HAL open science

Looking into the future: natural assurance schemes for resilience

Elena López-Gunn, Nina Graveline, Raffaele Giordano, Nora van Cauwenbergh, Philippe Le Coent, Peter van Der Keur, Roxane Marchal, Beatriz Mayor, Laura Vay

► To cite this version:

Elena López-Gunn, Nina Graveline, Raffaele Giordano, Nora van Cauwenbergh, Philippe Le Coent, et al.. Looking into the future: natural assurance schemes for resilience. López-Gunn, Elena; Van der Keur, Peter; Van Cauwenbergh, Nora; Le Coent, Philippe; Giordano, Raffaele. Greening water risks, Springer, pp.407-422, 2023, Water security in a new world, 10.1007/978-3-031-25308-9_20 . hal-04093862

HAL Id: hal-04093862
https://hal.inrae.fr/hal-04093862

Submitted on 10 May 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Distributed under a Creative Commons Attribution 4.0 International License

Chapter 20
Looking into the Future: Natural Assurance Schemes for Resilience

Elena López Gunn, Nina Graveline, Raffaele Giordano, Nora Van Cauwenbergh, Philippe Le Coent, Peter van der Keur, Roxane Marchal, Beatriz Mayor, and Laura Vay

Highlights
Main lessons learned include the new knowledge acquired, its integration and application in real environments presenting different geographical conditions and scales, with very diverse socio-economic arenas and very different institutional and regulatory settings.

20.1 Introduction

In Greek mythology, the Naiads (Ναϊαδες) were the spirits of small brooks, fountains, wells, springs, and other freshwater bodies. Different to the river gods, the naiads were smaller, more adaptable with different shapes and forms. The EU H2020 NAIAD project that provided the background for the work presented in

E. López Gunn (✉) · B. Mayor · L. Vay
ICATALIST S.L., Las Rozas, Madrid, Spain
e-mail: elopezgunn@icatalist.eu

N. Graveline
University of Montpellier, UMR Innovation, INRAE, Montpellier, France

R. Giordano
CNR-IRA, Bari, Italy

N. Van Cauwenbergh
IHE Delft Institute for Water Education, Delft, Netherlands

P. Le Coent
G-Eau, BRGM, Université de Montpellier, Montpellier, France

P. van der Keur
Geological Survey of Denmark and Greenland (GEUS), Copenhagen, Denmark

R. Marchal
Caisse Centrale de Réassurance (CCR), Paris, France

© The Author(s) 2023

E. López Gunn et al. (eds.), *Greening Water Risks*, Water Security in a New World, https://doi.org/10.1007/978-3-031-25308-9_20

this book takes inspiration from this freshwater ancient wisdom to look at disasters and the role of nature in risk prevention and management.

Particularly, by considering the prevention and reduction part of the disaster risk management cycle looking at nature, not just as part of the problem but as part of the solution. The ancient Greeks thought of the world's waters as all one system, which percolated in from the sea in deep cavernous spaces within the earth, to the sea. This systemic view on risks is very much at the heart of NAIAD. The approach is also focused on this versatility afforded by nature and the interest in understanding the protective role of nature-based solutions (NBS) in buffering risks posed by natural hazards through the development of natural assurance schemes (or NAS from now on).

Flood events have huge impacts worldwide. In Europe, numerous examples can be found from the past decade, that cause extensive damages (e.g., a cloudburst in Copenhagen in 2011, the Elbe floods in 2002, 2013, Danube floods in 2006, Alpes Maritimes floods in 2015, Lez floods in 2014, Seine floods in 2016 and 2018, Germany and Belgium floods in 2021, etc.). Around 90% of natural hazards are water-related and these are likely to become more frequent and more severe due to climate change. For example, climate change is projected to increase damages up to 50% by 2050 in France (Marchal et al., 2022), Chap. 3 this volume has presented a conceptual framework, a series of methods to implement this conceptual framework and their validation through examples to apply and test these in nine case studies, providing critical insights from practice.

This chapter reflects on what we have learnt from our conceptual frame, and the methods and tools to understand, assess and implement NAS. Our aim is that this conceptual frame, the tools and methods to develop NAS perdure in time, are adopted, improved and adapted to suit other contexts or challenges. This will lead over time to a better alignment of both the conceptual frame and methodologies to different contexts, institutional settings, risk types, scales, etc. to create a baseline for future actions to build on ecosystem services to mitigate water risks. One of the *reason d'étre* of the book is to show how others could develop their own natural assurance schemes, based on these tried and tested methods and tools, as well as others that might emerge to complement and strengthen the methods and tools presented here.

The book thus provides a comprehensive guide to select, assess and implement NBS considering the effectiveness of the implementation of these NBS specially for risk reduction, and thus the potential for investment based on a risk prevention and mitigation frame. An important lesson is that the identification and assessment of the co-benefits in the economic analysis of NBS considering the assurance value is built on the combination of the quantitative benefits (calculated avoided damages) and its qualitative co-benefits. The importance for context specific indicators to monitor the effectiveness and performance of NBS in DRR, for instance, is especially important. The recently published Handbook on NBS Impact will also help in this area of impact assessment and evaluation.

This final chapter will now revisit the main modules or blocks from the book, as well as the original questions we posed initially to summarise the main takeaways for the design, implementation, and evaluation of natural assurance schemes.

20.2 Conceptual Framing: What Added Value Does a Natural Assurance Scheme Bring into the Picture?

One of the main advances has been the conceptual framing developed that underpins the concept of a "Natural Assurance Scheme". This is an area where future further work could go deeper and wider, to address the central role that nature-based solutions can play to address the most frequent and costly natural hazards: water risks, through the development of natural assurance schemes. That is, building on the potential to avoid damages and generate co-benefits through the use of nature-based solutions for water related hazards.

We have argued in this book that there is a subtle but important difference between the "assurance" value and the "insurance value" of nature based solutions. The "assurance value" is the protective value of nature and the regulation functions that can both mitigate and help prevent water risks. This value oftentimes comes accompanied by the additional co-benefits from other ecosystem services that are also generated at the same time, like biodiversity, carbon capture etc., that add additional layers of value as multifunctional nature-based solutions. The insurance value we argue is the monetisation of this value as a risk transfer mechanism.

Assurance is a guarantee, a promise of something (Cambridge Dictionary). For the purpose of this book, we have defined Natural Assurance Schemes (Lopez Gunn et al., 2023 – Chap. 2 this volume) as "ecosystem-based risk reduction measures that reduce the level of risk in one area". The assurance value of nature, or of an ecosystem is the role that nature plays to help mitigate natural risks while also providing long term guarantees of the resilience of the ecosystem itself and in delivering flows of the full range of ecosystem services, like e.g. avoiding or minimising the risk of biodiversity loss, that will enable long term resilience of the socio-ecological system. When properly accounted and internalised through e.g., new SEEAW accounting or new sustainability company accounts, accrued benefits might be larger than short term risk reduction benefits. The Natural Assurance Scheme is underpinned by this central idea that nature both insures some assets in real monetary terms and that these schemes also assure (restores, protect) the ecosystem from anthropocentric threats. There is a double "dividend" from the Natural Assurance Scheme and double materiality in both financial and pure environmental returns.

The insurance value of nature or ecosystems is a money value and share of the insurance value that represents only the money value provided by the short-term protection provided by the NBS. It mimics the classical financial insurance instrument: an insurance service is a transfer mechanism between two parties- the insurance company and the subscriber that pays regular risk premiums in exchange for financial risk coverage, but there is no significant reduction in the global risk, it is just a reduction in the individual risk level (the damage will still occur). The economic value of the insurance value is conceptualized by Baumgärtner & Strunz (2014) as the value of one specific function of resilience: to reduce an ecosystem user's income risk from using ecosystem services under uncertainty. The nature assurance value is wider than just the financial insurance value: the compensation of the timely loss of a good or service is limited compared to the existence of an ecosystem and the provision of continued protection derived from healthy natural ecosystems that are fully functional (e.g. for the regulation of floods).

The following models can illustrate these different concepts:

- basic insurance scheme: asset owners pay a fee to have a certain level of risk, if they face more risk, these asset owners are compensated (not totally and in fact only for the monetary value). the insurance would pay out in case of an insured hazard occurring. Insurers and asset owners can decide or not to take action in terms of risk reduction investment (and as we demonstrated e.g. in the case of Lez, go for a grey strategy, a green strategy, a hybrid strategy or opt to do nothing).
- natural insurance scheme: an asset owner pays a fee to a fund; the fund maintains the basic and short-term functioning of the ecosystem regulation services, but could not substitute this by monetary value (ie. there is a limit in terms of substitution).
- natural assurance scheme: an asset owner and other stakeholder pay a fee or contribute with other values to maintain the ecosystem (the NBS) that ensures both short term risk reduction and long-term resilience of the SES.

We hope that other cases will emerge to deepen our understanding of these concepts as well as their quantification, and their limitations.

20.3 Physical Assessment

Nature-based solutions (NBS) have become a valid alternative to grey infrastructures for coping with climate-related risks in urban and rural areas alike. NBS are increasingly recognized for their capacity to foster the functioning of ecosystems and to generate additional environmental, economic and social benefits that are considered as essential backbones of actions for climate-change mitigation and adaptation.

Our overall aim is to better understand how to operationalise the assurance and/or the insurance value of ecosystems, i.e. a better knowledge and methods to help both prevent and mitigate risks associated with water (floods and droughts), while helping to generate valuable co-benefits like biodiversity, health, recreation, etc.

The baseline to provide evidence of the role of NBS on risk management associated with water (e.g. floods and droughts), was to gather biophysical information at the nine case studies and characterise the biophysical hazards present at each location (see Sect. 2.1). The ecosystem services delivered in each of the case studies were assessed applying several tools, methods and approaches at different levels depending on the readiness of the case studies. These approaches were further developed or adapted to the case studies, e.g. with decision support tools like

Eco:actuary, which assesses the role of natural capital in hazard mitigation (applied at the large scale case studies of the Thames and the Danube), and a set of tailored approaches suitable for the different conditions present in the rest of the case studies (with different geographical settings and scales). To assess the impact of the different NBS, monitoring stations that gather environmental data in real time (named Freestations) were set out in two of the case studies (Thames and Lower Danube) as an early warning system for near real time forecasting (see Sect. 20.4). Plausible climate, land and ecosystem scenarios were used to assess the role of ecosystems in providing ecosystem services in different conditions and a series intervention scenarios were explored for each case study.

20.4 Codesign and Stakeholder Participation: Lessons Learnt and Next Steps

The engagement of different stakeholders in the co-design and assessing the NBS is key for enhancing the social acceptance of these NBS solutions. Specifically, case study results showed that addressing the socio-institutional barriers – e.g. the lack of community's engagement, low level of institutional cooperation, lack of community risk awareness, etc. – could be even more important that overcoming the physical barriers. The experiences carried out in the different case studies demonstrated the suitability of two approaches. Firstly, ambiguity analysis allowed us to account for the diversity of risk perception, addressing potential conflicts among different groups of stakeholders in the early phases of the NBS co-design. Secondly, the participatory modelling approach enabled a collective learning process enhancing participants' understanding about the need to adopt an integrated approach in NBS design and implementation. In building the model for the design of the NBS, stakeholders become aware of the wide range of potential barriers hampering the NBS implementation, and of the need to define socio-institutional measures capable of transforming the barriers into enabling factors.

Co-benefits (reduced air pollution, reduction of heat in cities, improved landscape, climate change mitigation…) represent the largest share of the value generated by NBS strategies. They are needed for these solutions to be economically beneficial, despite the fact that these measures were initially designed to reduce water risks.

When all costs and benefits are considered in cost benefit analysis (CBAs), the overall cost-efficiency of NBS strategies appears to be context-specific, with positive and negative CBA results. The cost-benefit ratio nevertheless remains superior to alternative grey solutions for all of our case studies. In order to improve the economic balance of NBS projects, developers should consider closely the impact of land cost and the choice of NBS that maximize the production of co-benefits in addition to their risk reduction function.

- The assessment of NBS co-benefits represents a challenge considering the diversity of values associated with NBS: physical, socio-cultural and monetary values. The use of combined approaches is required to fully grasp the value of NBS co-benefits. Among these, the monetary estimation of co-benefits are key to convince decision makers and investors of the economic advantages of NBS. Economic methods relying on the involvement of the public such as stated choice approaches may be particularly useful to reveal peoples' preference for NBS.
- It is important to consider that NBS can also be associated with negative effects/disbenefits that should not be overlooked, since they may have a strong impact on residents' acceptance and the value local residents put on NBS. In addition, the heterogeneity of perception of NBS co-benefits may generate equity issues like for examples difficulties in the social acceptance of NBS when these harm some people and benefit others.
- Our results suggest that co-benefits represent a large share of the overall benefits of NBS aimed at reducing water risks. Cobenefits are therefore as important as risk-reduction benefits and should therefore be systematically considered in project design and assessment.

From a non-economic assessment of co-benefits, two main lessons were learned concerning the production or generation of co-benefits. Firstly, the stakeholders' engagement showed that, in several cases, the generation of ancillary environmental, economic and social benefits can be considered as the actual drivers of NBS implementation. Secondly, we learned that diverse beneficiaries might have diverse perception of – and preferences – over the co-benefits. The production of one co-benefit might hamper the production of others – e.g. the creation of wetlands could reduce agricultural productivity – causing potential conflicts between stakeholders with different preferences. The work done demonstrated the importance of detecting potential trade-offs among different co-benefits in the early phases of NBS design. Therefore, the co-benefits definition was used as the basis for designing the most suitable NBS, accounting for the potential conflicts due to the trade-offs.

20.5 Economic Valuation of NBS for Risk Reduction and Co-benefits

We developed an economic assessment framework, with detailed guidelines aimed at comparing the main costs and benefits generated by NBS for water related risks (Chap. 6). We particularly described and implemented methods for the monetary assessment of different costs and benefits:

- Costs of implementation are those that are necessary for the implementation and maintenance of the NBS included in the NBS strategies

- Opportunity costs are related to the loss of benefits of areas that are taken out of production, or land that is used for NBS and that cannot be used for other profitable purposes such as the construction of buildings. These are the indirect costs of the NBS strategies
- Avoided damages are the damages avoided due to the reduction of water risks generated by NBS strategies. Avoided costs are the primary benefit generated by NBS strategies aiming at reducing water risks.
- Co-benefits are the additional environmental, economic, and social benefits generated by NBS.

The economic assessment subsequently compares these costs and benefits over the life-time of alternative projects, grey, hybrid and NBS, with a Cost-Benefit Analysis. This assessment methodology was partially implemented in four case studies (Lower Danube, Thames, Medina and Copenhagen) and fully implemented in three (Lez, Brague and Rotterdam) with the following conclusions.

The cost of implementation of NBS appears to be lower than the cost of grey solutions for the same level of reduction of water risks (Braque and Rotterdam). This reinforces claims about the cost-effectiveness advantage of NBS and would urge decision makers to consider more systematically these solutions to address water risks. However, in urban areas, taking into account the opportunity costs of NBS can change the appreciation of their cost advantage. NBS may indeed take space that may not be available for real estate development. Considering that NBS can require a large area to be implemented as compared to traditional grey solutions, the inclusion of opportunity costs has a strong weight in the overall cost estimation, especially in urban areas where land cost is high. In terms of benefits, NBS have a significant impact on the reduction of water risks that translate into the monetary benefits of damage reduction. In our cases, the monetary benefits related to the reduction of flood damages are however not sufficient to fully cover capital expenses, operation and maintenance costs. This problem is however even more serious for grey solutions. Meanwhile, the economic value of co-benefits (reduced air pollution, reduction of heat in cities, improved landscape, climate change mitigation…) is very significant and may be the stronger argument for the development of NBS for water risks. Finally, there are no clear-cut conclusions on the results of the Cost-Benefit Analysis of NBS in our assessments. Indeed, NBS strategies have a Benefit-Cost-Ratio close to 1 or slightly superior in Lez and Brague and below 1 in Rotterdam. The picture is however more positive if we exclude opportunity costs from the economic analysis. Importantly, for Brague and Rotterdam, the economic efficiency of NBS strategies is much higher than the economic efficiency of grey strategies.

Our conclusion of that the large share of co-benefits in the overall value of NBS aimed at reducing water risks, combined with the limited avoided damages, has strong implications for NBS funding and business models. Indeed, support from sectoral policies is generally conditioned to a positive cost-benefit analysis on the specific benefit they target, such as for example flood risk reduction. However, NBS appear to be economically efficient only when all the benefits they generate are considered. Implications for project set up and financing are very significant. Rules applying for the public funding of NBS should therefore be adapted in order to take into account cross-sectoral benefits of NBS. This requires modifications of the silo approach currently still prevailing in the application of public water risk policies.

20.6 Decision Making Processes

We present a methodology developed to fully consider the biophysical, social and economic assessment of these potential natural assurance schemes, in a co-designed approach with stakeholders. The interactions with stakeholders are fundamental to engage the local community and decision makers to work together on risk perception and the potential NBS offer to address water related hazards in specific regions and locations from the city level to transboundary basins.

Several levels of integration exist; from science-society-policy integration, through disciplinary integration, through multiple objectives and multiple-method integration over time, space, resource and sectors. Analyzing decision processes ranging from technical decisions in a disaster risk reduction context to strategic planning of climate proof development can be a versatile methodological approach, as it combines a combination of data, information, stakeholders and procedures that are to be integrated in – for example – multi-criteria decision making, adaptive planning etc. As NBS address both hydrological risk reduction and the generation of a number of co-benefits, decisions will involve some level of multi-criteria analysis, where multiple objectives or benefits can be assessed with indicators.

This book showcases a series of tools and methods to help integrate these assessments, like adaptive planning, the natural assurance business canvas, or the financing framework for water security. This integration of knowledge and experience aims to come up with viable projects that can be implemented on the ground. The role of insurance is also incorporated into this analysis, i.e. the roles the sector can play in the effective implementation of NBS and in disaster risk reduction and prevention. The different roles of the insurance sector are discussed in relation to investment, new insurance models, data or through new modes of public private partnerships that ensure the insurability of the system under climate change scenarios.

A conscious use of information and the involvement of stakeholders in the framing of problems, the range of possible solutions and the metrics to assess e.g. the effectiveness of these solutions, will facilitate learning throughout the different steps of the planning process. This means that local stakeholders, consultants or experts involved in the evidence generation and communication around NBS have to pay specific attention to the needs of their audience when communicating information. This is also an essential part of managing uncertainty in the form of ambiguity and can help to avoid potential conflicts in the development of NBS-based adaptation plans.

The importance of capacity building in NBS across organizations and throughout the entire planning process is illustrated by Droste et al. (2017). It is however important to note that stakeholders are not only the recipients of capacity building, some stakeholders also build capacity either of other stakeholders or the very experts/managers mandating the planning process. Different actors in the process can improve the overall understanding of the system, the enabling environments, the definition of the problem, the identification of potential solutions, find ways on how to assess preferences and impacts, decide implementation arrangements are feasible and how to monitor and adapt NBS when changes in performance are assessed.

20.7 Business Models, Enabling Frameworks and Investments for Risk Prevention and Reduction Through Nature Based Solutions

One of the main challenges in ecosystem services supply, e.g. in insurance/regulation, is how to internalize the positive contribution that ecosystem services can bring to society or the economy, which normally are unaccounted for, and which if perceived and valued, could help to change behaviours. We have aimed to reflect on how to create value chains associated to risk reduction and other ecosystem services, as well as on how to set up the right incentives. Innovative business models – which tell the story of how value is created - have a financial and an institutional function. The cash profile of a project can be improved for instance by community in kind contributions for maintenance and/or to safeguard of ecosystem health. Changes towards NBS can be achieved in three ways, (i) the insurance as commercial proposition, (ii) government interventions (e.g. through economic instruments), (iii) markets for externalities[1] (which could also be seen as economic instruments). A number of chapters in the book have provided insights on how to effectively mobilize money for investments required, how to enable the economic transfer of values between investors, beneficiaries and "polluters" e.g. what are the business models and economic instruments that could help making this internalization of values happen (see Sect. 20.7).

The innovative business models, economic and financial approaches developed have focused on gathering and generating the required knowledge and tools to work out and operationalise the financing aspects required to take NBS or NAS projects from design to implementation.

This goal has been achieved through four stages: description of existing funding and financing instruments for NBS, the development of Natural Assurance Schemes

[1] Externalities are costs (negative externalities) or benefits (positive externalities), which are not reflected in free market prices. Externalities are sometimes referred to as 'by-products', 'spillover effects', 'neighbourhood effects' 'third-party effects' or 'side-effects'.

canvas, the elaboration of a Financing Framework for Water Security and documenting successful business models (Box 20.1).

Box 20.1 The Value of Prevention

Expertise in catastrophe risk modelling has been applied to the two French case studies (Brague and Lez) to assess the potentially avoided damages related to the implementation of preventive measures. For the hazard part, the overflow and runoff hazards have been modelled and mapped integrating locally based information at a 25 m-resolution. It produced maps of overflow and runoff for the studied flood events that occurred in these catchments for the October 2015 for Brague and the 2014 Cevenol events for Lez. Secondly, CCR provided information about the insured damage for the studied events at the catchment scale. The four 2014-flood events on the Lez case study represented 65 M€ of losses. The 2015 flood event on the Brague case study represented 200 M€ of losses.

Developing damage curves

Specific damage curves have been developed for the events and these two case studies, focusing only on residential homeowners. Damage curves are the correlation between hazard characteristics (height or flows) and observed damages defined by the destruction rate (the ratio of total claims divided by the insured value).

For the Brague, the damage curves for the overflow show a destruction rate of 40% for 1.5 to 3.5 m, with a 20 cm of water threshold on damages, which is clearly visible. This is the threshold when the electricity network is damaged. For the Lez, the damage curves for runoff hazard show a destruction rate of 12% for 4 to 5 m3/s. This high level of sinistrality is related to the high intensity of the September 2014 event.

Implementing damage curves to assess the effectiveness of fictive preventive measures

To then fulfil the objective of assessing NBS effectiveness on avoided damages for both case studies, a solution was developed by CCR. Once the damage curves were calibrated with the two events mentioned earlier and for residential homeowners only, it was possible to assess the effect of a potential percentage of runoff hazard reduction on insured damages.

– For the Brague: simulated and calibrated results show that with a reduction of 50% runoff hazard, the damages would be reduced by 45%. The damage could be lower at 2.2 M€ (as the current damage are 4 M€ for residential homeowners)

(continued)

- For the Lez: simulated and calibrated results show a reduction of 50% runoff hazard, which would reduce the damages to ~ 1.9 M€ (or −40.45%) (as the current damage are 3.3 M€ for residential homeowners)

Considering the future consequences of climate change, how important should prevention be?

Finally, Marchal et al. (this volume) introduced the climate change scenario of RCP8.5 to assess future exposure of the two case studies based on the potential climate change impacts on insured losses for the year 2050 (CCR, 2018). The evolution of the damage between the current climate and future climate was developed using calibrated damage curves on residential homeowners.

- For the Brague case study: the result highlights that climate change at horizon 2050 will increase losses by 25.5% for individual homeowners only. In order to maintain the losses to the current business as usual, the runoff hazard has to be reduced by 40% to limit the effect of climate change.
- For the Lez case study the losses are estimated to increase by 30% for the year 2050 according to the RCP 8.5. Then, CCR calculated the estimated percentage of potential hazard reduction, using NBS, to reduce the impacts from climate change compared to business-as-usual scenario estimated losses. CCR estimated that the runoff hazard must be reduced by 35%, using NBS, to limit the impact of climate change compared to the current business-as-usual losses.

The results summarized demonstrate the potential to use catastrophe risk models to assess the effectiveness of loss prevention and to the importance of sharing this information with stakeholders. It also demonstrates that preventive measures have to be ambitious to reduce the losses toward a bearable threshold today and in the future.

20.8 Capacity Building and Additional Resources – Do Your Own NAS

Training activities are a central element for the uptake of Natural Assurance Schemes. As part of the NAIAD project that supported the conceptual, methodological and case studies presented in this book a Massive Online Open Course “Greening Risk Reduction with Nature Based Solutions” on how to integrate the insurance value of ecosystem in environmental planning and infrastructure investment was designed and launched. The Materials to support the course introducing and explaining the work developed under the framework of the project. In addition an Electronic Guide on all the materials, publications and resources available was also developed and is freely available (see Box 20.2 Below).

Box 20.2 The H2020 NAIAD Eguide Online Resource

The E-GUIDE is a tool whose objective is to support external users to navigate through the extensive H2020 NAIAD results, so that interested parties can take advantage of these tools and examples. It also aims to make it easier for users to explore its possibilities, including those at the scientific level that are relevant to study local problems and formulate solutions.

The E-GUIDE is aimed at a wider audience of potential users of NAIAD's models, tools and methods, and all those who are interested in acquiring knowledge about its results. The models, tools and methods generated are presented schematically in compact web pages and in a language understandable to a non-expert audience. Particular attention is paid to the following questions that potential users of NAIAD's products might ask regarding each product:

What are the categories of users (technical, political, interested observer,…) for whom the product can be most useful?
What are the applications of the product for decision making/management in the water sector?
What is the added value of the product?
What management decisions/processes can be strengthened or improved thanks to this product?

For those readers interested in obtaining additional information on the products presented, references are provided to the relevant reports and publications generated within the framework of NAIAD, hyperlinks to the corresponding web pages, and contact details of the persons responsible for the product within the team of the draft.

The E-GUIDE is structured in a series of categories that collect the different types of knowledge and tools generated as a result of the project. These categories include the following:

(a) Information, reports and knowledge acquired in the project's DEMOs
(b) Models for evaluating the costs and benefits of SBNs and the costs of their implementation (including their insurance value)
(c) Publications, including scientific texts, and the hyperlinks to access them
(d) Access to the MOOC (Massive Online Open Course) on the implementation of SBNs and other training activities generated within the framework of NAIAD.
(e) Tools for use in various contexts

(continued)

These categories can be accessed through the web from the following entries:

(f) NAIAD Strategic Objectives
(g) Specific questions
(h) Specific use cases
(i) Guide to Nature-Based Solutions
(j) Type of result or product
(k) Demos or case studies

Therefore, this guide allows you to create a customized and ordered view of the knowledge and products generated by the project, allowing the user to navigate and access those that are of greatest interest, with a lower or higher level of detail.

20.9 Lessons Learnt and Main Conclusions

Main lessons learned are presented on the role of Natural Assurance Schemes and implemented nature-based solutions and demonstrated for a broad range of case studies across Europe. This books summarises the knowledge acquired, its integration and application to real environments presenting different geographical conditions and scales, from the neighbourhood scale in the Rotterdam case study to the very large scale of the Danube basin, with very diverse socio-economic conditions and very different institutional and regulatory settings. As a result of this not only have new knowledge, methods and tools emerged from the work presented in this book, but also lesson learnt can be shared and recommendations made for an effective implementation of NBS for risk reduction. NAS as a specific type of NBS schemes become a strategy in the reduction of risks associated with water-related climate events which are anticipated to increase in frequency and intensity under climate change. Biophysical assessments in most cases were done by physically based models, e.g. a groundwater model in Copenhagen and a hydraulic model in the Brague catchment, as well as ecosystem services DSS (Eco-Actuary) for the Thames catchment.

The main lessons learned from the biophysical assessments were (i) that evidence based decision making is key in the effective implementation of NBS. Monitoring and modelling are essential for evaluating the effect of Natural Flood Management (NFM) and NBS interventions; (ii) NBS strategies implemented as area-based interventions (e.g. conservation agriculture) have greater potential to reduce flood risk and provide more valuable co-benefits than point based interventions (e.g. leaky dams or retention ponds, as demonstrated for the Thames catchment); (iii) Operational and Maintenance costs of NBS interventions must be accounted for and kept low to be an attractive alternative for grey or hybrid solutions. Maintenance of NBS are not always well known and may have high costs, but without maintenance, interventions can fail, as for traditional grey solutions, and worsen flood risk.

The main lessons learnt from the social assessments were: (i) NBS effective implementation requires effective cooperation among different decision-makers (e.g. municipalities, river Basin authorities, regional government) and between them and the main stakeholders (e.g. local citizens, end users, NGOs); (ii) Eliciting stakeholders' perception about co-benefits plays a key role in NBS co-design, and not only in the NBS assessment; (iii) Ambiguity in risk perception should be considered as an enabling factor for NBS design and implementation rather than a barrier.

The main lessons learned from the economic assessment were: (i) Co-benefits represent the largest share of the value of NBS, despite the fact that these were initially designed to address water-related risks; (ii) The cost of implementation of NBS is lower than the cost of grey solutions for the same level of water risk management, confirming the cost-effectiveness advantage of NBS. Benefits in terms of avoided damages alone are however generally not sufficient to fully cover investment and maintenance costs; (iii) NBS cannot automatically be assumed to present benefits larger than their cost of implementation and opportunity costs. The evaluation of several combinations of NBS strategies aiming at maximizing the benefit cost ratio is therefore needed.

The main lessons learned for deploying an integrative framework were: (i) An integrated, multidisciplinary, co-designed framework is key to analyze the NBS multifactorial effects. For risk assessment, checking the physical effectiveness is a first key step before addressing other co-benefits. And in parallel communicating and making the information understandable are both necessary and crucial to assess NBS effectiveness; (ii) A new hybrid design methodology has emerged to combine classical and eco-engineering approaches with decision-aiding frameworks (e.g. multi-criteria, economic methods) to support decision-making process; (iii) a Climate Change perspective is necessary for understanding the impact of NBSs and also how climate change itself could affect the effectiveness of NBS under different climate change scenarios.

Main lessons learned from innovative business models and financial instruments: (i) One of the main difficulties in building business models was to engage indirect beneficiaries of co-benefits within the pool of payers and funders. This is critical because co-benefits often have an even higher value than the risk reduction itself; (ii) Legislation can become both a critical enabler and barrier for the development and implementation of business models for NAS schemes. In the case of the EU, the environmental legislation plays a critical driver pushing the interest in NBS and opening opportunities for its implementation; (iii) the Importance of flexible tools that enable replication, e.g. NAS canvas is a flexible and replicable tool applicable to any NAS scheme or NBS strategy regardless of the stage or the context; (iv) Normally, the proponents of NBS are organizations with an advocacy and/or scientific background with limited experience in public and private investment planning processes. As a result, often NBS pilots and demonstration projects are shaped more as awareness raising projects than as "investment projects" that could attract funds from either public authorities aiming at reducing a risk or private impact investors willing to accept lower returns in exchange for social and environmental impacts; (v) There is an Information gap between evidence proposed by NBS proponents and the required by public and private investors or implementers. The criteria and level of detailing regarding implementation costs and risks differ greatly between the project descriptions of NBS proponents and the requirements for allocation of public funding or granting of loans by impact investors; (vi) In order to move towards the implementation at scale of NBS it is of extremely important to move from pilots and monitoring systems that are designed to raise awareness towards the real monitoring of systems that develop the evidence base and the baseline required to move towards performance-based contracts and payment mechanisms.

Main lessons learned from policy uptake: (i) Scaling investment still requires enhanced coordination, capacity, and confidence among public authorities that would be primarily responsible for accessing their financing and overseeing their implementation. The demonstration cases also show that the implementation landscape across the EU is diverse. In many countries prioritized actions from the EU may still be required to ensure water-risks are appropriately recognised by governments and citizens, and that NBS are viable options for risk reduction; (ii) The use of NBS as part of strategies to maintain the insurability of assets under changing climate scenarios should be more strongly promoted. This may be a more urgent political motivator to local populations and governments than their potential to reduce the impacts from catastrophic hazards; (iii) Challenges to finance NBS show a "market gap", not only a funding gap. Under investment in NBS is seen a failure, at large, of those looking to access financing to produce viable projects to sustain and pay back investment. It also, however, signals a failure in the market where the value of services provided by NBS may be undervalued, or the values provided are not monetized sufficiently or through other KPIs to enable investment, or familiar finance instruments seem ill-fitted to non-traditional investments. Each of these scenarios may require public sector interventions and should be better analysed.

Our results provide valuable evidence that co-benefits represent the largest share of the NBS benefits in the design and implementation of Natural Assurance Schemes. Therefore co-benefits should be defined at an early stage to support the NBS co-design, and the structuring of their funding and financing. However, policy makers and decision makers have to be realistic: NBS alone will not be able to completely reduce the impacts from large events. However, NAS can however play an important role to help increase overall system resilience and help to reduce the effects of less frequent extreme events, reducing running or operational costs, and overall pressure on the system. This is the case for example of the urban water buffer in Rotterdam, which has allowed a football stadium to cope better with both drought and flood events through its continuity of service with water guaranteed through rainwater harvesting for the football fields.

This frees capacity and additional human and financial resources and thus allows for a higher response capacity during large events. Another lesson learnt is the critical importance of local knowledge and capacity, the tacit knowledge of stakeholders is critical not only for the problem definition itself, but also to fully document the range of social, environmental and economic benefits derived from NBS which by their very nature are multifunctional. Thus end user co-design is essential to fully characterize the problem and viable implementation contexts, options and key potential barriers and opportunities early in the design. It also raises awareness but most importantly, it increases the legitimacy and acceptance of the process and the chosen outcomes. Finally, we have also learnt how the regulatory framework and policy framing can help provide the right incentives to the different actors to reach collective natural assurance schemes at these locations.

In terms of future work, the conceptual frame and methodology provided seeks to provide a venue for practitioners, researchers, and others to help advance the entry points for NAS projects for risk reduction, advance a better quantification of the benefits of NAS, and finally, provide additional evidence of what works and what does not work. In short to develop a deeper understanding of the NAS concept and its potential implementation.

References

Baumgärtner S, Strunz S (2014) The economic insurance value of ecosystem resilience. Ecol Econ 101:21–32

CCR (2018) Département Analyses et Modélisation Cat Conséquences du Changement Climatique sur le Coût des Catastrophes Naturelles en France à Horizon 2050. CCR, Paris, France

Droste N, Schröter-Schlaack C, Hansjürgens B, Zimmermann H (2017) Implementing nature-based solutions in urban areas: financing and governance aspects. In: Nature-based solutions to climate change adaptation in urban areas. Springer, Cham, pp 307–321

Open Access This chapter is licensed under the terms of the Creative Commons Attribution 4.0 International License (http://creativecommons.org/licenses/by/4.0/), which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license and indicate if changes were made.

The images or other third party material in this chapter are included in the chapter's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the chapter's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder.