WHITE PAPER

An Orbia business.

Sustainable Resilience

Creating a city rainwater system fit for tomorrow's challenges

Through a number of relatively straightforward steps we can make transformational improvements to our cities' urban climate resilience.

We have known for centuries that water and its effective management are vital aspects of any liveable city. Today's planners, politicians and other decision-makers also know that various factors are now creating new water management challenges, for our urban sewer systems in particular. But by adapting our water management systems with solutions that facilitate the natural water cycle, we can equip our built environment to cope with the more extreme weather conditions being driven by climate change.

This white paper examines:

- the origins of current urban water management systems;
- the environmental and liveability challenges they create and need to see water differently;
- what can be done now – the solutions that are already out there;
- how we can encourage and drive adaption to a water-sensitive future.

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‘The gentle way’: freeing the natural water cycle to do its thing

We all know from our schooldays that water is vital for all life on Earth. We also know how the natural water cycle works (see Box 1 – The natural water cycle) and has worked for millennia unhindered. So why did the UN Water Summit of March 2023 feel driven to say that water management and protection is a global common good. Quite simply, because the state of our global water resources right now is far from perfect (see Box 2 – Water and the climate crisis).

Our water management systems were not originally designed to handle the escalating extreme weather conditions that we now encounter more frequently. Moreover, from both an economic and ecological perspective, it would be impractical to design the system to solely address these specific events. In addition, our current built environment, particularly in urban areas, tends to impede the natural water cycle. By paying attention to this, such as using fewer sealed surfaces, we reduce a range of dangers, including polluted stormwater, more frequent and severe flooding in rainy periods, drought in dry periods, and the destruction of aquatic habitat.

The good news is we have the capabilities and solutions to address this growing threat to our quality of life. In particular at the local level, by radically rethinking our urban planning we can move from a grey past of asphalt and concrete deserts to a blue-green future of water-sensitive built environments. Rather like in Judo (Japanese for ‘the gentle way’), where you use your opponent's strength to achieve your goals, we need to stop fighting Nature and start learning to use its power for the benefit of people and planet. In other words, we need to see water differently.

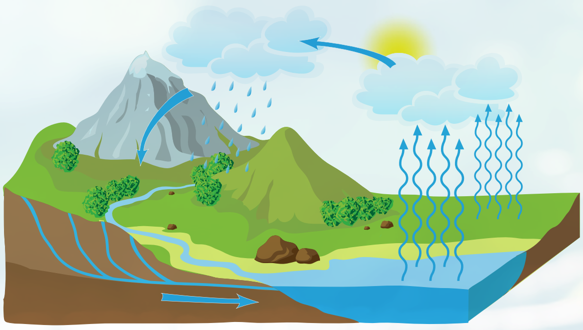
Municipalities, water authorities, businesses, other public and private organisations, and individual citizens can all contribute to water management improvements in our built environment. Making our neighbourhoods not only more climate resilient, but also more liveable and safer. And thus doing our bit on a relatively small, localised scale can help address global issues such as biodiversity. Because while good water management alone can’t solve the climate crisis, it can certainly reduce its impact significantly.

This doesn’t always have to involve major planning projects. In fact, steps taken by individual citizens can often be the most impactful of all. A simple example is the Dutch National Tile Flipping (Tegelwippen) championships[1]. The winning municipality is the one whose citizens have together flipped the most tiles that year to create flower beds, vegetable patches and garden ponds. This tongue-in-cheek competition between local municipalities has a very serious goal. Many people in the Netherlands have tiled grey gardens because it’s low-maintenance. The reality is, of course, that they cause waterlogging, increase heat stress and reduce biodiversity. Millions of tiles are flipped each year, so the positive impact of this grass roots initiative on soil sealing will over time be significant.

#1 | The natural water cycle: how things should work

The natural water cycle is a closed system. Not a single drop is lost, even though vast amounts of water are constantly moving between sea, air and land.

The sun and gravity keep the process of evaporation and precipitation in eternal circulation. The sun heats the water on Earth causing it to evaporate. Plants also release water vapor into the atmosphere through evaporation.



The moist, warm air rises upwards, where it cools and tiny water droplets form. When these water droplets become too heavy, gravity brings them back to Earth. If the temperature is above freezing point, it falls as rain. And if it is below 0°C, it is in the form of sleet, hail or snow. This precipitation is crucial for groundwater replenishment in the soil and for nourishing plants. The water then flows back into the oceans through streams and rivers. After which, the eternal cycle of evaporation, precipitation and runoff starts anew – unless humans and the world they have created interfere.

#2 | Water and the climate crisis

In the natural water cycle, vegetation plays a crucial role. Forests, in particular, act like sponges, retaining water after rainfall and gradually releasing it. The tree roots firmly hold the soil that stores the moisture. Their canopies provide shade for storage plants like mosses, and their leaves evaporate water, creating a cooling effect.

Whether it's through deforestation, intervention in wetlands, land degradation or infrastructure development, changed land use continues to advance worldwide and is having a dramatic global impact on these natural precipitation patterns.

As climate change continues, floods and droughts are occurring more frequently worldwide. And weather patterns are increasingly localised (e.g. persistent heavy rain or forest fires occurring in one location year after year). According to the Global Commission on the Economics of Water[2], this is not the result of population growth or economic development, but our mismanagement of water. Extreme weather phenomena are seen by the Commission as indicators that the global water cycle is out of balance.

This imbalance also affects the natural drinking water supply, which across the world is predominantly fed by groundwater. Current projections point to a 40% water deficit by 2030[3]. With only some 1% of the water on Earth directly drinkable, improved water management is urgently needed. Currently, the UN World Meteorological Organization (WMO) estimates that over two billion people globally are experiencing water stress.

The water crisis is closely linked to global warming and the loss of biodiversity. Warmer air can hold more water. Climate warming increases humidity, and with it the risk of heavy rainfall. Scientists believe that the moisture content of the atmosphere increases by 7% with every degree Celsius rise[4].

Addressing the big global challenges, such as climate change and biodiversity, is notoriously complex, requiring a shared vision and coordinated commitment across nations, industries and other stakeholders. In the meantime, however, as this white paper shows, there is a lot we can do at the local level to make sure we manage the water resources we have as best we can.

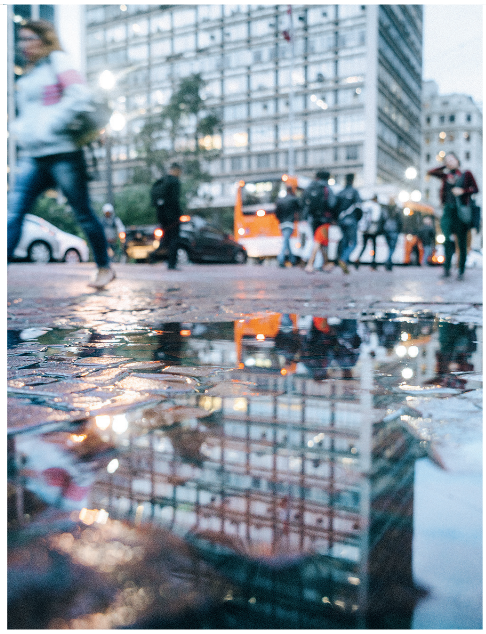
Sealing our fate: why yesterday's answers won't solve tomorrow's problems

The impact of undermining the natural water cycle is most evident in urban areas, where the proportion of green spaces tends to be low and soil sealing high (see Box 3 — Soil sealing: a varied picture). Sealed surfaces are a particular problem because rainwater doesn't seep into the ground to replenish our groundwater, but drains into the sewer system that then carries it to locations outside the city. So instead of a natural water cycle, in our cities we have created an artificial linear system.

As Steven Peck explains in Living Architecture Monitor[5], once upon a time these systems made sense (see Box 4 — How water management used to address society's challenges). But what we are left with today is essentially a sewer system designed to address a problem from another era, a problem that we no longer face. And not one designed to address the challenges facing today's conurbations, let alone the cities of the future.

High soil sealing affects the local temperature, as paved surfaces heat up during summer days and prevent the necessary cooling, even at night.
One of the simplest ways to alleviate this problem is at every level — municipalities, property managers and citizens alike – to see where we can plant additional trees. And municipalities can go a step further by introducing innovations like the Wavin Tree-Tank that maximise the positive impact of trees.

Urban Heat Island effect (UHI), to which high soil sealing contributes, means cities are significantly warmer than surrounding areas[6]. This creates serious health threats, including heat-related mortality, especially among the elderly, sick people and infants. In addition to more trees, another key way to mitigate UHI is for homeowners and commercial property owners to create green roofs on their properties.


These centuries-old legacy water management systems that cities have inherited have various disadvantages, for example:

Old sewage systems not designed to handle today's heavy rainfall events increase the risk of flooding, surface water contamination and overburdened sewage treatment plants.
Happily today we can improve pretty well every aspect of our traditional street-level and underground water management systems. From attenuation and infiltration tanks and pipes to smarter road and land drainage, and from flow control and rainwater harvesting to reuse systems and channel drainage.

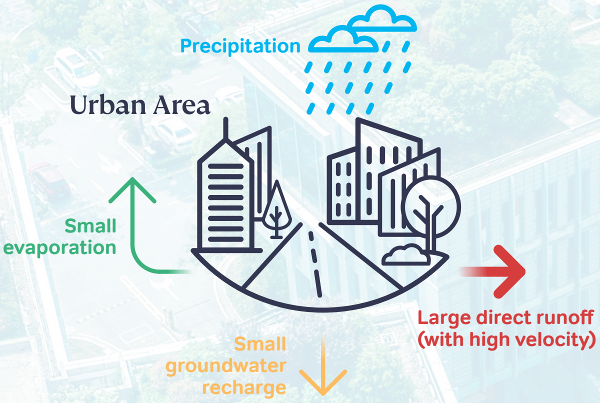
People around the world have been using a layer of vegetation to protect their roofs and insulate their properties for centuries. But today's solutions are far more sophisticated than a simple green roof. The Wavin PolderRoof[7], for example, is a solution that uses a water retention layer to hold water for greenery and can or can be equipped with sensors and valves to decide how best to manage the rainwater, which it then retains or releases in a controlled manner as needed.

#3 | Soil sealing: a varied picture

The extent of the soil sealing problem can vary enormously from city to city, even within one country. In Germany, for example, this ranges from Potsdam, which satellite images from Destatis (the Federal Statistical Office) show is only 13% 'sealed', to Ludwigshafen am Rhein, which according to a 'sealing study' commissioned by the German Insurance Association (GDV) to better assess the risk of flooding in cities, has 67% of its surface sealed. Unsurprisingly, the GDV is now urging municipalities to "take into greater account the risk of heavy rainfall in their urban and landscape planning".[8] Essentially, a plea to take the sort of water management initiatives found in this white paper.

Across European countries, the picture is even more varied. In Greece, for example, 20% of cities are more than 75% soil sealed, and some 90% over 50% soil sealed. By contrast, nearly 20% of cities in Sweden are less than 25% soil sealed, with all cities being less than 50% sealed.[9]

While you have to go to Asia for arguably the most impressive statistic: according to the Centre for Liveable Cities, nearly 47% of Singapore's surface area is green space. Showing that it is possible to make even this densely-populated, hyper-modern metropolis a genuine garden city.[10]



#4 | How water management used to address society's challenges

Modern day sewage systems are still largely based on those developed in 18th century England, where the link between cholera and contaminated water had just been discovered. In response, a new sewage system with pipes, pumps, sand filtration and chlorination was developed to improve drinking water quality, and separate wastewater from drinking water. As a result, "incredible public health successes were achieved. Water-borne diseases have all been wiped out in most of the developed world. Yet, as cities have grown and grown, new water challenges have emerged."

If 18th Century England's main water management challenge was preventing disease, today ours is the increasingly extreme and frequent weather events resulting from climate change. And if the answer in the 18th century was to drive water out of town so it could be purified, a key part of todays' answer is to develop a green-blue infrastructure that intelligently combines the grey infrastructure that is unavoidable in an urban setting with nature-based solutions in order to create hybrid systems.

Hybrid systems integrate vegetation and water features to improve resilience to climate impacts. The many benefits include:

- pollution control
- improved air and water quality
- better habitats for wildlife
- far cheaper than operating & maintaining traditional drainage systems
- flood prevention
- facilitating natural groundwater discharge
- enhanced living environment for citizens.

Step by step: if we know what to do...

So what is the most effective and deliverable way we can harness nature in our cities to positively influence the microclimate, mitigate the effect of heat islands and reduce the risk of flooding? In many ways, the answer is simple — to define, at least, if not always to implement: We need to increase the climate resilience of cities by moving to sustainable rainwater management and planning based on the natural water cycle. And each stage of that cycle is equally important. Which is why at Wavin, we refer to the 5Cs: Catch, Collect, Connect, Clean and Control.

But if we look at where we can have most impact on water management, we can break it down into three main areas where we can make transformational improvements to our cities' urban climate resilience simply through a number of relatively straightforward steps:

MORE GREEN SPACES

It is widely agreed that the share of land given over to settlement and traffic areas needs to be limited. One 'rule of thumb' adopted by Wavin and many others striving for the greenification of cities is the 3-30-300 principle[11]. This says that in an ideal urban environment:

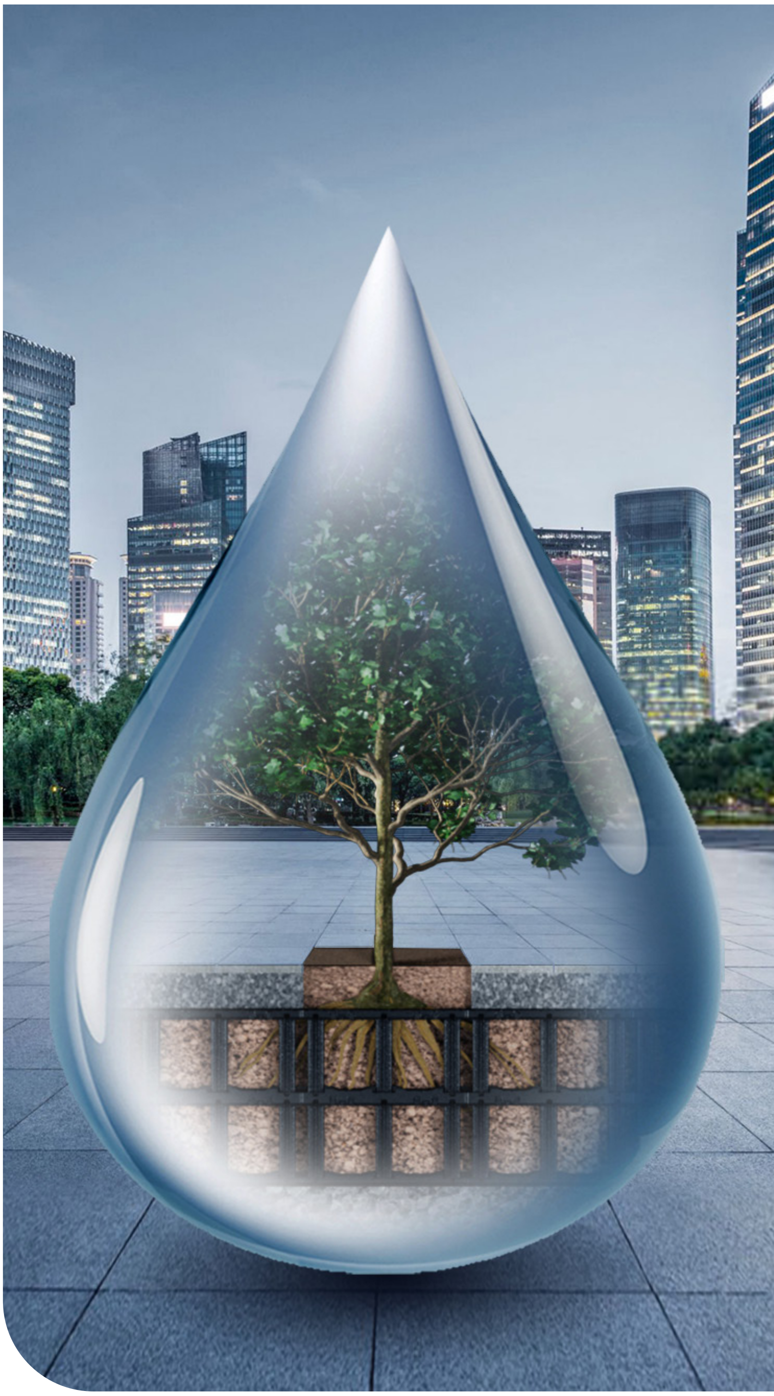
- you should be able to see 3 trees from your window;
- your city's tree coverage should be at least 30%;
- and you should never be more than 300 metres from a shaded spot.

And while this may not sound all that utopian, the fact is there are few if any cities on Earth today where this is already true (See Box 5 – Good things come in trees).

One simple way to not only increase the number of trees in a city, but also ensure they thrive, is the Wavin TreeTank. Normally placed under a pavement, the tank gives tree roots the nutrients and room to grow, while containing them in their intended area. The same tank principle can be applied to larger reservoirs.

And around the world, public authorities are trying to respond to the need for more green spaces. In Germany, for example, the government has set a goal to limit the average daily increase of areas used for settlement or traffic to 30 hectares by 2030, and for that figure to be net-zero by 2050 (creating a so-called 'area cycle economy'). But right now, those goals look a long way off: according to Destatis (the German Federal Statistical Office), from 2018 to 2021 the settlement and traffic area in Germany grew by an average 55 hectares (78 football pitches) a day.

So politicians and policymakers can have a huge positive impact not just through legislation and policy, but also by being first movers who lead by example. Winning over the public and private sectors, as well as ordinary citizens, to join and support the transition from a grey to a blue-green built environment with initiatives that have a clear positive impact on the city landscape, making it visibly greener.



A good example is by introducing depressions, or rain gardens. These are hollows in the terrain designed to receive, store and filter runoff from roofs or surfaces and so form ponds or small lakes. These depressions can also be specially planted with plants that cope with dry and wet conditions, helping the pond and local ecosystem flourish. In fact, depressions help move the dial on just about every aspect of the blue-green city, from increased biodiversity to enhanced quality of life.

The visionary policymakers of Curitiba, a city in Brazil with a population of nearly 2 million, have been pioneering these sorts of environmentally-friendly initiatives since the 1970s. Today, the city has 52m^2 of green space per person, making it one of the world's greenest conurbations. And unlike many cities in Brazil (and globally), which channel river systems with concrete walls and barriers, Curitiba has for decades allowed its vast green spaces to act as a natural stormwater management system, preserving the natural course of its rivers and mitigating the impact of the city's sealed areas.

Because it shouldn't be forgotten that a less sealed urban environment also makes other circular water management initiatives both easier to implement and more effective once they are implemented.

#5 | Good things come in trees

The continued shortage of trees in our urban landscape remains a curious phenomenon. Most citizens value having trees where they live, work and go to relax[12]. It is also widely accepted that trees have a huge positive impact on everything from people's ability to recover from illness to the absorption of CO_2. And surprising new positive findings are emerging all the time. Such as a recent study published in the leading medical journal, The Lancet[13], which found that trees can cool cities by up to 12°C on a hot day.

Step by step: if we know what to do…

SPONGE CITIES

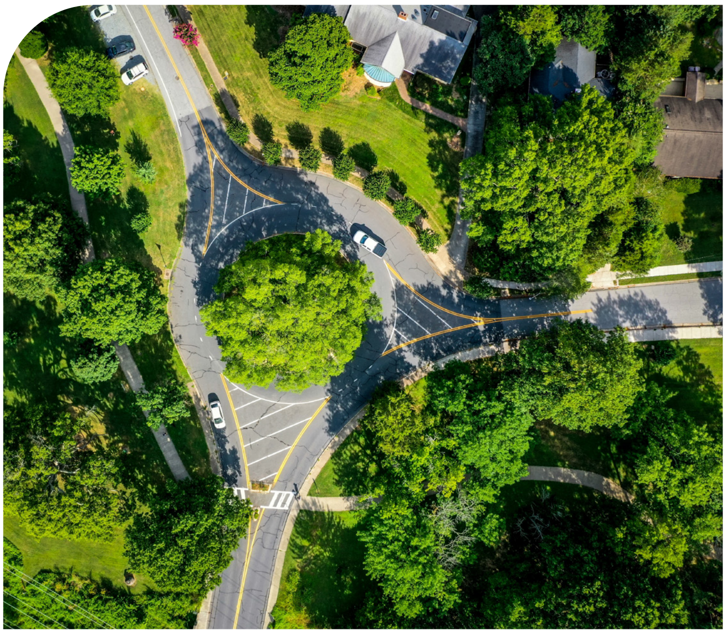
A 'sponge city' is one where rainwater is stored locally instead of being drained through the sewer system.

Built environment materials have two things in common: they absorb heat and they don't absorb water. So rainwater flows away from where it will later be needed. What you want, of course, is to be able to collect the water when you can and use it when it's needed.

This is relatively straightforward if you employ solutions like Wavin's AquaCell infiltration and attenuation units. These units are installed underground to capture rainwater, temporarily or year-round. This can be for infiltration back into the ground or for reuse, depending where the unit has been placed.

For infiltration if it's under a parking lot, for example, or reuse if it's under sport fields or a local park.

By maximising its sponge-like qualities and capacity, your city significantly reduces the risk both of flooding during extreme rainfall and of heat stress when the drought periods arrive. So, given that de-sealing urban areas on a large scale is a longer-term project, many believe that forward-thinking municipalities should be looking now to this sort of decentralized rainwater management solution.



Here are a few key components of any successful sponge city:

- **Permeable traffic areas and pavements** that precipitation can infiltrate, thereby replenishing vital groundwater reservoirs and relieving the sewer system.
- **Root chamber systems** (like the Wavin TreeTank) that provide the space and oxygen for trees to flourish. Urban greenery also improves air quality, cools the city during hot spells through evaporation, and absorbs rainwater.
- **Infiltration trenches** that capture heavy rainfall, then gradually release it to form groundwater in the soil.
- **Depressions** – see 'More green spaces' above
- **Facade greening**, which enriches the microclimate (and also softens the contours of the urban land-scape, with positive effects on live-ability and individuals' well-being).
- **Multi-functional areas** like sports fields or green roofs, which can serve as temporary storage during rainy periods.

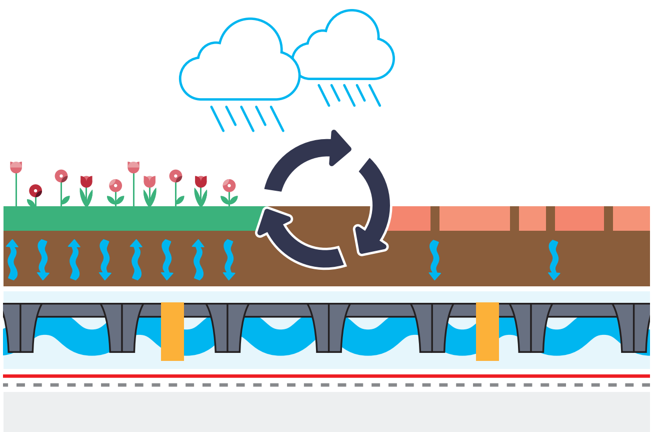
In a world where the demand for drinking water is projected to increase by more than 70%[15] over the next three decades , making it increasingly scarce, we need to maximise our use of rainwater in the ways here described. That way, we can stop as much as possible using our precious drinking water for other purposes, such as irrigation.

ROOF AREAS

With limited possibilities to create additional green spaces in cities at ground level, flat roofs offer huge potential. For instance, the German Association of Building Greening (Bundesverband GebäudeGrün e.V. – BuGG) reported that 90 percent of new roofs in Germany remained ungreened in 2021. Flat roofs can be transformed into aesthetically-pleasing, multi-functional rooftop gardens. With appropriate maintenance and good water management, these blue-green oases will flourish, offering a range of benefits:

- Collected rainwater reduces or delays runoff into the sewer system, vitally important during bouts of extreme rainfall;
- Stored water can be used for plant irrigation;
- Retention basins and vegetation provide cooling and healthier air quality;
- Cooling also helps mitigate urban heat islands;
- Thriving plant life attracts flora and fauna, enhancing biodiversity;
- The roofs provide community green spaces;
- Buildings are water autonomous, dealing with the rainwater that falls on them;
- Buildings can be water-neutral, by reusing their rainwater.

New, blue-green solutions that are designed specifically for roof gardens will optimise these various benefits. Take the rainwater retention rate (the percentage of water that is captured, retained and reused). This is significantly higher with smart blue-green roofs than less advanced green roof solutions – for example Wavin's PolderRoof. With a higher water management efficiency, the retained water not only provides a buffer – putting less strain on the sewage system during heavy rainfall – but the roof garden can also draw on the retained water throughout the ever-longer drought periods we now face in many parts of the world.



Catalysing change: encourage, incentivise, reward

As with any major transition, things never really take off until they are embraced at a grass roots level by homeowners and landlords, local schools and sports clubs, neighbourhood associations and community influencers. But also by particular sectors, such as tourism or distribution centres, and certain professions, such as architects or office managers. Getting all these stakeholders enthusiastic is partly a question of making the benefits clear to them.

One way to stimulate uptake of blue-green initiatives is to provide economic incentives. Take the example of roof gardens. In many countries rainwater fees are traditionally based on the area of a building's impermeable surface. So if you're a municipality, you could consider giving a fee reduction (e.g. per square meter) to users of blue-green roof systems.

Insurance companies and mortgage providers are also increasingly offering incentives to clients whose homes are more climate resilient. These range from leading UK bank, Lloyds , who offer cashback rewards to clients who make 'green' home improvements, to Dutch mortgage provider Woonnu whose whole offering and market positioning is built around rewarding sustainable homeowners.

Winning relevant sectors over can also sometimes simply be a question of how you communicate on climate resilience. People are rational, but also emotional. For example, government agencies, financial institutions, NGOs and others perhaps need to remind people who develop, own and manage buildings less about the big picture ('If we don't do something about climate change our children will suffer'), as people tend to feel impotent in the face of such huge abstractions. Thinking it's a problem too big for them to solve, and therefore doing nothing in response.

Instead, you can focus messaging on detail. For example, a local municipality could run a blue-green roof campaign targeted at the owners and developers of public buildings. Explaining how, by reducing the temperature on your roof, a blue-green roof garden also increases the efficiency of your solar panels and means your HVAC system requires less energy, as the air it draws in is already cooler. An apartment owner or office block occupier is probably then more likely to be triggered to look into the possibilities of a blue-green roof for their building.

You can also target those responsible for decisions for very specific types of buildings. For example suggesting to data centres, 90% of whose water use is for cooling, that they consider collecting and using rainwater for that cooling process. Or to the owners of buildings that are visited by consumers – bars, shops, restaurants – that they consider a green roof or walls.

These insulate their building, provide habitat for insects and small birds, and tell your clientele in a striking way that you're a daring company serious about sustainability issues.

You can also launch fun, inspiring, media-friendly initiatives aimed at individual citizens, like the Dutch Tile Flipping Championships (see 1 above).

In any case, it is important to continue to find new ways and means of keeping people engaged. With case studies on a human scale that they can relate to — because these are stories with which people, including decision-makers, can identify and will therefore hopefully want to emulate.

Does it hold water?
Preparing for the future.

Water is a global issue. Communities are interconnected through and interdependent upon the natural water cycle. The more this is impeded, the more our towns and cities literally start to fall apart. Governments around the world are responding by developing action plans, outlining how they intend to combat the water crisis and make their countries more climate resilient.

So, for example, Germany has pledged to ensure sustainable water management within its own borders. While the EU has made a €12 billion commitment for 2021-2027 to support sustainable water management within the EU[17] . This includes some dizzying numbers: 45,500 km of new/upgraded public-use water supply distribution systems; 37,000 km of new/upgraded pipes for wastewater collection networks; new/upgraded wastewater treatment for a population equivalent of 13 million; 16 million additional personnel for improved public water supply work, and more.

Meanwhile, on the other side of the planet, Singapore is further down the line with equally ambitious goals. In 2021, the Singapore government announced plans for a 'forest town' of 42,000 houses spread over 700 hectares, with extensive areas of public gardens and a nature reserve, along with a sustainable transport system and a range of other eco-friendly features.

With this scale of investment and level of ambition, we can move beyond just patching up legacy sewage water systems to invest in smart urban climate resilient solutions designed for the future. Local decision-makers around the world are now embracing the concept of blue-green cities, a concept that aligns closely with the UN SDGs and other global sustainability goals. We have never been more ready or better equipped to implement the changes needed to our water management systems to make our cities resilient to the climate challenges they will continue to face going forward. Or as we would put it at Wavin, there has never been a better time to see water differently.

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An Orbia business.

Address

World Trade Center (WTC)
Wavin Tower F9
Schiphol Boulevard 425
1118 BK Schiphol
The Netherlands

Contact

Wavin Netherlands (Hardenberg)
+31 (0) 523 288 165

For more information visit

www.wavin.com