CHANGING PERSPECTIVES ON STORMWEATHER MANAGEMENT IN NORWAY

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ABSTRACT

Climate change in Scandinavia leads to more rain over shorter periods of time, giving water management a central role in future urban planning. The aging sewage systems and urban growth in the Oslo region, as well as water supply safety and the lowering of groundwater levels, are factors that are forcing planners to rethink stormwater management (SWM). This article reviews literature that reveals how SWM thinking has changed over the last decades in Norway. The review provides insight into what is specific for the Norwegian context and gives perspectives on the development of trends within SWM.

KEYWORDS

Stormwater management, landscape architecture, infiltration, climate change, groundwater.

STORMWATER MANAGEMENT IN A NORWEGIAN CONTEXT

Climate change creates new precipitation patterns with more intense rain, which together with urban growth results in more intense run-off water. The risk factors in relation to human settlements depend on how SWM is handled, and on how infrastructure is implemented in the territory. A paradox of the northern latitudes with heavy precipitation is the decreased amount of groundwater. The melting snow that previously filled up the groundwater levels has now gradually been replaced by warmer winters with rain and quick run-off water that does not fill up the aquifers to the same extent, and the snow that falls in the seasons when the plants have started to grow is taken up by the vegetation before it reaches the deeper ground. In addition, the long periods with temperatures around zero degrees create frozen ground surfaces with ice cover that results in a high run-off coefficient and clogged stormwater infrastructure. The prolonged periods of shifting between snow and rain, or snow that melts during the day and freezes again during the night, also creates demanding circumstances for pedestrians and traffic safety.[1]

While this study deals with Oslo, the conditions vary across the country:

Norway's climatic change challenges are represented in three main regions by the European Environment Agency (EEA):

- The Boreal region around Greater Oslo has a prediction of raised precipitation and an increased frequency of heavy rains and less snow and ice on lakes and rivers.
- In the mountain regions in the central part of Norway, the effects of raised temperature are stronger than in the rest of Europe and imply a decrease in glacier size and snow cover.
- In the Atlantic region at the west coast, the main effects are sea-level rise and increase in heavy precipitation and river flows as well as winter storms.[2] This means that the SWM has specific local conditions to account for.

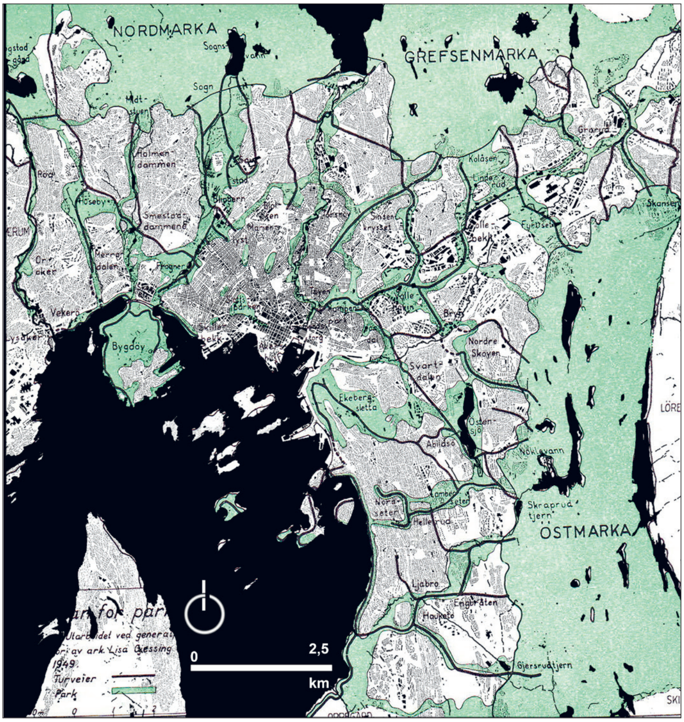

Figure 1. The superposition of the park system from 1950 with the actual urban situation of 2016 that erases some of the former planed park structure. From the Oslo general plan of 1950 elaborated in the period of planning director Eirik Rolfsen and today's situation based on GIS maps from GeoNorge 2016; illustration elaborated by the author in 2016.

A HISTORICAL BLUE-GREEN BACKGROUND TO OSLO

The Norwegian landscape architect Marius Røhne[3] started at the planning office of Oslo in 1916 and established a park plan for Oslo in 1916–17,[4] which provided the base for future planning of a green structure for the city of Oslo, developing an integrated park system that connected the Marka natural reserve with its mountains and woodlands with the sea.

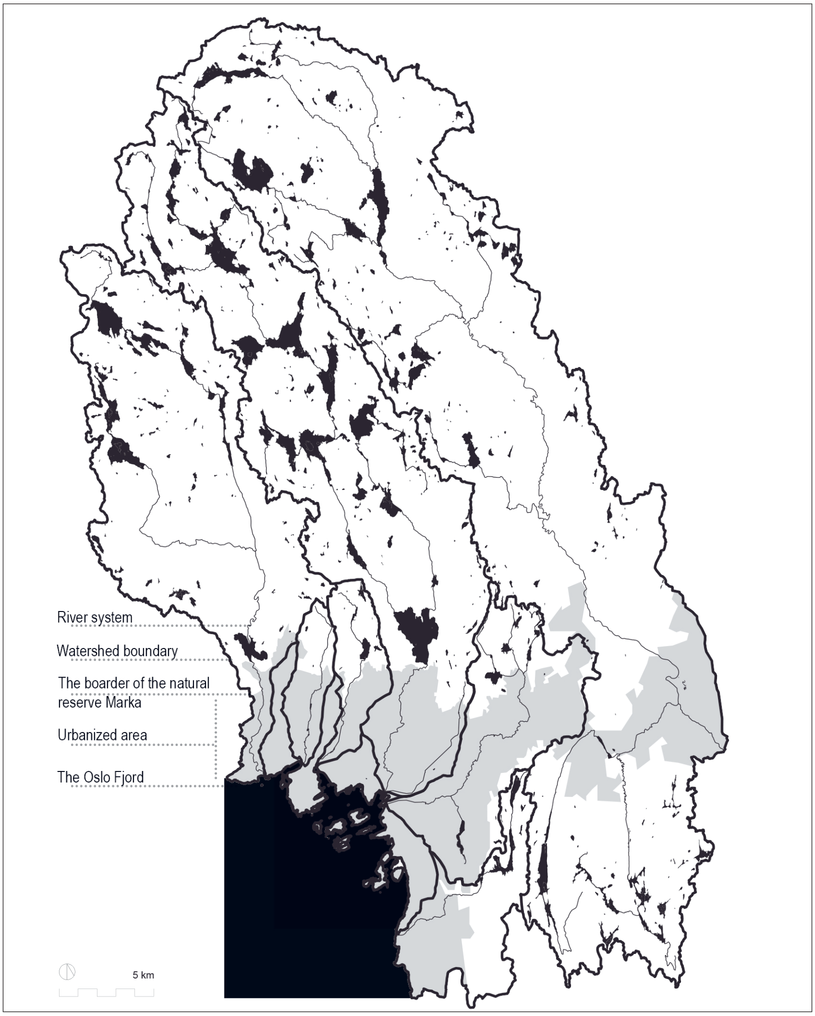

Figure 2. Illustration of Oslo's watersheds to the north, with its waterways that lead down to the urban areas and the fjord (in grey the urbanized area of the Oslo municipality delimited by the line of the Marka natural reserve to the north and south-east). Map elaborated by the Master Course "Sp(C)lash – Let's go swimming" in 2017 at the Oslo School of Architecture and Design.

Harald Hals, the city's urban planning director during the period 1926–47, saw the value of Oslo's green structures. In the years after his education as an architect, he had been working in the United States in Seattle and Chicago until 1911. From this time Harald Hals could have been inspired by the Boston "Emerald Necklace" (1878-1896), by Frederick Law Olmsted where one third of the park was established as a flood control and water quality project. This is shown in Olmsted's map of 1881, "General Plan for the Sanitary Improvement of the Muddy River", which indicates the water management aspect of the project.[5] However, over the decades, the clear green-structure of Oslo that guides the water from the higher levels of the natural areas of Marka has been gradually erased by urban development. In addition, Oslo has recently been one of Europe's fastest growing cities, where the main urban pressure is now found not in the municipality of Oslo, but in the surrounding regions, where clear green structures and floodways are to be defined.

REVIEW OF LITERATURE

The review of literature on stormwater management aims to reveal the change in thinking in Norway during the last decades. The review is mainly based on the journal *Vann* (Water), which is the Norwegian Water Association's publication.[6] This is a central publication for Norwegian professions related to water management. It contains scientific articles, as well as descriptions of technical facilities and investigations carried out, and offers practical advice and guidance. It has provided regular information about the activities of pivotal water-based environments in Norway and important academic events in Norway and abroad. The journal started one year after the inauguration of the Water Association in 1964. The review also utilizes the recent report published by the Norwegian Ministry of Climate and Environment, "Stormwater management in Cities and Villages: A Problem and a Resource",[7] which provides an additional overview of the Norwegian literature in relation to stormwater management.

The research is carried out through literature reviews asking: What have the main tendencies been in the discourse on stormwater management in recent decades in the Norwegian context, as reflected by central publications? In addition, a supporting question is: Which are the transferable thoughts in international readings and approaches to Norwegian SWM with relevance today? Based on the review, a set of perspectives on SWM over recent decades were identified that can be seen as phases of a development leading to the rapidly changing situation today.

STORMWATER MANAGEMENT IN RECENT DECADES

WATER QUANTITY AND QUALITY

In the 1970s, a research program for the purification of waste water was developed in Norway (prosjektkomiteen for rensing av avløpsvann, PRA). The main purpose of the program was to provide a better basis for the significant investments that were made in the waste water sector and to reduce water pollution problems that had been discovered in the lakes, fjords, and sea. In relation to this program, the Norwegian Water Resources and Energy Directorate (NVE) initiated a project where urban hydrological stations were installed to measure urban run-off.[8]

> Heavy rains are only corresponding to a small part of the yearly rain. The sewage system that leads rainwater is therefore not designed for the peak volumes that the heavy rain gives.[9]

The project revealed that the combined sewage (CS) system, which was the norm at the time, resulted in pollution, as the sewage system and treatment plants could not take the overload at heavy rains and thus let the rain and sewage go directly to the sea without cleaning. In Oslo, the CS overflow is still a problem, while some parts of the sewage system have the old combined system.

The concern in the discourse at that moment was mainly focused on the quantity and quality of the water, as well as the industrial sewage problems.[10] There are publications that suggest retention ponds, such as civil engineer Gunnar Mosevoll's PRA 2 report "Rainwater Overflow and Retention Ponds".[11] Here the suggestion is that the overflow system should be put into operation once the net is saturated as a reserve volume parallel to the general system. In this first phase, Stormwater management was viewed as a technical hydrological question.

THE IDEA OF INFILTRATION

The next phase revealed in the literature study was also a part of the PRA research project, where engineer Oddvar Lindholm suggested in 1975 to infiltrate more rainwater into the ground.[12] He later estimated that there are around twenty housing districts in Norway with an open SWM, and that there were approximately sixty at the end of the 1970s in Sweden.[13] He refers here to Westinand and to Malmquist and Hard.[14] The article shows that there is an international exchange of knowledge between researchers, but that the implementation of research into practice is taking its time.

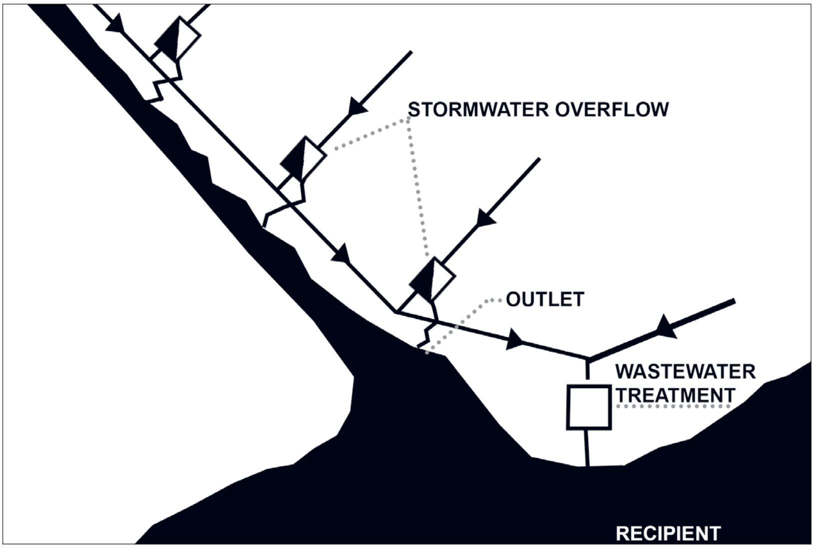

Figure 3. Source: stormwater overflow system from Mosevoll, 1975, PRA 2 "Regnvannsoverløp og fordrøyningsbasseng". Illustration based on diagram, p. 12, translated by the author in 2017.

In 2008, Lindholm published a three-step guideline for SWM, introducing the logic of trying to infiltrate as much water as possible close up to the source where it falls.

The principle is based on an open solution where the first step is to catch and infiltrate, then delay and retain, and, finally, to create secure floodways. This system has become the guideline for the stormwater management policies in many municipalities. The quantity of rain, of 20 millimetres of precipitation, is to be caught and infiltrated where it falls, on rooftops, permeable ground, et cetera, and up to 40 millimetres is to be delayed within retention ponds and areas that can be temporarily flooded. When this capacity is exceeded, the rain is to be guided into safe floodways. The exact quantity and time frame are to be determined in each area of intervention. The guideline thus exposes a key question of responsibility for Stormwater management: while each municipality in Norway (426 municipalities for a population of 5.3 million people) is charged with evaluating the water quantity within its borders, the actual stormwater management systems often transgress municipal boundaries, leaving individual municipalities with responsibilities

Figure 4. Illustration based on Oddvar Lindholm's SWM strategy of "The Three Step Principle", Norsk Vann Rapport R-162, p. 8. Further elaborated by Oslo Municipality SWM 2013–30, "Tre trinns princippen". Traced and translated by the author in 2017.

for only parts of the overall system. In addition, the fragmented government system means that few municipalities have full competence within the field.

The articles in *Vann* demonstrate that the question of water quality was the most central from the 1970s to the mid-1990s. In the 1990s, Norway's biggest LOD (Local SWM) project, the Gardermoen Airport, and its consequences for the groundwater became vital to the discourse.[15] The SWM was to be handled on the surface, but the airport activity with de-icing chemical treatment for the planes, fuel, and oil, et cetera, implied a risk for drainage of toxic contaminants' down to the groundwater.

NATURAL DISASTERS AS ENGINES FOR CHANGE

In recent years, there has been an increase in articles dealing with stormwater management from the year 2000 up until today. At the beginning of the 2000s, the focus in the *Vann* journal increasingly dealt with the question of flooding. Climate change is becoming a more central theme, and in 2010 the Norwegian Ministry of the Environment presented a report on "Adaptation to a Climate in Change".[16] The question of flooding became accentuated in 2011 when Copenhagen had its extreme rain event, resulting in extensive flooding. This promoted articles like "What If the Monster Rain from Copenhagen on the 2nd of July 2011 Had Fallen in Norway?"[17]

This article summarizes the societal effects of the flooding and refers to an evaluation report from the Copenhagen Fire Department[18] that revealed that several critical infrastructures were hit hard by water damage, including emergency centres, the main hospital, the police, and the railway service.[19] In Norway, a comparable rain event, "Frida", fell over the smaller town of Nedre Eiker in 2012 and dropped 70 millimetres in forty minutes. The overall consensus in the debate was that secure floodways had to be provided in the urbanized areas of Norway.[20] As a result, and as an example, Nedre Eiker started to use GIS as a relatively simple way to show the floodways at the property level.[21]

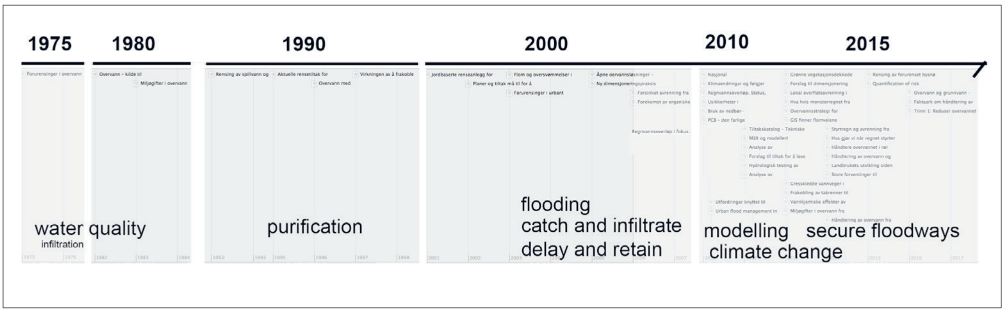

Figure 5. Overview of articles in Vann which deal with SWM. Illustration by the author made with Zotero and Photoshop in 2017.

STORMWATER MANAGEMENT TODAY

STORMWATER MANAGEMENT AS PART OF LANDSCAPE ENGINEERING

The current literature converges on a set of themes. First, the landscape is increasingly seen to have a capacity to deal with stormwater, which can also introduce new qualities within the urban setting. Leading proponents within the landscape architectural field of "water urbanism" Bruno De Meulder and Kelly Shannon argue that "visions for territories can be designed for resilience, remoulding landscapes and reconstructing settlements to bend from hazards but not break".[22] Aligning with the development on Stormwater management in Norway, they criticize a hard engineering approach and argue for a "softer" engineering method that reads the territory and its existing logics, and one in which interventions adjust to the natural logics of water. This, they state, is a realistic landscape engineering form where future challenges can be dealt with, and adapted to: nature's own forces.

The Societal and Economic Question of Stormwater Management

Second, a focus on the wider societal consequences of stormwater management events has emerged. In Norway, a major flood in south-eastern Norway in 1995 resulted in damages that amounted to about 1.8 billion NOK (200 million US dollars).[23] The consequences of flooding were also seen in August 2016, when heavy rains stopped traffic on one of the nation's most important roads in Oslo for several hours. The temporary collapse of mobility caused delays in the flow within the city, including transportation of goods, shutting down evacuation routes and access to hospitals, et cetera. The greater flooding events make the importance of SWM clear for all inhabitants, planners, and politicians, as it transforms from being a technical hydrological issue to a real conditioning event for everyday life. In a neoliberal planning regime such as the Norwegian one, this indicates that there is a need for a stronger juridical framework that strengthens the status of the cities' flood structures, in order to secure values.

The greater flood events are often exposed in the daily media, but in terms of costs it is rather the sum of the small stormwater damages to a wider range of households that represents the greater expenses, such as sewage overflow that is drawn back in the sewage system at moments of heavy rains and floods the cellars.

The city of Malmö can serve as an example of how such events lead to real change. Professor Peter Stahre commented that in some projects at the Municipality of Malmö, it might have helped to move towards a landscape-based stormwater management, because it was very difficult and costly to solve the stormwater management in a traditional way. Here, the open solution was the only economically reasonable way to solve the stormwater issues.[24] The question of economy could be developed further through a comparative cost calculation of traditional versus landscape-integrated stormwater management: its maintenance and its long-term economic effects.

There are a broad scope of ecosystem services based on water. As water is one of the fundamentals for life, it therefore has an outstanding position in terms of value. On the other hand, the economic effects of stormwater management can be relatively easily valued in the implementation of SWMwithin the landscape structures, versus traditional tube systems. In Oslo, this investigation is started with the work of evaluation of the ecosystem services "Values of Urban Ecosystem Services: Four Examples from Oslo".[25] As an example, this project compares the cost of implementing SWM in a traditional and a landscape-integrated solution, in the newly built area of Ensjø in Oslo. This can give clear argumentative tools for practitioners that promote landscape-based SWM solutions in their daily work.

SWM Can Become a Part of Cities' Drinking Water Security as Decentralized Systems

Third, the fresh water supply of a city can depend on one single system or be divided into a multisource system, which is a fundamental question for the cities' drinking water security.[26] Recent years of threat in cities has raised the issue of water security higher up on the agenda. This is especially the case in municipalities that receive their major intake from one fresh water source.

In the case of Norway with its rapid urban growth, this may lead to a more direct interaction between buildings and the landscapes of water that surround them. Here, increased run-off because of urbanization can be turned into an advantage in terms of water supply for an urban region that is in need of it. The idea of a "linear stormwater management" can be summarized in three steps: 1. catch and infiltrate, 2. delay and retain, and 3. create secure floodways.[27] Using stormwater for drinking water in the Norwegian context can seem absurd at first as there is an abundance of water. But taking into consideration that Oslo has been close to water shortage in recent summers, and that an alternative water supply is being evaluated as the water tunnel project that opens up to the next water reserve Holsfjorden 2.5 kilometres to the north-west of Oslo, a circular use of stormwater presents itself as a viable solution. A circular use of water would permit the stormwater management to become an integrated part of the built-up environment, which is to be further investigated within the Norwegian context.

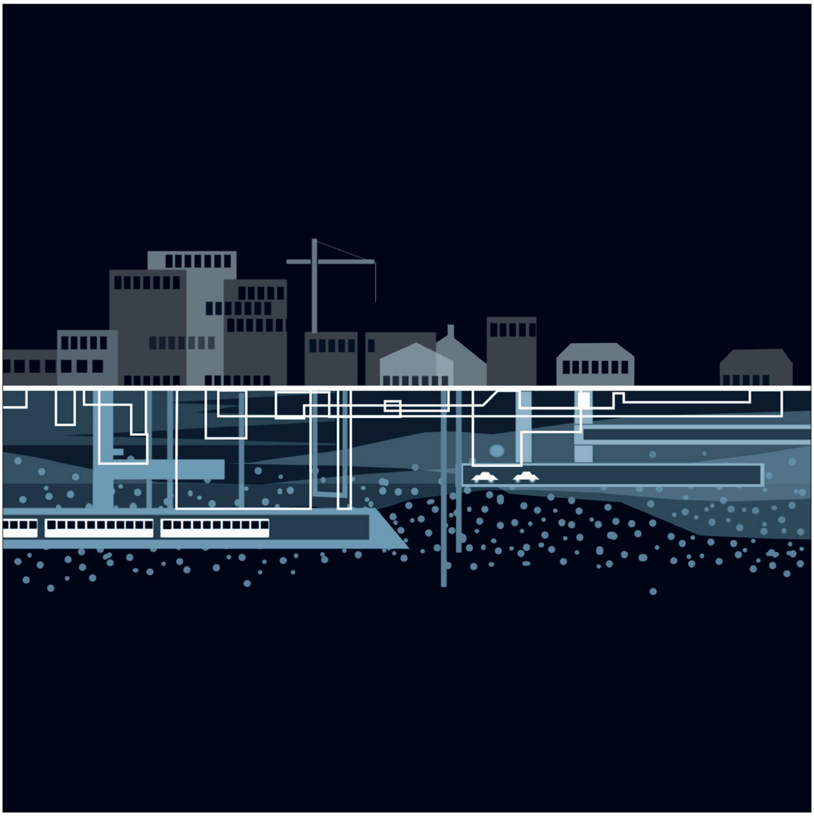

Figure 6. Illustration of the urban underground with its groundwater, made by the author in 2017.

"Underground Urbanism": More Active Consideration of Groundwater in Planning

Fourth, while research has found that groundwater was addressed in various articles as part of a bigger picture, in 2016 a reading of the territory from the perspective of the groundwater appeared in the article "Surface and Ground-

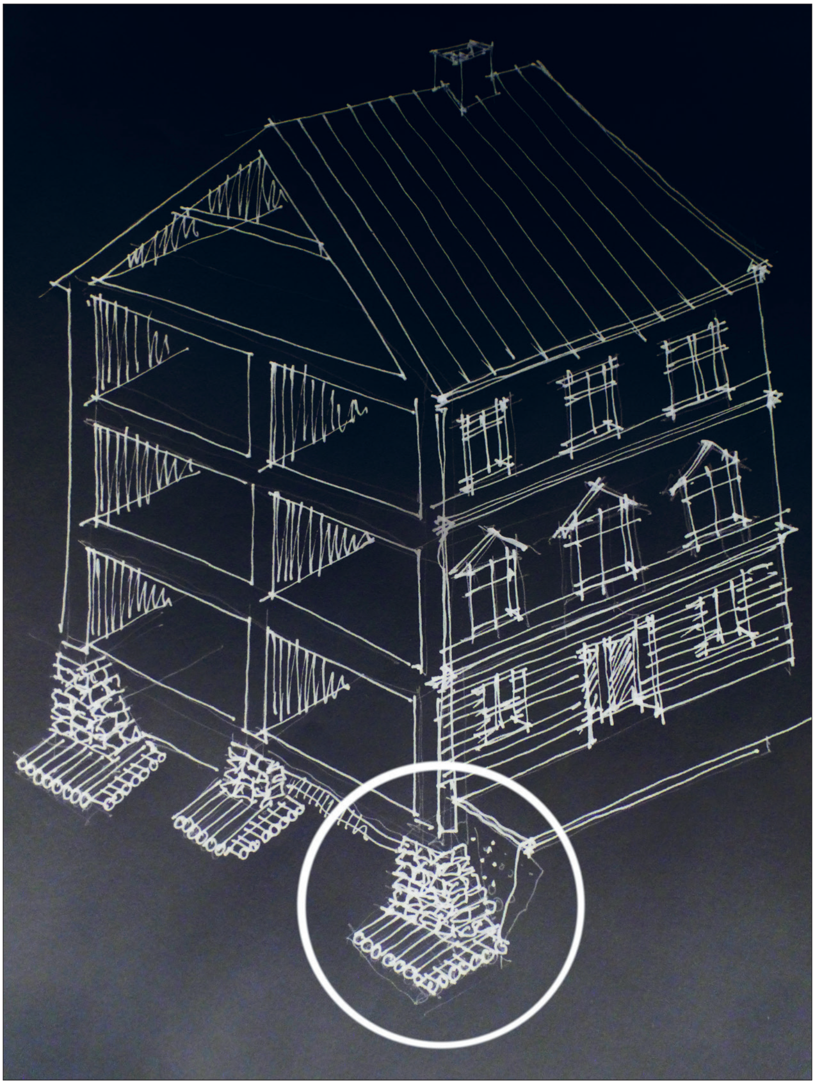

Figure 7. Older houses in Oslo, lower part constructed on fundaments of wood called treflåter; illustration by the author in 2017.

water: Interaction and How to Better Exploit the Interaction" by Hans de Beer. He suggests that the city's underground is important for an adaptable and sustainable urban development, not least in relation to how we handle stormwater. He argues that in contrast to the visual expressions in the cities, we see a significantly lower valuation of the importance of the subsoil among those who plan, develop, and manage our cities. "Stormwater management has traditionally focused a lot on the water's movement on the surface. Fortunately, today we see a turn towards a more holistic approach, where the potential of the subsoil is given more importance."[28]

Knowledge about the characteristics of the subsoil is of great importance in understanding the absorption capacity and the sub-water flows. This is especially true in Norway with areas of quick clay that can be destabilized by water, and where solid soil can become liquid and start to move. The ground component of alum shale, as in the Oslo region, can also be affected if in contact with water, where it swells and releases heavy metals.[29] As illustrated by Beer's article, the general principle in the municipalities' use of the three-step principle of linear stormwater management is to first have a clear overview of the site- and soil-specific characteristics. Beer concludes, "today's knowledge and data about the underground are unfortunately, limited and fragmented. This prevents cost-effective and sustainable urban development, not least implementation of nature-based solutions for stormwater management".[30]

One of the important effects of groundwater decline in the Oslo area is that the ground loses volume, and oxygen enters the ground and changes its properties.[31] When the water does not cover the building foundations, oxygen reaches the wooden foundations causing them to rot, which destabilizes the buildings.

The groundwater affects various other factors in the Oslo region beyond the lowering of the groundwater table and its effect on older building foundations. For instance, the movement of pollutions from one site to the general water system, such as older waste dumps that, with the progression of urban growth, are being integrated into the urban fabric. In addition, the urban expansion that is taking place underground, with garages, storage, et cetera, increases the risk of modifying and cutting off the underground water system flows. Further, the lowering of the groundwater table affects local wells and the possibility for thermo-well installations. Based on these issues, there is actually a need for an "underground urbanism" that puts into context the already built and the planned future installations in relation to the natural underground systems.

SWM as a Widening Field of Concern: From a Technical Question to a Central Societal Question Involving Many Professions

Finally, the review of the literature reveals that a major challenge in the relationship between water and city is that water crosses not only administrative borders, but also – increasingly – disciplinary ones. Solving the stormwater problem within the landscape rather than in separate pipes requires an opening of the disciplines, which includes hydrology, civil engineering, environmental engineering, and economics, as well as urban planning, landscape architecture, and architecture.

The integration of stormwater management in the landscape means that several disciplines have to collaborate closely.[32] The fact that the work implies a multidisciplinary approach means that there is also a need for structural changes within the planning administration system, and a clarification of each entity's responsibility in terms of SWM.

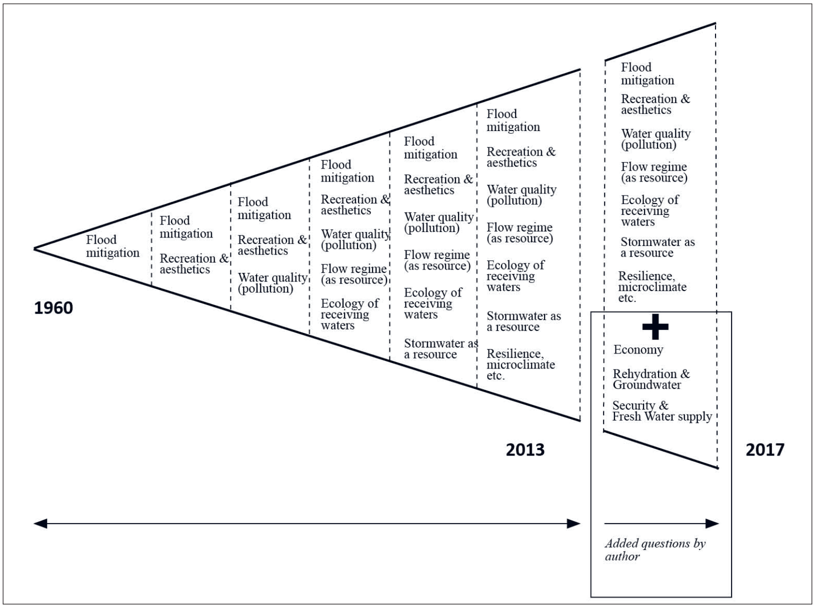

Figure 8. Illustration of the evaluation of storm water-related issues by Fleicher et al p. 534, based on an adoption from Whelans et al 1994.

The scarcity of space in urban areas, and the recognition of broad use of the blue-green structures in planning, requires even more functions to be integrated along with the management of stormwater.

The situation in Norway illustrates how stormwater management is becoming a widening field of concern. SWM has undergone important changes in recent decades: from a focus on flood mitigation, to the integration of a variety of conditions, such as recreational, environmental, and health aspects.[33] At each stage, new terms have been coined to describe the evolving set of parameters, such as best management practice (BPM), sustainable urban drainage systems (SUDS), water-sensitive urban design (WSUD), integrated urban water management, and so forth. In relation to the literature review, even more aspects can be added, such as social, economical, fresh water security, and rehydration of the ground.

DISCUSSION

As the literature study has shown, there are different phases in stormwater management, not clearly chronological, but partly overlapping and interwoven. The literature has mainly been restricted to central Norwegian sources in order to reflect the tendencies on SWM within the Norwegian setting. This might have excluded international publications that could have provided other contrasting insights and approaches.

The study has revealed that the number of experts on SWM has increased over time, and that the field is getting more multidisciplinary. Future reviews should incorporate this broader perspective, analyzing the different sources of publications.

CONCLUSION

The trends within stormwater management in Norway show that in the 1970s there was a general focus on the quantity and the water's quality, while the sewage system was made of combined pipes that were not dimensioned for the heavy rain peaks. Already in the 1970s, Lindholm put forward a case for dealing with the stormwater through infiltration. The years around 2000 saw the introduction of the three-step principle of: 1. catch and infiltrate, 2. delay and retain, and 3. create secure floodways.[34] This linear use of stormwater and its potentials to become a circular use of the water is worth researching further. This would help to deal with water scarcity, and the stormwater can become a part of the solution to the cities' drinking water security with a decentralized system.

Today, stormwater management is increasingly more present in municipal planning. However, the fact that research articles on the effect that built-up areas have on the stormwater – that it can aggravate its effects up to six times according to international studies[35] – were published in the 1960s demonstrates that it is not only a question of having the knowledge, but also the time that is needed for its application.[36]

Current issues within Norwegian stormwater management include drinking water, groundwater, and economic aspects as a widening concern. Overall, current trends and theories suggest that stormwater management is to be resolved within the urban landscape: further research on principles and practices for social and spatial landscape and architectural solutions as well as cold climate specificities are to be developed further.

Stormwater management has become a widening field of concern, moving from a technical question to a central societal question involving many professions. There is a need for adaptation of the administrative system that facilitates tasks such as stormwater that crosses both municipal and administrative borders. There is equally a need for an "underground urbanism": an urbanism that takes the underground characteristics and already built environment into a more active consideration within planning. In the case of stormwater management, the relation between the ground's physical conditions, built environment, pollution, and groundwater merit further consideration in urban planning.

NOTES

[1] Gunnar Mosevoll, *Hva gjør vi når regnet styrter ned?, Vann*, 49/3 (2014), pp. 382–91.

[2] European Environment Agency, 2017. *Climate Change, Impacts and Vulnerability in Europe 2016*, EEA Report, January 2017.

[3] The politician Fernanda Nissen worked for social reforms; she was active in the late nineteenth century and equally underlined the importance of the town's green spaces. See Jonny Aspen, *Byplanlegging som representasjon: en analyse av Harald Hals' generalplan for Oslo av 1929* (2003), pp. 231–32, AHO, Oslo.

[4] Ibid.

[5] Anne Whiston Spirn, *The Granite Garden: Urban Nature and Human Design* (New York: BasicBooks, 1984).

[6] Vannforeningen.

[7] Norwegian Ministry of Climate and Environment, *Stormwater managment in Cities and Villages: A Problem and a Resource*" (2015).

[8] The measures were not completely reliable as they did not have the capacity to register extreme precipitation.

[9] Gunnar Mosevoll, PRA 2: *Regnvannsoverløp og fordrøyningsbasseng*. PRA-brukerrapport, (1975), p. 12.

[10] Themes of concern in the PRA 2, p. 2, are: 1. The quantity and quality of the sewage water; 2. Cleaning of sewage water and sludge treatment; 3. Use of recipient for disposal for sewage water and sludge; 4. Transport system; 5. Emission of polluted water in recipient; and 6. The industries' sewage problems.

[11] Mosevoll, PRA 2: *Regnvannsoverløp og fordrøyningsbasseng*.

[12] Oddvar Lindholm, *Forurensinger i overvann*, PRA 4.7, *Vann*, 10/4 (1975), pp. 297–307.

[13] Oddvar Lindholm, *Overvann – kilde til forurensning av grunnvann?, Vann,* 17/2 (1982), pp. 177–82.

[14] Lisbet Westin, *Miljömessige aspekter på dagvattenhandtering-Litteraturgenomgång* (Stockholm: Statens Råd för Byggnadsforskning, 1977); Per-Arne Malmquist and Stig Hård, *Grundvattenpåverkan av dagvatten infiltration* (Göteborg: Geohydrologiska forskningsgruppen, 1981).

[15] Torbjørn Damhaug, *Rensing av spillvann og forurenset overvann fra ny hovedflyplass, Vann*, 27/1 (1992), pp. 17–20; Svein Bøe, "Aktuelle rensetiltak for oljeforurenset overvann fra flyoppstillingsplasser", *Vann*, 30/1 (1995), pp. 147–52; Per Kraft and Roger Roseth, "Overvann med avisingsmidler på Gardermoen – laboratorieforsøk som grunnlag for prosjektering av jordbaserte renseanlegg", *Vann*, 31/2 (1996), pp. 196–207.

[16] Norges offentlige utredninger, *Adapting to a Changing Climate,* Official Norwegian Reports NOU 2010: 10 (15 November 2010).

[17] Oddvar Lindholm and Simon Haraldsen, *Miljøgifter i overvann fra tette flater, renseanlegg og overløp – Case Indre Oslofjord, Vann*, 48/2 (2013), pp. 223–29.

[18] Copenhagen Fire Department (2011).

[19] The fire department in Copenhagen received 180 different alarms during a four-hour period, relating to issues such as: flooding of the basement of the police headquarters resulting in telecommunication failures, flooding of the main hospital resulting in the need to evacuate trauma patients without functioning elevators, flooding in the basement of a prison with a risk for the power supply which put security at risk, and a general power failure that affected 10,000 inhabitants.

[20] Jarle Bjerkholt, Lars Buhler, and Oddvar Lindholm, *Hva hvis monsterregnet fra København 2. juli 2011 hadde falt i Norge?, Vann*, 48/3 (2013), pp. 361–70.

[21] Rune Bratlie, *GIS finner flomveiene, Vann*, 48/2 (2013), pp. 272–77.

[22] Kelly Shannon, Bruno De Meulder, Viviana D'Auria, and Janina Gosseye (eds.), *Water Urbanisms, UFO1* (Amsterdam: Sun Publishers, 2008), p. 57.

[23] According to The Norwegian Water Resources and Energy Directorate (NVE).

[24] The project of open SWM of "Toftanäs Wetland Park" is an example of a project where a solution of tubes was not economically defensible.

[25] Augustenborg in Malmö has also been a reference for the Norwegian SWM. Rasmus Reinvang, David Barton, and Anders Often, *Verdien av urbane økosystemtjenester: Fire eksempler fra Oslo,* Vista Analyse, 46 (2014).

[26] It has historically been a tactic to conquer a city by cutting a supply line of basic needs. Today, it is relatively easy to make the water useless through highly polluting elements. Antoine Picon, *Constructing Landscape by Engineering Water,* in Institute for Landscape Architecture, ETH Zurich (ed.), Landscape Architecture in Mutation (Zurich: gta Verlag, 2005), pp. 99–114.

[27] Oddvar Lindholm. *Veiledning i klimatilpasset overvannshåndtering*. No. R162 (2008). *Norsk Vann* p.8.

[28] Translation by the author. Hans de Beer, *Overvann og grunnvann – samspill og hvordan bedre utnytte samspillet, Vann*, 51/2 (2016), pp. 188–90, esp. p. 188.

[29] Ibid.

[30] Ibid., p. 189.

[31] When oxygen enters the ground, it breaks down organic matter, including cultural heritage from former generations. Geological Survey of Norway. (2013), *Groundwater and Cultural Heritage*, (22nd NGU Seminar on Hydrology and Environment, NGU Report No. 3013.024). Geology for Society.

[32] Peter Stahre, *Blue-Green Fingerprints* (Malmö: VA Syd, 2008).

[33] Tim D. Fletcher et al., *SUDS, LID, BMPs, WSUD and More: The Evolution and Application of Terminology Surrounding Urban Drainage*, Urban Water Journal, 12/7 (2015), pp. 525–42.

[34] Ibid.

[35] For example, Luna B, L. (1968). *Hydrology for Urban Land Planning. A Guidebook on the Hydrologic Effects of Urban Land Use*. (No. 554). Geological Survey. Washington: U. S. Department of the Interior.

[36] The 11th International Conference of Urban Drainage, 31 August to 5 September 2009, Edinburgh, Scotland.