BUILDING WITH NATURE: MORE THAN 10 YEARS OF PRE-COMPETITIVE KNOWLEDGE DEVELOPMENT

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ABSTRACT

Building with Nature (BwN) is an innovative design philosophy that optimizes the utilization of natural processes in the development of resilient and sustainable hydraulic infrastructure. BwN aligns the interests of human, economic and nature development. .In 2008 an initial Building with Nature (BwN I) innovation program started, managed by the Ecoshape foundation, as a 30 mln€ Public-Private Partnership (PPP). After this first program, EcoShape and partners have established the on-going second Building with Nature program (BwN II). In the second program, the knowledge developed in the first program is tested in field pilot applications in a broad range of environments. The scope of the second program is nearly 47 mln€ in pilot projects and associated research initiatives. Contrary to the first program, this program is funded 'bottom-up' via a diversity of subsidies, research grants, project development funding as well as a significant cash and in kind contribution from partners of the EcoShape consortium. Anticipated end time for this research program is December 2020.

Within the two research programs a variety of projects, research and pilots have taken place to demonstrate the applicability of BwN principles as integral part of the design of hydraulic infrastructure. During the period of activity of the EcoShape-consortium, the thinking about nature-based solutions has become more common. Already quite some projects have been realized that include BwN principles. Yet nature-based philosophies still require greater diffusion and mainstreaming worldwide to improve resilience of infrastructure and areas threatened by the effects of climate change and ecosystem degradation.

This paper will discuss the activities of the EcoShape-consortium in the two BwN knowledge development programs, provides a detailed overview of the current BwN II program including some examples and highlights of pilot projects. Furthermore, it addresses questions regarding the wider application of the BwN-philosophy and the more general dissemination of nature-based solutions.

Keywords: Building with Nature, nature-based solutions, knowledge development, design philosophy.

INTRODUCTION

Due to growing population in urban areas located near rivers, deltas or coasts, the development of hydraulic infrastructure such as harbors, access channels, land reclamations and flood defenses will continue to be a priority in accommodating growth and welfare. Climate change, sea level rise and its related uncertainties, form a complication for this development as does the growing public concern about the durability of investments in this infrastructure. Complex social settings or fragile governance structures further increase difficulties in decision making, with different priorities for different stakeholders.

Multipurpose design solutions, that are aligned with natural processes, are more suitable for dealing with climate and societal uncertainties. Adaptable designs are more robust with respect to changing conditions or uncertainties, whether related to the physical environment (like sea level rise and climate change) or societal variables (like the values associated with the economic and ecological developments). Designers of hydraulic infrastructure today are challenged with developing multifunctional designs that are both sustainable and adaptable.

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Traditional approaches usually focus on a single purpose while attempting to minimize negative impacts (building *in* nature) and/or trying to compensate for any residual effects (building *of* nature). BwN requires a paradigm shift to move towards proactive utilization of natural processes and to provide opportunities for natural development: Building with Nature (see De Vriend and Van Koningsveld, 2012).

Results Of The BwN I Program

A decade ago, when EcoShape's BwN I program was established, this way of thinking had not yet matured, nor was it mainstream. Therefore, the program was set up with the objective to 'Show that it works' (see De Vriend and Van Koningsveld, 2012). Some of the specific objectives of this €30 million innovation program that ran from 2008 to 2012 were (De Vriend and Van Koningsveld, 2012):

- gathering and developing knowledge of ecosystems that enable water-related Building with Nature;
- developing scientifically based and location-specific design rules and environmental norms;
- developing expertise in applying the Building with Nature concept and
- demonstrating through practical examples that Building with Nature can work..

Some of the results of the BwN I program are realized pilots, such as the Delfland Sand Engine project, smart nourishment and oyster reefs protections in the Eastern Scheldt, seabed landscaping in the sand extraction area for the Maasvlakte-2 development and tests with adaptive approaches to the shores of the Ijsselmeer. However, this is only the visible tip of the iceberg of the tremendous volume of knowledge that was developed and laid down in promotional papers (De Vriend, 2013; Stive et al. 2013), articles (Temmerman et al., 2013; De Vriend et al., 2014; other examples), a wiki-based guideline (accessible through www.ecoshape.org) and a booklet 'Building with Nature: Thinking, Acting and Interacting Differently' (De Vriend and Van Koningsveld, 2012). In all this material the developed philosophy and step-wise approach to application of the BwN design methodology is captured, and summarized perhaps most holistically in De Vriend et al. (2015).

PROJECTS AND PILOT APPLICATIONS IN THE CURRENT BWN II PROGRAM

After that first phase of concept development and a first set of pilot projects, BwN has moved towards a phase of introducing the principles in mainstream hydraulic engineering (De Vriend, 2014). The BwN II program was initiated in 2013 with the main objective to 'make it happen'. As in the first program this is done by implementing and learning from BwN pilot applications in a broad range of environments, but now the program is developed 'bottom-up': financially it is arranged on a project-by-project basis forming various partnerships with (local) stakeholders, government bodies and financers.

Table 1 contains the current overview and vision (as per September 2018) of the projects and overarching knowledge transfer framework in which the BwN II program has been involved. The projects are grouped by BwN themes Nature Based Flood Defences, Sustainable Port Development, Ecosystem Restoration and Resilient Delta Cities and test a multitude of BwN concepts as schematically indicated in Figure 1. Next to the theme-wise grouping, EcoShape also tries to integrate knowledge on specific topic via a diversity of initiatives, such as the Living Lab for Mud, sandy solutions etc. This paper will not further discuss these initiatives, but rather we will shortly discuss our project focus on a theme-by-theme basis, illustrated with one or more practical applications. Subsequently, the overarching knowledge transfer Framework is presented. The Framework is set up to translate project specific knowledge in generic applicable guidance, best practices, guidelines and inspirational materials. The BwN II program will run to the end of the year 2020, so changes to the program can still be made.

Nature Based Flood Defences

Including natural features as part of flood protection works is one of the more well known applications of the BwN approach. By using and applying ecosystem services coastal and flood protection works can become more sustainable and economically efficient. On top of that BwN designs can create opportunities for nature, landscape and recreation. Within this theme, we study on a different approach to nourishments, other approaches for sandy solutions as well as coastal protection in a muddy mangrove coast.

Table 1. Overview of the projects and Framework of the BwN II program (as per September 2018).

BwN Themes	Project name	Project cost
Nature-based flood defences	Sand Motor project – EFRO	€ 6,750,000.00
	STW research NatureCoast	€ 5,240,000.00
	Pilot Frisian Sand Motors	€ 275,000.00
	Pilot Houtribdijk	€ 4,400,000.00
	Innovation project Hondsbossche Dunes	€ 1,490,000.00
	BwN Indonesia (FDW-grant)	€ 4,950,000.00
	BwN Indonesia (IKI-grant)	€ 105,000.00
	STW BioManCo	€ 775,000.00
Resilient Delta cities	BwN in the city – EFRO	€ 1,800,000.00
Sustainable harbour development	Saltmarsh development Koehoal by application of a Mud Motor	€ 1,300,000.00
	STW research Mud Motor	€ 805,000.00
	Marconi project: salt marsh development + Pier van Oterdum	€ 640,000.00
	LLM program development	€ 195,000.00
	Pilot Kleirijperij (clay ripening pilot)	€ 6,590,000.00
Ecosystem restoration	Knowledge and innovation program Markerwadden (KIMA)	€ 905,000.00
Other supported fundamental research programs		€ 2,560,000.00
Framework	Business case development (INTERREG NSR Building with Nature)	€ 430,000.00
	Concept integration	€ 550,000.00
	Guideline improvement & development	€ 700,000.00
	CO_2-board	€ 200,000.00
	Communication	€ 605,000.00
	Education	€ 50,000.00
	Demonstration BwN @ Waterloopbos	€ 320,000.00
EcoShape Foundation Management and administration		€ 5,565,000.00
Total program		**€ 47,200,000.00**

Figure 1. Overview of concepts currently tested by EcoShape

The ability to nourish sandy coastal and flood defence systems on a different spatial or process scale by application of natural processes rather than frequent short term nourishments is one of the main study objects in this theme. The icon project of the Sand Motor (Delfland Sand Engine) is the most well-known experimental (mega-)nourishment and the BwN II program has had an active contribution in the study of its development and learning of its existence. A variety of aspects of its evolution (physical, biological and societal) are monitored in a comprehensive program jointly funded by the Netherlands Government and the European Commission (EFRO). Data are analyzed, interpreted and translated into generic knowledge and information for practical application in a joint research program with 12 PhD students and 3 postdocs, funded jointly by the STW Technology Foundation and partners of the EcoShape consortium (see https://www.ecoshape.org/en/projects/naturecoast/). On a much smaller scale, the Pilot Frisian Sand Motors is a study onto the development of two much smaller sand motors in the lake IJssel, which were created as part of the first BwN program.

The Sand Motor

The Delfland Sand Engine is a full-scale experimental mega-nourishment, initiated by the Province of South-Holland and the Netherlands Ministry of Infrastructure and the Environment (see http://www.dezandmotor.nl). It reflects the idea that one big disturbance every 20-30 years will be preferable to smaller nourishments every 3-5 years. In the first half of 2011 a 21.5 mio m3 nourishment was placed at the coast of South-Holland near Terheijde. This amount of sand was predicted to suffice for at least 20 years for maintaining this 16 km coastal strectch.

Figure 2. Evolution of the Sand Engine. Left: situation July 2011; right: situation December 2015.

The initial form of the nourishment was a sandy hook (Figure 2, left panel), but soon this evolved into the more natural coastline shape of a bell which is gradually spreading alongshore (Figure 2, right panel). In the first 16 months of its existence, about 1.6 mio m3 (10%) of the nourished sand had moved, of which most was found in an accretion on the two sides of the peninsula (De Schipper et al., 2014). Other locations were the sand is transported to are the dunes (thus feeding the dune area) and the lower shoreface (thus reducing the over-steepening problem).

Next to the goal of coastal protection, also the expansion and enrichment of the area was an objective of the project by ways of creating new dune habitat types, the provision of habitat, nursery and resting places for fish, sea mammals and birds and the creation of new opportunities for recreation. Two years after completion, the Sand Engine was covered with juvenile dunes and pilot vegetation (Lennartz, 2013), it had become an attractor for beach recreation and a kitesurfer's paradise, its bay functioned as a nursery for fish such as plaice, and as a resting place for seals and a variety of birds. After 6 years a coastal stretch of more than 6 km has received sand from the Sand Engine; hence, this large-scale feeder nourishment functions as expected. Analysis of measurements and model predictions tells us that the lifetime of the Sand Motor is likely to be more than 40 years (Luijendijk et al, 2018 in preparation). Moreover, it has developed into an icon project of Dutch coastal engineering.

The pilot Sandy Foreshore Houtribdijk

In partnership with the Innovation fund (theme Building with Nature) of the Flood Protection Programme (in Dutch: HWBP) of Rijkswaterstaat, EcoShape is executing two innovation projects regarding a sandy solution for dike strengthening. At the Hondsbossche dunes innovation project, the development of a constructed coastal sandy solution at the former dike of the Hondsbosche and Pettemer Sea Defence has been monitored to learn lessons for future application of the concept. Both the development of the natural habitats and the morphological changes in this newly created dune landscape are investigated as well as the positive perception of these kind of coastal developments. The other project is the "Pilot Houtribdijk" in which a small section of the south side of the Houtribdijk between Lelystad and Enkhuizen is strengthened with sand to test this innovative way of dike reinforcement in lake environments. The pilot was built in the summer of 2014 and researchers studied this test section until the summer of 2018 to see how this body of sand evolved and how effective it is as a means for strengthening the dike.

The pilot Sandy Foreshore Houtribdijk was a full-scale experiment in which a 400 m long test section was constructed with 70,000 m^3 sand, varying in width and height, see Figure 3. On designated areas of the test section, different types of vegetation were planted. By doing so, various situations can be tested simultaneously for their effectiveness. With the knowledge gained in this project the concept can be applied with more certainty in other locations.

Morphological monitoring results indicate that the sandy foreshore can reach a stable profile shape in a time span of weeks and that remains effectively dissipating the incoming waves (Steetzel et al., 2017). With regards to vegetation development it is observed that at least two growing seasons are necessary for vegetation to fully establish and that with proper protection it is impossible to establish vegetation at the waterline, due to the exposure to waves. This endorses wider findings that 'engineering with vegetation' is one of the more difficult challenges as part of sandy solution strategies (Van Thiel-De Vries et al, 2016)

Figure 3. Overview of the pilot Houtribdijk as constructed.

Coastal restoration in Demak, Java

The project Building with Nature Indonesia, aims to protect 70,000 vulnerable people in Central Java (Indonesia) against coastal erosion and provide them with long term perspectives for sustainable economic development. This is accomplished by through the application of engineering measures such as permeable wooden dams that trap fine sediment and mud nourishments, alongside rehabilitation of mangroves that settle on the near shore bed. Secondly, sustainable land-use regimes will be installed, to revitalize the fisheries, aquaculture and agriculture sectors, all important drivers for the local economy.

The coast of Java, Indonesia, is facing severe erosion problems, mainly due to groundwater extraction, causing land subsidence, and the removal of natural mangrove forests to build extensive fishponds. Especially when the latter have been abandoned and are no longer maintained, for instance when they have become too polluted with nutrients, antibiotics and aquaculture chemicals, such coasts are susceptible to severe erosion. Figure 4 shows an example from the Demak district, Mid-Java, where both mechanisms are working and coastal erosion over the last decade extends over large areas.

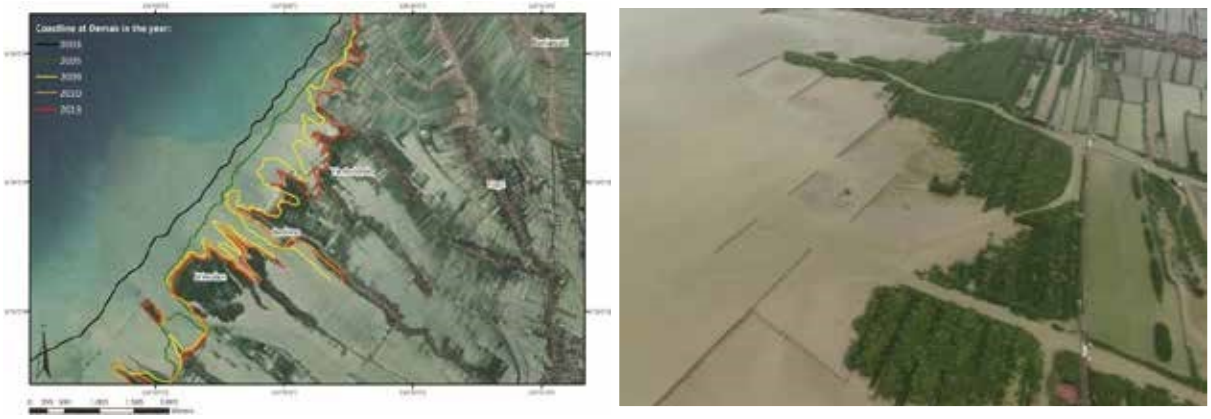

Figure 4. Coastal erosion in Demak, Java (left) and the applied solution (right).

In order to stop the erosion process and regain a stable coastline, the first necessary step is to restore the sediment balance. Semi-permeable barriers have been built from poles and brushwood to dampen the waves and capture sediment. Once the near shore bed level rises enough, mangroves will regenerate naturally, developing a natural defence that will protect the hinterland from further erosion. Where the coastline has not yet been eroded, we are encouraging the conversion of ponds into mangrove forests in close collaboration with local communities. In addition, a model will be put in place for sustainable aquaculture that provides space for mangrove restoration and requires less use of chemicals, in order to enable vulnerable communities and economic sectors to prosper, to be more self-reliant and to increase their hazard resilience. The measures will be controlled using community bylaws and rooted in community development plans and government master planning for sustainable development.

This project is funded by two main donors: the Sustainable Water Fund (SWF-RVO) and International Climate Initiative (IKI)., resulting in the following focus areas: coastal restoration and replication (SWF-RVO) and integrated water resource management and mainstreaming BwN in Indonesia (IKI). Furthermore, two fundamental research projects have started and underpin the scientific base of the Building with Nature program: BioManCo (on coastal dynamics and mangrove rehabilitation) and PASMI (sustainable aquaculture)

Resilient Delta Cities

Climate change and increasing population puts pressure on delta cities. By multifunctional solutions based on and including natural features the livelihood of these cities can be positively influenced. Multifunctional designs combines flood risk protection services, with nature, landscape and recreational space. This type of solutions are often relatively small in scale and could be combined in the form of a 'stepping stone approach' throughout larger scale urban areas to connect the city with the natural features of the delta in which it is located.

Building with Nature in the City - Dordrecht

EcoShape has executed a 3-year program together with the municipalitiy of Dordrecht in 2013-2015, which was co-funded by the European Commission (EFRO). In this program three showcases were executed. Findings are presented online (see Figure 5, which is a screenshot of www.buildingwithnatureinthecity.com).

Figure 5. Screenshot of www.buildingwithnatureinthecity.com.

- Showcase 'Stadswerven'; situated in the town of Dordrecht this former business area will be transformed into a housing area. At the shore of the river Merwede eco-engineering concepts were used for the design of a public park.
- Showcase 'Kop van 't Land'; located in the rural area of Dordrecht, its dike location was a good spot to test and showcase the effect of willow vegetation on the foreshore for the protection against high water levels in the river Merwede.
- Showcase 'Harbour of Rotterdam'; being part of a larger project 'The river as tidal park', focus was laid on design principles for environmental friendly quays with opportunities for tidal nature.

Sustainable Harbor Development

Harbors are often located in or close to valuable ecosystems. When maintenance and development of these

harbors should take these ecosystems and their function as the starting point, both ecological and economic development can profit from these developments. Especially the sediment management of these harbors is a topic of concern and of opportunity. Smart solutions for this sediment management include opportunities to transform these fine deposits (mud) into building material.

Within this theme, special attention is given to the harbors in the Wadden Sea and their struggle to develop. In order to continue economic development and growth, to safeguard the protected status of the Wadden Sea and to unbundle the headlock, the BwN approach is applied. The BwN Wadden Sea Harbors program started in 2013. Its focus is on decreasing siltation rates and increasing the potential for harbor development whilst at the same time enhancing the ecological state of the harbor and its direct surroundings. A 'learning by doing' approach is followed in which a variety of BwN-concepts is tested and studied in the most promising locations within the Wadden Sea area. Projects that are in execution include the Mud Motor near Harlingen, which consist of a development project funded by the Waddenfonds that puts the Mud Motor concept in practice to create salt marshes near the location of Koehoal, and a fundamental research project funded by STW to obtain further insights in the working of the concept. Next to these developments, the BwN II program was and is involved in various parts of the Marconi project at Delfzijl. Relevant concepts that are tested as well as initial ideas and findings are presented in Van Eekelen et al. (2016) and Baptist et al (2017).

Marconi Project, Delfzijl

The Marconi project is a multi-purpose project meant to improve the spatial quality of the city of Delfzijl, the Netherlands, by reconnecting it to the Ems Estuary, whilst allowing for strengthening the coastal defence and increasing the natural and environmental quality of the area. It consists of several parts (Figure 6), among which the construction of a recreational beach near the city centre and an artificial marsh along the harbour dam. Part of the plan is also to remove a mound of calcium carbonate (offshore shaded area), a by-product of soda (sodium carbonate) production which has been deposited in the estuary. Currently, EcoShape is involved in experimenting with various methodologies and variables to developed newly constructed pioneer salt marshes.

Figure 6. Marconi project, Delfzijl; conceptual sketch including all proposed developments.

Optimizing sediment management and integrating human developments into the natural sediment balance is one of the greatest challenges as well as greatest opportunities of our present days dredging industry. Sediment is a precious resource that should not be blocked behind dams or dispersed at seas, but needs to be reintegrated in the natural cycle. The Living Lab for Mud (LLM) is an initiative created and managed by the consortium EcoShape – Building with Nature in The Netherlands. The main objective of the LLM is to develop, show and share innovative knowledge and techniques regarding the sustainable use and re-use of fine sediments (i.e. mud) based on the Building with Nature approach (EcoShape, 2017; Van Eekelen et al., 2017). The LLM includes and connects five EcoShape pilot projects in The Netherlands and Indonesia, out of which three are included in the Sustainable Harbor Development theme.

Pilot Kleirijperij, Delfzijl

With the pilot Kleirijperij, sediment dredged from the harbour channel of Delfzijl and the nature area Breebaart is directly transported on land across the dike and it is let ripen for three years to produce clay soil to be utilized in the so called Brede Groene Dijk. While ripening dredge material it is not new, for the first time this pilot aims to producing clay that respects the requirements for application in dikes from ripening local dredge sediment. Simultaneously, this pilot contributes to decreasing the turbidity of the Ems River and improving its water quality. The project is a collaboration between EcoShape, the Province of Groningen, the waterboard Hunze en Aa's, the Delfzijl harbour developer Groningen Seaports, nature organisation Groninger Landschap and the Dutch ministry of Infrastructure and Environment, partially financed by the Waddenfonds. Dredged sediments is hydraulically transported on land and deposited in 24 tests cells (14 in Delfzijl (Figure 7), and 10 in Breebaart), covering an area of about 22 ha and a varying depth. Various deposition and ripening strategies will be tested in the cells such as different deposition layer thickness, dry or wet consolidation, seeding vegetation or enhancing ripening by mechanical tools. During ripening, the cells will be monitored to test consolidation and desalination rates. The ultimate objective of this pilot is to determine the most efficient ripening strategies with respect to economy and clay quality. At its termination in 2021, the pilot will have to deliver 70,000 m3 of clay for use in a demonstration project of the green dike concept 'Brede Groene Dijk'.

Figure 7. Left: The Kleirijperij site of Delfzijl seen from Google maps, Right: Image of one cell of the Kleirijperij at Delfzijl about one month after the second layer was deposited.

Supported Fundamental Research Programs

Next to the execution of various pilots and projects, of which some are in itself coupled to fundamental research programs and proposals, the BwN II program also has financially supported several fundamental research projects that do provided a further strengthening of the (academic) knowledge base of the BwN concept. BE SAFE is looking to the flood risk reduction capacities of vegetated foreshores, combining the fields of flood defence, biogeomorphology, ecology and governance to make a step towards including these foreshores in the safety approach, as it has been demonstrated that vegetated foreshores are a promising supplement to conventional engineering methods for dike reinforcements (Vuik et al., 2016) Also the NWO research proposals 'Smart EcoSystems' and 'Emergo' have received support from the BwN II program.

Framework

The pilots, projects and research works described above form the tangible result of application of the BwN concept. However, due to the local setting and the associated limitations of these projects, the results are site specific and therefore not generically application. In order to provide guidance to project proponents, engineers, ecologists and others interested in applying BwN, it is necessary that the knowledge obtained in these pilots, projects and research works are made generic. Within the BwN II program, the overarching Framework is set up to translate project specific knowledge in generic applicable guidance, best practices, guidelines and inspirational materials. The Framework is divided into clusters, that focus on specific items required to reach this goal.

The first cluster focusses on business case development for the BwN application. Rather than via simply comparing the costs for a particular solution with the value of its sole purpose, the multidisciplinary and integral approach of Building with Nature requires the inclusion of other positive values, which can both be economical,

social and ecological and for that reason might be harder to address in monetary terms. The generation of added value (at none or limited extra costs) is one of the key enablers of sustainable infrastructure (Laboyrie et al., 2018) and therefore one of the intended starting points for the Building with Nature approach. EcoShape had the opportunity to join the INTERREG North Sea Region project 'Building with Nature' and develop a guidance on business case development as part of their scope.

The second cluster focusses on the determination of several BwN concepts. The pilots and projects are example applications of generic BwN concepts, but as site specific application often not directly transferable to other settings. The underlying BwN concept should on the one hand be sufficiently high-level for more generic application, however, on the other hand have a clear distinctive feature founded in the BwN approach. Clarifying, presenting and providing inspiration on the application of BwN concepts is thus an important feature for the dissemination of the BwN philosophy. The aim is to deliver a BwN book of concepts to inspire decision makers at various (potential) project proponents, financers, regulators as well as other relevant stakeholders on the various possibilities with BwN concepts.

Within the third cluster, the knowledge base on BwN design that was created in the first program in the form of a wiki is being updated and reworked towards a more structured guideline approach. The structure of the wiki-setup was less intuitive, especially for users that were relatively new to BwN and could therefore lead to users missing some viable information that was provided. The re-structuring and updating process that has taken tries to present the information more from an 'outside-in' perspective, rather than an 'inside-out' perspective, which is in line with the change from 'Show that it works' from the first program towards 'Make it happen' in the second program. After the restructuring, the BwN Guideline was officially launched at the EcoShape-congress of June 2018. The team will continue to improve guideline and add relevant content that is being developed in the current program.

The relevance of CO_2-footprint for infrastructure development is ever increasing. Due to the natural features that are used or promoted by BwN solutions, it is expected that in principle the CO_2-footprint of BwN solutions is smaller than those of traditional solutions. However, this has not been demonstrated before. Traditionally, assessing CO_2- footprint of infrastructure developments focusses mainly on the deployment of equipment (e.g. emissions due to fuel consumption) and material use but less on the disturbance/creation of ecosystems and the role of sediments as a carbon sequester. The EcoShape partners in the cluster are working on tools that enable them to assess to what extent Building with Nature solutions contribute to the reduction of the CO2 footprint of projects. Calculation methods to do this and determining boundary conditions

Another linking pin in the framework are the communication activities by EcoShape. The development and maintenance of the Building with Nature-community is a point of ongoing attention in the form of delivering a valuable contribution to the discussion on sustainable development (via publication of white papers, participation in congresses and forums etc.), creating networking events (for instance EcoShape congress, exposition in the dredging museum in Sliedrecht etc.), online activities (webpage, LinkedIn, Facebook, Twitter etc.) and addressing requests for news features of our pilots. Also the provision of BwN information to informative presentations of hydraulic infrastructure such as being developed in the 'Waterloopbos' fits into this portfolio.

In line with the communication efforts, education is a key topic of the Framework as well. Although limited in financial contribution, the EcoShape-organisation tries to be actively involved in (the development of) courses at various universities, both at BSc and MSc-level. Another great example of educational involvement has been the MassiveOnly Open Course (MOOC) Building with Nature (https://online-learning.tudelft.nl/courses/ engineering-building- with-nature/)that was developed by Delft University of Technology .

EcoShape Foundation

As indicated before, the complete BwN II program has not been designed upfront, but is developed 'bottom-up' on a project-by-project basis. This requires that the EcoShape-management has time available to follow up and the administration of each of these projects takes place individually and on different financial and organisational terms. EcoShape holds an office in Dordrecht and provides for various digital services necessary within the pilots, projects and the Framework.

TRENDS AND OBSERVATIONS DURING 10 YEARS OF BUILDING WITH NATURE DEVELOPMENT

One of the most obvious differences between the world nowadays and that of the start of the BwN I program is that the attention for and understanding of sustainability and associated concepts has enormously increased. The

development of and attention for the UN Sustainable Developments Goals and associated initiatives indicates the recognition of the importance of sustainability as a topic. Still, while being recognized as one of the most important challenges of our time, the ways to ensure sustainability find its way to the shop floor of developing and executing projects are not exactly known and certainly have not fully matured (Silvius & Schipper, 2010). It is certain that the interest in EcoShape and its BwN-programs have on the one hand benefited from this attention, but on the other hand also have contributed in making the sustainable concept more tangible in the field of hydraulic infrastructure development especially via the use of pilot projects and practical demonstrators it was focussed on.

Apparently the world was receptive for philosophies like BwN, as we have seen that concurrent action was undertaken not only within the hydraulic infrastructure development sector (such as the Engineering with Nature initiative of the USACE and the Working with Nature initiative by PIANC). Similar concepts arise from outside our traditional sector in the environmental science and nature conservation contexts. Nowadays, also international organisations search for ways to work with ecosystems – rather than relying on conventional engineering solutions (such as seawalls) – to adapt to and mitigate climate change effects, while improving sustainable livelihoods and protecting natural ecosystems and biodiversity: the so-called Naturebased Solution (NbS) (Cohen-Shacham et al., 2016). Although the concept of NbS is being recognized and embraced, a lack of operational clarity hinders the credibility and applicability of derived concepts for specific issues (Cohen-Shacham et al., 2016). For this reason, EcoShape strives for the 'learning by doing' approach in its pilots and combination of fundamental and applied research works. With the Framework we furthermore aim to upscale project findings to a generic operational understanding on nature-based hydraulic infrastructure development. Part of our approach is to cooperate with other (global) organisations that are promoting the implementation of NbS such as the World Bank (see for instance: World Bank, 2017).

Also for the governance setting necessary to apply the innovative features of BwN/NbS concepts, the methodology of 'learning by doing' in the form of pilots could be beneficial. Both the challenge in getting the actual pilot financed in a public-private partnership as well as obtaining regulatory approval for the execution of innovative applications in pilot projects have shown that work is necessary to ensure that large-scale application of these concepts are realised. It was already concluded that major innovations in the field of hydraulic infrastructure development can only be realized on the basis of well-established, open networks between public parties, private companies and research institutes. In addition, we have learned that full scale experiments have the unique capacity to focus multidisciplinary research efforts and end-user interests, hence act as an important driver for public-private innovations (Aarninkhof et al., 2012). As some of our pilots have demonstrated that applying BwN in the design process contributes to successful project-level outcomes in stringently managed nature reserves, such as Natura 2000 areas (Vikolainen, 2012), it is clearly possible for a regulatory context to encourage and enable application of BwN/NbS (Vikolainen et al., 2014).

All of the above contributes to the positivity that EcoShape has observed towards the BwN philosophy and concept at the various conferences, events and publications it has organized. High attendance and enthusiasm of the BwN MOOC that was developed by Delft University of Technology with contributions from EcoShape and its partners demonstrate that the upcoming generation has an interest in its application. It even seems an observable trend that this younger generation does no longer need to make the paradigm shift that we have opted for during the BwN I program, but that this quite naturally anchored in their overall attitude.

Nonetheless, application of BwN, for instance in coastal protection, must demonstrate its value and (cost-) effectiveness in comparison to other solutions. The viability of nature-based coastal defence projects need better reporting of effectiveness and cost effectiveness from the growing number of example or pilot sites (Narayan et al. 2016). For full scale application, the business case for the BwN or NbS approach in comparison to its more traditional single-purpose alternative should be made. When looking to cost-effectiveness for the intended single-purpose, the traditional approaches are usually scoring better or at least with a more certain outcome. However, whether that is also the case for a more holistic approach in the form of societal cost-benefit analysis or similar is up for debate. Better estimates of maintenance costs and the additional services and benefits (including coastal access, fish production, carbon sequestration) or lack thereof, for both artificial and nature-based defences are required for making that evaluation (Narayan et al., 2016). As a logical response to this knowledge need, EcoShape is trying to address these issues in an European context in the business case project of the Framework.

CONCLUSION

BwN is an innovative design philosophy that optimizes the utilization of natural processes in developing resilient and sustainable hydraulic infrastructures. Within the BwN I program that EcoShape has executed in 2008-2012 it has developed this view and has been predominantly communicating its basics and values via pilot projects and a

variety of publications of the results. Because of the positivity regarding the concept, EcoShape has established the BwN II program 'bottom-up' via a multitude of interested partners and financers to continue mainstreaming the philosophies; in the mean time nature-based solutions thinking has become more common and various (global) initiatives and institutions have been focusing on getting these type of sustainable approaches adopted and implemented. Despite these efforts, there are still barriers that hinder the large scale application of BwN or NbS in practice, such as governance and regulatory settings, the determination of the societal business case and cost-effectiveness or in some cases the certainty or uncertainty related to the functioning of the natural/ecological component of the solution. For upscaling BwN/NbS, the following actions remain critically important (Ovink & Nieboer, 2018):

- Educate the new generation of engineers, designers, ecologists, policy maker, politicians and mangers in the principle of BwN/NbS;
- Develop a credible narrative of BwN/NbS on landscape scale for various water related challenges, including business cases and examples of successful (pilot) projects;
- Implement large scale pilot projects worldwide and disseminate the experience and knowledge gained;
- Involve communities in the planning and implementation of BwN/NbS solutions and equip them with knowledge and financial means in order to scale up and sustain such solutions, working side by side with governments and private sector;
- Scale up existing pilots and replicate these in international consortia across the globe, in partnership with the financial sector (such as multilateral development banks, climate funds, governments, private sector and pension funds.

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