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Hydrolink

Using Nature-based Solutions to address water security changes

By Ellis Penning

Global water security challenges are many, and relate to either too much, too little, or too polluted water in relation to societal and environmental needs. A vast range of management solutions is available to mitigate the potential negative impacts of floods, droughts and contaminated waters. In recent years, more and more attention is being paid to the potential role of Nature-based Solutions (NbS) as part of the overall strategies for managing water security challenges. This article aims at giving an overview of the range of topics related to NbS for addressing water security challenges and the role of science in facili tating the uptake and implementation of these solutions in practice.

An introduction to Nature-based Solutions

On the 2nd of March 2022, the United Nations Environmental Assembly agreed on the definition of Nature-based Solutions as '*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.*' This is an adapted version of the IUCN definition[1] and an important milestone in maturation of the concept of NbS in the widest sense, indicating their potential application in a multitude of different ecosystems and for a wide range of social, economic and environmental challenges. Yet, using NbS is not new: already in the early 1970s H.T. Odum acknowledged the role of eco-engineering[2]. Other terms such as Building with Nature, Engineering with Nature and Blue-Green infrastructure are and have been used for methods in which 'working with nature, rather than against it to mutually solve societal and environmental challenges. Using natural processes is a key aspect of NbS, for example, the smart use of hydrodynamic processes may aid the transport of strategically placed sediment nourishments along coasts to reduce erosion in wider areas[3]. Many NbS are inspired by ancient, ecologically sound technologies, such as permeable dams to trap sediment for salt marsh and mangrove restoration[4] and the use of small-scale wadis and natural water retention in catchments to mitigate floods and droughts.

Co-benefits of NbS

In contrast to 'single-objective', traditional engineering solutions, often referred to as 'grey solutions', NbS often provide multiple co-benefits next to a primary objective, that can be of high relevance in overall and integrated management strategies. For example, NbS for reduction of flash floods in the urban environment (e.g. through implementation of blue-green infrastructure such as green roofs, and urban parks where water storage is facilitated) also provide human well-being through higher-quality public urban spaces and reduce the impacts of heat islands during droughts. Another example is the restoration of wetlands to improve sponge functioning in catchments, in which the wetland itself not only reduces peak flows and improves baseflows, but also creates additional valuable habitats for wildlife, improves biodiversity values and related ecosystem services such as the provisioning of food and drinking water to local populations. Increasingly also the potential role of multiple types of NbS for carbon sequestration is mentioned as a co-benefit of relevance, although their exact contribution to this particular topic is highly dependent on the local context, scale and correctness of implementation.

Adaptiveness of NbS

Many NbS are characterized by being adaptive to change as ecosystems can adapt to slowly altering conditions over time. For example, sedimentation in saltmarshes and mangroves can enable long-term adaptation to Sea Level Rise, provided that enough sediment input is available for this vertical growth. Large-scale ecosystem restoration provides more resilient buffers to climatic instabilities and using a catchment approach to flood management using NbS can also contribute to better resilience for droughts and improves biodiversity in the area. At the same time, there are boundaries to what ecosystems can resist, as is clearly demonstrated by e.g. the sensitivity of coral reefs to bleaching due to high seawater temperatures, and the risk of forest fires during heat waves which diminishes the potential of forests to contribute to reduced soil erosion and landslides on hillslopes.

Increasing the evidence base of NbS

The evidence base for the functioning of different types of NbS for various water security challenges is growing. Research in field pilots, large-scale implementation projects, experimental settings and modelling of long-term dynamics contributes to the trust and successful implementation of NbS, especially when this is done in close interaction with stakeholders. This evidence base provides the fundamental system understanding that is needed for proper NbS design and implementation and is always of a multi-disciplinary nature. For example, the role of vegetation dynamics in hydromophological processes is of crucial importance to the long-term dynamics of ecosystems, such as mangrove coasts, salt marshes, riverine floodplains and vegetated banks, wetlands in upstream catchments and forests on hillslopes that affect rainfall runoff processes. This ecological knowledge is combined with engineering knowledge to quantify the dynamics of ecosystems and related NbS in time and space. The resilience to extreme events, such as extreme storms is being tested in large-scale experimental settings[5] and via remote sensing after events. Increasingly, system understanding for proper design is combined with life-cycle cost-benefit analysis and business cases requiring further cooperation with economic, social and political science are essential.

Drawing on in-depth experience from planning, implementing and governing NbS in research and innovation projects of inter-and transdisciplinary character. Successful NbS amplification may be achieved by [1] using multi-scalar action to balance differing interests and reconcile governance levels, [2] providing financial and other institutionalized incentives and strategies for integrated participation processes, [3] using appropriate governance and management scales effectively integrating mediators, [4] using opportunities for transformative change offered by crisis, and [5] learning from worldwide amplification experiences.

System understanding as a key feature taking a landscape approach as the basis for working on water security challenges

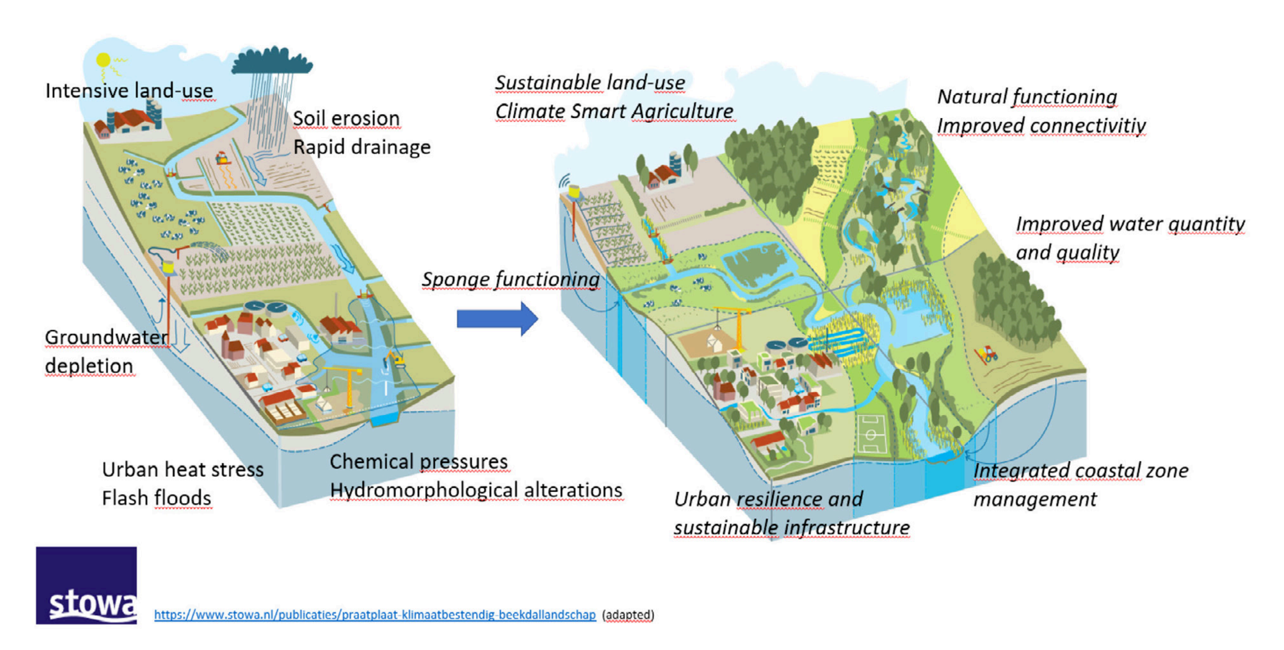

Figure 1 | From a current impacted catchment towards a sustainable and resilient catchment taking a landscape approach as a basis.
Adapted from: https://www.stowa.nl/publicaties/praatplaat-klimaatbestendig-beekdallandschap

Water management challenges are most often related to the dynamics and use of water in a landscape context. Human interference in landscapes has reduced their natural functioning and dynamics, resulting in a wide variety of water security challenges, such as depleted groundwater, soil erosion and accelerated drainage, chemical and hydromorphological pressures, heat stress, and flash floods, especially, in densely populated zones. When working on improvements for water security challenges, the interplay between these different aspects calls for integrated strategies that work on improvements of all aspects within a catchment approach, all the way from source to sea.

Various individual NbS should be combined (together with 'grey measures' where needed) into integrated strategies considering these integrated linkages.

A good example of this is the 'Room for the Rhine' project in the Netherlands[6], where a combination of 43 individual measures, both green and grey, were implemented along the entire Rhine river in the Netherlands to provide room for the river during floods and improve natural values of the floodplains, simultaneously providing increased landscape values, recreational opportunities and upgraded infrastructure where needed.

A new working group on Nature-based Solutions in IAHR

In order to exchange knowledge and scientific advance related to NbS, IAHR has initiated a new working group on Nature based Solutions. This working group will have its first live meeting during the IAHR World Congress 2022 in Granada, Spain.

IAHR-members interested in joining this initiative are more than welcome to contact the leadership team, which consists of Ellis Penning, Jochen Hack, William Nardin, Leon Kapetas, Julia Mullarney, YuJun Yi and QiuWen Chen.

Ellis Penning
Dr. Ellis Penning is an expert in the field of Nature Based Solutions and ecohydraulic research. She leads the research programme on Nature Based Solutions and carries out a variety of projects related to this subject. An ecologist by training, Ellis Penning is specifically focussing on the role of vegetation in aquatic systems, both from a flood risk and environmental quality point of view. Ellis Penning active in various EU projects such as the MARS and Hydralab projects and has extensive experience in international cooperation both in Europe and Asia. At present she is the co-chair of the International Steering Committee of the River Experiment Centre of the Korean Institute of Civil Engineering and Building Technology and leads the Deltares contribution to the joint project on vegetated flows in this unique large outdoor flume facility.

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