

Nature-based solutions

Supporting climate adaptation





Foreword

The scientific evidence in the 2022 IPCC report is unequivocal: climate change threatens human well-being and our planet's health. Climate change causes sea level rise as well as more frequent heavy rainfall, heat waves, and dry spells, resulting in losses to our ecosystems, infrastructure, cities, and people's wellbeing and livelihoods. A report published by National Oceanic and Atmospheric Administration and NASA confirmed that 2010 to 2019 was the hottest decade on record – and this trend is only escalating. We can no longer wait; it is now time for climate action. We need to reduce our carbon footprint and adapt to climate change simultaneously.

Cities are both key contributors and solution providers to climate-related challenges. The number of people living in cities and their economic activities make them responsible for 70% of the world's energy consumption, producing an immense carbon footprint. This same population density also makes cities incredibly vulnerable to climate risks. The way we manage, plan, build, and develop our cities will determine how we can mitigate and adapt to climate change. Nature-based solutions provide an interesting answer – contributing to improving climate resilience in cities in a more sustainable way, while reversing biodiversity loss and reducing our carbon footprint.

At Arcadis, we have partnered with public and private sector stakeholders across projects worldwide to adapt to climate change, mostly in cities, and along coastlines and deltas. These areas are densely populated and vastly impacted by climate change. The use of nature-based solutions here has helped cities and communities adapt to climate change by managing and working with (instead of against) the forces of nature.

In this whitepaper, we focus on these areas, together with best practices and lessons learned that can help cities and communities adapt sustainably and resiliently to climate change. In doing so, we hope to inspire others to commit to investing in nature-based solutions that help improve quality of life for all.



Piet Dircke
Global Director, Climate Adaptation

The climate is changing

The increasing frequency and intensity of extreme weather conditions is pushing natural and human systems beyond their ability to adapt¹. The consequences of climate change are already being felt directly through material, social and economic damage. The devastating Australian 2019-2020 bushfire season², the summer floods of 2021 in northwestern Europe³, the deadliest heatwave in north-west America on record in 2021⁴, and the 2022 floods displacing millions of people in South Asia⁵ are examples of disasters partially attributed to climate change.

According to a recently published study⁶, climate change is the greatest threat to public health: “Rapid climate change is having serious impacts on every aspect of human life, exposing vulnerable populations to extreme weather events, infectious diseases and changes in food security. The global availability of safe drinking water and clean air is at risk.” A Deloitte study indicated that inaction on climate change could cost the world’s economy US\$178 trillion by 2070⁷.

Preventing future costs and losses from climate change has been a key incentive for decision-makers around the globe to commit to the

Paris Agreement, which aims to limit temperature rise to 1.5°C. At the recent COP27, a commitment was made by 200 countries to support crisis response and alleviation efforts for climate vulnerable countries in the Global South through the set-up of a [Loss and Damage Fund](#). There was also a recognition that climate adaptation, particularly with biodiversity and ‘just transition’ considerations in mind, must be a focus at pace with decarbonization targets.

There is progress being made in addressing climate change challenges, but is it enough? And how can we accelerate action?



1 IPCC, 2022: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegria, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press. In Press.

2 IDMC (2020). The 2019-2020 Australian Bushfires: From Temporary Evacuation to Longer-Term Displacement. Retrieved from [here](#)

3 Copernicus (2021). Widespread European flooding, July 2021. Retrieved from [here](#)

4 The Guardian (2021). Record-breaking US Pacific north-west heatwave killed almost 200 people. Retrieved from [here](#)

5 CNN (2022). Millions affected after deadly floods hit India and Bangladesh. Retrieved from [here](#)

6 Watts, N., Amann, M., Arnell, N., Ayeb-Karlsson, S., Belesova, K., Berry, H. & ... Costello, A. (2018). The 2018 report of the Lancet Countdown on health and climate change: shaping the health of nations for centuries to come. *The Lancet*, 392 (10163), 2479 – 2514. [https://doi.org/10.1016/S0140-6736\(18\)32594-7](https://doi.org/10.1016/S0140-6736(18)32594-7)

7 Deloitte. (2022). Inaction on Climate Change Could Cost the US Economy \$14.5 Trillion by 2070

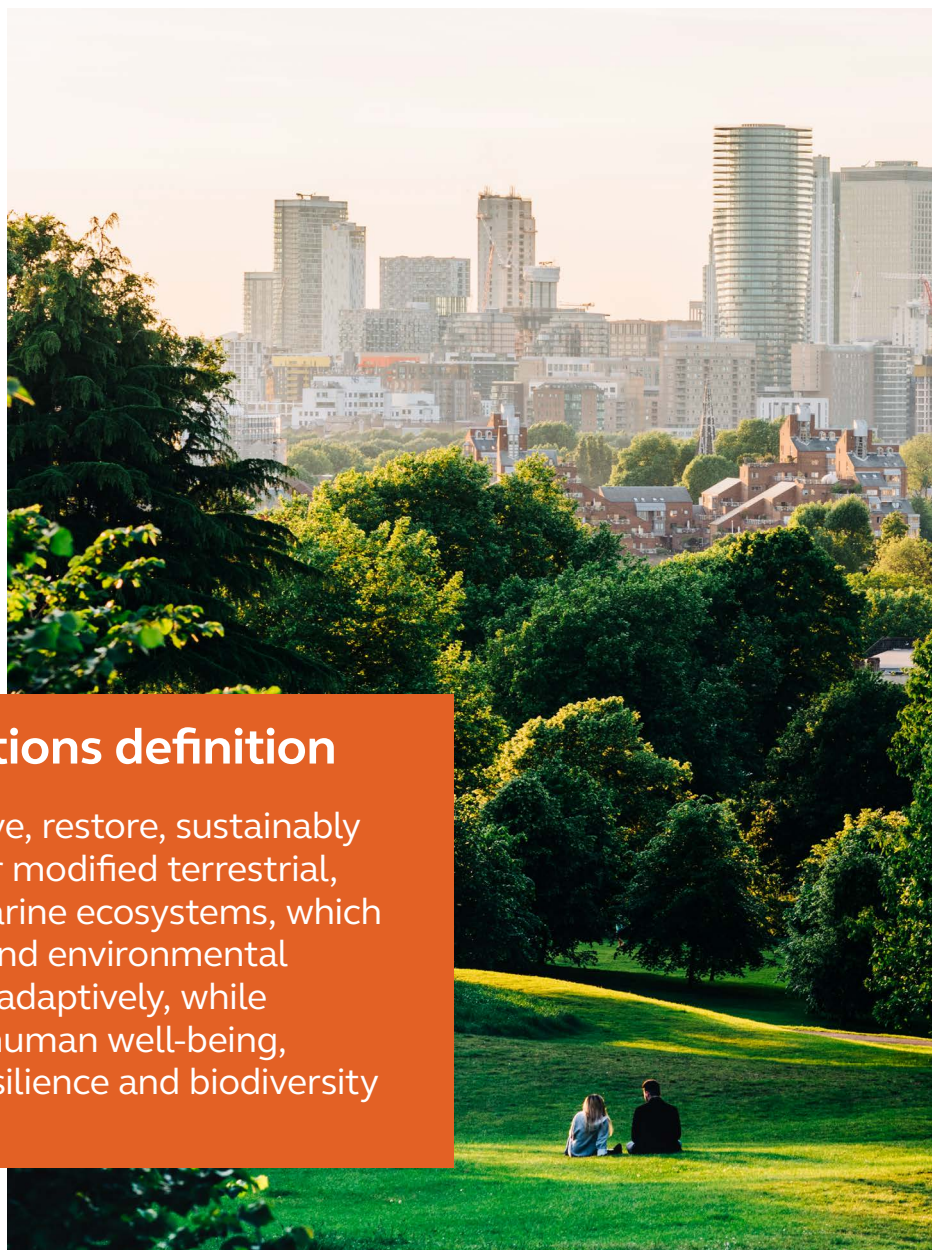
The U.S. economy could gain \$3 trillion over the next 50 years if it accelerates towards a path of low-emissions growth. Retrieved from [here](#)

Nature-based solutions

Well-planned and well-designed nature-based solutions can contribute significantly to both climate mitigation and climate adaptation, while protecting and improving the natural system. Nature-based solutions align with and support all the United Nation's Sustainable Development Goals (SDGs). Most directly impacted are Climate Action (SDG 13), Life Below Water (SDG 14), Life on Land (SDG 15), Good Health and Well-Being (SDG 3), Clean water and Sanitation (SDG 6) and Responsible Consumption and Production (SDG 12).

It is not always possible to choose an exclusively nature-based solution. Compromises must be made to make climate-related solutions as integrative as possible and to address multiple issues at once. The costs of these adjustments are often offset by reduced risk of damage, lower energy bills and maintenance costs, carbon credits, and increased quality of life. Solutions therefore need to be considered that are beneficial for nature, society, and the economy together.

Re-establishing lost or degraded coastal ecosystems, restoring riverbanks and flood plains, or bringing green into our cities, provide opportunities to give back to nature and maintain these vital environments for generations to come.



Nature-based solutions definition

Actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems, which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services and resilience and biodiversity benefits. (UNEA-5, 2021)



The City of Birmingham: an environmental justice approach

As a one-time industrial giant of England's West Midlands, Birmingham has long considered a comprehensive, integrated approach to the challenges it faces. Most recently it has applied this approach to climate crisis challenges. This year, Birmingham released its 25-year plan to become a City of Nature, where the value of parks and greens spaces to both climate and health is promoted and recognized.

The Birmingham Climate Change Adaptation Partnership showed that the most deprived areas in the West Midlands are clustered in city centres making them most at risk of the urban heat island effect and increasing health inequality. When equipped with this knowledge, greening can be designed in such a way to lower ambient air temperature, while providing additional benefits to mental health and flood mitigation, both of which are also climate change risks for Birmingham.

City of Nature, which is a key theme of the soon to be revealed new Vision for Birmingham - Our Future City Plan - aims for 25% of green infrastructure and nature recovery to be joint funded through Green or Climate Bonds/Investment. To prioritize investments in these nature-based solutions, the Birmingham City Council maps ecosystem services against the index of multiple deprivation to create an [environmental justice map](#).

Deborah adds, "[City of Nature](#) plots a path to addressing nature recovery and inequity of access, as well as being a major component of Birmingham's Route to Zero Climate Emergency Plan. In the face of the increasing impacts of climate change, we will continue to work with both people and nature in finding solutions. In a recent event, [PolliNation](#), this approach was celebrated highlighting the importance of access to green spaces and a healthy planet alongside the diversity of people and culture in the city."

"As cities around the world stand at the forefront of the climate and biodiversity crises, adaptation solutions which address both simultaneously are the foundation of any urban strategy. For those solutions to succeed, we must consider the social component. Too often, the needs of those least well provided for are overlooked, leading to an exacerbation of vulnerability to climate."



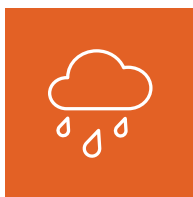
Deborah Cadman OBE
Chief Executive, Birmingham City Council

Climate adaptation challenges for nature-based solutions

For a long time, climate adaptation efforts mostly related to water management with a focus on flood protection. But as climate change is becoming more significant, integrated nature-based solutions can help tackle multiple challenges from coastal and river floods (both urban as well as rural), droughts, and water shortages, to heat stress in towns and cities, and wildfires and biodiversity impacts in more rural areas. Icons in Figure 1 below illustrate these challenges which will be referenced throughout this paper.



Flooding



Heavy rain



Wildfires



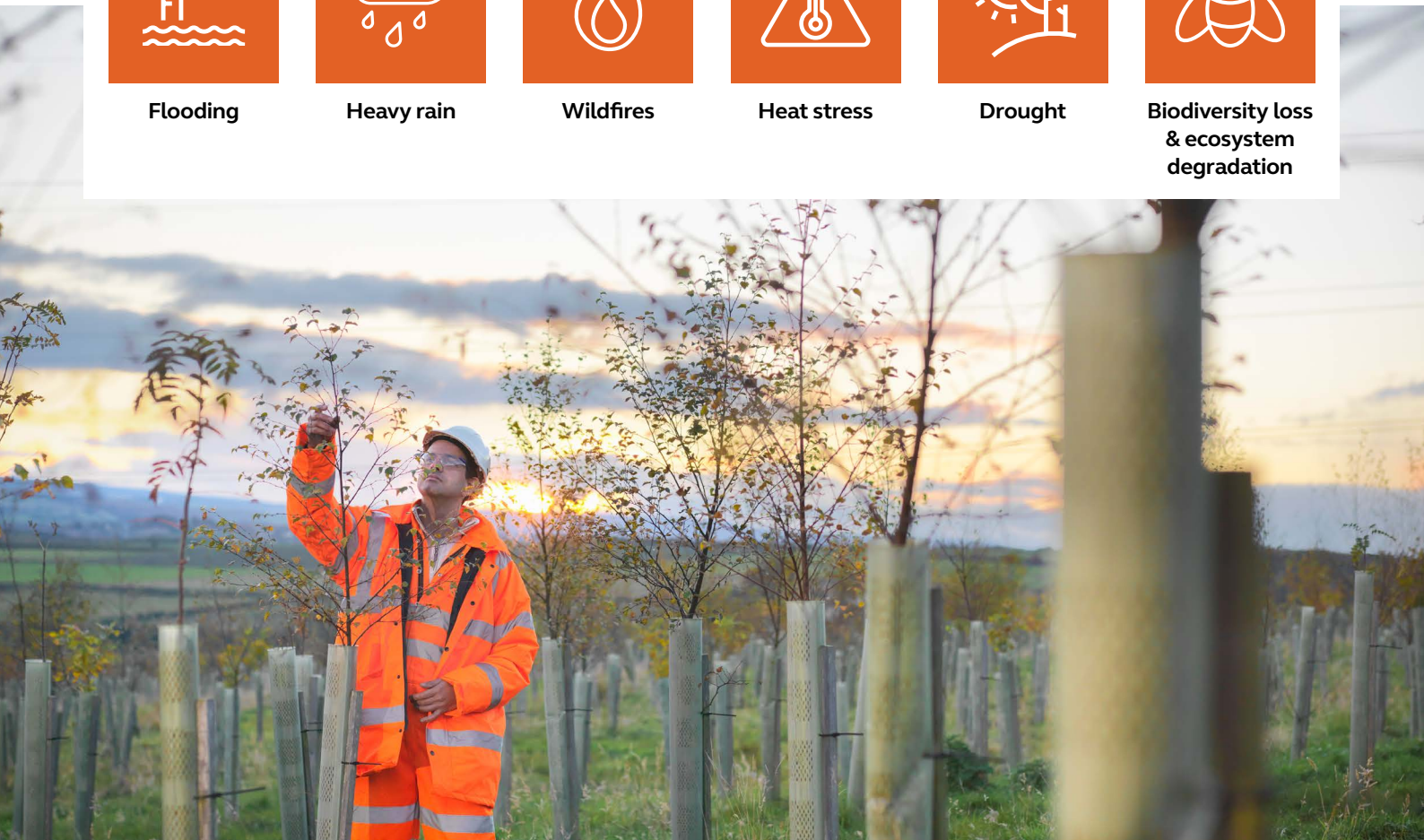
Heat stress



Drought



**Biodiversity loss
& ecosystem
degradation**





Coastal flooding

Around 40% of the world's population lives within 100 km of the coast. People are drawn to coastal areas because of the economic benefits that ensue from access to global trade, coastal fisheries, tourism and recreation. However, coastal areas are particularly exposed to natural disaster risks such as hurricanes, cyclones, tsunamis, and coastal floods. These hazards will increase because of climate change and sea level rise, and are intensified by the degradation of coastal wetlands, mangroves and coral reefs.

Building with nature

This concept, developed by the *Dutch EcoShape consortium*, of which Arcadis is part, entails a new approach to coastal hydrodynamic and ecomorphological engineering, using the forces of nature to strengthen the coast. This design approach develops nature-based solutions for water-related infrastructure such as flood defences, sustainable port development and the restoration of ecosystems.

Communities across the globe can adapt to rising sea levels and storm surge events in a sustainable and resilient way. There are possibilities to reuse locally dredged material that is often disposed, use the power of waves and tides, and work with native flora and fauna to reinforce dunes and dikes, restoring coastal ecosystems and their services. Also, creating innovative hybrid designs to soften traditional civil engineered defence structures.



Dune-in-front-of-dike

Hondsbosche and Pettemer coastal protection in the Netherlands

The Hondsbosche and Pettemer Sea coastal protection is a 6-kilometre-long dike along the North Sea. With rising sea levels, this stretch needed further strengthening to make the coastline climate resilient, while preserving the valuable surrounding landscape and creating a connection between the area and the natural reserves. An integrated approach was chosen that focused on landscape, cultural heritage, nature development, recreation and liveability.

Instead of raising the existing dike, the coast was fortified with a natural barrier of almost 36 million cubic meters of sand. Adding to that, a thriving new dune system that's overgrown with native vegetation (see Figure 2). Arcadis was involved in the planning, engineering, coastal morphology investigation, scenario analysis, environmental assessment, archaeological assessment and much more.

This project resulted in climate-proof flood protection, and a complete makeover of the area blending the newly created landscape with the Dutch coast. It has created space for nature conservation and recreational activities, improving quality of life for the local community and visitors.

Figure 2: Picture and visual presentation of the new dune at Hondsbosche and Pettemer coastal protection.

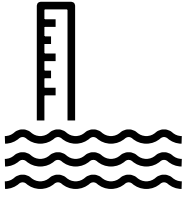
Louisiana Coastal Area Beneficial Use of Dredged Material (BUDMAT) program, USA

The natural deltaic processes of the Mississippi River have led to the formation of the extraordinary diverse wetland ecosystems along the Louisiana coastal zone. These ecosystems are among the country's most productive and important natural assets, providing coastal protection and a vital habitat for birds, fish and other species. However, due to the hydrologic alteration of the Mississippi River, land subsidence, and development pressures, these beneficial ecosystems and their protection function are deteriorating.

Sediments from local maintenance dredging operations were reused to develop a 150-ft marsh platform and restore 34 acres of the Spanish Pass coastal ridge and 60 acres of coastal wetlands. Our team worked on altering the Mississippi water management strategy and removing sediment from the upstream riverbed, resulting in some 85,000 cubic feet of sediment-rich water per second which will be naturally fed to Louisiana's coastal zone. Over the next 50 years, this will build up and restore 25,000 acres of coastal wetlands, while reducing land loss to strengthen Louisiana's coastal protection and ecosystems.



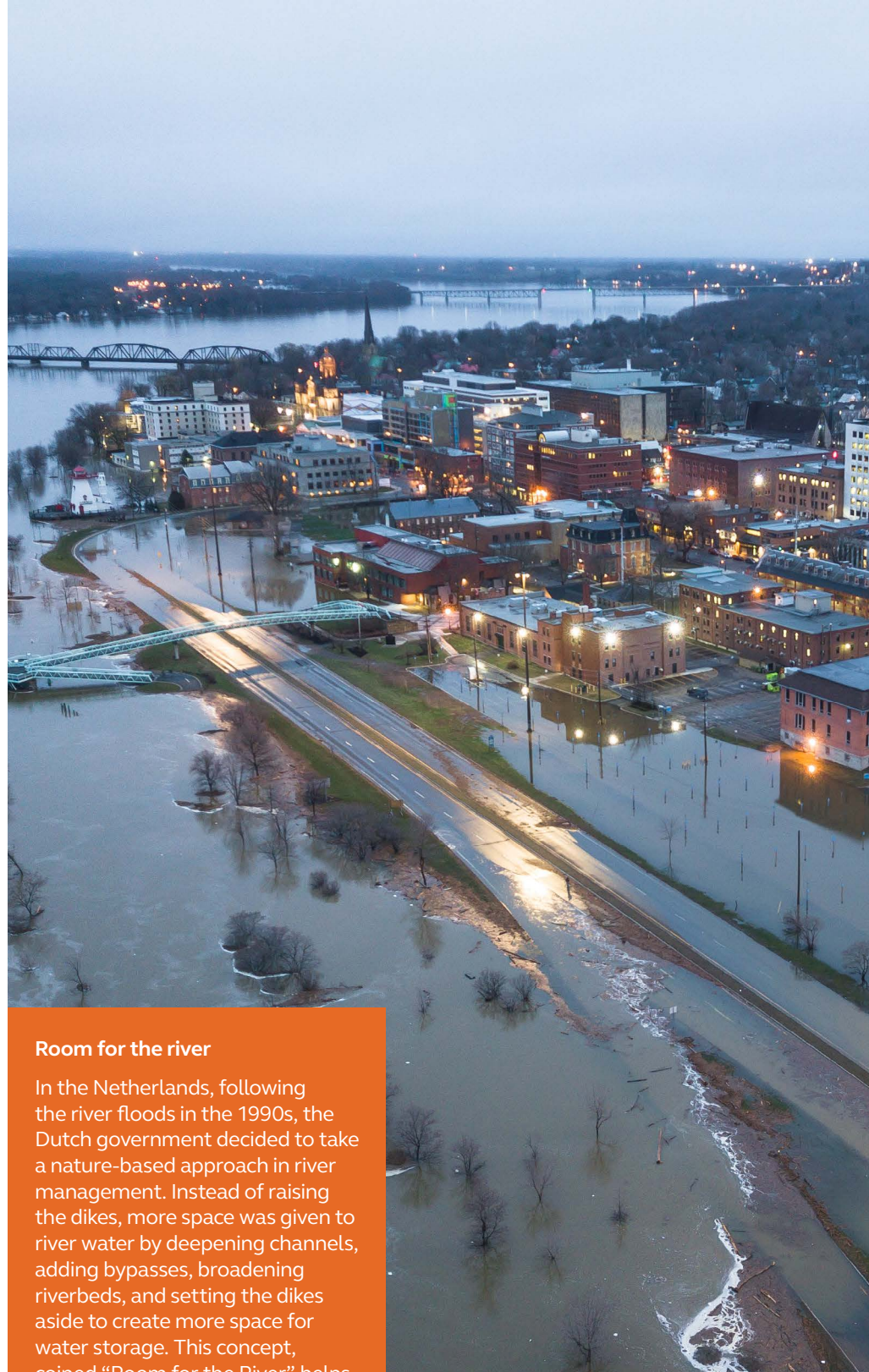
Figure 3: Louisiana's wetlands were naturally built up by accumulating sediments



River flooding

Humans have traditionally lived close to freshwater sources such as rivers and lakes for their water supply⁸, the surrounding fertile lands, transport, trade and much more. Many cities were established along rivers and are still home to millions of people. Rivers also play an important role in the water cycle as they channel surface water and drain nearly 75% of the surface land on earth. Due to this characteristic, rivers are prone to swelling during heavy rainfall and can spread beyond their banks to cover surrounding lands. This can be extremely dangerous to ill-prepared cities and their inhabitants.

Climate change and human development have further exacerbated this over the last 50 years. Frequencies and magnitudes of floods are anticipated to become more severe due to global warming worldwide^{9 10}. Another study¹¹ found that human losses from flooding could rise by 70–83% with an uneven regional distribution.



Room for the river

In the Netherlands, following the river floods in the 1990s, the Dutch government decided to take a nature-based approach in river management. Instead of raising the dikes, more space was given to river water by deepening channels, adding bypasses, broadening riverbeds, and setting the dikes aside to create more space for water storage. This concept, coined “Room for the River” helps enhance biodiversity and water security, reconnects communities with nature, and creates economic opportunities for nature, society and the economy.

8 Kummu, M., de Moel, H., Ward, P. J., & Varis, O. (2011). How close do we live to water? A global analysis of population distance to freshwater bodies. PloS one

9 Di Baldassarre G, Viglione A, Carr G et al (2013). Socio-hydrology: conceptualising human-flood interactions. Hydrology and Earth System Science 17:3295–3303. Retrieved from [here](#).

10 Alfieri L, Bisselink B, Dottori F et al (2017). Global projections of river flood risk in a warmer world. Earths Future 5:171–182. Retrieved from [here](#)

11 Dottori F, Szewczyk W, Ciscar J-C et al (2018). Increased human and economic losses from river flooding with anthropogenic warming. Nature Climate Change 8:781–786. Retrieved from [here](#)

Noordwaard & Overdiepse Polder in the Netherlands

Noordwaard is one of the leading projects in the Dutch Room for the River program and entails transformation of a 2000-hectare area into a flood plain. The primary dikes were lowered, creating a 1250-hectare space that serves as a 'through-flow' area. The remainder of the space hosts agricultural units with their own water management system (called "polders" in Dutch) which is used as a flood plain in case of extreme high water. The Noordwaard project demonstrated its value in February 2020, when the river water rose above the dike, flowing into the polder, leaving the surrounding houses and roads dry.

The Overdiepse Polder (see Figure 4) is an area chosen to be controllably flooded during extreme river runoffs to alleviate other areas along the river. The resulting multifunctional area is used both for agricultural purposes and water retention when needed.



The project has been co-created together with the rural inhabitants of the Polder. They proposed the creation of 'dwelling mounds' which help secure their farms from flooding when the lower laying fields are controllably inundated.

The existing dike around the polder has now been lowered, and a new dike has been raised further inland, along which eight 6-meter mounds have been created. Arcadis has been involved in the contract preparation and has supervised the execution of the project.

Figure 4: An aerial view of the Overdiepse Polder

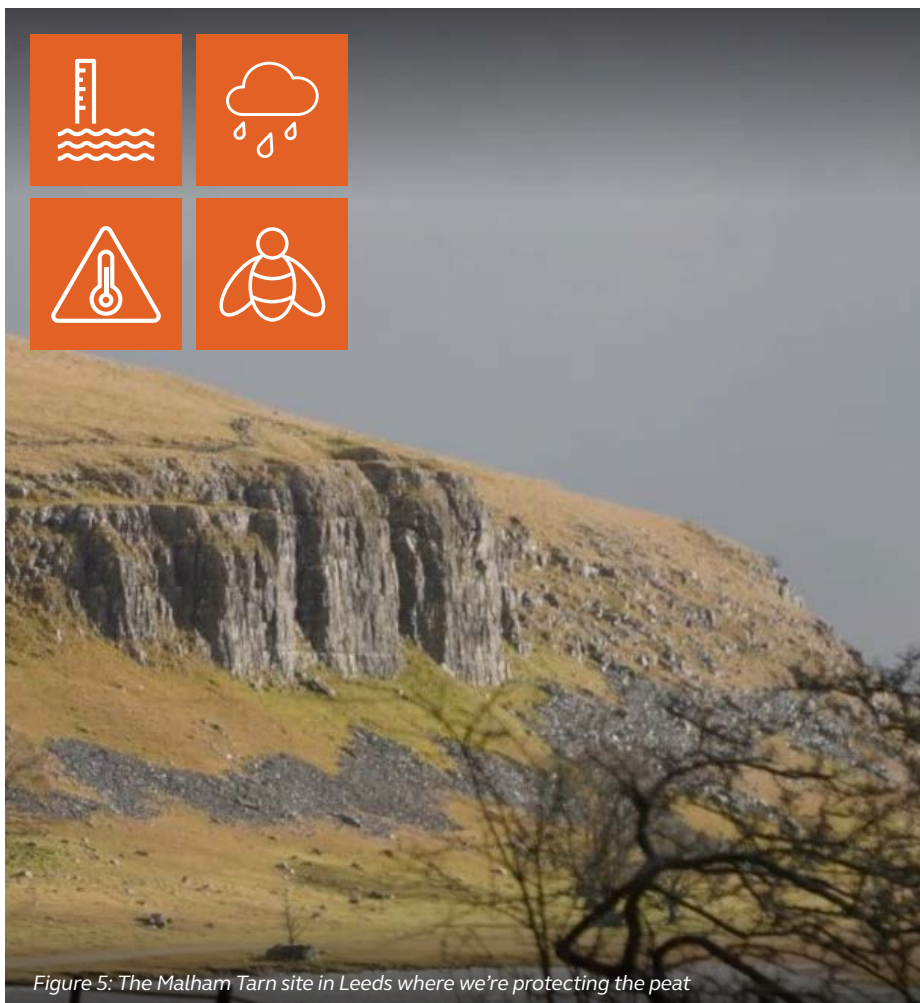


Figure 5: The Malham Tarn site in Leeds where we're protecting the peat

Natural flood management to alleviate flooding in Leeds

In the UK, Leeds experienced devastating floods on Boxing Day in 2015. Leeds City Council has adopted a catchment-wide approach to protect homes and businesses from the risk of flooding, with a combination of traditional engineered defenses and nature-based solutions, to offset climate change and maintain levels of flood protection.

Through the 'Leeds Flood Alleviation – Natural Flood Management project', Arcadis is collaborating with the Leeds City Council to deliver nature-based solutions and natural flood management interventions throughout the 700km² Upper River Aire Catchment. This includes the use of nature to absorb and store more flood water along the River Aire, particularly near the source. Not only is this solution estimated to double the effectiveness and lifetime of the engineered defenses in the city, but it's also creating a more livable, safe and enjoyable place for residents thanks to the planting of more than two million trees, protecting over a thousand homes and nearly five hundred businesses.



Heavy rainfall

Due to climate change, rainfall intensities and frequencies are increasing. In dense, paved, urban environments with limited water storage capacity, this poses a high risk of overflowing sewage systems and flooding due to runoff and high river levels, with an increased risk of dirty water potentially spreading diseases or waste.

Sponge City Wuhan

Bringing nature-based or hybrid solutions into cities can improve water discharge and create more permeable surfaces for underwater reserves that can also serve as water storage for dryer times.

With a growing population and more extreme weather events, the city of Wuhan is faced with the challenges of water scarcity, urban flooding and water quality. The Government of China decided to develop its National Sponge City program, with its first pilot in the city, developed by the Wuhan Water Authority. The program enables the city to act as a 'sponge' with an urban environment planned and constructed to soak up almost every raindrop and capture that water for sustainable reuse.

Arcadis provided technical, policy, and program management related advisory. The new sponge city water strategy will be implemented through an integrated water management system, combining green infrastructure, an upgraded urban drainage system, water storage, and purification facilities. These measures will result in reduced peak runoffs, increased water storage capacity, and improved water quality. In addition, the realized green infrastructure also enhances carbon storage, urban cooling, the urban ecosystem and air purification throughout the city. Sponge cities also prioritize the protection and restoration of original ecosystems in the urban area, such as rivers, lakes and wetlands.

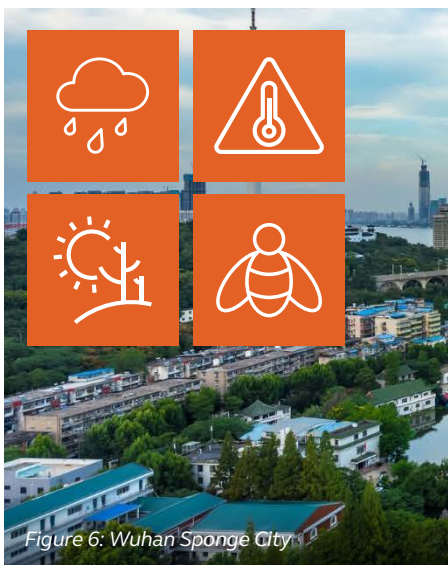


Figure 6: Wuhan Sponge City



Drought

We can never solve the climate challenge without addressing the world’s pressing water crisis. In some parts of the world, this manifests itself in the form of droughts, which leads to a lack of drinking water, poor sanitation, and in some cases unsafe environmental conditions that can lead to fire risks.

It doesn’t just stop there - droughts have severe direct and indirect impacts on ecological, agricultural, and economic sectors, such as damage to wildlife habitats and crops. Low water availability can also have strong ramifications on renewable energy supply such as solar thermal, geothermal, and hydropower generation – negatively impacting our world’s transition to low carbon energy sources¹².

2022 saw record drought conditions sweep Europe – the World Weather Attribution service found that climate change has made droughts in the year 20 times more likely in the continent. In the US, more than 43% of the country was in drought at the end of July, and the Horn of Africa experienced its worst drought in over 40 years with more than 18 million people facing severe hunger.

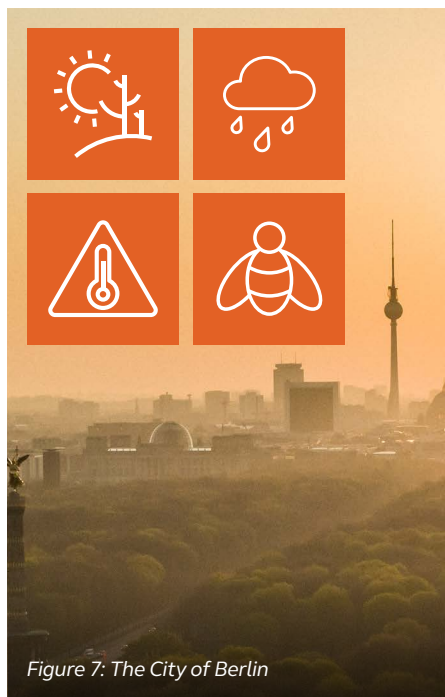


Figure 7: The City of Berlin

Sponge City Berlin

Sponge cities provide an interesting solution for periods of heavy rainfall as seen in the Wuhan example, but they also pose a good solution for extreme drought. The design of such cities enables storage of rainfall and excess water through nature-based permeable ground surfaces, such that it can be reused in periods of water shortage. The sponge cities are multifunctional and therefore a good solution for multiple hazards.

In Berlin, climate change is putting a strain on its citizens. With extreme droughts and short-term flooding threatening urban life, Germany’s capital is in dire need of professional water management.

There is a wide range of technical tools and solutions available to create a sustainable urban rainwater management system. These include green roofs, facades and walls, unsealed and semi-permeable pavements, infiltration systems, artificial water basins, and cisterns for rainwater storage and reuse. In close cooperation with experts in engineering, landscape architecture and urban planning, Arcadis was able to support Berlin Stormwater Agency in developing an orientation guide for the integration of these tools. The project will result in an 8,910 m² annual reduction of sealed urban surfaces, providing groundwater reserves that can help the city cope with extreme dry periods in the future.

¹² Chiang, F., Mazdiyasi, O. & AghaKouchak, A. (2021). Evidence of anthropogenic impacts on global drought frequency, duration, and intensity. Nature Communications 12, 2754. Retrieved from [here](#)



Urban heat stress

By 2030, it is estimated that 1.9 billion people will be exposed to heat stress, especially those in cities¹³. Cities are also warming 29% faster than rural areas¹⁴. They are tremendous absorbers and retainers of heat, and with an expanding urban population, this will only get worse.

As more people flock to cities for the promise of better living, there's increased pressure on available living spaces. New construction and expansion can reduce green areas and decrease biodiversity – which studies have shown adversely impacts mental and physical wellbeing. Adding to this, cities are expected to face higher stresses due to growing climate-related challenges¹⁵.

During heat waves, these factors together create potentially dangerous conditions for certain groups of people. According to the World Health Organization, more than 166,000 people died because of heat waves between 1998 and 2017. Reactions to heat are hugely dependent on people's ability to adapt. Those with chronic diseases, the elderly and children are therefore at greater risk.

When looking at climate adaptation solutions that mitigate the impacts of urban heat, we need to plan our cityscapes and neighborhoods in a way that the needs of all are considered. Greener public spots provide respite for those who may not have access to cooling solutions, and pleasant areas for those who are isolated, like the elderly, to get a sense of community.

Urban forests throughout the city of Paris

The Paris City Council, acknowledging successive summer heat waves, decided to create five urban forests to help cool the city and create pleasant, shaded spaces for its residents.

Arcadis is working with the city of Paris to transform 100 hectares of asphalt, planting 170,000 new trees by 2026. This will be across five key areas: the paved square of the Hôtel de Ville, the paved square of Euronext Paris, and Place Saint-Gervais located behind Hôtel de Ville, which will be the site of the future memorial of the Paris attacks.

Our team is conducting a feasibility study, environmental analysis and digital mock-ups for three of the five sites selected, demonstrating the impact of 'greening' the city's public spaces in terms of carbon footprint and limiting heat. This project not only will help 'cool' the city, but also transform the city's appearance, store rainwater, help reduce air pollution, and create a more enjoyable place for Parisians.



Figure 8: Greening of Paris' city square

13 McKinsey. (2021). Protecting people from a changing climate: The case for resilience. Retrieved from [here](#)

14 WEF. (2022). Cities are warming 29% faster than rural areas. Could urban greening fix this? Retrieved from [here](#)

15 Cortesão, J. P. A. G. (2013). Thermal retrofitting of public spaces in compact urban areas: A bioclimatic approach (Ph.D. thesis). University of Porto, Porto, Portugal. Retrieved from [here](#)



The City of Rotterdam: multi-functional, innovative solutions

Climate adaptation strategies have been a key focus for the City of Rotterdam for over 15 years now. As a low-lying port city in a delta, the effects of climate change have intensified exponentially in recent years, impacting Rotterdam and its citizens. Recognizing this, in 2008, the City of Rotterdam set out its first climate adaptation program, largely centered on actions that could be taken in public spaces. In 2019, this was further expanded through the launch of the [Rotterdam Weatherwise program](#), focusing beyond steps to reduce CO2 emissions to concrete measures towards adapting the city by 2030, also considering the impact and actions that can be taken by citizens and across private spaces.

Johan Verlinde, Program Director for Rotterdam WeatherWise shares: “Due to Rotterdam’s unique geographical position, the city is susceptible to six climate change challenges: extreme precipitation, flooding, rising

groundwater, land subsidence, urban heat stress and drought. Adding to this is the stress of a rapidly growing urban population. To tackle these, we are looking at tailor-made approaches with clear standards set for the city and citizens – every neighborhood is different, and we must consider the unique infrastructure and needs of all the citizens in our decision making.”

In order to keep the promise of a livable, prosperous city for its residents, Rotterdam has set out to take district focused actions together with Rotterdam’s residents and companies. Most recently, launching a framework that provides a set of maps showing what’s happening in cities, where the biggest challenges lie, and what actions can be taken. Actions that aim to fight the effects of climate change, reduce carbon emissions, and ensure equitable development for its citizens.

Johan adds: “To truly be a climate-resilient city, we need to consider our physical and natural environment together, ensuring everyone’s needs are met – at the individual, housing corporation, community and company levels. Nature-based solutions are an important part of Rotterdam’s climate adaptation strategy, including across the 50 climate adaptation measures we’ve set out to realize by 2030. We’re also integrating this in seven big projects in the city, including the transformation of the Hofplein Roundabout to a city park. Throughout these projects, we see innovative, greening solutions go beyond just restoring biodiversity. When done right, they provide solutions like rainwater harvesting which can help in dry months; better public spaces for people to enjoy; and improve livelihood by generating new job opportunities.”



Johan Verlinde
Program Director for
Rotterdam WeatherWise



Figure 9: Mapping of optimal zones to increase greenery, trees and water features at the Hofplein

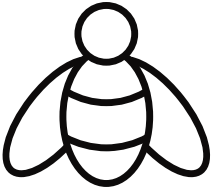
Greening the city of Rotterdam

With a growing population and complex urban challenges, such as climate change, mobility issues, affordable housing and recreational spaces, the demand for limited available urban space is increasing.

The City of Rotterdam is looking at transforming Hofplein, a busy traffic junction, into a green oasis. Using the Tygron software, Arcadis was able to analyze optimal zones to increase greenery, trees, water features, and create natural air corridors, which would help provide relief on a hot summer day. The optimal solution, once fully implemented by 2030, could lead to an average maximum temperature decrease of 7°C, significantly reducing heat stress experienced by the neighborhood.

And, as part of Rotterdam’s climate adaptation strategy, Rotterdam has a unique solution to the challenge of limited space: lifting the city to a higher level by using its potential of 18.5 square kilometers of flat roofs. The city has invested in developing nearly 500,000m² of green roofs, with a plan to further develop an additional 20,000ha of green roofs in the next four years. These flat roofs are multifunctional – for water harvesting, generating sustainable energy, even providing cooling or pleasant places for residents through green roofs and rooftop terraces.

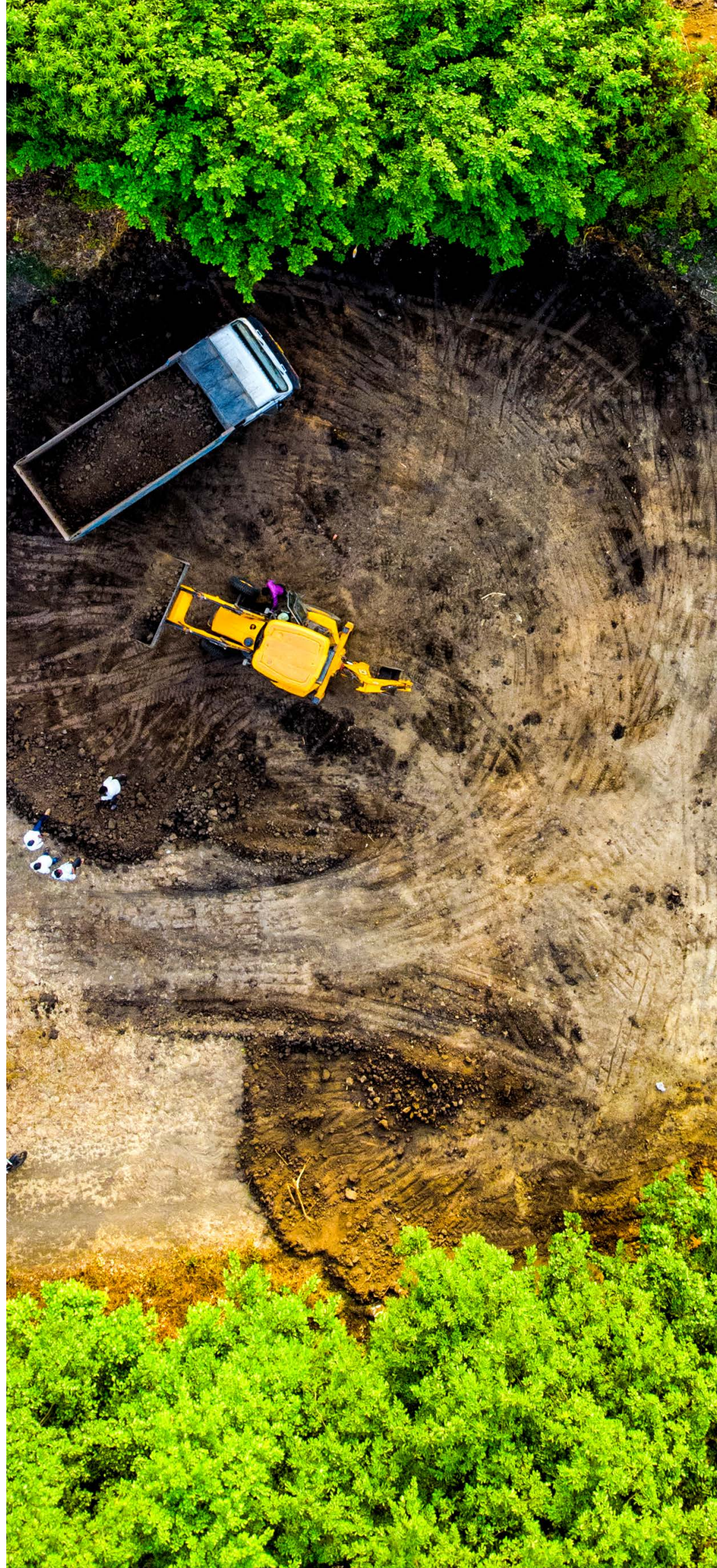
Recognizing this unique opportunity, the Municipality of Rotterdam collaborated with Arcadis and LIFE@Urban Roofs to create The Multifunctional Rooftops Tool. The tool supports investment decisions, from financial business cases to social cost and benefit analysis of these multifunctional roofs.



Biodiversity impact

According to a 2019 report by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystems, around one million animal and plant species are currently threatened with extinction. Common causes of biodiversity loss include habitat destruction, invasive species, over-exploitation, pollution, and climate change. Climate change, in particular, is impacting the vitality of the scarcely available natural habitat.

Using materials that are naturally occurring or otherwise by-products, like mud, silt and sediments instead of grey construction material to develop landscapes can provide great solutions that reduce the environmental impact and support biodiversity development. This also increases applicability and affordability across the globe.



The Marker Wadden Islands in the Netherlands

The Marker Wadden Islands were established to increase the biodiversity in a large manmade freshwater lake after the Houtrib dike had reduced the natural water flow of the Lake IJssel, causing much of the wildlife to disappear.

With the help of Arcadis' experts, an archipelago of new islands was developed in a sustainable, cost-effective, and ecologically resilient way, that now serves as a nature reserve. Here, vegetation can grow, fish can spawn, and birds and other wildlife can flourish. The islands were built with dredged material that was taken from the bottom of the Lake IJssel. This project is one of the largest ecosystem restoration projects in Western Europe, and a pioneer for nature-based solutions.



Figure 10: The Marker Wadden Islands in the Marker Lake, separated from the Lake IJssel via a dike

Safeguarding biodiversity in the Amazon

The Amazon is the world's largest tropical rainforest, said to house more than 10% of the planet's biodiversity. Arcadis Brazil is involved in several efforts to safeguard this biodiversity, from financial needs assessments to climate change studies, and species protection projects. Using impact and dependency assessments and studies, field experts can consider nature-positive approaches in the planning stage, well before construction takes place, and throughout all stages of the project lifecycle.

As a result, more than 3,000 species of fauna have been surveyed and over 800,000 animals have been rescued. We've also taken steps to improve biodiversity, safeguarding 893 species of flora, and through improvements in biodiversity management actions. This focus on biodiversity has also improved the Amazon's resilience against the impacts of climate change.



Figure 11: Restoring biodiversity in the Amazon

The team worked alongside the traditional riverside communities and indigenous people recognizing the importance of their involvement for the long-term maintenance and recovery of species and ecosystem services. The project improves quality of life for the Amazon's local community through promotion of the formation of women's associations, and provides an additional economic stimulus through additional livelihood activities like cassava flour production and the use of local plant material in production of drums, bags, packaging and jewelry.



Wildfires

Droughts resulting from climate change combined with other human-induced activities like regular burning of land are increasing the occurrence of wildfires in already dry areas across the globe. During wildfire seasons, there is massive destruction of natural area and human capital. The scale and occurrence rate of wildfires we've recently seen have been unprecedented.

In France, wildfires ravaged more than 148,000 acres of land across the country, causing tens of thousands of people to evacuate. In the United States, the McKinney Fire in northern California charred 60,138 acres, killing four people. And the 2019-20 bushfires in Australia saw Victoria endure over 1.5 million hectares being burnt, with 420 houses lost and five fatalities.

Wildfires the world over result in big losses on all aspects: people, planet and profit. The increasing heat and therefore loss of traditional vegetation also results in the ground retaining less water, which would typically function as a buffer for dry spells, further propagating the spread of wildfires. Until now there was mainly a reactive approach, where most work went to fire extinguishing and restoration after an occurrence. But with these increasing numbers, there is a need to focus on better prevention.

Nature based solutions can support prevention, but with the additional impacts of climate change, there is still more to be done and explored in solutions.

Solutions that tackle the root of the problem, like retaining original vegetation, or partially replacing high risk vegetation (which has high combustibility and high ember production) with those that have lower risks like grasslands and wetlands help create buffer zones. Community led management can also reduce the occurrence of wildfires. Making these solutions nature-based provides a double advantage: supporting the ecosystem and preventing wildfires from destructing natural habitat.



It's time for bold, nature positive actions that address the climate emergency

It's clear that nature-based and hybrid solutions can provide long-term, sustainable answers to the climate emergency and its impacts we're all faced with today. Investment is needed to drive this forward. But with the perceived high capital investment cost with these solutions, the business case is often unclear. The longer-term impacts, like lower maintenance, greater biodiversity, improved socio-economic stimulus must be considered when assessing value. Arcadis has been working with clients over decades in realizing the benefits of these. In the following page, we explore a few of these considerations.



Climate adaptation and mitigation, hand-in-hand

The intersection where climate adaptation and mitigation solutions meet can create value. For instance, the areas that are most favorable for natural carbon capturing are coastal ecosystems. These are often also most vulnerable to the impacts of climate change. Seagrasses, mangroves, salt marshes and algae comprise up to 50% of global carbon storage with only 2% of surface. Mangroves can protect against the impacts of sea level rise in tropical zones. At the same time, they can capture substantial amounts of carbon dioxide, creating new jobs and generating revenues for local communities. Planting seagrass offers a low cost, high impact solution. But seagrass has become extinct in Western Europe. We need to look at ways to restore this valuable ecosystem and efficient carbon storage solution.

Applying hybrid, multi-functional solutions

Nature-based solutions cannot always fulfil all safety requirements. Hybrid solutions that combine natural solutions with hard structures can provide that safety. Multifunctional solutions, in addition to their hybrid flood protection functionality, also serve other functions like tourism & recreation and parking facilities, help integration into the urban fabric and increase attractivity for investors.

Valuing the added benefits of climate resilience

There is no ‘one solution’ when it comes to nature-based solutions. As outlined earlier, this often creates an initial barrier when it comes to assessing the business case and financing such models and projects. However, cost-benefit analyses that value social and ecosystems benefits can help solve this challenge by taking multiple, indirect and hidden climate equity services and other benefits into account. In Brazil, an innovative Arcadis solution called the ‘Green Metrics Analytics’ calculates the carbon emission equivalent generated in each phase of a project, including the lifecycle of the materials used, visualizing this in an interactive dashboard.

Ensuring no one is left behind

Strong collaboration and partnerships across various governance levels, businesses and disciplines, as well as active, fair and equitable inclusion of stakeholders and communities is crucial to achieve effective, attractive, and feasible climate adaptation with nature-based solutions. It is important to look at the value of nature-based solutions from a holistic perspective to be able to get a full picture of the benefits. Social and health advantages are equally as important as their technical aspects. The Western world needs to take responsibility and invest more in climate adaptation in the Global South, to help the most vulnerable countries. Solutions that are nature-based and multifunctional, contributing to carbon capture while adding value for local stakeholders and the economy through job creation are the answer.





About Arcadis

Arcadis is a leading global Design & Consultancy organization for natural and built assets. Applying our deep market sector insights and collective design, consultancy, engineering, project and management services we work in partnership with our clients to deliver exceptional and sustainable outcomes throughout the lifecycle of their natural and built assets. We are 36,000 people, active in more than 70 countries that generate €4.2 billion in gross revenues (based on 2021 full year pro forma results). We support UN-Habitat with knowledge and expertise to improve the quality of life in rapidly growing cities around the world.

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