TEXT: Laura Wendling

MANAGING URBAN WATER IN A CHANGING CLIMATE

The impacts on climate change on the global water cycle intensify the effects of surface sealing in urban areas, increasing stormwater surface runoff, the overexploitation of available water resources, water pollution, and pressure on ageing infrastructures. There is a clear need for robust and reliable techniques to manage flooding and improve the quality of surface runoff in urban areas whilst simultaneously facilitating water capture and re-use, and reducing greenhouse gas emissions and energy use.

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THE increase in both the frequency and intensity of extreme weather events is a primary driver of climate adaptation efforts worldwide. Parts of Eastern Europe and Scandinavia are among those considered subject to the greatest flood risk due to increasingly intense and frequent heavy precipitation events[1].

Urban areas are particularly vulnerable to flooding because where the soil surface is covered by impenetrable materials, like roads, parking lots, sidewalks, and buildings, the water cannot infiltrate the underlying soil. The effects of climate change on the water cycle are readily apparent in urban areas where changes in rainfall frequency and intensity exacerbate the effects of surface sealing and increased surface runoff in urban areas.

Most urban stormwater runoff is currently discharged directly into rivers, lakes and the sea without any treatment. Only the portion of stormwater captured by sewer networks can potentially be treated in municipal water treatment facilities. Combined sewer networks, common in older town centres and some industrial estates, collect both stormwater and wastewater together for transport to a central water treatment facility.

The volume of surface runoff during heavy rainfall events or periods of rapid snowmelt can exceed the capacity of combined sewer networks. This may lead to discharge of combined stormwater runoff and untreated wastewater. More modern sewer systems have individual pipe networks for stormwater and wastewater, respectively. These separate sewer systems reduce the potential for wastewater overflows but localised flooding by stormwater runoff remains a concern.

Stormwater sewer networks are designed based on storm frequency analysis using historical precipitation data, stormwater management plans, flood studies and water transport system analyses. Sewer systems are highly reliable under the conditions for which they were designed, but extreme weather events and increased surface imperviousness

Figure 1. A constructed wetland in Vuores, Tampere, filters stormwater runoff to remove pollutants before discharge to the area's oligotrophic surface waters. Image © Maarit Särkilahti.

in a drainage area can result in surface runoff volume greater than the capacity of the stormwater sewer network.

NATURE-BASED SOLUTIONS TO MITIGATE URBAN FLOOD RISK

Flood risk management in urban areas has traditionally been accomplished using "hard" engineering, or "grey" infrastructure, solutions. These include not only sewer networks, but also dams, levees, channels, and embankments constructed to control floodwaters. Sewers, drainage channels and similar infrastructure are reliable and can be highly effective for blocking and channeling water away from inhabited areas.

However, grey infrastructure solutions do not resolve the discontinuity of the urban hydrologic cycle presented by surface sealing and limited infiltration. The concept of urban drainage has evolved worldwide from draining all stormwater as rapidly as possible to a focus on meeting multiple environmental, social, and economic objectives.

The increased volume of stormwater runoff in urban areas has traditionally been managed by increasing the number and size of sewer pipes and drainage channels. Replacement or expansion of sewers and drainage channels can attenuate runoff but fails to address the discontinuity of the urban water cycle presented by surface sealing and limited infiltration.

Diversion of surface runoff away from urban structures as rapidly as possible can result in increased downstream flood risk, reduced groundwater recharge and, in the long term, reduced groundwater resource availability as well as potential contamination of receiving waterbodies. In addition, major subsurface engineering works are costly and may limit or disrupt other underground services.

Nature-based solutions (NBS) have gained popularity for urban stormwater management and

Figure 2. Vuores, a new greenfield district in Tampere, is comprised of existing and developing residential blocks located around multifunctional parks. Image © City of Tampere / FCG

Figure 3. The heart of Vuores' nature-based stormwater management system is Central Park, where retention ponds (above), swales, and wetlands retain and purify waters before discharge to Lake Koipijärvi. Image © City of Tampere / Vuores

flood risk mitigation due in part to their many documented co-benefits. Nature-based solutions represent natural "green" solutions to societal challenges such as flooding, environmental pollution, biodiversity decline, and human well-being (Fig. 1). Nature-based solutions are co-created systems that achieve the desired outcomes using natural features and ecosystem-based processes.

In practice, NBS protect, manage or restore ecosystems and their services. Water cycle and water flow maintenance is an important service provided by natural ecosystems, and NBS are an important element in effective schemes to mitigate urban flood risk. Nature-based solutions that address urban flooding by increasing infiltration of rainfall and/or snowmelt or increasing water storage capacity include, but are not limited to:

- Urban forests - afforestation/reforestation of cleared land;
- Establishment of riparian buffers;
- Construction, restoration or conservation of wetlands and marshes;
- (Re)connection of rivers to floodplains;
- Green roofs and/or walls;
- Rain gardens;
- Green spaces, e.g. parks, gardens, and multifunctional green spaces (Fig. 2);
- Wet/dry detention ponds;
- Infiltration basins, bioretention basins, and biofilters; and,
- Vegetated filter strips, vegetated swales, and infiltration trenches.

Co-design and co-implementation with stakeholders, as well as cross-disciplinary and cross-sector engagement, are key characteristics of NBS. The systematic involvement of all stakeholders, including citizens, supports environmentally, socially and economically beneficial outcomes[2].

Urban populations are expected to approximately double from 2.6 billion in 2000 to 5 billion people in 2030, with nearly 70% of the world's population residing in urban areas by 2050[3]. It is further estimated that by 2030 the global urban land area will triple relative to that in 2000[4].

A growing body of empirical evidence indicates a causal relationship between time spent in natural areas and human health and well-being. Urban densification together with the rapid conversion of rural to urban landscapes challenges both ecosystem function and human well-being. Management of urban stormwater runoff using NBS can deliver a number of co-benefits, including increased biodiversity, new recreational opportunities, improved air quality, reduction of the urban heat island effect, and improved human health and well-being (Fig. 3).

A range of alternative planning options are available to decision-makers from grey engineered solutions to "green-blue" ecosystem-based approaches. These options are not exclusive alternatives; a combination of approaches may provide optimal long-term climate resilience and cost-effectiveness.

Integration of NBS with grey urban water management systems, along with flood early warning systems and land use planning informed by risk flood evaluation, can substantially reduce vulnerability to flooding whilst delivering additional co-benefits that improve urban liveability. There is no universally-applicable urban flood management solution, but hybrid measures that combine NBS with conventional grey infrastructure have been identified as the optimal mix of security provided by grey infrastructure with the multiple co-benefits of natural solutions. ril

FURTHER Reading

To learn more about current developments in NBS check out the Urban Nature Labs webpage at www.unalab.eu/. For information about using NBS to manage urban stormwater runoff in Finland see the report "Filtration Systems for Stormwater Quantity and Quality Management: Guideline for Finnish Implementation", available from www.vtt.fi/inf/pdf/technology/2018/T338.pdf.

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