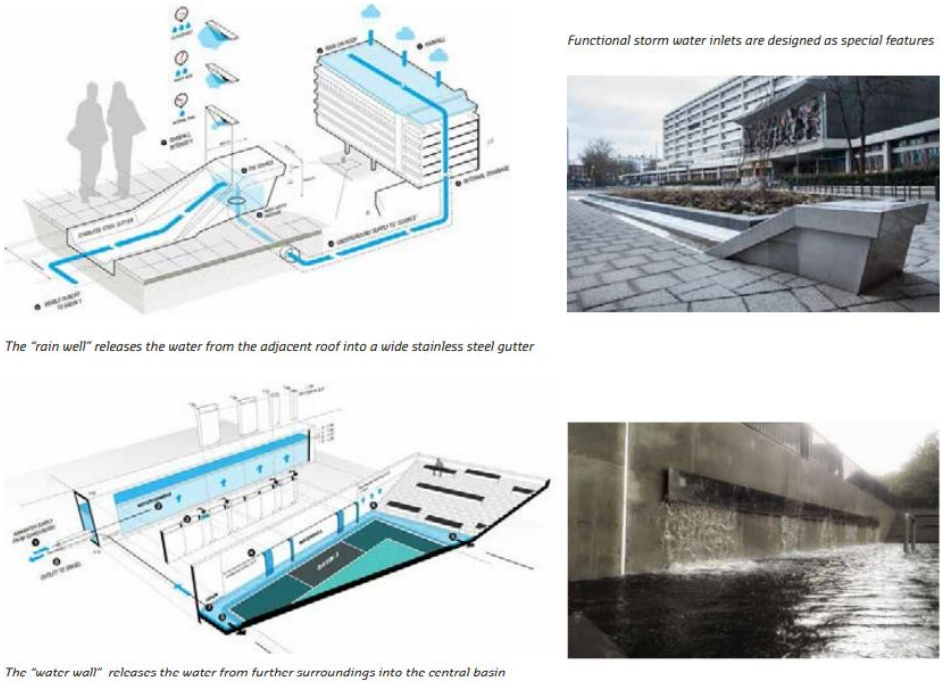

Figure 18/perspectives of functional storm water set inlets/

Figure 19/The central basin after a serious cloudburst in August 2014

POLDER ROOF:

"*The Polder roof project proposes the transformation of the roof of the 'Katshoek' parking garage into an attractive green roof that stores and reuses rainwater from the nearby buildings in a controlled way. The Polder roof takes the rainwater out of the sewage system and into the ZOHO-raingarden to infiltrate. It also is a collective place for urban agriculture, everyday recreation, and small outdoor events. By doing this, the Polder roof adds new social, economic, environmental, and ecological values to the ZOHO district*" [18].

Figure 20/Polderroof Plan; the roof is both an attractive community space for ZOHO and an innovative storm water storage facility

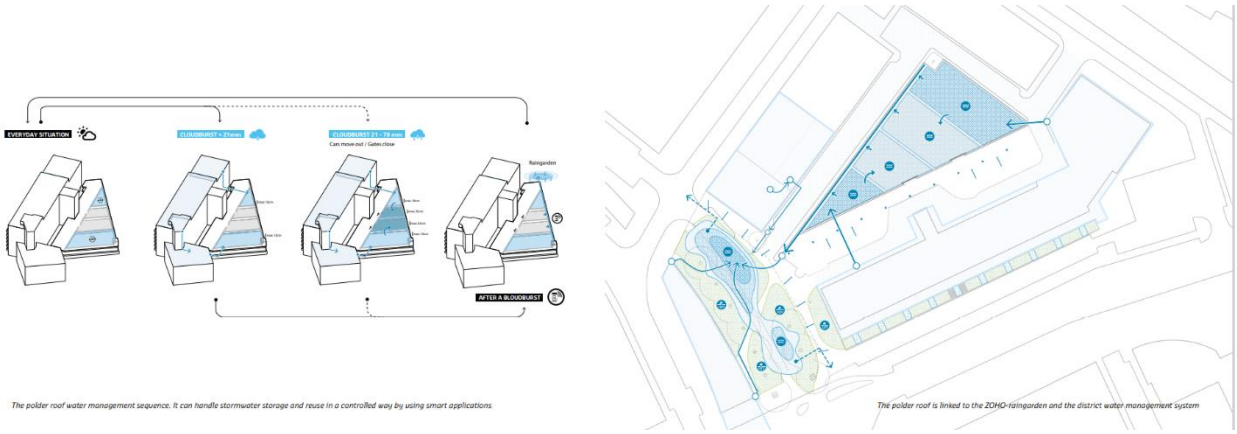

Figure 21/The polder roof water management sequence. It can handle stormwater storage and reuse in a controlled way by using smart applications

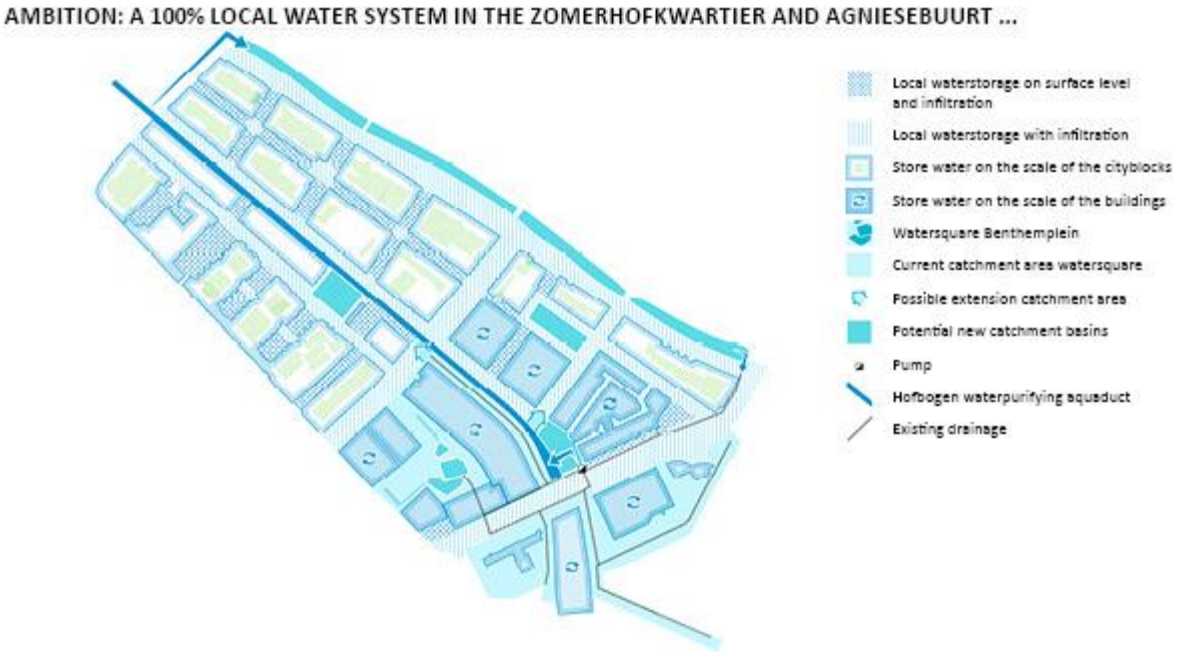

Figure 22/map diagram with legend for managing local water system in ZOHO district

To sum up the project, the previous case study of ZOHO district in Rotterdam city, shows an excellent result through the diagrams of development procedure, the actual pictures were taken during and after execution, development of old system that used in middle ages by experimenting with new technologies. finally, they examined these approaches through the inhabitant's interaction, as well as the creation of livable places.

2.2 Urban storm water management in Augustenborg, Malmö

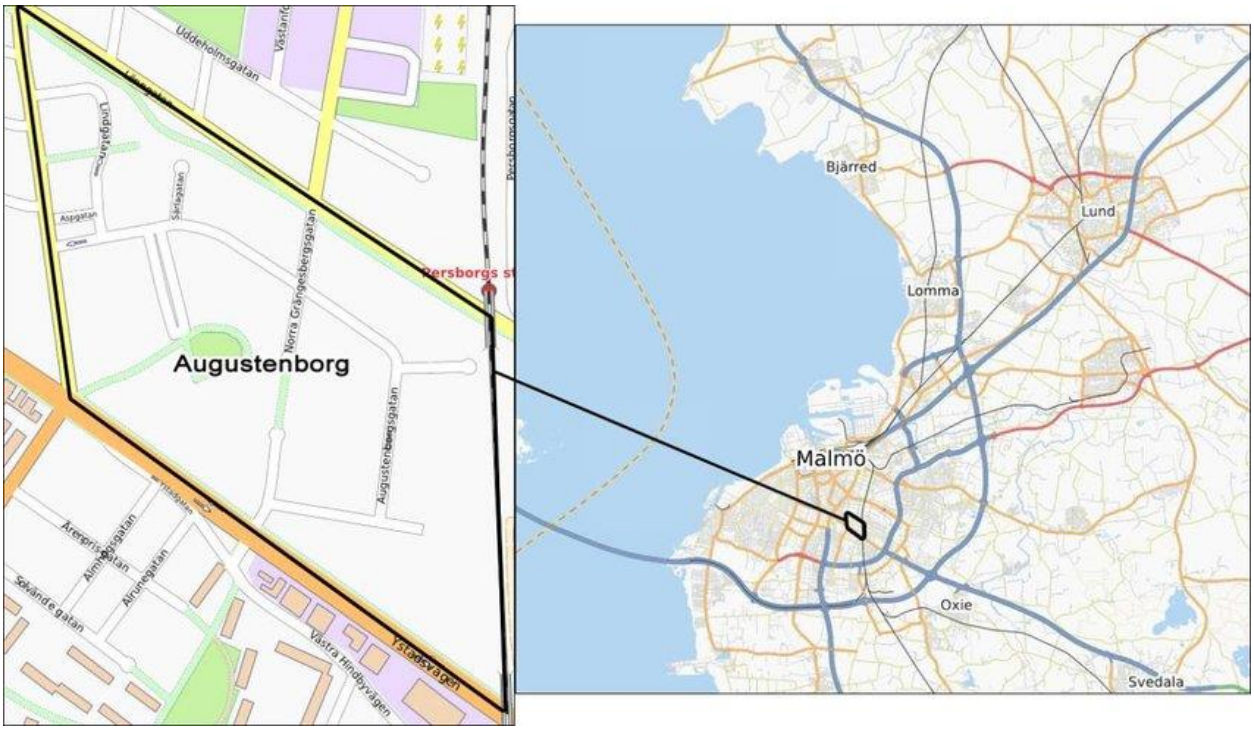

Figure 23/A map over Malmö showing Augustenborg Eco-City (OpenStreetMap, 2010)/https://www.researchgate.net/figure/A-map-over-Malmoe-showing-Augustenborg-Eco-City-OpenStreetMap-2010_fig1_252931582

Project background:

The project located in in Malmo which is the largest city in the Swedish county. The main issue of Augustenborg neighborhood is the stormwater problem that must be solved toward new approach of sustainability. The result of this issue many of inhabitants were not satisfied so they moved. Even though, the climate adapting strategy was elder than in Rotterdam, it considered the beginning of the eco-district aspects that made successful result through social interaction and adapting environment development.

"*Built in 1948-1952 by the Malmö City Housing Company Ltd., the neighborhood of Augustenborg was one of the first housing estates under Sweden's new post-war social housing policy. At that time, it consisted of 1,800 apartments and was Malmö's first energy-independent housing area supported by a local coal-fired heating system. The apartments were spacious and of high quality for 1950s standards. During the decades of industrial decline, social and economic problems severely hit the area. Consequently, many residents moved, and the residual population became marginalised with high levels of unemployment. In addition to the unoccupied apartments and the associated poor building appearance, the area of Augustenborg had particularly suffered under seasonal flooding mainly caused by the old sewage drainage system. Thus, in the beginning of the*

1980's, the municipality and related actors began to discuss the possibility of transforming the area into a small eco-friendly district. In 1990 the city of Malmö, the MKB Housing Company and residents of Augustenborg slowly started to consider retrofitting in the area. This culminated in the initiative of "Ekostaden Augustenborg" in 1998 and concrete aims of the regeneration of the area have been. The overall aim was to turn the neighborhood into an environmentally adapted urban area.

The neighborhood of Augustenborg, during the 1980s and 1990s an area of social and economic decline, was frequently flooded by an overflowing drainage system. Between 1998 and 2002 it was regenerated. The physical changes in infrastructure included the creation of sustainable urban drainage systems (SUDS), including 6km of water channels and ten retention ponds".

"The city had decided to renovate the areas as early as the 1980s. From the beginning of 1990's, several implementation steps according to sustainable urban development standards were constantly pursued. Ecological improvements of the local rainwater system for instance and of the housing stock were carried out in combination with approaching social issues, too. One basic principle was the participation of the local population in planning and implementation"[19]

Challenges

"*The Augustenborg neighbourhood suffered from annual flooding caused by the old sewage drainage system being unable to cope with the combination of rainwater run-off, household wastewater and pressure from other parts of the city. Resulting flooding was leading to damage to underground garages and basements, and restricted access to local roads and footpaths. Untreated sewage also often entered watercourses because of increasing pressure on the sewage treatment works".*

"Under the changing climate, the number of heavy downpours in autumn and winter are projected to increase, with up to 8 days with over 10mm of precipitation possible by 2080s. This is likely to exacerbate the problems associated with rainwater runoff management in urban areas."

"In addition, Augustenborg, one of the first housing estates delivered under Sweden's social housing policy in the 1950s, was characterized by high levels of unemployment, high turnover of residents and high percentage of immigrants".

Solutions

"*While no climate change analysis was carried out on the open storm water system, it was designed to accommodate a 15-year rainfall event as the baseline. The project involved retrofitting SUDS within existing development and infrastructure, and with residents in situ.*

The completed stormwater management system includes a total of 6km of canals and water channels and ten retention ponds. Rainfall is collected in natural ditches and reservoirs before directing it into a conventional sewer system. The rainwater from roofs, roads and car parks is channeled through visible trenches, ditches, ponds and wetlands. These landscape features are integrated into the townscape within 30 courtyard areas, which also provide recreational green spaces for the area's residents. Whilst green spaces were increased in size and number, the specific style of the 1950's was maintained so as not to compromise the aesthetics of the area. Some of the green spaces can be temporarily flooded, which helps to manage water by slowing its entry into the conventional storm water system".

"*In addition, green roofs have been installed on all developments-built post 1998. Some buildings existing prior to 1998, such as garages that have been reused as offices, have also been fitted with green roofs. Altogether, there are 30 green roofs in the neighborhood and 2,100 square meters of green roofs are provided on houses. In addition, a Botanical Roof Garden, which covers 9,500 square meters of an old industrial roof, was developed between 1999 and 2001, and remains the largest green roof in Scandinavia*."

As a result of the implementation of the initiative, there have not been any floods in the area since the open stormwater system was installed. Moreover, a 50 year rainfall event was experienced in the summer of 2007, which cut most of Malmö off from rest of Sweden. Augustenborg was not affected by this event, suggesting the design of the storm water system is performing better than conventional design standards and that Augustenborg is well prepared for more intense rainfall events in the future.

It is estimated that 90% of the stormwater from roofs and other impervious surfaces is led into the open storm-water system. In addition, the total annual runoff volume is reduced by about 20% compared to the conventional system. This is due to evapotranspiration from channels and retention ponds between the rain events. Also, the runoff peak flows are delayed and attenuated.

The implementation of an open stormwater system at Augustenborg has improved not only stormwater management in the area, but also the performance of the combined sewer system that serves the surrounding area. The volume of stormwater draining into the combined system is now negligible, and this system now drains almost only wastewater.

The alternative option of reducing flooding via a conventional separated stormwater system for Augustenborg would have meant major earthworks. This approach could also have caused problems further along the stormwater drainage network, such as bottlenecks where the system joins with older pipes. Moreover, the receiving areas could have suffered increased flood risk, erosion, or water quality degradation. Therefore, the implementation of the open stormwater system described above was the most sustainable option aligning with the vision of the regeneration initiative Ekostaden Augustenborg.

Results and impacts:

Today almost 90% of the rainwater from roofs and other surfaces leads to the new sustainable urban drainage system established by the initiative. Since the new system was installed there has not been any severe food or water related problems. Hence, the green space aspect helped the management of former local flood and ecological impacts and increased biodiversity by 50%. In terms of waste separation 80% of the local waste is being collected or reused. The world's first electric road train is operating in Augustenborg. Also speed limits of 30 km/h have recently been introduced by residents. Despite those significant ecological alterations, also social changes have occurred since the initiative's launch. Unemployment fell from 30% to 6%, and participation in elections increased from 54% to 79%.[20]

Figure 24/Sustainable urban drainage system in Augustenborg (Photograph: GRaBS) /source :Kazmierczak, A. and Carter, J. (2010) Adaptation to climate change using green and blue infrastructure

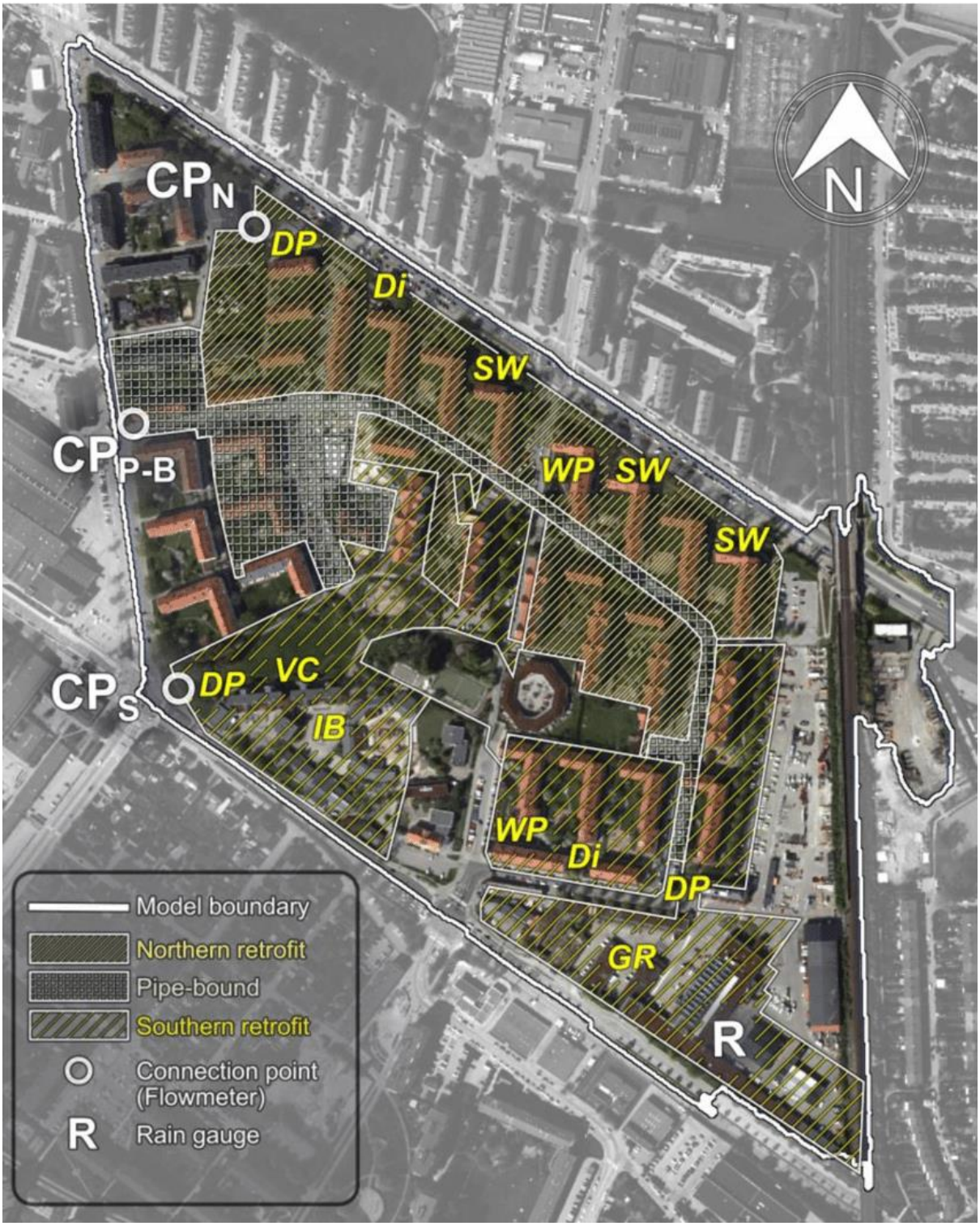

Figure 25/ Pipe-bound system, Northern and Southern blue-green retrofits in Augustenborg and their connection points to the municipal sewer network. Connection points marked as CPN, CPP-B and CPS are the discharge points for the Northern retrofit, the pipe-bound catchment and the Southern retrofit, respectively. Note that the flow is in the Northwest direction, i.e. towards the connection points. Different types of SCMs are shown in the figure as follows: DP: dry pond; Di: stormwater ditch; SW: swale; WP: wet pond; VC: vegetated channel; IB: infiltration basin; GR: green roof.

Background picture: GSDOrthophoto, courtesy of The Swedish Mapping, Cadastral and Land Registration Authority, ©Lantmäteriet (2015)

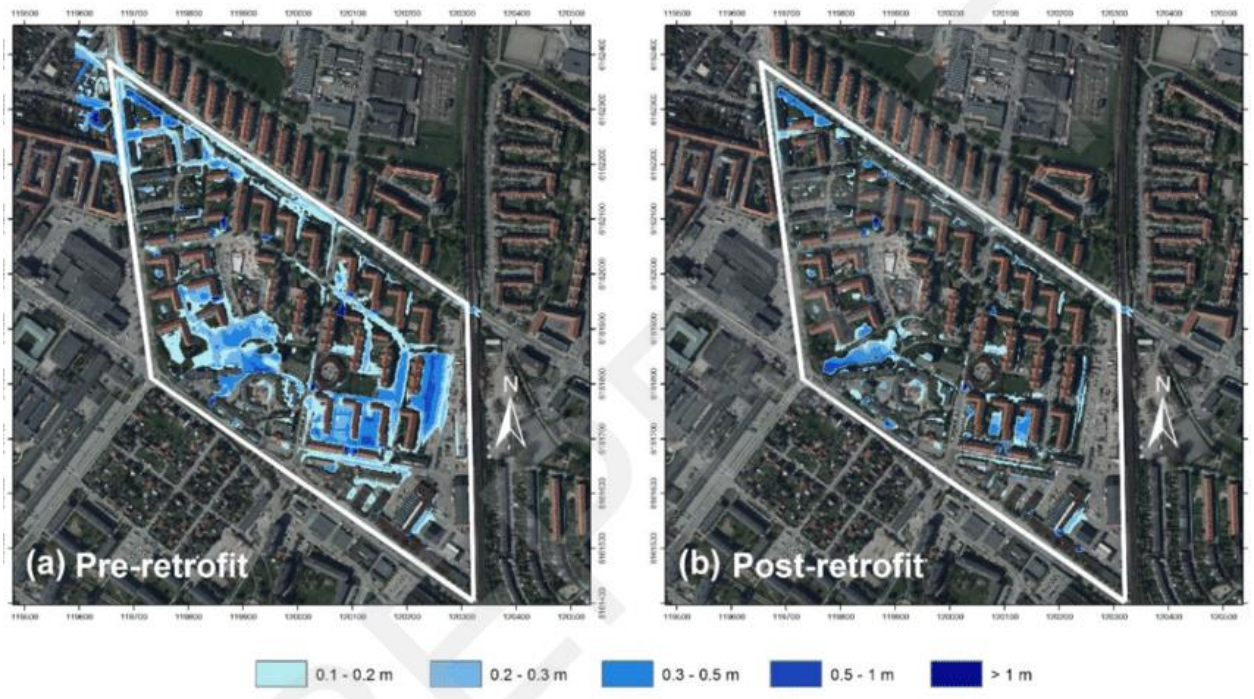

Figure 26/ Flood map (maximum flood depth) of the Augustenborg area based on simulations of the cloudburst on 31 st of August 2014 for both (a) pre-retrofit and (b) post-retrofit cases. Background picture: GSD-Orthophoto, courtesy of The Swedish Mapping, Cadastral and Land Registration Authority, ©Lantmäteriet (2015).

To summarize the Augustenborg district in Malmo, the essential problem was the flood. This issue affected the inhabitant by moved out, which motivate the engaged stockholders to take the first step on changing the district. Although, the solution concentrated on sustaining the old sewage system in the district, it gives important results that changed the way of thinking whether for the other district that has the same issue, or for the community interaction.

Figure 27/Maximum node flooding in the open stormwater system caused by the 140 mm/hr intensity rainfall for the duration of 20 minutes.

3.Analytical case studies of the two projects

3.1-Process of development:

The initial concept of the development process of ZOHO district was introduced by the city council of Rotterdam who has established climate change adaptation strategy in district wide of Rotterdam city. The development procedure took almost four years of progress in climate, proofing the city districts the of 'Zomerhofkwartier' and 'Agniesebuurt', together called ZOHO. The book of Rotterdam-climate change strategy mentioned that "*The story of ZOHO moves from policy making via ideas and plans to physical realizations in collaboration with many stakeholders*"[19].Also mentioned that the primer concept is to make ZOHO into an attractive and climate proof district. The participants include: Arnoud Molernaar who is the chief resiliency officer , Jeroen Laven the programmer appointed by havensteader housing cooperation , Hans Kervezee the socially engaged entrepreneur , Nils Berndsen the Rotterdam city council ,and Dirk Van Peijpe the de-urbanisten the interior climate proof Zomerhof district and others .Sharing knowledge with neighborhood and forming diverse groups participants to choose design options , it is a very good tool to promote the process in a positive way . The collaboration between participants was extremely affective to put all the districts studies on the table and to discuss the issues of the city and the districts by making an affective strategy to achieve the attraction and climate proof ZOHO district.

the adaptation strategy was long term procedure. According to the cities, official policy document the "Water plan 2" in 2007 to "Rotterdam Water City 2035" the International Architectural Biennial Rotterdam. It was already started in 2005 by using the concept of Water square Benthemplein, water storage, greening and Libran farming, event spaces, and polder roof.

The motivation of the cooperation between the participants is not just continuing the process, but also working in progress. However, the idea was already started by collecting all the needed data. They used the catchment area of the basin to set up the water squares. Several kinds of vegetations were also used for greening to support the biodiversity concept. For recycling material, they used barrels to storage rainwater and used it for toilets flushes, and for watering flowers as well.

the main concept for the development process of Augustenborg Malmö, is to regenerate the physical infrastructure by creating a sustainable urban drainage system (SUDS), channels and retention ponds. The lifetime of the development strategy is corresponding to traditional urban greening and drainage projects. The Green and Blue Space Adaptation for Urban Areas and Eco Towns (GRaBS) website which is published in CA (2016) mentioned in the article about the Stakeholder Participation that "*The key actors involved in the regeneration of Augustenborg were the MKB housing company and the City of Malmö, represented by the Fosie district and the Service Department. However, several individuals were particularly important to the success of the project. The process of creation of Ekostaden Augustenborg began in 1997 and was started by discussions about closing down a nearby industrial area. Peter Lindhqvist from The Service Department, City of Malmö, suggested that an eco-friendly industrial park opened in the area. At the same time Bertil Nilsson, former headmaster at the school in Augustenborg, had become one of the co-ordinators of the Swedish Urban Program in Malmö. He contacted Christer Sandgren at MKB who their housing manager for Augustenborg was and had the mission to renew the area. The three men gathered a group of senior officers, colleagues and active residents in the area who all wanted to turn the area into a sustainable district of Malmö. A project leader, Trevor Graham with experience from Groundwork in England, was hired in 1998. As the project progressed, local businesses, schools and the industrial estate became involved. The Botanical Roof Garden was developed in a partnership with several universities and private companies*" [22].

The collaboration between different departments in the municipality is well structured. Focusing on the adaptation strategy of open systems in the suburbs taking design rain criteria into account. The main strategy has also like in Rotterdam long term procedure. Which is started from 1990 - 2050. It is written in the article od Journal of water management and research (2014) that the municipality has a very important role for the Malmo development strategy. The amin version of the document was published in 2000, the late version was in 2007. It is also mentioned that Malmo faced difficulties that took approximately 10 years of negotiation. Today the strategy in Malmo is different because now the municipality realized the importance of the storm-water management as it is taken into consideration at very early stages of city planning.

The implementation level in Malmo was separated in two lands, private lands which consist on source control and on-sit control. The source control has green roof, infiltration, local ponds, using roof runoff for toilets, flushes ..etc. Filter strips, ponds, and deliberately flood designed area. Meanwhile, the public lands consist of slow transport: canals, swales, creeks/ditches. The downstream controls have large ponds, wetlands, lakes.

3.2. Public space and social infrastructure:

The team De-urbanisten and other participants that involved in the ZOHO urban development strategy. They realized that the idea of ZOHO is not only focusing on climate adaptation, but also is focusing on the future of the district to create new structure of public spaces. It can re-position ZOHO in the fabric city. In the book of Rotterdam (2018), the main participants have mentioned the vital role of creating public space and how can effect on the social neighboring activity. JEROEN LAVEN said that "O*ne of the main drivers for the changing use of public space is the slow urbanism movement in ZOHO. A new way of city making takes place here, with a focus on re-programming the existing urban fabric and a bottom up approach to planning. Instead of workers coming by car disappearing into anonymous office buildings, the place is being populated by a diverse group of urban users that mainly come by bike and inhabit the urban space as lingering pedestrians. There is a lot of creative energy in the area with great potential to experiment on all different levels. Currently, almost every week there is something to do in or around the Yellow building*". HANS KERVEZEE mentioned that" *An initiative like the vegan restaurant Gare du Nord with its own little urban farm in front, forming the backdrop of the pleasant outdoor terrace, has become one of the main public spaces of the area. A few blocks up in the Agniese district there is a communal garden where some of the Gare du Nord crops are being grown. The harvesting and cooking is done in the educational setting of an anonymous school building next to the emblematic train wagon. Showcase and social return are being combined here into one overall concept. Less visible, but as emblematic are 'De Viltmannen' (the Feltmen) who employ women from the neighborhood in their small-scale factory hall. Wool from regional sheep herds is being processed here into wearable gear where ancient crafts of North African women is being merged with fresh design ideas of students from the Rotterdam arts academy*." [19].

The same with DIRK VAN PEIJPE when he referred that "*Climate proofing the ZOHO district can be a catalyst for realizing attractive public space. With the ratification of the Rotterdam Adaptation Strategy we agreed to appoint ZOHO as the district to experiment with many ways of climate proofing an urban area. This experiment is about physical interventions that deal with excessive storm water, heat stress and periods of drought on one hand and improve the quality of public space on the other hand. In this process we deliberately are seeking collaboration with stakeholders from the neighborhood: entrepreneurs, inhabitants, activists and institutional parties all work together to realize an attractive and climate proof ZOHO district*".[19].

The main idea of Malmo strategic adaptation concept is to provide recreational green spaces for the area's residents in Malmo. Also, green spaces were increased in size and number, the specific style of the 1950's was maintained so as not to compromise the aesthetics of the area. Some of the green spaces can be temporarily flooded, which helps to manage water by slowing its entry into the conventional storm water system. It's also considered one of initial objectives of Augustenborg was to "*was to enable residents to play a significant role in the planning and implementation of*

the initiative. The Augustenborg project incorporated extensive public consultation. This included regular meetings, community workshops, and informal gatherings at sports and cultural events. The approach became increasingly open and consultative". "*The greatest challenge in involving the public was maintaining continuity, which involved keeping a steady focus on the environmental awareness of the residents and informing the newcomers to the area about what had been done. He also observed that in order for people to become involved they need to have more control over the project outcomes, and the authorities therefore have to accept that things do not always happen exactly as they were planned*"[22].

3.3Green stormwater management infrastructure (instillation):

The case of Rotterdam adaptive measures that used in Green stormwater infrastructure are four different tools: the multifunctional Dike system used for flood protection, water squares for collecting rainfall season, extra surface water to prevent Drought, and greening the city to reduce heat weather. The technical procedure of water squares is "*the underground infrastructure that makes sure the rain water reaches the square quickly and also gets out of there after a while as well; partly into the open water of the 'Noordsingel' and partly infiltrating back into the ground water*".During the implementation procedure, the participants build an interesting seating benches in the side walk by adding plants to create space for garden and infiltration planters. Installing the rainwater storage tank, the water will be used for waters the garden plants. Finally, cutting the pipe that coming from courtyard and connecting to water tank. "*at the same time the technical university of delft developed 'brain drain': a smart app that can predict the water storage capacity that is needed in relation to weather forecasts*". Furthermore, "*The ZOHO-rain barrel is a participative water storage system. It is designed to be an icon for ZOHO and a smart solution for rainwater reuse and storage at the same time. The ZOHO rain barrel will be produced in the district by local businesses. It creates awareness and a shared community feeling with the users. The system also will be used in educational programs on climate adaptation at schools. A smart control device - (B)Rain barrel - makes it possible to control storage capacity within the system*".[19]

The sustainable development measures that Augustenborg district used is "*improvement of energy efficiency and energy production, electric public transport and carpooling, and recycling*". *The stormwater management system created in cooperation with MKB, the Water Department, landscape designers, and local residents in Augustenborg interested in water management issues, now includes a total of 6km of canals and water channels and ten retention ponds. Rainfall is collected in natural ditches and reservoirs before directing it into a conventional sewer system. The rainwater from various roofs, roads and car parks is connected through visible trenches, ditches, ponds, and wetlands. These landscape features are integrated into the townscape within 30 courtyard areas, which also provide recreational green spaces for the area's residents*" [27].

4.conclusion and discussion:

The conclusion method of the two interesting projects of ZOHO in Rotterdam and Augustenborg in Malmo districts is using the comparative tool according the analytical procedure that has been written previously. It focuses on three important points which consist of; development process, public space and social infrastructure, and green stormwater infrastructure. Each feature has a specific impacts on the two different district. Thus, it will be given a useful result that to use it in the recommendations for the future of other districts and for the future community.

Rotterdam challenged a heritage flood issue due to the geographical position where is located at the mouth of Nieuwe Maas river. In this way the city started to use many tradition tools to protect their community from such kind of natural threat. However, the starting point of the water sensitive in ZOHO district was obviously from robust engagement of stockholders to create the robust system of the district. the municipality wasn't the only affective part of the adaptation strategy, but also the neighborhood community. As a result, it turns to bursting and activity to create affective and beautiful city. although, Malmo city has the same geographical characteristic flood affect, the engagement stakeholders are different than in Rotterdam, the policy in Malmo has faced inflexible reaction regarding collaboration between different actors of the city. it mainly took exactly 10 years to achieve the last version in 2007 of documentation as principle and practical approach. The neighborhood participation who gave the opportunity to share their ideas with their stockholders was almost missing.

The eco-district in ZOHO has made significant positive results in the way of public space activities. The concept of water squares has direct physical impacts on the surrounding. For instance, it gives possible extension of catchment area, ongoing sewage renewal (splitting the system), The open water of Noordsingel, good opportunity for Rainwater catchment area of the water square. All the important interventions create very good life quality for social life in the district. Besides this, the inhabitant participated in every single detail of the project. Creating the liberal farming concept by maintaining the gardens, to pursue the result of zero beget garden. As well as planting several types of vegetations along the channels to attain the biodiversity that is one of the initial structures that helps the city to fight the heating stress. Similarly, in Augustenborg district the interesting result of the adaptation aim is the re-creation ofpublic spaces between the housing estates that give the inhabitant excellent chance to create their concepts of vegetation, plant many kinds of seeds that can used for their own food. At the same time, they design their own spaces for relaxation, and affordable playgrounds for kids. The biodiversity which also is an important adaptation structure for the district has increased up to 50%, the open storm water management gives the opportunity to the wildlife to rebuild itself again with human life. Consequently, the co_2 emission mitigates to 20%. These percentages are based on the climate change Adaptation by using green and blue infrastructure database case study article (2010) Kazmierczak, A. and Carter , Which also found out that between 1998 and 2002 : Turnover of tenancies decreased by 50% , Unemployment fell from 30% to 6% (to Malmö's average), Participation in elections increased from 54 % to 79%.

Obviously, the local community have been super affective on the strategy of the adaptation environment improvement.

There are a lot of tools regarding the green stormwater management in ZOHO district, that has been used. For example, eco-friendly materials like wood, it is used as a structure to hold the rain barrels and as benches that are built in sidewalk zones. Local and recycled materials are used for collecting rainfall season like barrels, pipes. Besides this the most important modern tool is the smart application system that can control the water level for the whole district. However, Augustenborg has the same way of thinking. Since the concept was 10 years elder, so the tools were also simple without new technologies. The district has focused on the drainage system by using the recycled materials. These kinds of recycled material were installed as water channels, and for collecting water in different roofs through visible trenches.

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