



Longread

Nature-based solutions for water management

11 minutes

Across the globe, we are increasingly using nature as a model. From architecture to medicine and from energy to infrastructure, nature serves as an inspiration in a wide range of sectors. Things are no different at Wageningen University & Research, where we embrace nature-based solutions within our degree programmes on biodiversity, sustainable cities and water management. This long-read article gives an overview of nature-based solutions at Wageningen in the field of water management.



“If you look to natural systems for inspiration, you'll find solutions that are more resilient.”

Ivo Demmers, programme leader Sustainable Water Management

“If you’re looking for sustainable solutions to particular challenges, such as those relating to water, then it’s a good idea to base yourself on nature wherever possible,” says Ivo Demmers, head of the Sustainable Water Management programme. “Take our system of dykes, for example. That’s actually an artificial solution,” he explains. “Down the centuries these dykes have protected us against the water, but what we’ve done is to change the

natural dynamics of our delta. This has been at the expense of the system's resilience. Our technological solutions are designed for today's situation, but this means we're vulnerable to future changes." Sea-level rise resulting from climate change is an important example. "Natural systems move with such changes," says Demmers. "If you look to them for inspiration, you'll find solutions that are more resilient, and often more efficient as well."

Demmers doesn't mean that nature-based solutions are always superior. "There are situations for which nature has no solutions," he says, "and which call for innovative technological solutions. At Wageningen we're working on those too. And often it's a combination of the two that works best."

Nature-based solutions often involve elements from multiple disciplines, such as ecology, hydrology and soil science, as well as the social sciences, technology and data management, for example. "Researchers at Wageningen have a long tradition of forging links between these different disciplines," says Demmers. "We also work closely with different levels of government, with industry and other institutes. And we apply our knowledge abroad and bring experience from abroad back to the Netherlands. This enables us to contribute to better knowledge and sustainable water solutions for the future – all of which ties in nicely with the 'Nature-based solutions' theme for World Water Day 2018."

Streams as natural reservoirs

The world around us is changing rapidly. As a result of climate change, villages, towns and landscapes are having to contend with a surplus, or shortage, of water – and the problems are exacerbated by the world's growing population. Researchers at Wageningen are studying these changing systems and designing new, future-proof solutions for agriculture, nature, industry, cities and citizens.

"In the past, people didn't pay much attention to climate change when designing the landscape and the built environment," says Ralf Verdonschot, a researcher at Wageningen Environmental Research. "That's slowly beginning to change. '[Building with nature](#)' is now an accepted concept. It involves making small interventions that trigger certain natural processes, which then automatically reinforce one another."

Excess water

Verdonschot himself is investigating how stream and river landscapes can help to absorb peaks in water supply. "A natural stream valley acts like a sponge," he explains. "During times of heavy rainfall it absorbs lots of water, and in times of drought it ensures that the water gradually becomes available again. But in the past we straightened out many of our streams and turned the gentle slopes of natural stream banks into steep walls. This causes the water to flow in one great wave."



Verdonschot and his colleagues are experimenting with various interventions in stream landscapes that are designed to reverse that effect. "Starting mainly in nature reserves," he says, "but in the future hopefully on farmland as well. For example, we place dead trees and bundles of twigs in the stream and create small local swamps. We restore the vegetation on the banks by mowing them differently. And we import sand to raise the soil level that has worn down."

Interventions of this kind bring rapid results, says Verdonschot, such as around the Hierdense Beek in the Veluwe area. "It's unbelievable what's happening there. Prior to this project the stream valley was very dry, with the stream deeply carved into it. There were almost no plants growing on the banks. After sand and dead wood were introduced, within two years the valley has become completely green again, full of flowering plants and wildlife. And water and soil processes have also improved. The whole ecosystem benefits from the change, right up to the large mammals in the woods around the stream. All of this means better water quality, and the peak discharges have halved."

Testing ground

A restored stream valley is all well and good, but does it really make a difference when applied to an entire river basin? "The idea is that we gain experience in this testing ground and learn which elements work best," replies Verdonschot. "Ultimately, of course, we want to scale up this approach. The big challenge is lack of space, especially in northwestern Europe, where we want to cram so much into a very small area. But is it logical to want to grow potatoes right next to a stream? I don't think it is." It boils down to making landscape choices, he emphasises. The research at Wageningen helps to make those choices, based on good arguments.

"Ultimately we need to organise our landscape in a more future-focused way," says Verdonschot. "We have to give streams and rivers more room. That's a huge political challenge. But fortunately, more and more people are seeing the benefits of that approach. There's a growing number of successful examples. I'm very optimistic."

Natural coastal protection

Nature also offers solutions for other water-related challenges, such as flood safety. Martin Baptist, a researcher at Wageningen Marine Research, knows all about this. One of the things he and his colleagues are studying is the effect of building oyster reefs in the Oosterschelde, where sand banks are in danger of disappearing as a result of erosion. "We're putting down cages with oyster shells, where young oyster larvae can attach

themselves and grow,” says Baptist. “This can develop to become a living oyster reef. These reefs form a buffer against the waves and they trap sand. You also create a valuable natural environment, since the reefs offer protection to all kinds of organisms. And you can harvest the oysters, which is a further advantage in many developing countries.”

The Netherlands isn’t the only country that is battling the sea, Baptist emphasises. “There are many low-lying deltas facing these problems, especially now that we also have the issue of rising sea levels. We are currently anticipating a rise of 60 to 85 cm per century, but new scenarios from the KNMI (Royal Netherlands Meteorological Institute) are already showing values of one to two metres. Those rates would exceed the natural capacity of sandbanks and mud flats to keep pace.”

Enhancing functions

Baptist mentions another project, the Zandmotor, off the coast of South Holland, where large-scale sand was sprayed in the form of an artificial peninsula. The idea is that wind and sea currents will transport the sand, distributing it along the coast. This supports the natural process of dune formation. “It’s a fantastic example of a [nature-based solution](#),” says Baptist. “We are studying the impact of this beach nourishment on the ecosystem. For instance, the Dutch coast is an important juvenile habitat for commercially interesting species of flatfish. We’d like to know how to best maintain this function and perhaps even enhance it, for example, by creating underwater ledges.”

In the Wadden Sea, Baptist and his colleagues are studying the role of salt marshes as natural breakwaters in front of dykes. “We are looking at how you can promote salt-marsh growth in order to protect the dykes,” he says. In a trial project the researchers are using silt removed during operations to deepen the harbour at Harlingen. The silt is used in test fields elsewhere along the Wadden Sea coast. “We don’t put it onto land on the salt marsh, but deposit it in a channel off the coast. Currents and wave action then bring the silt naturally to the salt marsh.” In the Dollard region, Wageningen University & Research is experimenting with letting the silt consolidate into clay, which can then serve to strengthen the dykes.

All this research is of a highly interdisciplinary nature, Baptist emphasises. As well as ecologists, there are also ‘hard engineers’ working on these projects. They come from TU Delft and other knowledge institutes as part of the EcoShape consortium. “Delft approaches things more in terms of grains of sand, water movement and wave power,” he says. “Our particular strength is ecology, and using a systems approach. We’re biologists but with a solid technological foundation.” Wageningen University & Research also brings significant social and administrative expertise to the table. “This places us in an ideal position to combine disciplines.”



Flood protection, soil subsidence and nature

Several departments of the Wageningen University & Research are working on salt marshes, beaches and dunes as natural coastal defences. For example, they are researching the role of vegetation in salt-marsh and dune development. "We're taking a broad view that encompasses the coastal landscape as a whole," explains Jantsje van Loon-Steensma, a researcher with the Water Systems and Global Change Group. "Take the research on salt marshes – that focuses on the entire system of salt marshes, dykes and the area inside the dykes. These are closely interrelated, and you therefore have to explore combinations of measures."

Tension

Van Loon and her colleagues are researching the possibilities of nature-based solutions not only along the coast, but also alongside rivers and large lakes like the IJsselmeer and Markermeer. "The natural foreshore that absorbs waves can also be very useful. Wageningen is investigating which plants play a role in wave absorption, in what densities and with what kind of management." There's a very interesting tension going on here, she explains. "From the point of view of flood protection, we sometimes need intensive management, but that isn't always good for natural values. Can real nature be used to achieve flood-defence goals? I find that a real challenge. It's by looking at the whole system, in other words at other functions as well, that we can make well-considered choices."

Sea dykes are often covered with asphalt. "But if you design the dykes slightly differently," explains Van Loon, "for example, by making them a little wider, with gentler slopes, and include the foreshores in the design, you can allow certain types of vegetation without this being at the expense of safety. A wide, green dyke of this kind can be more robust than one that is covered in asphalt. Diverse vegetation is also less vulnerable to disturbance and creates a habitat for all kinds of insects."

Large-scale application

Van Loon was involved in various projects within the Delta programme. "We worked closely together with the water boards," she says. "In the meantime there are various pilot projects and follow-up studies, for example on grass-covered dykes and more natural banks along the Houtribdijk – the dyke between Enkhuizen and Lelystad. And Wageningen is involved in monitoring soil subsidence as a result of natural gas extraction. For instance, we're investigating whether you can use vegetation to capture more sand and silt and in

this way compensate for subsidence.”



The same tension applies here, according to Van Loon. The projects have to serve both flood protection and nature, while at the same time satisfying various criteria, such as cost effectiveness. “In the beginning, the traditional hydraulic engineers were sometimes sceptical,” she says. “Now you see that a number of projects have been successful and water boards and engineers are responding enthusiastically. What’s more, every effort is being made to model the processes even better. This will deliver the technological information we need to soon be able to apply solutions on a large scale.”

For the time being many of the projects are experimental in nature. “But we have clearly helped to put nature-based solutions on the agenda, including internationally. This way of thinking is finding favour everywhere, especially in the context of climate change,” says Van Loon. “It’s great to see that we at Wageningen are playing a driving role.”

Water in cities

Climate change means that in the near future cities will have to deal with [more flooding and more drought](#). “Much of the world’s population lives in cities,” says Tim van Hattum, programme leader for Green Climate Solutions in the Environmental Sciences Group. “And the urban population will double by 2050. We are investigating how you can use nature-based solutions in the design and development of cities in order to ensure that peaks in rainfall are absorbed and then retained for use in dry periods.”

This calls for an entirely different way of looking at cities, he stresses. “For example, vegetation is also part of adapting to climate change. Vegetation helps water retention and it has a cooling effect. It increases a city’s liveability.”

Less asphalt

Healthier water management also requires a different layout for streets, squares and gardens. “At present, 70 to 80 percent of an average city is paved or asphalted,” says Van Hattum. “Almost every drop of rainwater goes directly into the drains. That’s a crying shame because it means you can’t do anything more with it. Added to that, full drains are often the cause of flooding.” Van Hattum and his colleagues are therefore investigating the effect of having less asphalt and concrete in public spaces. This could involve the [construction of parks](#), ponds and special infiltration areas.

“In 2014 more than 120 mm of rain fell in Arnhem in the space of two hours,” continues

Van Hattum. "When it rains so heavily, the soil doesn't have enough absorption capacity, despite the vegetation. You need to ensure that there are depressions where the water can flow to. Using our knowledge of soil type, vegetation and urban development, we investigate which measures can be effective and where. We call this 'landscape-based adaptation'. The landscape determines which solution is most appropriate."

One of the places where Wageningen researchers are testing their ideas is Park Lingezege, a large landscape garden situated between Arnhem and Nijmegen. "That project is part of our work on cities," explains Van Hattum, "because it explores different ways of organising city fringes. We look at whether you can combine certain functions, such as water retention and storage, as well as nature and recreation."

Predicting

Achieving water collection and water storage in the same area is a practical challenge, Van Hattum emphasises. "Just think about it: you want a water retention zone to be empty most of the time so that it can collect a maximum quantity of water during a downpour. But at the same time you want to be able to store water in that area for dry periods. This creates tension." Researchers are using modern technology to try to predict more accurately where rain will fall. For instance, they use the latest generation of sensors and methodologies in order to link weather models, information flows and data streams. "If you have a more precise idea of where and when a heavy downpour will occur, you can adapt your water management accordingly. It's really very innovative. And this approach can definitely be upscaled to other countries."

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Waste water as a resource: aquafarms

The search for solutions for a sustainable society often focuses on just one aspect of sustainability. But why not combine more aspects in a single approach, such as water treatment, waste reduction, the extraction of raw materials and supporting biodiversity? All this is being done in [Aquafarm, a Wageningen trial project](#).

"At present, the residues from waste-water treatment are often burnt or discharged into the surface water," says Piet Verdonchot, Professor of Wetland Restoration Ecology and a researcher at Wageningen Environmental Research. "We want to retain these waste materials and use them as a basis for new products. For example, the plants growing in the system supply fibres that can be processed into clothing or furniture, while worms can serve as food for fish. The plants, worms and micro-organisms contain fats and proteins that you can use as a basis for a host of new products, from binding agents to toothpaste."

Successive steps

The Aquafarm mimics a natural water-treatment system, with different organisms succeeding one another in a 'cascade' of water treatment and materials production. Each step provides input for the next. "In nature these cascades often extend across many kilometres, for example in a river," says Verdonchot. "But of course that's not practical for industrial application. What's special about the Aquafarm is that it contains different compartments in which organisms are selected so that they work together optimally. And

we can also further optimise the conditions, such as temperature and light. This makes the system many times more efficient than in nature.”

Verdonschot and his colleagues ran an 18-month pilot. “It was even more successful than we had dared to hope,” he says. “The organisms reinforced each other’s functions. Together they extract more from the water than by themselves. It’s like a puzzle: we find out how organisms react to one another and to environmental conditions, and we then try to design an optimum treatment and production system.”

Upscaling

The group has just received funding to continue the project for a further four years, involving two PhD students. Verdonschot: “We’re absolutely delighted. We can now start to investigate different cascades, and to find out how you can upscale them and use them in practice – not just in a treatment plant, but elsewhere too. For example, to recirculate water on a plot of land, whereby you bring waste materials from the ditches back to the land as fertiliser. That would require very different organisms than if you were treating waste water from, say, a brewery. For each system we’d like to find an ideal mix of organisms.”

But are these applications realistic? “Definitely,” says Verdonschot, “because raw materials are becoming scarcer and industry is always looking for more efficient ways of using them. With this type of system they can save on water treatment and at the same time on their raw materials.” In that respect, projects like Aquafarm also create markets, he adds. “If you devise a circular system that solves a waste problem and produces enough materials, an industry will automatically develop around it.”

Models for the whole region

For nature-based solutions to work best, scientists have to understand the underlying system, including on a larger scale. This system approach is a Wageningen specialism. Wageningen researchers from different disciplines are working together to model soil, water management, climate, land use and social structures. They are also doing so in places where nature-based solutions can help to address water challenges. One example is [HI-AWARE \(Himalayan Adaptation, Water and Resilience\)](#), an international project looking at the impact of climate change on water management in the catchment areas of the Indus, Ganges and Brahmaputra rivers.

Applications

“For example, we look at water allocation across different sectors, such as nature, agriculture, energy and drinking water,” explains Hester Biemans, a researcher at Wageningen Environmental Research.

It involves three enormous catchment areas with rivers, plains, hills and high mountains. We use different disciplines to look at adaptation to heat, drought and floods in different sectors. What adaptations are there, and why do they work better in one place than another?”

Often the answer lies not just in physical factors, but in socioeconomic ones. “We look at those too, together with our counterparts from other countries – with economists, social scientists and policy researchers,” says Biemans. In all, 175 people are working on the

project, spanning some five years, until the end of 2018.

Biemans' own focus is on modelling water and food availability. "What happens if you take certain measures, and why does that differ by area? These are quite fundamental questions. But they do have a direct link with practice: what happens if the snow and glaciers melt earlier because of global warming? Should you perhaps start sowing crops earlier, or choose different crops?"



Digital atlases

Ultimately the researchers want to make this information available to farmers, policymakers and other stakeholders in an accessible form, such as interactive maps and digital atlases. The project team is organising workshops in the region to help people use these resources effectively. "As Wageningen partners we are considering alternative ways to make things clearly comprehensible," says Biemans. "Ways that are more closely linked to practice, so that we deliver information that people can actually do something with, in a way that matches the local situation."

□ *"As Wageningen partners we are considering alternative ways to make things clearly comprehensible"*

Hester Biemans, expert adaptation and water security

Nature-based solutions for a better future

Water will play an ever more important role in the future. Increasingly, we will have either too much of it or not enough. We will no longer be able to take many things for granted the way we do now. And vice versa: tomorrow's world will present solutions and adaptations that we can't even imagine at present. All these changes are happening at a rapid pace – and scientists have an important role to play.

They are devising technological, logistical and social solutions, and new economic and administrative models. They are closely monitoring how the world is changing and to what extent the solutions are working. And they are increasingly looking to nature for inspiration. Together with industry, citizens and different levels of government, Wageningen University & Research is contributing to this research for the future. It is by combining different disciplines that we see new possibilities for a world filled with sustainable, nature-based solutions to water challenges.



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