THE IMPACT AND COSTS OF BUILDING WITH NATURE PROJECTS

The use of nature and natural processes is an innovative way to increase water safety and create added value through nature development and recreation. This exploratory study provides an initial inventory of the impact and costs of existing Building with Nature projects in the Netherlands. It also includes an analysis of the decision-making process in choosing this type of project and identifies success factors. Building with Nature projects deliver added value but often also involve additional costs compared to traditional reinforcements. These costs give an indication of what we as a society are prepared to pay for the development of nature and recreation as part of hydraulic engineering projects.

A key tenet of Building with Nature projects is the combination of objectives for flood protection, nature development and spatial quality.

This study surveyed the characteristics of 11 Building with Nature projects (see Table 1). The projects are examples of natural solutions for the reinforcement of primary flood defences, coastal management and river management but also specifically for nature development. This inventory discusses the impact on flood protection, nature development and recreation. It also contains a reflection on the costs of Building with Nature projects and identifies critical aspects in the decision-making process for selecting this type of project. As part of this study, a literature review was conducted and interviews were held with those involved in several projects, such as the Houtribdijk, the Hondsbossche Dunes, the Marker Wadden, the Hertogin Hedwigepolder, the Prins Hendrikzanddijk, the Sand Motor and the Room for the River programme.

Impact of Building with Nature

The inventory shows that natural solutions create added value for the various stakeholders in different ways. A key tenet of Building with Nature projects is the combination of objectives for flood protection, nature development and spatial quality. Building with Nature measures are often a response to flood protection issues; flood defences that no longer meet safety standards are strengthened using natural materials and processes.

The Sand Motor is a prime example of how a Building with Nature project can be used for dynamic coastal management. Instead of replenishing smaller quantities of sand periodically, a huge volume of sand is deposited in one go. This protects the coast over a longer period. The benefits of dynamic coastal management are also evident in the Hondsbossche Dunes project. The sand deposits in this area are sufficient to keep pace with a rising sea level and subsidence.

Building with Nature projects stimulate nature development. Over the past 25 years, 12,000 hectares of additional nature have been created by widening rivers as part of flood protection projects. Building with Nature facilitates the preservation and strengthening of habitats. Thanks to the Marker Wadden project, the Natura 2000 targets for various bird species will be achieved by an ample margin (De Rijk et al., 2018). Active management is required to achieve all nature objectives; one example of this is limiting the amount of woodland in order to create pioneering biotopes.

Nature development and recreation often go hand-in-hand in Building with Nature projects but in some instances, this involves making choices about day-to-day management and determining which function takes priority. In the case of the Houtribdijk and the Hertogin Hedwigepolder, opening the nature area to the

TABLE 1

Characteristics of Building with Nature projects.

Project	Year	Implementation/ design type	Approx. construction costs [in EUR millions]	Approx. additional costs [in EUR millions]	Approx. surface area of above-water nature [ha]	Nature type (SB; Sandbanks, D; Dunes, SM; Salt march; RB; Reed banks, L; Lagoon, M; Marshland)	Approx. costs per ha [in EUR thousands]	Ca. costs per km dyke [in EUR millions]	Recreational pressure	Source
Zandmotor	2011	Peninsula, foreshore nourishment	50	20[1]	100	SB, D, L	200	-	High	Finselier (2010)
Houtribdijk	2012	Hard and soft reinforcement, foreshore nourishment	90	0	530	SB, RB, L	0	3.6	Low	NH nieuws (2020)
Prins Hendrikzanddijk	2018	Along existing dyke, dune, salt march	55	12[2]	100	SB, D, SM	120	18.3	Medium	Hoogheemraadschap Hollands Noorderkwartier and Witteveen Bos (2016)
Hondsbossche Duinen	2015	Along existing dyke, dune	210	30	100	D, L	300	26.3	Medium	Warringa (2010)
Veur-Lent	2015	Side channel, island	338	183	-	-	-	-	High	Egbregt et al. (2005)
Noordwaard	2014	Depoldering	365	71	4500	SB, M	1.6	-	Low	Egbregt et al. (2005)
Kierbesluit Haringvliet	2018	Restoration of saline ecosystems	75	-	1500[3]	-	503	-	Low	Hees and Peters (1998)
Kop van Schouwen	2010	Dune restoration	5	-	800[4]	D	64	-	Medium	Province of Zeeland (2017)
Marker Wadden	2021	Construction of islands, channel system	90	-	500	SB, RB, L	180	-	High	IJff et al. (2018)
Eiland Griend	2016	Nature restoration, foreshore nourishment	2	-	16	SB, SM	125	-	Low	Govers et al. (2020)
Hertogin Hedwigepolder	2023	Depoldering, channel system, panorama hill	50	-	300	D, SM, L	166	-	Low	Scheltjens et al. (2013)

[1] Additional costs are equal to the costs of research and monitoring. [2] Additional costs are equal to the grant provided by the Wadden Fund.
[3] Number is equal to the number of hectares of underwater nature. [4] Concerns dune restoration, is not included in the cost analysis.

public is not desirable. However, opportunities for recreational use have been created at the periphery of the Hertogin Hedwigepolder, including the dyke and the neighbouring Drowned Land of Saeftinghe.

Building with Nature projects are often implemented with a time horizon of 50–100 years. Ecosystems need time to develop, which for some habitat types can be several decades. It is precisely for this reason that Building with Nature measures are often combined with long-term research and monitoring programmes. For example, the 40-metre-high Argus mast on the Sand Motor is equipped with cameras to closely monitor developments and at the Houtribdijk, a research and monitoring programme will run until the end of 2022 to examine, among other things, whether replenishment will be required after 10 years. Besides contributing to the development of knowledge, these research programmes make it possible to intervene when things do not develop as expected.

Varying costs of Building with Nature

Unlike Building with Nature projects, traditional reinforcements for flood protection are often monofunctional, primarily aimed at improving flood protection. However, traditional dyke reinforcement projects are often less expensive than Building with Nature projects. In the cost analysis, a distinction is made between nature development projects primarily intended for nature development and flood protection projects primarily intended to increase flood protection.

For the preliminary investigation of the costs of Building with Nature projects, two broad indicators were derived: the costs per hectare of developed nature and the costs of dyke reinforcement per kilometre (for reinforcement projects only). These broad indicators are not intended for drawing conclusions about individual projects but are used to present a range of costs for flood protection and nature development projects.

In Building with Nature projects, the contractor is usually responsible for the construction, as well as several years of maintenance. This is included in the inventory as construction costs (see Table 1). For flood protection projects, an estimate is given of the additional costs compared to traditional reinforcement projects. In many cases, the additional costs are derived from Environmental Impact Assessments (EIA) and are the difference between the preferred alternative (Building with Nature) and the reference alternative (traditional). The number of hectares of nature is the surface area of above-water nature; nature areas that are permanently under water are not included. Given the integrated nature of hydraulic engineering projects and Building with Nature projects in particular, it is difficult to derive additional costs.

For nature development projects, the costs amount to an average of EUR 130,000 per hectare realised and vary between EUR 50,000 for nature restoration and EUR 180,000 for the development of the Marker Wadden per hectare of newly established nature. For flood protection projects, the additional costs per hectare amount to an average of EUR 120,000 and vary between EUR 1,600 per hectare for the depoldering of the Noordwaard polder and EUR 300,000 for the reinforcement of the Hondsbossche and Pettemer sea defences using sand.

There is also a considerable difference when it comes to the costs per kilometre of dyke reinforcement; the costs for the Houtribdijk amounted to EUR 3.6 million per kilometre, whereas the costs for the Prins Hendrikzanddijk and Hondsbossche Dunes amounted to EUR 18.3 million and EUR 26.3 million respectively. The inventory revealed several reasons why the costs of Building for Nature projects differ greatly from one another and are often higher than those for monofunctional projects aimed at improving flood protection. A few of these reasons are discussed in more detail below.

Each project is unique and has its own specific list of reasons as to why costs vary. However, certain factors are common to several projects. Natural solutions often require large quantities of sand. The low price per cubic metre and low transportation costs make reinforcement using sand an attractive option.

In the case of the Sand Motor project, transportation costs were limited because the equipment used for the construction of Maasvlakte 2 (the expansion project of the port of Rotterdam located west of the Maasvlakte) could also be used for depositing 20 million m³ of sand. In the case of the Houtribdijk, one half of the dyke was reinforced with sand, the other with rock revetment. The limited depth of the stretch between Trintelhaven and Enkhuizen meant that the costs of a sand-based reinforcement were lower than those of a hard reinforcement. During the planning phase for the Houtribdijk, it transpired that the realisation of part of the Trintelzand nature area would be cost-neutral since the sludge released during sand extraction could be used to create the nature area.

For the Marker Wadden project (a cluster of five new, uninhabited natural islands, artificially created), the costs for sand were kept low by combining the construction of the islands with digging a system of channels for nature. A similar approach is being used for the development of a panoramic hill at the Hertogin Hedwigepolder, which will contribute to the recreational use of the area and will be constructed using the soil released during the digging of the channel system. The demarcation of the project area is key here; if sand can be extracted within the

FIGURE 1

Reinforcement of the Hondsbossche dunes using sand.

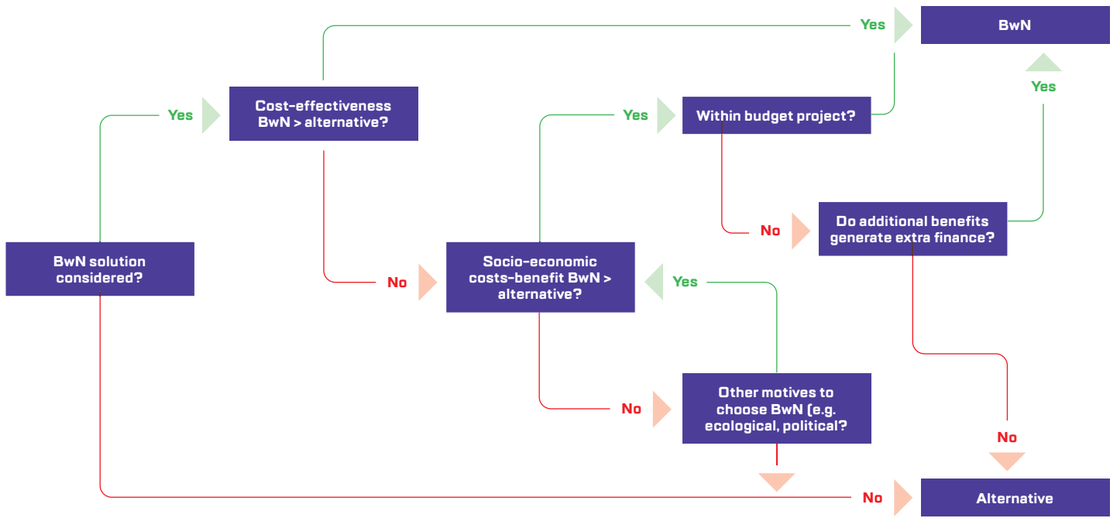

FIGURE 2

The decision-making process involved when choosing Building with Nature projects.

project area, this is not only cheaper but is also easier to use the resources released during one project to work on another.

In addition, depending on the location, costs are also incurred for changes in land use. For example, approximately half of the costs for the development of the Hertogin Hedwigepolder relate to real estate such as the purchase of agricultural land and considerable costs have been incurred to create a new primary defence around the area.

Building with Nature solutions are inherently more dynamic. They require a broader approach to planning and design that prioritises the functioning of the natural system. When natural processes are used, it is more difficult to accurately forecast how the implementation of the project will progress. For example, sand drifts occurred at the Houtribdijk, which meant the dyke had to be closed to road traffic on a number of occasions. Of the EUR 11.8 million risk reserve, which corresponds to about 15% of the value of the contract, EUR 3.4 million was spent on tackling the sand drifts.

The expectation is that costs will decrease as more experience is gained in implementing natural solutions. At the same time however, an adaptive approach to implementation, management and monitoring will continue to be necessary due to the dynamic nature of such projects. Additionally, the differences in costs are difficult to interpret, primarily because it is hard to determine how the costs for various parts of these Building with Nature projects are distributed. On the one hand, this is a result of the integrated nature of such projects, which makes it impossible to connect a specific part of the costs to a function, and on the other, it is due to the absence of an accurate inventory of the costs for different projects. For example, information on how much of the contract value was spent on construction and how much on maintenance is not always available, which makes it difficult to fine-tune the above-mentioned indicators and to gain new insights. Therefore, one recommendation is to create a database to record the breakdown of costs for existing and future Building with Nature projects.

Key factors in decision-making and planning

For the projects under review, interviews were also conducted with project owners to investigate the decision-making process. How did they actually end up choosing a Building with Nature solution? There are several similarities between the motives for selecting natural solutions and the planning and implementation phases.

The decision to implement a natural solution for dyke reinforcement is often taken early on in the planning phase. It is often made by a small group of people from different organisational units who endorse a Building with Nature solution and its advantages. A crucial factor here is the early conclusion of an ambition agreement that combines objectives for flood protection, nature and recreation. This is exemplified by the Houtribdijk project, where an early decision was taken to reinforce half of the defence with rock revetment and the other half with sand. The ambition agreement for the Sand Motor, in which shared goals are laid down, also formed the basis for selecting a Building with Nature project. The interviewees mentioned the following key reasons for favouring Building with Nature projects.

Building with Nature measures utilise space in a different way than traditional reinforcements, which often require space inside the dykes. This can make natural solutions a more attractive option for increasing flood protection. Reinforcing the Prins Hendrikdijk using traditional methods would be at the expense of agricultural land, buildings and nature areas located within the dyke. Consequently, the local community had a strong preference for a reinforcement outside the dyke that combines flood protection with nature development. Similar arguments were also put forward in the Hondsbossche Dunes project; here, a Building with Nature solution makes it possible to increase flood protection whilst using as little space as possible in the area protected by the dyke.

Co-financing by nature organisations can be a decisive factor in selecting natural solutions. With additional funding, it is possible to broaden the scope of the project rather than opt for a monofunctional solution. The sand-based solution for the Prins Hendrikzanddijk was awarded a EUR 12 million grant from the Wadden Fund. Without this contribution, and the additional funding from other parties, it would have been impossible to implement a natural solution. The depositing of 5 million m^3 of sand has created a varied sandy area with dynamic character in front of the sea dyke. This project also includes the creation of a new 200-hectare estuarine nature area and a breeding island. The initiative for the realisation of the Marker Wadden came from the Dutch Society for Nature Conservation (Natuurmonumenten). Thanks in part to a contribution of EUR 15 million from the Dutch Postcode Lottery, they were able to undertake the planning and part of the construction of the project.

Additionally, knowledge development is a powerful incentive for implementing Building with Nature projects. Long-term knowledge programmes such as NatureCoast at the Sand Motor and the Marker Wadden Knowledge and Innovation Programme (KIMA) also attract additional funding from organisations such as the Dutch Research Council (NWO). EcoShape, a foundation under Dutch law that facilitates the Building with Nature network, develops and shares knowledge on pilot projects in which Building with Nature is applied. More parties are involved in the planning and implementation of natural solutions than in traditional dyke reinforcement projects, such as government bodies, research institutes, the business community, social organisations, nature organisations and knowledge partners.

Since these projects have multiple objectives, it can often be beneficial to put them out to tender in a different way. Collaborating with the market at an early stage opens up opportunities for creating added value from the outset. This way, the contractor also has more freedom when it comes to shaping the project. For the reinforcement of the Hondsbossche and Pettemer sea defences, this led to the construction of a lagoon that had not been included in the original plan. For the Marker Wadden project, a conscious decision was made not to use a detailed design in the tender but to focus on building using natural processes as much as possible.

However, innovative tendering is not always possible. In the case of the Hertogin Hedwigepolder, an agreement was reached with the Flemish Region setting a lower limit of 600 hectares of estuarine nature. In the Netherlands, tender specifications are usually based on functional requirements; however, Belgian clients often prefer to work with a strict framework of what has to be delivered. This once again underlines the fact that not all positive findings from this exploratory study are directly applicable to other projects. They do however, provide useful pointers for future initiatives.

Conclusions

Building with Nature projects are generally effective in combining flood protection, nature development and recreation. The projects reviewed in this study are regarded as success stories that will inspire future initiatives. Besides the impact on flood protection, nature development and recreation, there are several other factors that also increase the appeal of Building with Nature projects, such as not taking up space in the area protected by the dykes.

The costs of natural solutions are typically higher than for projects solely aimed at reinforcing flood defences. The additional costs of Building with Nature projects as part of flood protection projects are similar to the costs of nature development projects. The additional costs per hectare of developed nature are on average EUR 120,000 per hectare, with considerable differences between the projects. The differences in costs are partly due to the varying flood protection challenges, the characteristics of the working environment and the possibilities for cost-neutral nature development by using the resources released during one project in another. The findings of this study can be used to inform the planning and decision-making process for future projects, including cost figures and drivers for successful decision-making.

To obtain a more complete information base, further research into the benefits of Building with Nature solutions is required. The impact on flood protection, nature development and recreation is monitored through monitoring and research programmes and, where possible, quantified. This exploratory study also demonstrates the value of investigating the actual costs of Building with Nature projects, hence the recommendation to compile a database in which the costs, broken down by project component, are recorded. This database can also be used to compare the costs of hydraulic engineering Building with Nature projects with the costs of nature development at other locations throughout the Netherlands. Reliable insights into the costs could further reduce the barriers to implementing Building with Nature projects, which will ultimately ensure that such projects move beyond the pilot stage and are applied more widely in hydraulic engineering.

The expectation is that costs will decrease as more experience is gained in implementing natural solutions.

Summary

Several appealing Building with Nature projects have been realised in the past 10 years. The use of nature and natural processes is an innovative way to increase flood protection and to create added value through nature development and recreation. In this exploration, an initial inventory was made of the costs and effects of existing Building with Nature projects in the Netherlands. In addition, the decision-making process for a number of these projects has been mapped out and success factors have been identified. Building with Nature projects for flood risk management provide added value but often result in additional costs (approximately EUR 120,000 per hectare of realised nature – with a considerable spread over the projects) compared to traditional reinforcements. These costs provide a first indication of what we as a society are prepared to pay for the development of nature, recreation and other functions as part of hydraulic engineering projects. Insights into costs can be used to inform planning and decision-making in future Building with Nature projects, for example with regard to cost indicators and motives for successful decision-making. The findings of this study can be used to inform the planning and decision-making process for future projects, including cost figures and drivers for successful decision-making.

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