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NAture Insurance value: Assessment and Demonstration

NAIAD Case Studies:

Chapter 15
The Netherlands – Rotterdam DEMO

1.1 BACKGROUND

In the coming years, The Netherlands will face a range of water challenges, not least of which concern rising sea levels, as well as risks from the three large rivers that flow through the country (the Rhine, the Meuse and the Scheldt). However, within cities other obstacles are emerging. The onset of climate change is bringing increasingly frequent extreme precipitation, as well as higher temperatures and longer periods of drought. In this context, Dutch cities are finding a need for renewed investment in water infrastructure and climate adaptation, if they are to retain their renowned liveability and high quality of life. As such, cities are increasingly turning to emerging technologies and innovations with keen interest, particularly those that can address multiple issues integrally.

The city of Rotterdam lies in the province of South Holland, within the Rhine-Meuse-Scheldt River delta near the North Sea. The city has a population of 639,587, with a density of 3,060 inhabitants per km2 (Rotterdam, 2017). Like the nation at large, much of Rotterdam's past and future successes are strongly linked to water; it is Europe's largest port, approximately 36% of the municipal area consists of water and 80% of the city lies below sea level. As such, the city is both highly dependent on, and yet vulnerable to threats from, water.

As with many cities, the proportion of impervious surfaces in Rotterdam has increased over time, due to urbanisation and changing land use priorities. Over a century ago several canals, which previously took care of household water management, were filled up to make space for new infrastructure. Since then, drainage has become increasingly reliant on a sewage system which now appears insufficient to cope with heavy rainfall events (De Greef, 2005). With the aforementioned emerging climate change impacts, Rotterdam is now becoming susceptible to not only flooding, but also higher levels of heat stress and degradation of building foundations in many parts of the city (Figure 1).

In acknowledgement that this combination of urbanisation and climate change pose a significant threat to the city's future prosperity, the municipality of Rotterdam set the objective of making the city 100% climate-proof by 2025 through the Rotterdam Adaptation Strategy (RAS). This aims for a robust water system that protects the city and avoids climate related nuisances, achieved through forming connections across disciplines, programmes and diverse stakeholders. A consequence of this is a change of approach within the municipality, where water policy is shifting from catch-store-dispose, towards infiltration and local storage-reuse. As will be elucidated throughout this chapter, this broader policy objective has been able to act as an entry point for innovative projects on the ground that aim to break with traditional approaches.

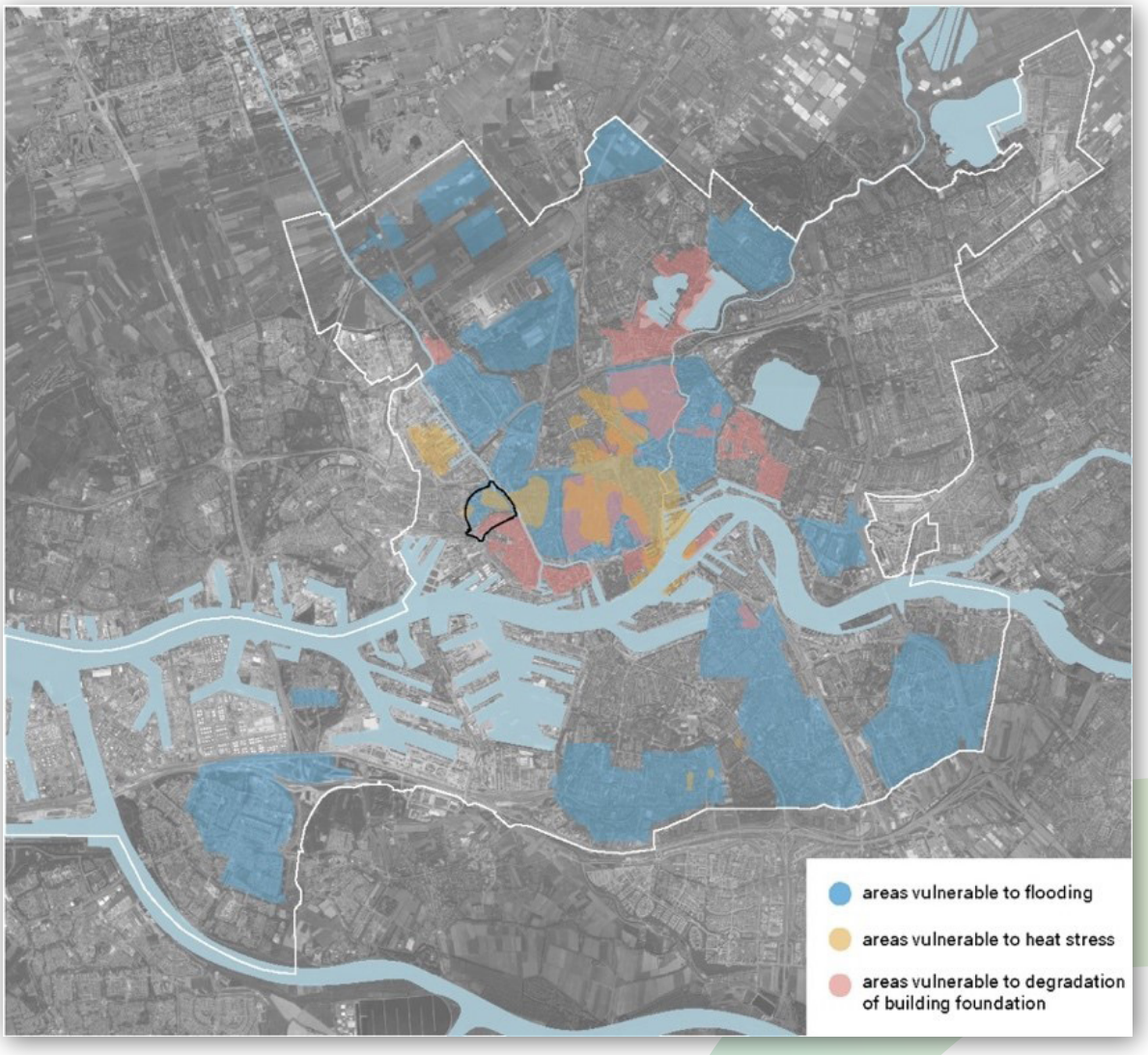

Figure 1: A map of Rotterdam, showing areas vulnerable to flooding, heat stress and subsidence. Source: NAIAD D6.1

1.2 THE DEMO AREA: SPANGEN NEIGHBOURHOOD

The Rotterdam demo focuses on Spangen, a low-lying neighbourhood in the west of the city, spanning roughly 65 ha, with around 10,000 inhabitants. In Spangen, as with much of the city, the effects of urbanisation are clear - hard surfaces dominate and there are few green areas. Including streets, public squares and buildings, and a large proportion of the area is impervious (Figure 2).

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Figure 2: A representative view of the Neighbourhood of Spangen, showing the high percentage of impermeable surfaces. Image: Bilderdijkstraat facing West, Spangen (Google Earth, 2016).

With the low elevation and lack of green space, the neighbourhood has been suffering frequent pluvial flooding during heavy rain in recent years. After Spangen was identified by the Waterboard as in need of additional water infrastructure to mitigate flood risk, an opportunity emerged to tackle some of the other underlying issues in the neighbourhood simultaneously. The Rotterdam Demo within NAIAD assesses how these issues have been addressed through the implementation of an innovative circular urban water system. For this assessment, the Rotterdam DEMO has had three core focus areas:

1. An assessment of the recently implemented hybrid solution in Spangen, known as the Urban Waterbuffer (UWB). Spanning a 4ha catchment, this system reduces pluvial flooding using an underground buffer tank, then utilises biofiltration with aquifer storage and recovery (ASR) to provide long term, large-scale storage and reuse of the captured rainwater (see insert on next page for more information).
2. An assessment of the impacts of the UWB and NBS more broadly, when nested within a neighbourhood scale hybrid water management strategy, and how this compares with full green solutions and full grey alternative strategies (See insert on next page for more information).
3. An integration of the lessons learnt across both temporal and spatial scales

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The assessments of the Urban Waterbuffer and the three neighbourhood strategies have been executed in line with the methodologies developed within in NAIAD. In Figure 3, an overview of the various linkages between the Rotterdam DEMO and the NAIAD assessment framework is presented. The scale at which the methods were applied (UWB versus neighbourhood strategy) was dependant on the particular approach and the likely insights that could be derived.

NAIAD METHODOLOGIES APPLIED IN THE ROTTERDAM DEMO.

- RISK ASSESSMENT (CHAPTER 3)
- STAKEHOLDER ANALYSIS (CHAPTER 4)
- ECONOMIC ASSESSMENT (CHAPTER 5)
  - LIFE CYCLE COSTS
  - AVOIDED DAMAGES
  - OPPORTUNITY COSTS
  - CO-BENEFITS
- ADAPTIVE PLANNING (CHAPTER 6)
- BUSINESS MODELS FOR NBS IMPLEMENTATION (CHAPTER 7)
- IMPLEMENTATION STRATEGIES (CHAPTER 8)

Figure 3: An overview of the NAIAD methodologies applied in the Rotterdam Demo and in which chapter more information can be found.

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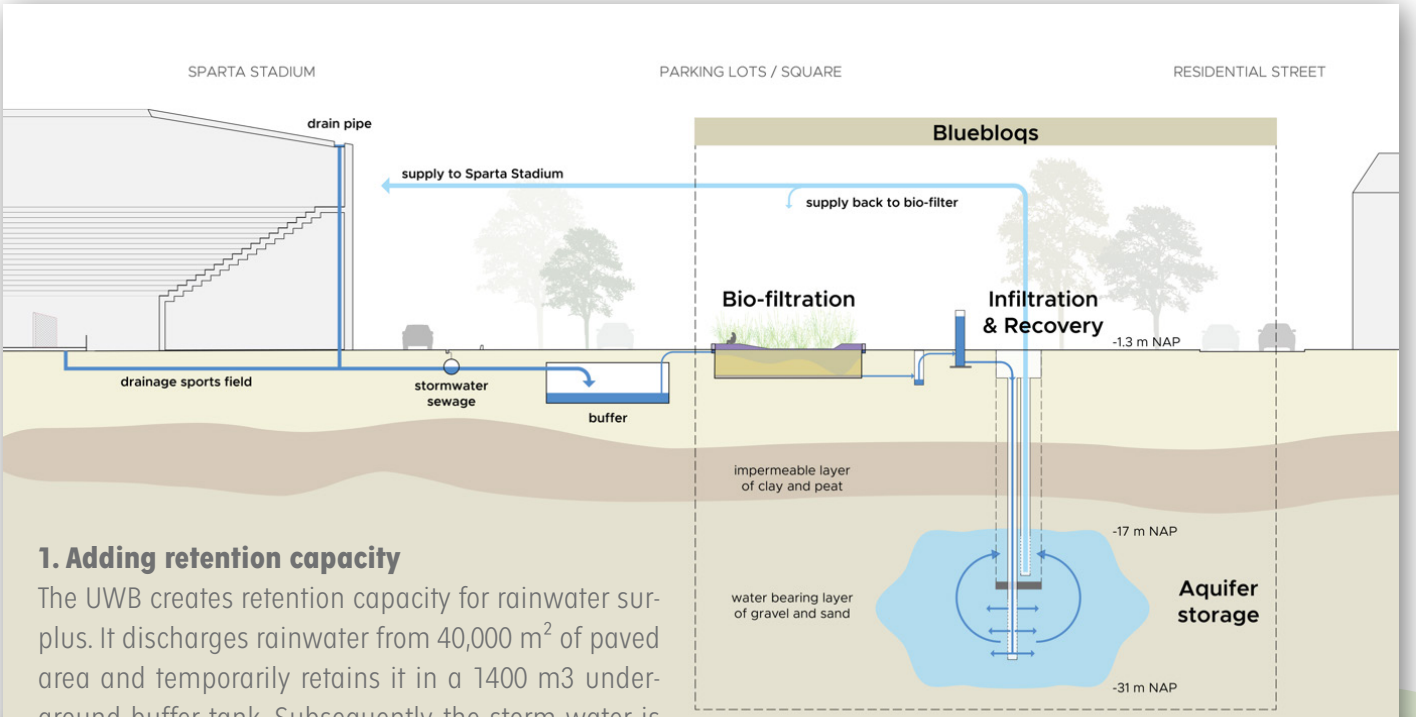
THE URBAN WATER BUFFER (UWB)



1. Adding retention capacity

The UWB creates retention capacity for rainwater surplus. It discharges rainwater from 40,000 m^2 of paved area and temporarily retains it in a 1400 m3 underground buffer tank. Subsequently, the storm water is treated and stored in the subsurface to minimise the required floor space at ground level.

2. Adding green

The runoff needs treatment before it is safe to infiltrate and store the water, and this is achieved with the Bluebloqs biofilter. This compact vegetated slow sand filter adds greenery to the neighbourhood at the same time, and the seating elements around the filter also improve the spatial quality of the area.

3. Providing a sustainable water supply

The purified water is stored underground in a sand layer at a depth of 15-30 m via a well. The recovered water irrigates the Sparta stadium, creating a sustainable alternative water supply. The UWB supplies around 15,000 m3 of water per year and will store and estimated volume of 30,000 m3 in wet years.

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SPANGEN NEIGHBOURHOOD ASSESSMENT

Strategy 1 (Grey)
Traditional and centralised

- Separated sewer
- Permeable pavement in road edges

Strategy 2 (Hybrid)
Infiltration via public squares

- 2 x Urban Waterbuffers
- Retention ponds
- Expansion of central green space
- Separated sewer for water collection and distribution

Strategy 3 (Green)
Local infiltration through green infrastructure

- Green roofs
- Façade gardens
- Green strips and swales
- Retention ponds
- Expansion of central green space

1.3 CHAPTER OUTLINE

From the retrospective examination of the historical and contextual factors leading to the implementation of the Urban Waterbuffer, to the exploration of long-term potential future costs and benefits of NBS, a variety of important insights have been derived from the Rotterdam demo. This chapter aims to share these insights through exploring eight key lessons that have emerged from the research. These lessons link to, and were the results of utilising many of the methodologies outlined earlier in this deliverable. The background on these methodologies and the assessment of the Rotterdam DEMO specifically, can be found in earlier NAIAD deliverables and chapters of this book. The lessons presented here aim to support stakeholders in their future assessment of and decision-making on NBS implementation, by bringing the different methodologies together and shedding new light on the impact of urban NBS and their potential for wider uptake.

2. LESSONS FROM THE ROTTERDAM DEMO

2.1 THE UWB IMPLEMENTATION WAS DRIVEN BY ITS ABILITY TO ADDRESS MULTIPLE STRATEGIC POLICY OBJECTIVES INTEGRALLY.

The implementation of the UWB in Spangen was the result of a window of opportunity that arose when multiple initiatives coincided in 2016. The municipality had just launched the Water Sensitive Rotterdam program aiming to improve the city's climate resilience, and since the Spangen neighbourhood suffered from excess run-off in periods of heavy rainfall, the municipality had already identified the area to be in need of additional water retention measures. Simultaneously, residents in Spangen had been requesting (aesthetic) improvements to the neighbourhood by increasing the amount of green areas. Additionally, the municipality got involved with researchers, engineering companies and technology suppliers in the Urban Waterbuffer Consortium in their search for pilot locations to test this innovative hybrid solution in practice under the umbrella of a research project, subsidised through the national Top sector Knowledge and Innovation (TKI) fund. Consequently, the Sparta Football Club came on board as end-users of the rainwater that could be treated and stored by the Urban Waterbuffer, allowing them to reduce their drinking water footprint by 10-15,000m^3 per year. The integral approach of the Urban Waterbuffer offered a single solution to these various issues, leading to its successful implementation in the summer of 2018.

2.1.1 Drivers of the implementation process

Based on interviews with key stakeholders, a timeline was developed to summarise critical milestones in the decision-making process (Figure 4). Through this assessment, the various key success factors were identified. One of the notable insights from this process was the importance of various policy programmes within the Municipality of Rotterdam and Waterboard Delfland (eg. Water Sensitive Rotterdam [1], Resilient Rotterdam [2] and Waterbeheerplan 2016-2021 (Delfland, 2015)) to guide internal discussions towards measures beyond traditional sewer replacement. The authorities aimed to exploit multi-functional approaches to improve the city's climate resilience, aiming to increase the amount of green infrastructure in the city.

Also, the spatial improvements (added green space, mini-playground, seating elements, cooling) that the UWB brought to the neighbourhood through the incorporation of the biofilter were an important motivation to invest in the Urban Waterbuffer. In particular, the Waterboard Delfland had a clear policy objective to stimulate water awareness among inhabitants, which is facilitated through the open and visible water treatment in the biofilter and the ability for children to pump up water from the well.

[1] https://www.watersensitiverotterdam.nl
[2] https://www.resilientrotterdam.nl

Besides the core functionality of the Urban Waterbuffer (to provide additional retention capacity in the area to prevent the neighbourhood from flooding in case of extreme rain events), the ability to reuse the rainwater with the Urban Waterbuffer was a critical benefit. Since the water from the Urban Waterbuffer is sufficient to meet the total water demand for irrigation of the football field in the Sparta Stadium, this led to a new business case involving the Sparta football club as end-users of the water. The creation of this new local fresh water source also increases the city's resilience to future droughts.

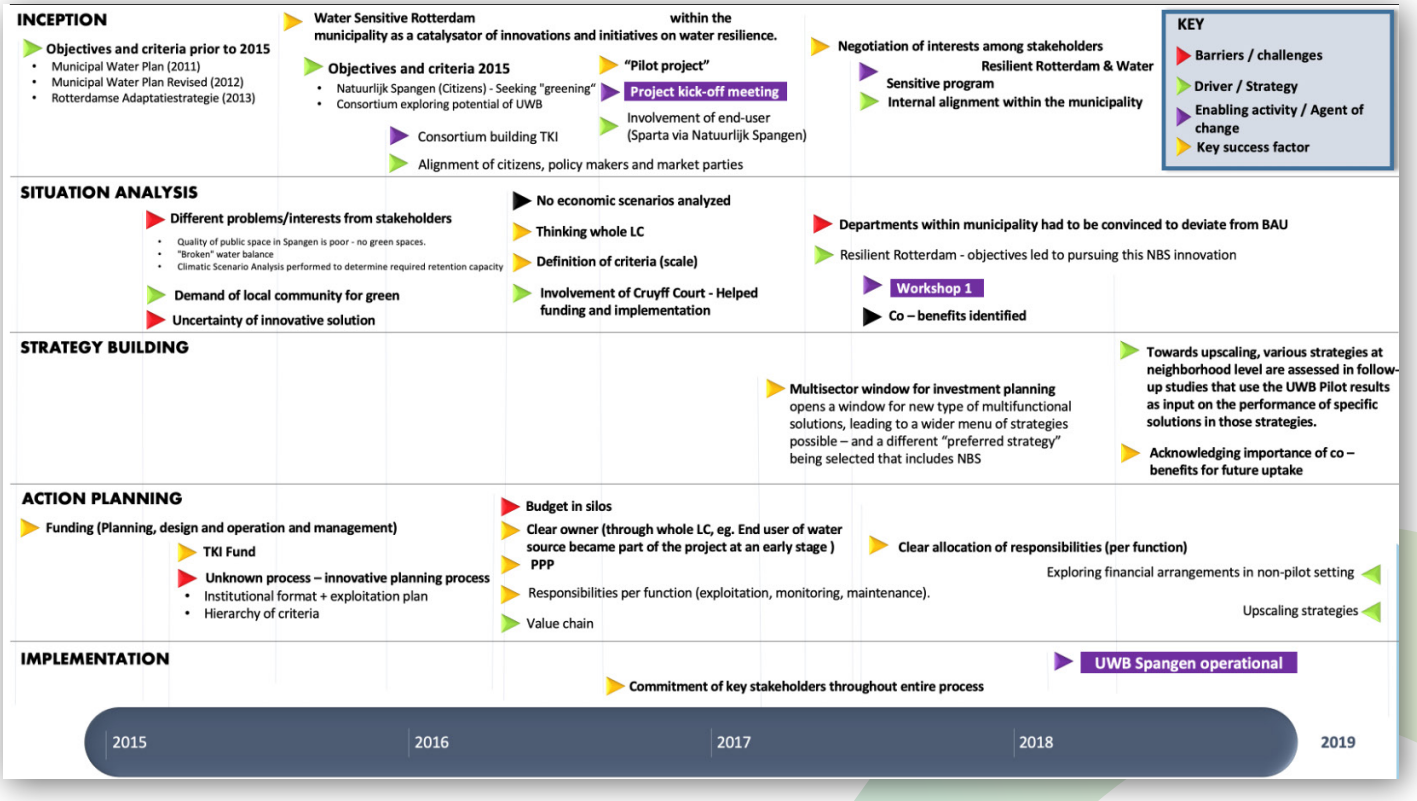

Figure 4: Analysis of adaptive planning process around the implementation of the Urban Water Buffer Spangen: Timeline of the decision-making processes (Dourojeanni, 2019).

2.1.2 Stakeholder perception analysis

The multiple functions of Nature based solutions such as the Urban Waterbuffer naturally leads to the involvement of many different parties with different interests and responsibilities. If these parties are well aligned, this can create opportunities to benefit from cost-savings through one integral solution. On the contrary, the involvement of many stakeholders can also be a burden on the decision-making process, with risk of protracted disputes and missed opportunities. Overall, the alignment of stakeholders in the case of the Urban Waterbuffer was effective. A reflection on the alignment of the stakeholders led to the identification of two key drivers.

First of all, a couple of individuals were highly committed to making the project work from the outset, and took a leading role in aligning the stakeholders and their interests. Secondly, there was a common understanding between stakeholders that action was required. Various interviews were analysed using Fuzzy Cognitive Mapping to identify the different stakeholder perceptions regarding the main problems that needed addressing. These results showed a large common understanding of the problems at hand and the potential for the Urban Waterbuffer to resolve these issues integrally (see Figure 5).

For the successful implementation of NBS, it is important that stakeholders share a common understanding that achieving climate resilience in urban areas will require new, cross sectoral approaches; having to deal with both more extreme rain events, longer lasting dry periods and increasing temperatures requires measures that go beyond traditional sewer replacement and address these multiple issues integrally.

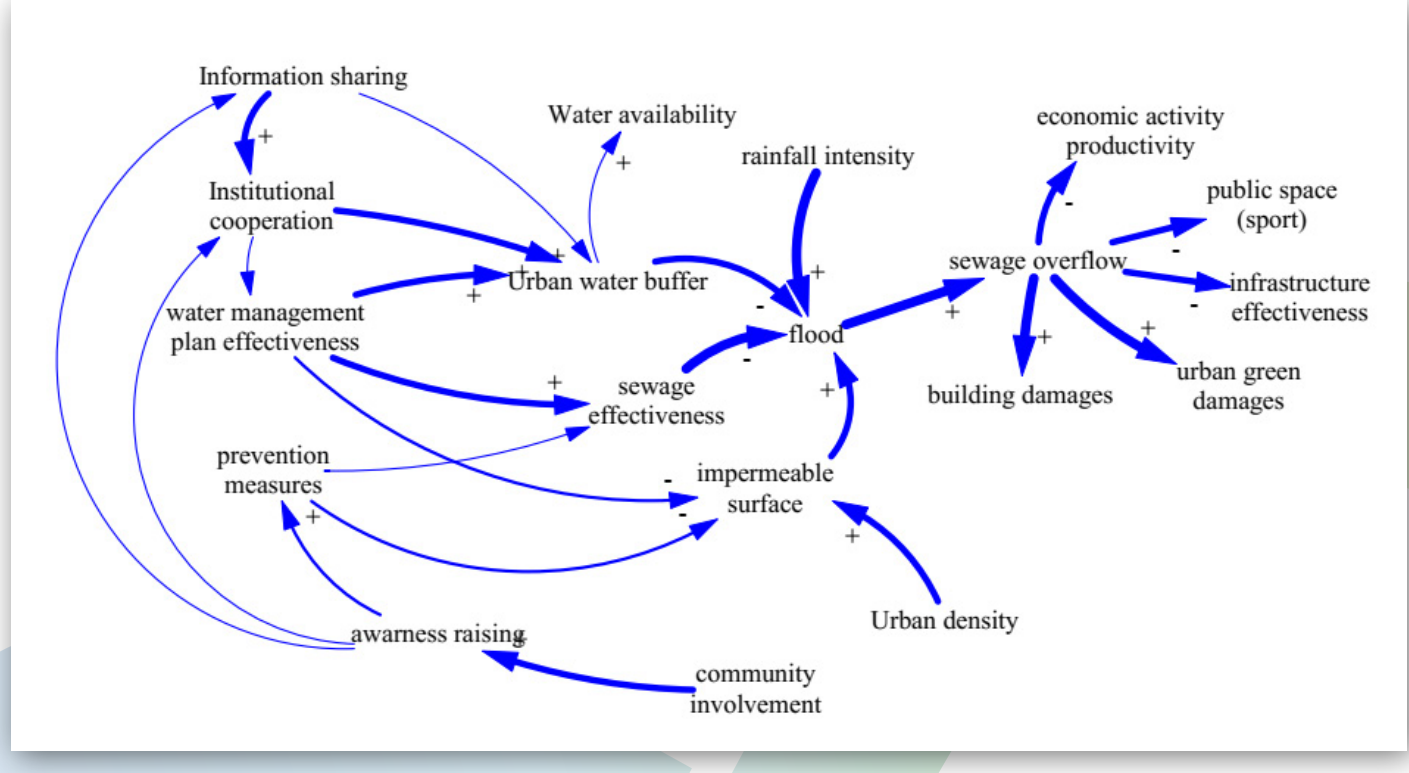

Figure 5: A Fuzzy Cognitive Map (FCM) showing the relationships between factors related to flood risk as perceived by stakeholders in Spangen (developed for the Rotterdam DEMO by Giordano & Pagano, 2018).

2.2 CURRENT PLANNING REGULATIONS AND POLICY MAKING DO NOT SUPPORT THE UPTAKE OF NBS.

Despite the high political willingness to implement NBS as a means of improving climate adaptiveness, the current planning regulations and processes in the Netherlands do not support the uptake of NBS. Throughout the implementation process various challenges arose that nearly blocked the realisation of the Urban Waterbuffer, for example when the business as usual approach was initially preferred by certain departments of the implementing authorities. During the stakeholder workshops, special emphasis was put on the upscaling perspectives of NBS for climate adaptation in the Dutch urban context. What emerged, from a variety of stakeholders, was that the current frameworks in Dutch planning practices do not facilitate the uptake of NBS at the operational level.

One of the reasons for this that was identified in the Rotterdam demo is the sectoral silos and split responsibilities among various public organisations. Typically, organisations and departments within organisations have a dedicated budget and responsibility for a "single" task. As NBS typically address multiple elements of urban planning and water management, they require the integration of tasks, responsibilities and budgets across the various silos. Without clear tactical and operational guidelines to assess measures based on their wider impact on other silos, operational decisions are typically based on a measure's mono-functional efficiency. In addition to the strategic willingness, broader political objectives at tactical level are necessary to transform willingness into action, without having to be dependent on passionate individuals or dedicated cross-silo programmes like the Water Sensitive Rotterdam program.

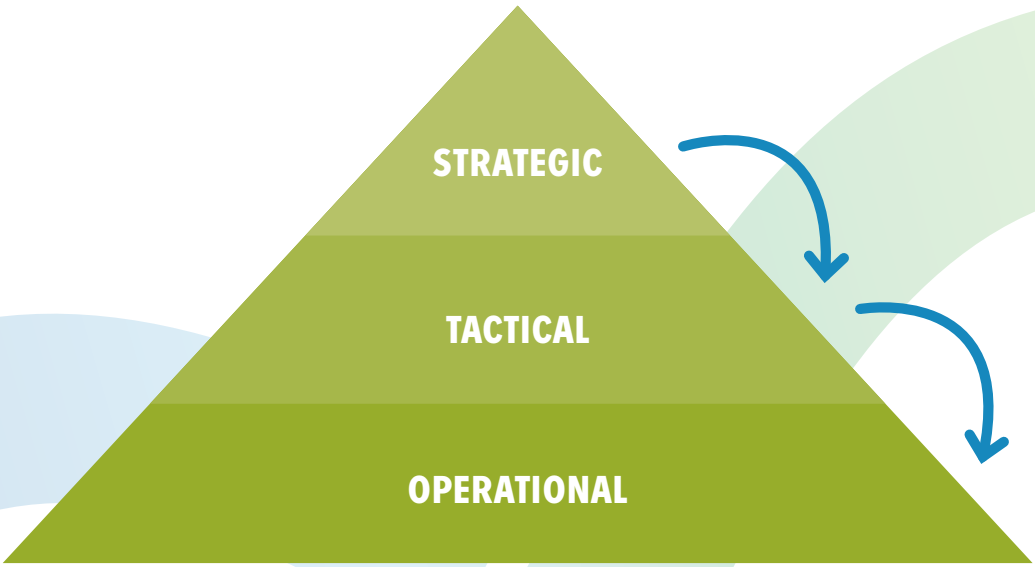

Figure 6: Schematic representation of the different levels of decision-making that need to align within an organisation vertically. Additionally, the silo structures add another layer of complexity.

The Urban Waterbuffer project also encountered various moments in the decision-making process in which the silo-structures nearly blocked the implementation. One of the main challenges in implementing the Urban Waterbuffer Spangen was the required involvement and collaboration of many different stakeholders. Each stakeholder could have resolved their own challenges and needs differently, independent of each other. It took time to convince and align all stakeholders on the benefits of collaboration in one project. Thanks to the following unique circumstances, the project did get implemented:

- **As cross silo policy programme on climate resilience.**
- **A TKI research fund, which lowered the required investment and uncertainties for the various project commissioners. This pilot approach helped to work cross-sectoral and step outside of some of the more rigid planning regimes and regulations.**
- **Strong commitment of stakeholders throughout the project.**

2.3 NBS CAN COMPETE ON IMPLEMENTATION COST WITH GREY SOLUTIONS, THOUGH STRATEGIES MUST BE CAREFULLY DESIGNED.

Uncertainty about the costs of NBS consistently emerged as a concern for a wide range of stakeholders throughout the NAIAD project. These concerns ranged from the potential impact of high upfront costs on municipalities, to the uncertainties of long-term maintenance requirements, and even the difficulties in internalising many of the acknowledged co-benefits. What emerged was a clear desire amongst stakeholders for more information on how the costs of these new approaches compared to business as usual, not only initially, but also over the long term.

As part of the economic assessment of NBS (NAIAD approach outlined in Chapter 5), the Rotterdam Demo compared the costs of the three neighbourhood-scale water management strategies – grey, hybrid and green - through the application of life cycle costing (LCC). The strategies were specified with similar retention capacity in order to provide equivalent flood risk reduction, which allowed for a good comparison between the strategies on their cost effectiveness for a certain level of service (see D6.3 for more information on this approach).

When gathering cost data, the Rotterdam demo was unique in NAIAD in that it was possible to draw upon real implementation costs for the UWB, which was considered as a central measure in the hybrid strategy, however the many additional measures considered across the three strategies also necessitated the use of value transfer from literature and industry documentation. A tiered system was applied to help guide our choice of reference sources, prioritising recent Dutch sources wherever available, so as to achieve the highest possible relevance and reliability of the data used. Additionally, this tiered system helped to identify possible knowledge gaps in terms of lacking recent and/or local data on specific costs drivers.

- **Tier 1 = Costs taken directly from the DEMO in Spangen**
- **Tier 2 = Costs derived from Dutch sources**
- **Tier 3 = Costs derived from international sources from the past 5 years**
- **Tier 4 = Costs derived from international sources from the past 5-15 years**

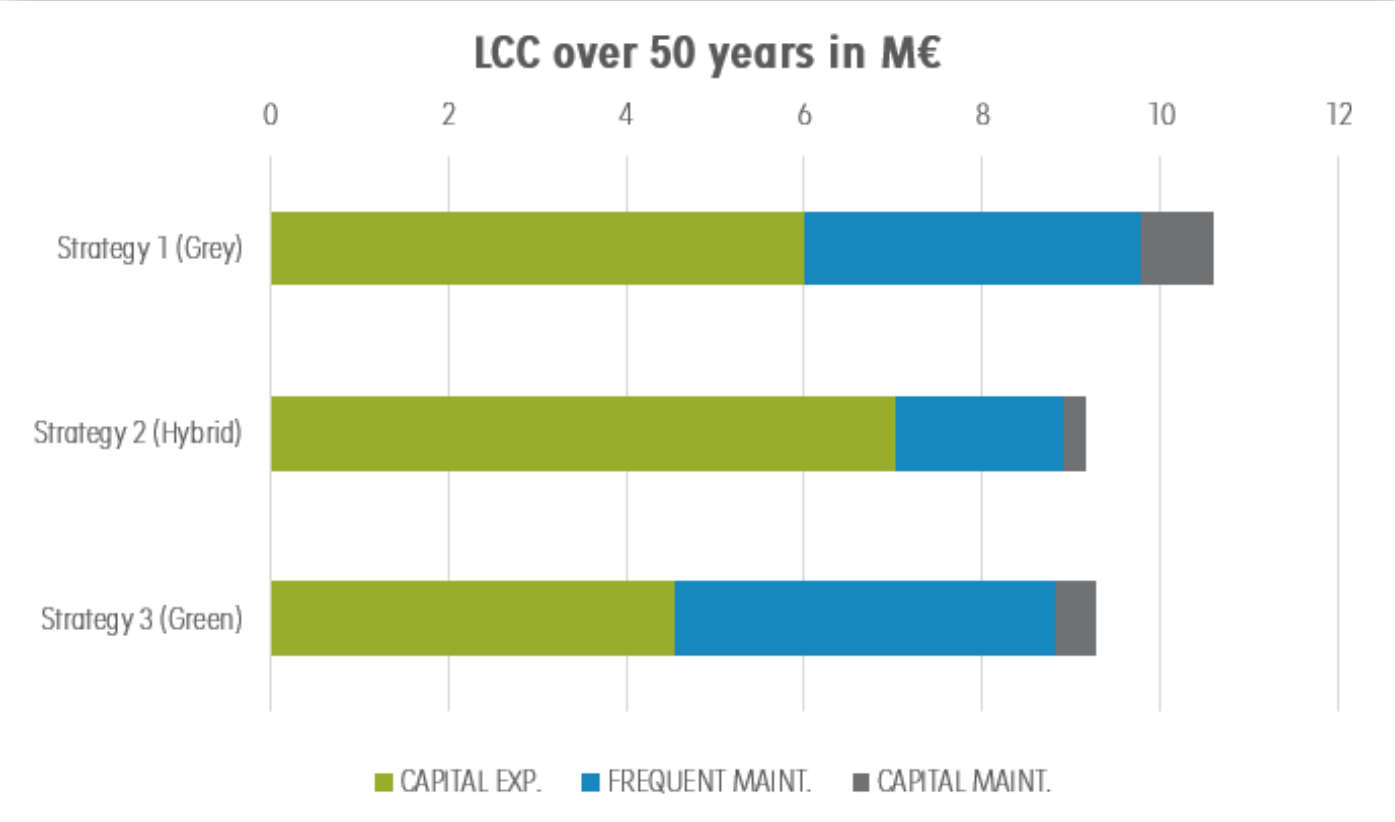

Figure 7: The LCC results of the three strategies in the Rotterdam Demo.

Over a 50-year time period, the results were relatively close, which given the wide variety of measures considered and the long timeframe was somewhat unexpected. The results appear promising for NBS, as the comparison showed hybrid and green strategies proved marginally cheaper than the grey for the same level of service (Figure 7). However, two key factors must be taken into account when considering these results. Firstly, there was considerable variation in cost effectiveness between different measures, meaning that the strategy design of each measure, in terms of both type and amount, can have a significant impact on the overall cost of strategies. Figure 8 demonstrates this, highlighting for example that the choice to rely on a large amount of permeable pavement for retention in the grey strategy pushed up the overall costs significantly, due to high maintenance costs over time. In our demo, the strategies were finalised based on a variety of factors (land use type, land ownership, retention capacity) before being costed.

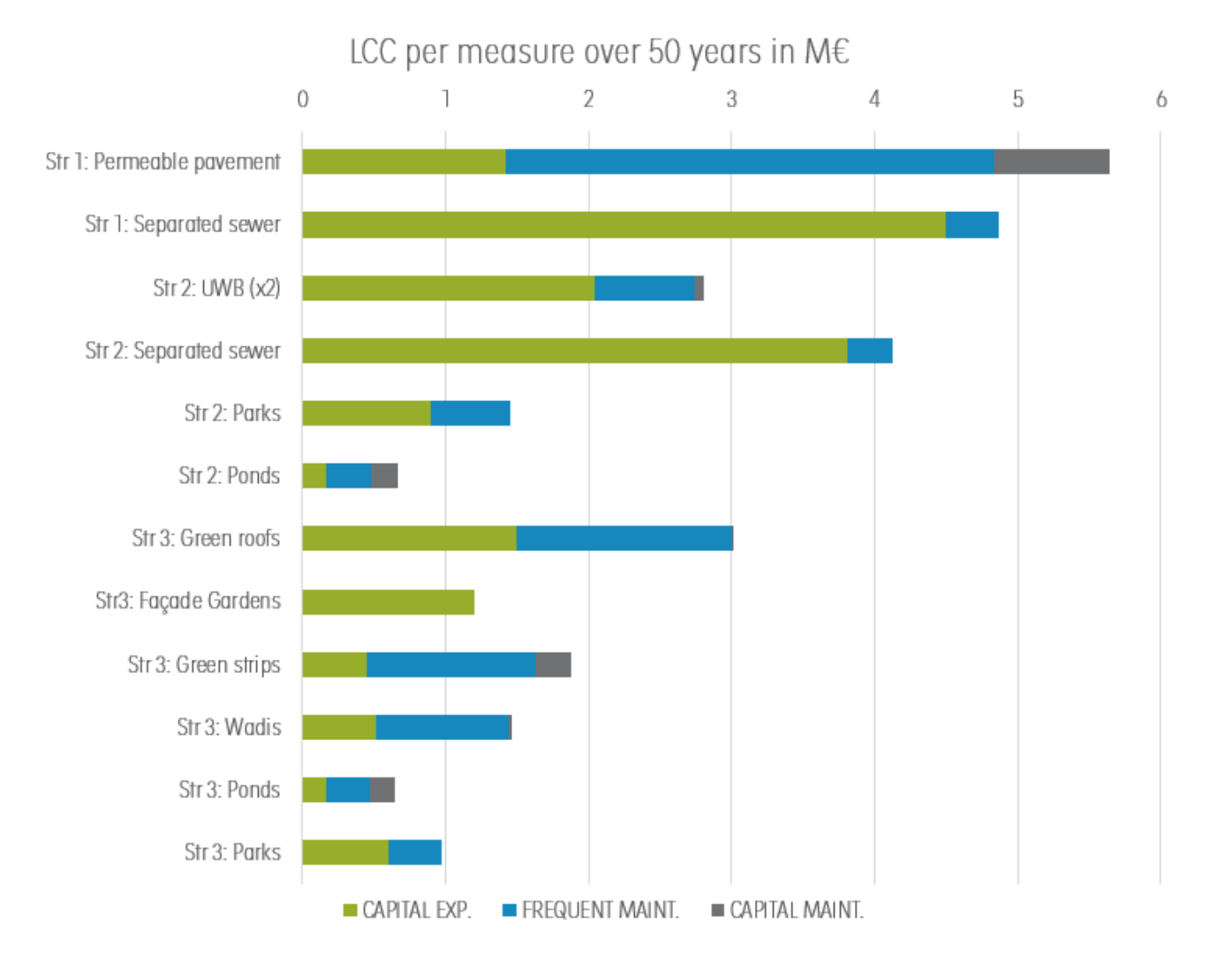

Figure 8: The Life Cycle Costs per measure for the three strategies in Spangen.

A second consideration is that whilst there was highly accurate data available from the site in Spangen for some measures, for others there was greater reliance on tier 3 and 4 data than would be considered ideal. The main gaps identified were in the capital maintenance expenses for green measures, with older British and American literature still serving as the reference standard. The results are thus subject to a relatively high degree of uncertainty, as it is not clear how closely the estimated costs would represent the Dutch context, and how the industry has changed over time.

2.4 WHETHER MONETISED OR NOT, MONITORING AND ASSESSING ENVIRONMENTAL, SOCIAL AND ECONOMIC BENEFITS IS CRITICAL TO SUPPORT THE WIDER UPTAKE OF NBS

Much of the debate around NBS centres on their multifunctionality, and indeed one of the key motivators for the implementation of the UWB in Spangen was due to the multiple issues it tackled simultaneously. In Rotterdam, the identification of co-benefits for the urban water buffer began prior to implementation through stakeholder engagement, which identified the following potential co-benefits:

- **Local temperature regulation**
- **Water quality regulation**
- **Cost reduction of water treatment**
- **Storm water re-use**
- **Spatial quality betterment**
- **Increased green**
- **Increased water awareness**
- **Increased social cohesion.**

During the economic assessment, the list of co-benefits was expanded to account for the variety of different measures under consideration and the multiple impacts they can provide. 16 co-benefits were identified and considered for assessment (Figure 9). Direct valuation was the dominant method used, drawing values predominantly from peer reviewed literature, except in the case of the UWB, where some data was available directly from Spangen.

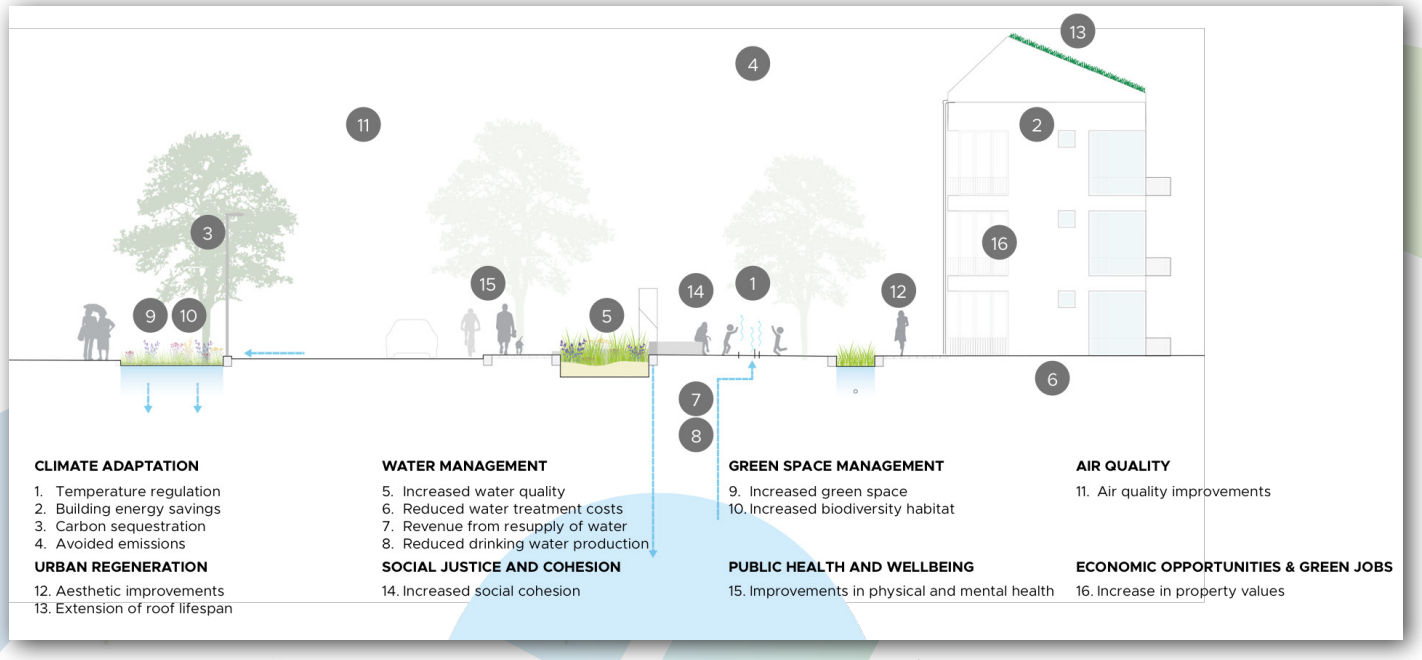

Figure 9: Overview of the co-benefits assessed in the Rotterdam Demo.

Whilst our assessment aimed to monetise as many of the co-benefits as possible so as to capture the full value provided by NBS, some of the co-benefits were not able to be valued monetarily, mainly due to one of two reasons:

1. **Insufficient data/reference literature**
2. **Risk of double counting**

The monetised results from the co-benefit assessment (Figure 10) showed that the kinds of co-benefits that deliver value in dense urban areas can be very different from those provided by large scale ecosystems. By far the largest benefits were derived from avoided health care costs and labour loss, as well as property value increases. Many other co-benefits provided marginal value at this small scale.

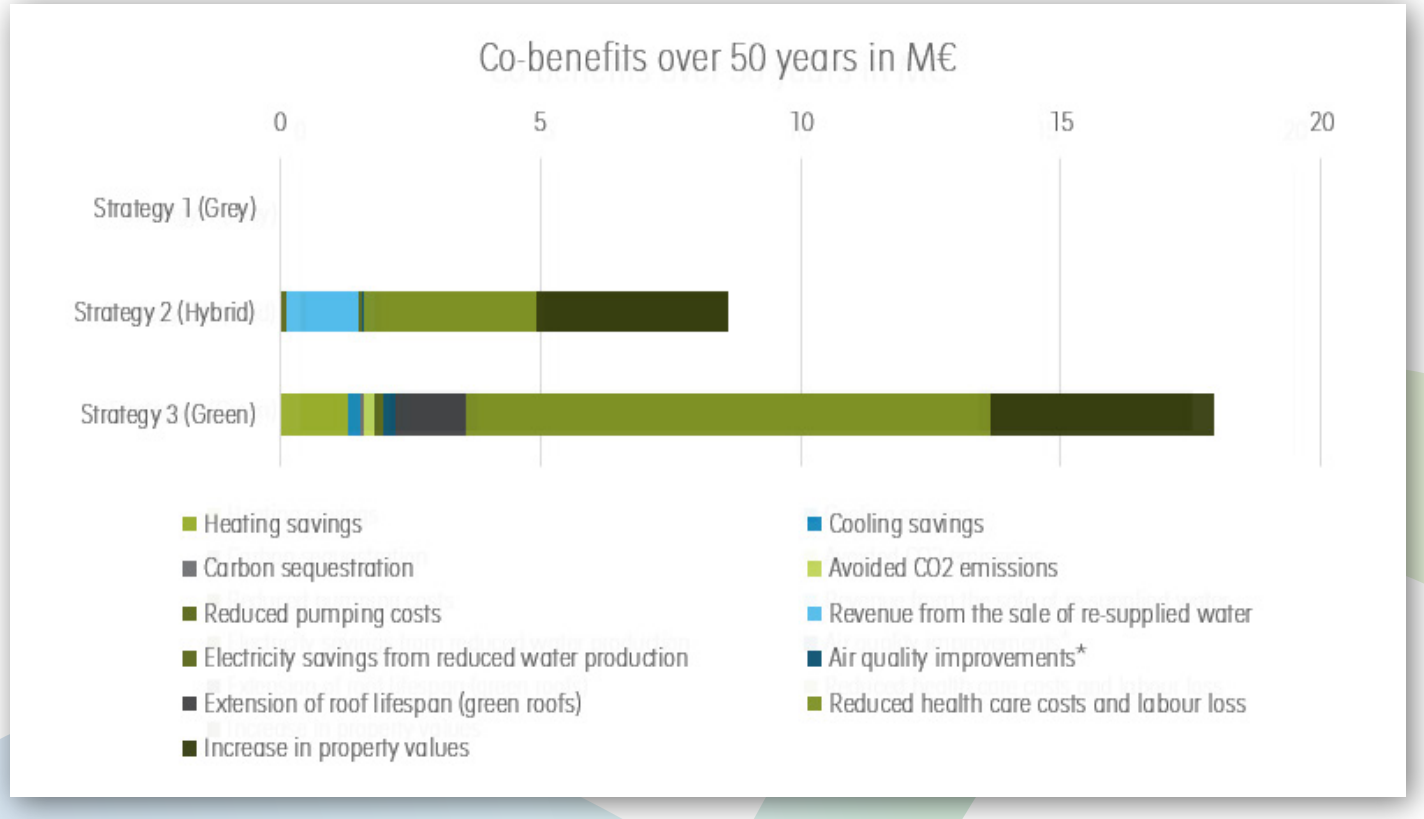

Figure 10: The co-benefits delivered by each strategy in Spangen over 50 years.

Interestingly, whilst the economic assessment provided results in a common, relatable currency, some of the most important co-benefits for stakeholders throughout the implementation of the UWB could not be monetised. This included mitigation of the urban heat island effect through local temperature regulation, which in an era of both ongoing urbanisation and rising temperatures could prove increasingly significant, and is often central to the discussion on NBS in The Netherlands. Similarly, with growing concerns about long term fresh water supplies, the potential for NBS measures to increase water awareness through making the water cycle visible is seen as important in helping to change behaviour and conserve precious resources in the private sphere, and was highlighted in Spangen by the municipality, the waterboard and the residents themselves as an important co-benefit. This co-benefit is also closely related to the fact that 60% of the land within the municipality is privately owned (De Doelder, 2019). As such, the municipality and waterboard are partially dependent on private actions to increase the city's climate resilience.

As can be seen, in the current climate of enthusiasm for NBS, certain potential co-benefits, tied to specific contextual objectives, can prove decisive for project implementation even in the absence of clear quantification of their monetary value. However, evidence that NBS can actually deliver these potential co-benefits is likely to become increasingly important as the initial enthusiasm around NBS begins to fade. As such, it is important that monitoring and assessment of co-benefits be prioritised, particularly in the social sphere, to build a better understanding on performance in some of the areas where data is lacking. However, this evidence in support of the delivery of co-benefits need not be exclusively monetary. It is important to reiterate that multiple forms of value are involved in decisions about NBS, and the consideration of only the benefits that have been monetised can lead to decision making based on incomplete information. **The multifunctionality of NBS is their key advantage, and the case for them is most compelling when impacts are considered holistically, meaning that consideration of a range of environmental indicators alongside economic valuation may be most suited to capturing the full scope of their benefits and functions.**

2.5 IF THERE IS SPACE, FULL NBS IS ACE; IF SPACE IS TIGHT, HYBRID MIGHT BE RIGHT.

The Netherlands is one of the most densely populated countries on earth, and as a consequence, the value of land in urban areas is high. This means that there is always competition for space among potential users, and that any water management interventions that require additional space compared to business as usual will involve trade-offs. To fairly compare NBS with grey infrastructure, it is thus important to consider the opportunity costs associated with their implementation, which in the Rotterdam demo was achieved through using the value of the land required for each strategy as a proxy, taken from Levkovich et al. (2018). Whilst this is a widely used approach, it should be applied with caution, as the small, decentralised nature of many NBS measures means that they are often unlikely to be impeding on any real alternative development potential, and thus the use of a single land value risks overstating the opportunity cost. If more granular land value data is available this is likely preferable. In the Rotterdam Demo, given the use of a single high land price, the opportunity cost assessment indeed saw significant negative impacts on the NBS strategies (Figure 11).

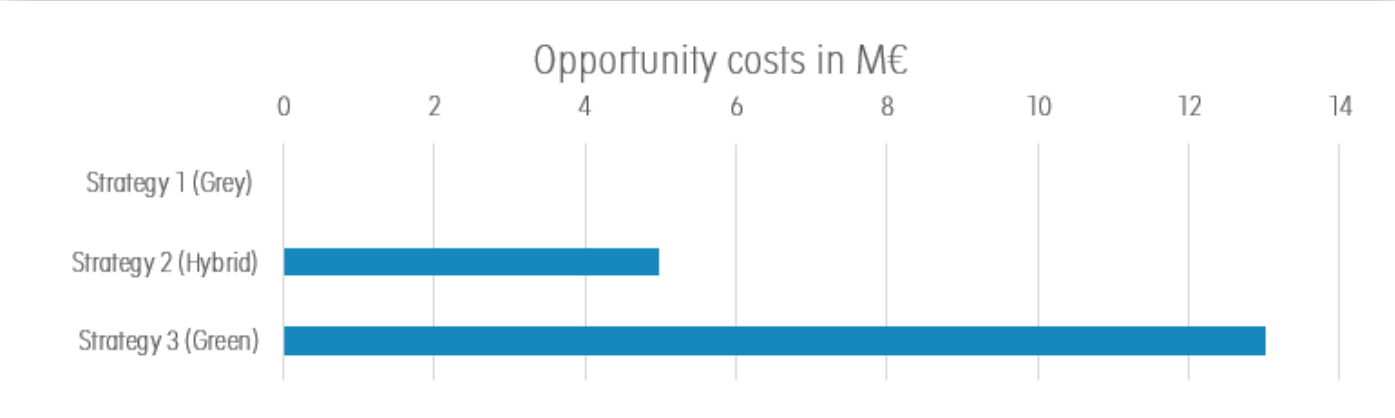

Figure 11: Opportunity costs for the three strategies, using value of the land required for implementation.

Consequently, when bringing together the various results of the economic assessment, it became clear that neither the equivalent avoided damages, nor the relatively small differences in implementation costs between the strategies would prove decisive. As a result, it was opportunity costs and co-benefits that emerged as the key differentiators (see Figure 12).

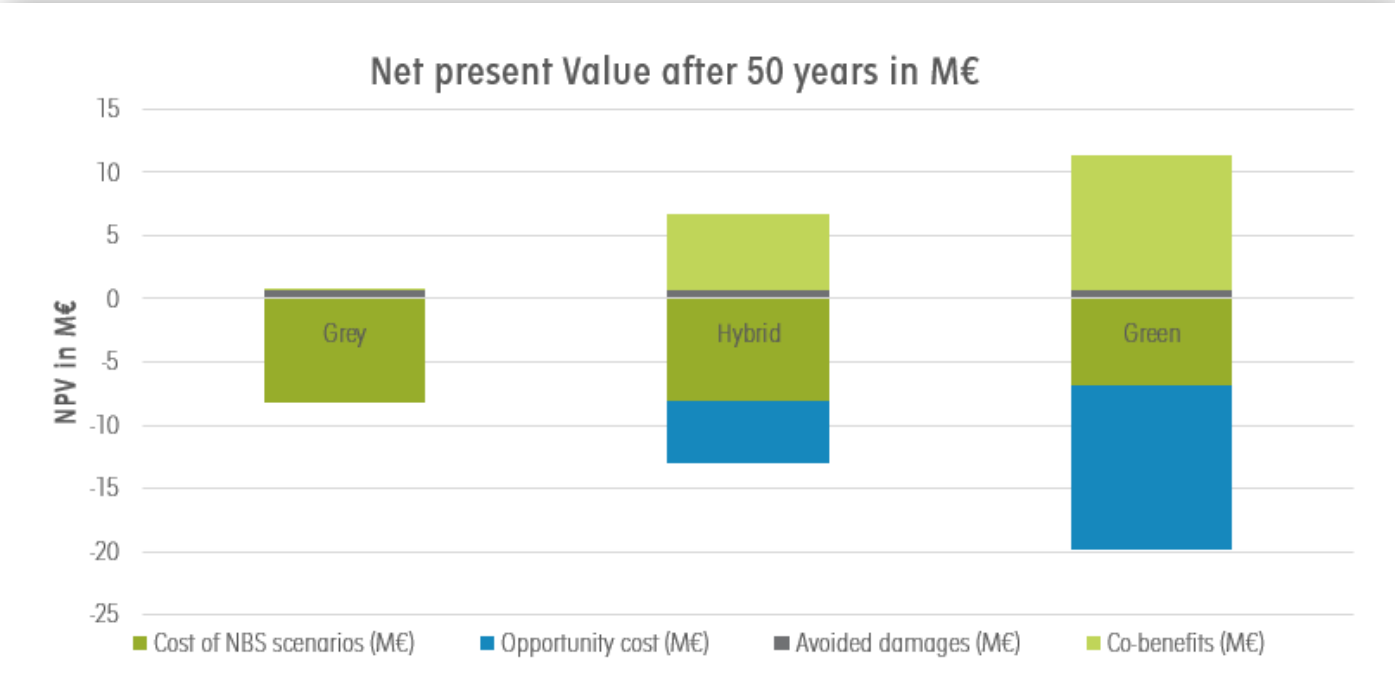

Figure 12: The integrated economic results for each strategy, showing the large influence of co-benefits and opportunity costs.

Whilst the assessment was subject to substantial variability, particularly given the long timeframe and large number of measures, the order of magnitude difference between the various pillars nevertheless allows for a broader lesson to be drawn with a relatively high level of confidence. That lesson is: when deciding between NBS and grey infrastructure to mitigate flood risk in dense urban areas, the question can to some extent be boiled down to whether the opportunity costs imposed by the additional space requirements of NBS can be offset by the co-benefits that they can provide. Table 1 shows the Benefit Cost Ratios (BCR) of the integrated economic results - the sum of all of the benefits divided by all of the costs for the three strategies, expressed in economic terms.

CATEGORY	STRATEGY 1 Nominal	Discounted	STRATEGY 2 Nominal	Discounted	STRATEGY 3 Nominal	Discounted
LCC	- € 10,590,000	- € 8,210,000	- € 9,160,000	- €8,100,000	- € 9,280,000	- € 6,920,000
Opportunity costs		-		- € 4,980,000		- € 13,020,000
Co-benefits	€ 40,000	€ 20,000	€8,570,000	€6,014,000	€17,700,000	€10,730,000
NPV		- € 8,190,000		- € 7,054,000		- € 9,070,000
BCR		0.002		0.46		0.54

Table 1: The total costs, benefits, Net Present Value (NPV) and Benefit Cost Ratio (BCR) of the three strategies over 50 years. Source: NAIAD D6.3.

What can be seen is that when considering the economic results alone, no strategies resulted in a BCR above 1 – the point at which an intervention is generally considered cost effective. However, considering the difficulty in including all direct and indirect damages in the assessment and the strong societal relevance, responsible authorities in The Netherlands do frequently invest in risk reduction measures with a BCR<1. This means that in this case the BCR is more useful in comparing the strategies to one another than in assessing cost effectiveness in absolute terms. When viewed in this light, the results show that the hybrid and green strategies bring significantly more benefits per Euro spent than the grey approach.

The fact that the motivation to act on pluvial flooding in The Netherlands lies outside the realm of the cost benefit analysis reiterates the findings on the importance of non-monetary co-benefits in shaping decision making. Careful consideration of quantifiable costs and benefits is prudent, yet even within the current water management paradigm, there are values and drivers of action not captured in the budget bottom line. Such drivers are likely to play an even greater role in the uptake of NBS, given their multi-faceted impacts and beneficiaries.

The results of the economic assessment support the assumption that if there is space available NBS are likely a better choice than standard grey approaches, given that they can potentially provide similar core functionality for an equivalent or slightly lower cost, whilst also delivering an array of co-benefits. However, if the opportunity costs of implementation are high and space is scarce, hybrid solutions may prove a better choice as they can provide many of the benefits without such large space requirements. The single strongest case for grey infrastructure remains familiarity and institutional embeddedness, but in the Dutch context at least there is widespread and growing understanding that the multi-faceted challenges of the 21st century are likely to be best served by multifunctional approaches.

2.6 MULTI-FUNCTIONALITY OF NBS ALLOWS FOR THE DEVELOPMENT OF NEW BUSINESS CASES.

As an almost a text-book example of an effective Public-Private-Partnership, the implemented Urban Waterbuffer offered valuable insights on potential business cases for NBS. The partners included two public authorities (municipality & waterboard), a semi-public utility provider, and private companies. The financial and legal arrangements were differentiated based on the various functions of the Urban Waterbuffer, to link these components to each partner's interests and responsibilities (see Figure 13).

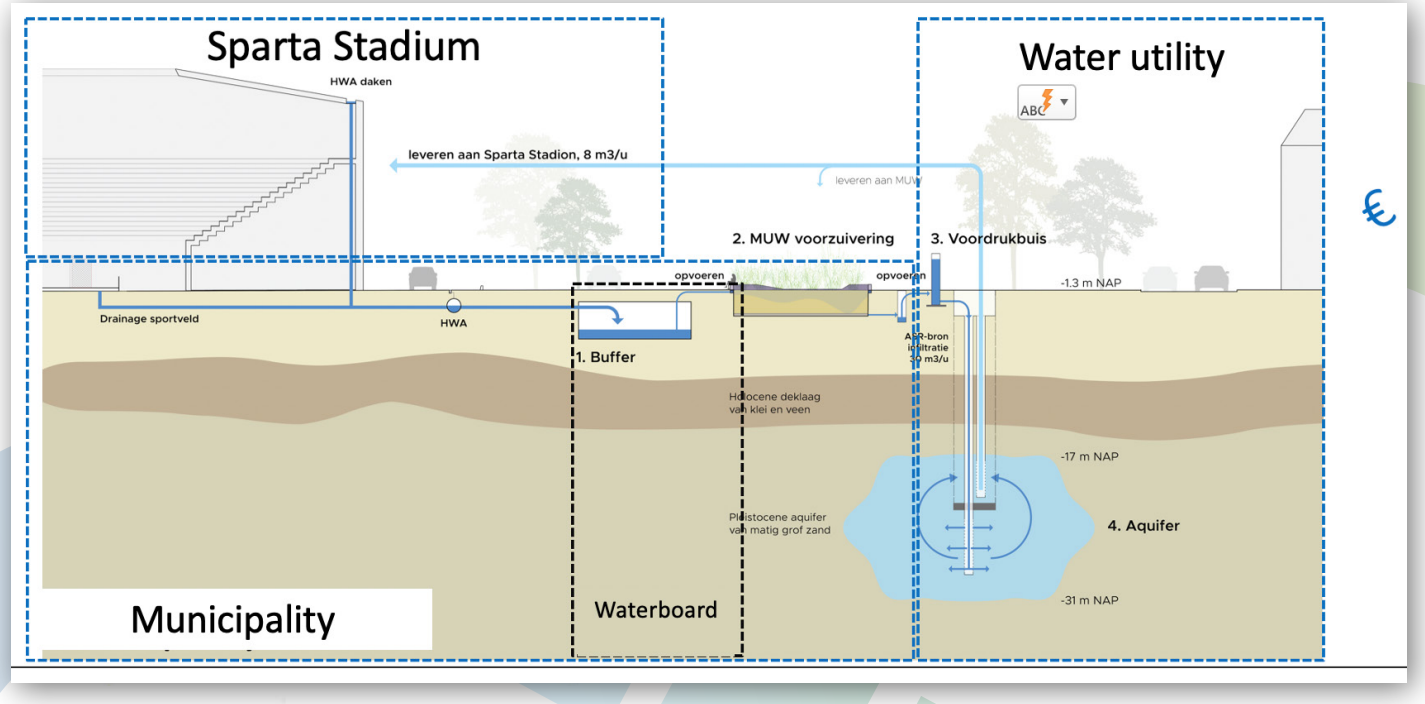

Figure 13: Distribution of responsibilities between stakeholders in relation to Urban Waterbuffer Spangen.

However, the business case is not fully representative for future implementations of similar NBS, due to a large dependency on the TKI research fund. Through the TKI fund, the threshold for the various stakeholders to collaborate was reduced, and the fund allowed to partially overcome uncertainties typically related to new innovations by allowing for more intense monitoring and research of the Urban Waterbuffer. The system in Rotterdam is the first-ever implementation of this technology, and as such the whole project has been considered to be a pilot, which allowed for slightly different legal arrangements to be used. These advantages will no longer be available in future implementations of the system. As such, a workshop was held with key stakeholders to reflect on the upscaling potential of the Urban Waterbuffer and NBS in general and what is needed to build sustainable business cases for this.

2.6.1 Developing new business cases towards upscaling of NBS

One critical driver for the current and future business case of the Urban Waterbuffer is the exploitation of the new water source, as this can generate direct cash flows through the water prices paid for the supply. Tap water rates in The Netherlands, however, are currently extremely low. However, since projections show increasing pressure on fresh water availability and security of supply throughout longer lasting dry periods, the drinking water prices are expected to rise, generating an even bigger saving to be achieved through the re-use of treated storm water. Simultaneously, the value of available water increases even further, considering the potential damages droughts might incur on existing green space, infrastructure and human health.

In the case of the UWB, as it generates a saleable commodity in the form of the stored water, there are more opportunities for developing business models with private sector partners, as there is a clear source of future revenue that can create a return on investment over time. Public-Private-Partnerships are expected to remain the main implementation arrangement for the Urban Waterbuffer. However, in order to facilitate the cooperation of various partners, it is important that NBS provide a distinct level of service that the relevant parties are willing to invest in. In current practice, the impact of interventions on co-benefits is seldom addressed in terms of an increased level of service. As a result, building financial and legal arrangements that are based on the exchange of these benefits is very challenging, particularly since often the implementing partner is not the same entity as who will receive the benefits. Another challenge in making the business case for NBS is the fact that there can be a vast difference between the monetary value of co-benefits in an impact assessment, and the tangible contributions to a budget bottom line that these co-benefits can actually provide. This means that for NBS in general, it appears that municipalities and other public bodies are most well suited for implementing them, as the broader societal benefits can be considered as meeting other objectives or responsibilities, whereas for private investors, the case can be a lot harder to make.

What did come forward during the various interactions with stakeholders in Rotterdam is that there is a high willingness among stakeholders to collaborate across disciplines in order to benefit from the multi-functionality of NBS. However, the role of the insurance industry in future business cases for implementing NBS in The Netherlands is concluded to be very minimal, except for facilitating the development of water awareness among citizens.

Even though the assessments of various alternative measures do not always explicitly consider co-benefits, in The Netherlands the majority of the larger public investments require a social-cost benefit analysis to be performed and there is growing understanding of the relevance of the societal and environmental impacts of alternative measures. In order to be able to capitalise on the various co-benefits over time, working with integral and long-term contracts might create a better incentive for decision-makers to consider their investments in terms of their wider impact and potential multi-stakeholder value creation. Also, it was pointed out that better alignment of the various responsibilities of public authorities in The Netherlands could help to make room for more integral and multi-functional measures and allow for more cost-effective interventions in the long-term.

2.7 EVEN STATE OF THE ART SURFACE FLOW MODELS CANNOT ACCURATELY ESTIMATE AVOIDED DAMAGES AT A NEIGHBOURHOOD SCALE WITHOUT HIGH RESOLUTION DATA

Hydrological modelling is challenging, no matter at what scale it is undertaken, yet pluvial flooding in small urban catchments proves particularly difficult. During the risk assessment in the Rotterdam Demo, some of these key limitations to applying hydrological modelling in small urban catchments became clear.

In flat neighbourhoods such as Spangen, the flow of excess storm water can be very difficult to calculate, due to the outsized influence of even minimal changes in street profile, kerb height, building entry elevation and other seemingly minor details. The high resolution required to account for these variations is computationally intensive, yet the core issue is more that in many areas, including Spangen, the input data is simply not available at a sufficient level of detail to obtain accurate flows and estimate flood damages which properly account for the outsized influence of local peculiarities. As a result, the simplifications and assumptions that are required due to gaps in the dataset (such as building entry elevation) can have very significant impacts on the modelling results.

The underlying issue is partly one of data availability, but more fundamentally it is about the scale at which it is appropriate or practical to apply these tools, and the type of information that can be gained from them. When applied at a broader scale, tools such as Eco:Actuary and 3Di can provide important guidance at the city and basin level in identifying critical weaknesses in water systems, without needing to rely on hard-to-obtain and incredibly granular data. At this level, the modelling results can assist in identifying high risk areas, or understanding the broader downstream impacts of an (nature-based) intervention.

The computational power of these tools is always increasing and through research like NAIAD and assessment in case studies, as well as advances in technologies such as remote sensing, the necessary data for small scale urban modelling is also slowly becoming available. If this can be even further developed, these approaches might also soon become relevant to the assessment of neighbourhood scale pluvial flood risk in flat urban areas. However, at present, at least in the Dutch context, the limitations of the models, combined with the inevitable impact of contextual factors, mean that few reliable conclusions can be drawn from modelling water system design configurations at the neighbourhood scale.

2.8 IMPLEMENTING AND MONITORING NBS IS NEEDED TO CATALYSE WIDER ACCEPTANCE, INTEREST AND FUTURE UPTAKE.

One of the challenges with the Urban Waterbuffer was the management of uncertainties related to the implementation of an innovative solution: actual effects on the water system and the underground, the water quality achieved, and the need for a new operation and maintenance regime. The best means to overcome these challenges was to simply implement and intensively monitor system performance. The availability of the TKI-fund proved highly valuable as it allowed for some of the aforementioned uncertainties to be addressed in a pilot setting with additional research activities. Reflecting on the entire process, it was apparent how much impact the implementation of the Urban Waterbuffer had on the wider acceptance of and interest in NBS. Being able to showcase the technology and prove the concept works, was a critical milestone in order to build capacity for the larger uptake of other Urban Waterbuffers or similar systems.

Figure 14: The Biofilter component of the Urban Waterbuffer in Spangen.

Particularly in the Dutch water management sector, standardization, robustness and economies of scale have long dominated business as usual practices. Given NBS offer completely different characteristics, the evidence of NBS effectiveness is often still limited. So long as this remains the case, it will be difficult to convince stakeholders of the efficacy of the investment in NBS. With the emergence of co-benefits as a crucial component of the case for NBS, how they are best to be assessed remains a key question.

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On several occasions over the course of the UWB implementation, stakeholders identified the difficulties in assessing co-benefits, particularly those in the social sphere, as a key challenge for the upscaling of NBS. **Social co-benefits also prove less transferable than some environmental research, due to contextual specificities.** In the Rotterdam demo, direct valuation drawing on reference values from literature was the dominant approach, yet there were certain areas where there was very little research to consult. Another challenge is that it although co-benefits are central to the case for NBS, it is difficult to imagine every potential future project conducting an in-depth co-benefit assessment during the development of the business case, whether based either on empirical data or on value transfer from literature. However, there are equally valid concerns about the vast generalisations and lack of contextual awareness that underpin the growing array of simplified co-benefit valuation calculators, which aim to provide a quick and easy approach to these assessments. As such, so long as decisions in urban management remain largely based on financial factors, one of the core tasks for the upscaling of NBS will be to negotiate these trade-offs in the approach taken to the monetisation of co-benefits. Extensive monitoring of the impact of NBS on these co-benefits will help to generate the required knowledge base to substantiate these trade-offs.

Therefore, building more NBS, monitoring their impact and using that to overcome uncertainties regarding effectiveness, costs and co-benefits is needed in order to provide the necessary evidence base to facilitate their wider uptake. Being able to engage with stakeholders around the actual implementation of an NBS in Spangen and being able to communicate and discuss the NAIAD results with these stakeholders, has resulted in the beginning of a paradigm shift in which NBS are considered a worthy equivalent of and maybe even a better alternative to hard engineering structures.

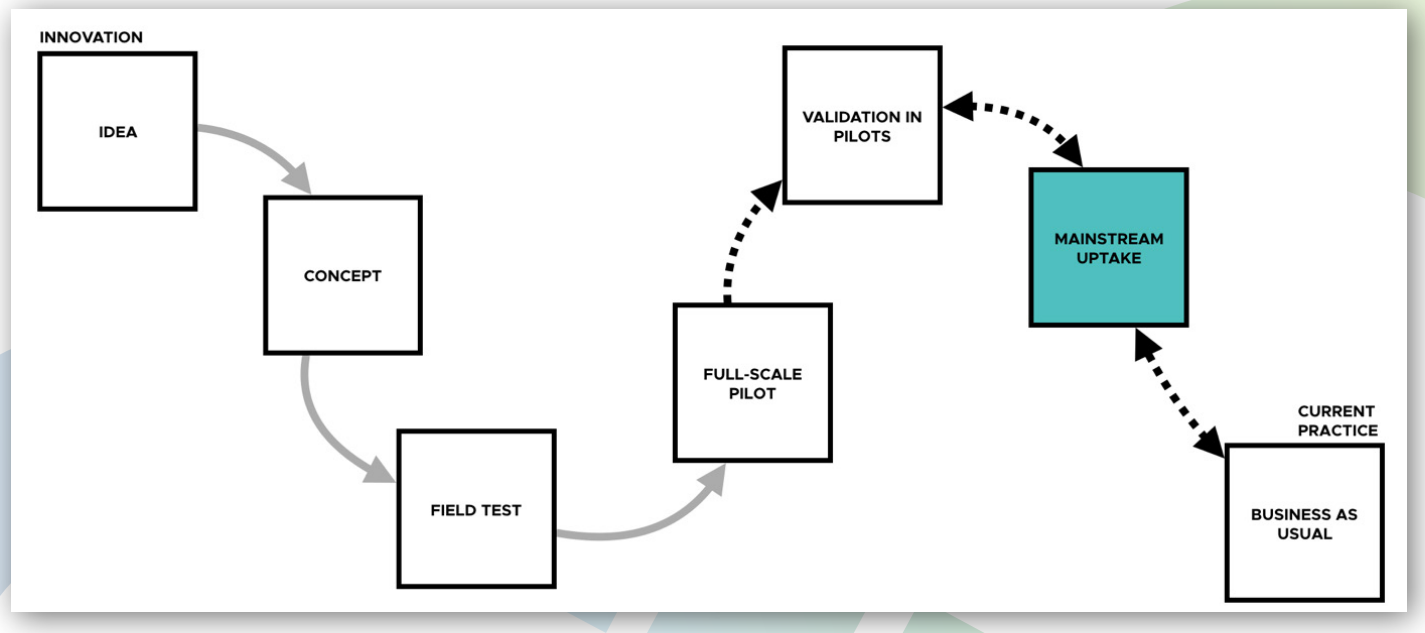

Figure 15: Pathway to mainstreaming NBS. Having validated the effectiveness in multiple pilots is needed to be able to take on business as usual practices.

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3. CONCLUSIONS

In the 18 months since implementation, The Spangen UWB has performed strongly, having reduced pluvial flooding, whilst also storing and re-supplying 15 million litres of water for irrigation of the sports field in the Sparta stadium, reducing the waste of drinking water for non-consumable purposes. It has garnered widespread approval from a range of stakeholders, and interest in implementing other such systems is growing, both in The Netherlands and abroad.
The benefits of a realised pilot project extend beyond raising awareness and proving efficacy, as pilots also offer important research opportunities. With the Rotterdam demo built around this actual piece of hybrid infrastructure, important insights were possible that may not have been derived from modelling and forecasting alone. From the UWB, these include valuable lessons around the various motivations and disincentives for NBS uptake in the Dutch context, and the need for diverse stakeholders to work together. The smaller scale of the Rotterdam demo compared to other demos in NAIAD, though it posed some challenges, was also able to highlight the similarities and differences in NBS effectiveness and viability across a wide range of spatial scales.

The broader neighbourhood assessment indicates that in certain contexts, NBS do appear able to deliver a comparable level of service for an equivalent or lower capital outlay than grey solutions, whilst also delivering a multiplicity of additional benefits. However, they often require more space to achieve this, and in order to justify this use of space, it is important that the many co-benefits NBS can provide are valued and properly accounted for, despite the complexity of achieving this. Finally, the relatively high levels of uncertainty still involved with a lot of the research surrounding NBS can best be resolved through a greater number of implemented projects. Which would be just one of many co-benefits of implementing more NBS to resolve pressing urban water challenges and design for climate resilient cities.

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About the NAIAD Project

'NAIAD' (Nature Insurance Value – Assessment and Demonstration) is an advanced, first of a kind, EU Horizon 2020 applied research programme focused on Nature Based Solutions (NBS) in risk management strategies, with a focus on water. NAIAD aims to operationalize the insurance value of ecosystems to reduce the human and economic cost of risks associated with water (floods and drought) by developing and testing - with key insurers and municipalities - the concepts, tools, applications and instruments (business models) necessary for its mainstreaming.

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