Water poses challenge to major cities

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Too much water, too little water, or contaminated water. Cities around the world are facing major water-related challenges. These challenges are further aggravated by global trends such as urbanization and climate change. The time has come for water to become an asset rather than a problem in 'smart liveable cities' of the future.

All over the world, people are migrating to ever larger cities. According to the UN, in 2009, for the first time in history, the balance has tipped in favour of more people living in urban areas as opposed to rural areas.

Global urbanization poses new water-related challenges—chief among them supplying clean drinking water, disposing of wastewater, and managing extreme precipitation.

"In many parts of the world, there's not enough water. This is partly due to climate change, but in particular, increasing urbanization. Today, many residents have to travel further and further away to collect water—e.g. in Istanbul, where the city has built a 160 km long water pipe to supply the city with clean water. In California—which is plagued by drought—and in the Middle East—it is no longer possible to supply water to major cities without desalinating it," says Søren Hvilshøj, Global Market Director, Water from consulting engineers, Ramboll. For the past 20 years, he has been involved in development of the international water and environment sector.

Interdisciplinary approach needed

In 2014, DTU established Water DTU to solve the water-related challenges facing major cities. The aim of the centre is to ensure that the University's researchers adopt an interdisciplinary approach to identify new solutions in the field of water management. A special task force with experts from 11 departments and DTU Diplom will coordinate interdepartmental expertise. Thus, environmental researchers from DTU Environment will work alongside statisticians and modellers from DTU Compute, management experts from DTU Management Engineering and civil engineers from DTU Civil Engineering—among others.

The researchers will couple their knowledge of risk analyses, for example, with sustainable technologies, water technologies, precipitation simulations, and traffic and system analyses to create 'smart liveable cities'. Cooperation can also take place in constellations—e.g. where DTU Space, DTU Fotonik, and DTU Nanotech in the future can combine new techniques for monitoring, automation, notification, and

control of water flows inside and outside major cities.

"We cannot solve the water problems facing major cities by focusing on the water problem alone. Many areas of expertise are involved. If we are to build cloudburst roads, we also need to think about how we can make the city a nice place to live in. We therefore need new working methods and software that help planners, architects, traffic, and water engineers to work together," says Peter Steen Mikkelsen, Head of Water DTU and Professor at DTU Environment.

Fit for purpose water

The challenges of supplying sufficient water has led authorities, water utility companies, technology suppliers, and knowledge institutions from all over the world to coin the phrase 'fit for purpose water'—where water of a quality other than drinking water is used for washing clothes, watering lawns, and cleaning the car, for example.

According to Martin Rygaard, Associate Professor at DTU Environment, in some parts of Australia the authorities supply consumers with two different qualities of water. One is drinking water—and the other—collected rainwater or treated wastewater, which is used to wash clothes and flush toilets, and other daily operations that do not require drinking water quality. Now, the 'Fit for purpose water' idea has also found its way to Denmark. As a general rule, Denmark has a plentiful supply of water. However, in the Copenhagen area, extracting sufficient quantities of groundwater to meet the city's water needs is proving to be a challenge. Heavy precipitation has also spiked interest in using rainwater for purposes that do not require water of drinking water quality. Danish manufacturing companies are also interested in 'fit for purpose water' as a way to reduce their consumption of drinking water. By recycling and reusing water for cleaning operations, businesses can reduce the costs associated with clean drinking water and the discharge

and treatment of wastewater.

Wastewater is a resource

Urban water consumption also generates large volumes of wastewater. The challenges of wastewater disposal have led to an unexpected development: from being an undesirable product for immediate disposal, wastewater is increasingly considered a resource that can provide energy, nutrients, and new drinking water, explains Barth F. Smets from DTU Environment.

"Nitrogen and phosphorus can be recovered from wastewater and recycled as fertilizer for farming. Through a process of careful cleaning, drinking water can also be extracted from sewage—something they have been doing for several years in Singapore. In addition, the waste-water content of carbon can be converted into methane, which can be used in power production. We are beginning to view wastewater plants as energy producing, rather than energy consuming. However, accomplishing this turnaround will require further development and research," explains Barth F. Smets.

A parched city

Since 2002, Denmark's challenge in dealing with extreme rain events has meant that many urban areas have been immersed in water following heavy rainfall. According to Professor Karsten Arnbjerg-Nielsen from DTU Environment, these huge volumes of rainwater must be managed above and below ground:

"From a purely engineering perspective, the most cost-effective approach would be to build larger and broader channels, roads and tunnels that quickly lead the rainwater away. But that would leave you

with a boring, parched city that no one wants to live in. It is all about creating value for the people living in the city. We must exploit the rainwater for the benefit of the city while relieving pressure on the sewers. We therefore need to devise models that tell us how the technical solutions impact the environment, how to optimise the infrastructure, how to reduce flood risk, and the overall effect of people being happy."

According to Associate Professor Lotte Bjerregaard Jensen, DTU Civil Engineering, the task of creating 'smart liveable cities' requires that knowledge from different sectors be incorporated into the early stages of city planning.

"Often, we think about water in the design process after decisions have been made about urban space design, landscaping, and the layout of the buildings. But we could avoid problems in the future if we designed cities with water, sun, and wind in mind from the get-go. Good climatic comfort in urban spaces is a key element of 'smart liveable cities' because we have to make it desirable to walk and cycle. It is a sustainable approach, and one which creates a city with a greater range of experiences, greater quality and a sense of security in urban spaces."

Green and blue spaces

In the consulting engineering firm Ramboll, water is seen as a major growth market. Among other things, the company has helped to design a cloudburst mitigation plan for Copenhagen and Frederiksberg. One proposal is to create more green and blue spaces—e.g. planted areas and streams—that can retain rainwater locally. The plan also involves establishing cloudburst roads that quickly and efficiently channel the water out of the city while taking into account traffic flow and urban quality of life. The plan has generated interest in Asia and the USA, among other places.

"Green solutions are attractive. People want to look at something that is blue, green and pleasing to the eye. But residents around the world perceive sustainability differently. Denmark is unique in that we have good conditions for cyclists and people can go swimming in the inner harbour. In the Middle East, the focus is on being able to stroll along the beach promenade. We therefore need to find local solutions," says Søren Hvilshøj.

He expects an annual growth rate of four to five per cent for water consultancy services in the global market. According to the report 'Vandvision 2015' (Water Vision 2015) prepared by the Danish Ministry of the Environment Denmark and the Confederation of Danish Industry in collaboration with several players in the water industry—including DTU—Denmark has an important part to play. Denmark is a world leader in the field of water technology. Professor Hans-Jørgen Albrechtsen, DTU Environment, elaborates:

"In Denmark, we follow a gentle water extraction policy that avoids draining streams and lakes, and where water is treated with as few chemicals and using as little energy as possible. Our technologies for mapping and monitoring water resources and treating water form a complete package which can be very interesting to other countries."

Facts about water

- Globally, 80 per cent of water is discharged without purification with major consequences for our ecosystem. (Vandvision 2015).
- World Economic Forum points in 2015 to the over-exploitation of water resources as being the biggest global risk to human well-being and prosperity over the next decade.
- The UN estimates that half of the world's population in 2030 will live in areas with limited access to clean drinking water. At global level, approximately 70 per cent of freshwater resources

are consumed by agriculture and 20 per cent by industry. (Vandvision 2015).

- Currently, 750 million people are without access to sufficiently clean drinking water. (Vandvision 2015).
- Global freshwater resources water projects at DTU: 68.9 per cent is accounted for by glacial ice, 30.8 per cent by groundwater and 0.3 per cent by lakes and rivers. (UN).
- Every 20 seconds a child dies as a result of diarrhoea caused by a lack of sanitary conditions. (Vandvision 2015).

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