Chapter 7
Designing Natural Assurance Schemes with Integrated Decision Support and Adaptive Planning

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Highlights

This Chapter provides an illustration on how to support the decision-making process of selecting and applying NBS. In this chapter you will learn:

- Which decisions need to be taken in the analysis, selection, design and implementation of NBS, considering the common steps in strategic planning;
- Which tools, methods and models can be used to support the decision-making process;
- How to integrate all the information, data and results to reach a robust strategy that fulfils the requirements for decision-making;
- How NBS solutions can bring benefits in terms of DRR, water resources management (WRM) and CCA;
- The substantial co-benefits that NBS can bring in terms of economic growth, service provision and social equity, while protecting the environment.

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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_7

7.1 Introduction: Integration of DRR, WRM and Climate Change Adaptation Planning

Natural Assurance schemes mainly deal with issues coming from three arenas that address hydrological risk: Disaster Risk Reduction (DRR), Water resources management (WRM) and Climate Change Adaptation (CCA). Whereas all approaches look at nature-based solutions to reduce hydrological risk, the larger framework in which NBS are used differs. Main differences between DRR, WRM and CCA are in relation to objectives and scope (see Table 7.1). The distinction is important since it has important implications on how problems are assessed, and which kinds of solutions are proposed. To understand how the different approaches can be integrated in NAS, this section presents each of them in a nutshell to then discuss how they can be integrated, contributing to the design of NAS.

7.1.1 DRR in a Nutshell

Disaster risk management (DRM) is a framework used to respond to disasters at local, municipal, and national level. The goals of DRM are (Warfield 2020):

1. To reduce or avoid losses from hazards;
2. To assure prompt assistance to victims and;
3. To achieve rapid and effective recovery.

Table 7.1 Similarities and differences between DRR and WRP contexts

Disaster Risk Reduction (DRR)	Water Resources Planning (WRP)	Climate change adaptation (CCA)
Differences		
Anticipate and prevent disaster consequences (ex-ante), combined with ex-post activities such as response and recovery	Purely ex-ante, forward looking approach, with combination of development and adaptation actions	Combined responsive and preventive action with both short- and long-term effects of climate change
Objective is reduction of disaster risk	Objectives are multiple (and possibly competing)	
Minimizing risk at its core	Maximizing benefits of the water resources system at its core	
Similarities		
Involving stakeholders		
Use of models and tools to understand the water system		
Cross-sectoral activities requiring understanding of institutional and stakeholder environment		
Cyclical exercise: involving multiple scenarios		
Look at combination of adaptation and mitigation Focus on adaptation		

In order to achieve these goals, DRM follows a process of four steps from mitigation, preparedness, response to recovery (see Fig. 7.1). Specifically, one can distinguish pre-impact and post-impact assessment phases. Specifically, the existing links between Drivers-Pressures-States that occur beforehand can be evaluated in terms of Preparedness and Mitigation, especially when concerning the application of NBS as protective and mitigating measures for risk reduction, as well as other measures.

DRM utilizes DRR and combines the principles of mitigation and preparedness with a management perspective through the added principle of response. DRM includes the management of risk and disaster and is a framework to establish policy and administrative mechanisms related to emergency response (Baas et al. 2008).

Whereas the majority of DRR activities focus on response, and therefore present a mainly post disaster approach, the typical strategic planning in water management is a forward looking or pre-disaster approach that aims to create a strategic position in the future. This is based on understanding of the current challenges and identification of pathways and action plans to overcome all possible identified problems.

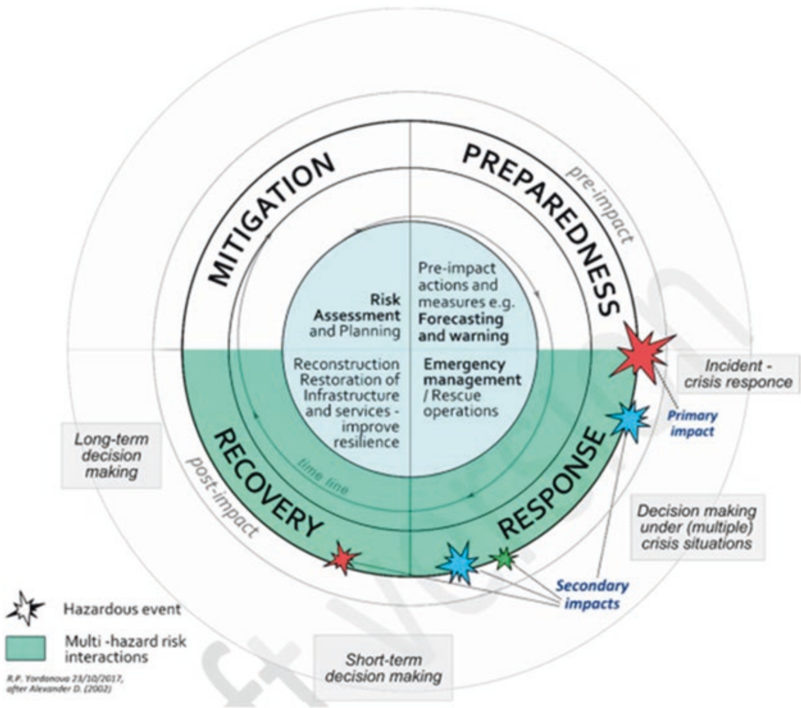

Fig. 7.1 The disaster management cycle principles and the spiral principal redrawn after (Alexander 2002). The importance of the existence of multi-hazard impact occurring prior or after an event is depicted on diagram

7.1.2 *Integrated Water Resources Management (IWRM) in a Nutshell*

In water systems, strategic planning usually aims at reaching several objectives linked to the social, economic and environmental dimensions of the water system:

- The main purpose is to ensure the sustainable exploitation of water resources in support to the production of goods and services required to meet national and regional demand objectives;
- Systematic procedures to generate a synthesis of information in such a manner as to gain insight into the nature and consequences of possible management strategies;
- In a risk context, planning will target the present and future risks and develop strategies for both mitigation and adaptation.

In this regard, IWRM provides the guiding principles to achieve water security for all by means of strategic planning, or also called master planning (Fig. 7.2). Water security is the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability (UN-Water 2013).

IWRM planning is a cyclic process in which a logical sequence of steps is implemented bolstered by continuous management support and stakeholder

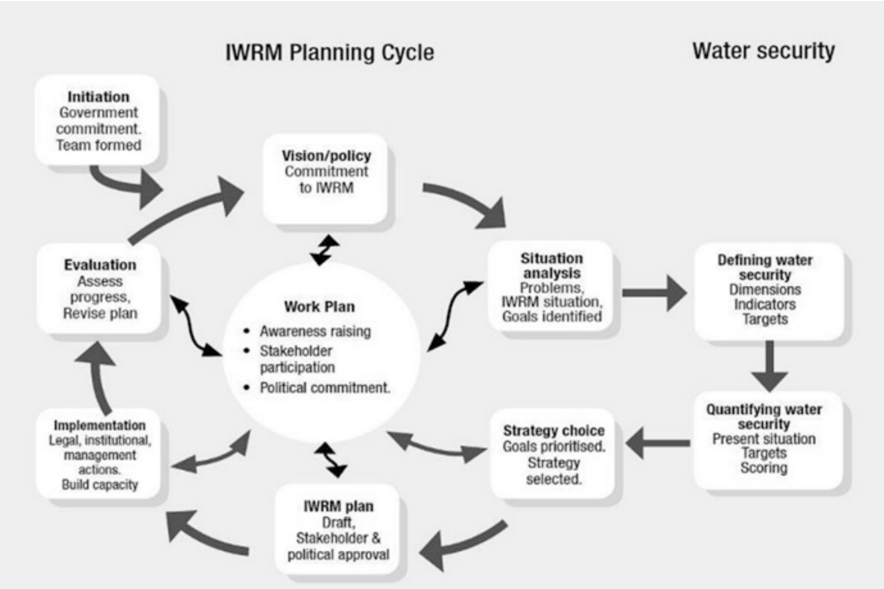

Fig. 7.2 IWRM planning cycle to achieve water security. (Source: Van Beek and Arriens 2014)

involvement (see Fig. 7.2). The expected outcome of the IWRM process is a concrete plan, approved and implemented by decision-makers (for example the government) and stakeholders. Following the process, decision makers and stakeholders will get a good understanding of an area's water system, its performance, and the importance and benefits of managing the resources in a sustainable manner. It will serve as a roadmap for longer term initiatives needed to achieve the overarching objectives of (i) sustainable environment, (ii) social equity and (iii) economic growth.

7.1.3 Climate Change Adaptation in a Nutshell

Climate change adaptation is focused on adjusting or adapting to the actual or expected future climate. The main objective is to reduce vulnerability to harmful effects of the changing climate (such as sea-level rise and increased frequency and intensity of weather events). In doing so, CCA follows a number of steps similar to the stages in strategic water resources planning (WRP) (Fig. 7.2) and mirroring more general problem structuring planning methods. The steps followed by the climate-adapt tool proposed by the EU Climate adaptation community (Prutsch et al. 2014) are shown in Fig. 7.3.

7.1.4 Integration: Merging Approaches and Different Policies

The approaches introduced above, are guided by a series of EU and global policies such as the Sendai framework for DRR, the EU water policies (e.g. Water Framework Directive, Floods Directive and river basin and drought management plans) and

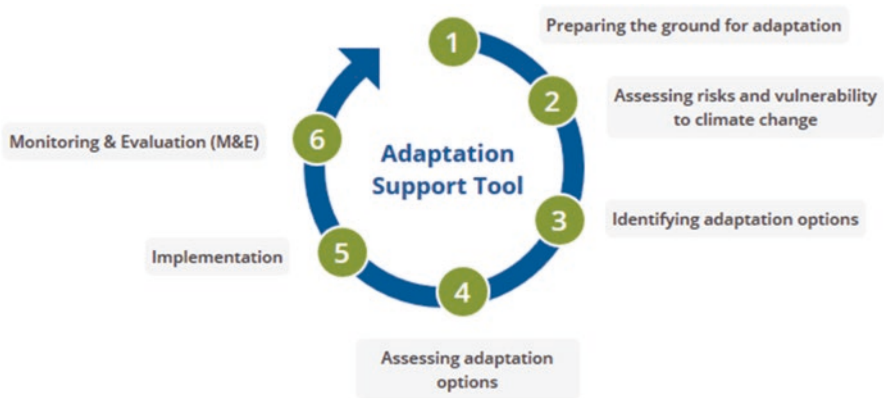

Fig. 7.3 Climate-ADAPT tool. (Adopted from https://climate-adapt.eea.europa.eu)

policies focusing on climate adaptation specifically (e.g. Paris agreement, EU Adaptation strategy). In addition, NBS related policies as the EU strategy Green Deal and the Sustainable Development Goals play an important role when shaping responses under before mentioned policies.

The main similarities and differences between the three approaches are summarized in Table 7.1. The differences are mainly related to the scope, objectives and anticipative character (or not) of the approach. Because of these differences in the objectives and approach between DRR and IWRM, their coordination is challenging. However, both approaches have in common that they deal with complex decisions and involve multiple methods and actors. The latter is managed using stakeholders' engagement processes (*see Chap. 5 Giordano et al., this volume)*, use of multiple value capturing and method integration. Whereas these are common approaches, large part of the integration approach in NBS will be coloured by the context of a given case study. In terms of contexts, we distinguish:

- Time (e.g. rapid response vs strategic planning) and spatial scales;
- Decision-making contexts;
- Thematic focus;
- Institutional and business or investment readiness levels.

Role of Stakeholders in Integrated Decision Support and Adaptive Planning of NAS

The participatory nature of the proposed planning approach addresses broad societal and scientific calls for democratizing decision making in DRR (e.g. Okada et al. 2018; Samaddar et al. 2017), CCA (Cvitanovic et al. 2019) and natural resource management (e.g.Grimble and Chan 1995; Van Cauwenbergh et al. 2018) in general.

Throughout the entire planning process discussed in this chapter, involvement of stakeholders is key to a number of issues. First of all, it helps to assure a good understanding of the often complex issues and to handle trade-offs in a societal acceptable way. However, stakeholder involvement is also necessary to anticipate and adapt to a number of implementation issues to avoid producing results that those potentially impacted will not support. Stakeholder involvement brings both knowledge and preferences to the planning process—a process that typically will need to find suitable compromises among all decision-makers and stakeholders if a consensus is to be reached.

Choices about managing water and other natural resources trade-offs involve more than hydrology and economics. They involve people's values, ethics, and priorities that have evolved and been embedded in societies over thousands of years (Priscoli 2004). International policies, e.g. the Dublin principles and Aarhus convention, drive governments to engage stakeholders as an explicit operationalization of involving people's values, ethics and priorities, in line with principles of democracy and transparency. These principles have been adopted by the main policies and institutional frameworks in the fields of DRR, CCA and WRM mentioned earlier.

7.2 Strategic Planning Framework

7.2.1 Definition and Main Steps

The strategic planning framework approach is a forward looking or ex-ante approach that aims at creating a strategic position for the future (Deltares 2020; Loucks and Van Beek 2017). This is based on the understanding of current challenges in the identification of measures and action plans to overcome them. In water systems, strategic planning aims at achieving numerous objectives, by looking at the socio-economic and environmental dimensions of the water system. It provides a systematic procedure to generate a synthesis of information, so we can develop an effective and efficient water management plan. The framework is illustrated in Fig. 7.4. It consists of five phases namely: (i) inception phase, (ii) situation analysis, (iii) strategy building, (iv) action planning and (v) implementation. The engagement of stakeholders and decision-makers is key to ensure the sustainability and ownership of the planning and decision-making process and the outcomes from the process. In each of the phases, relevant stakeholders and the extent of their engagement must be identified. Also, there are various methods and tools that can be used to carry out each of the steps. The tools and methods used to design and monitor natural assurance schemes will be explained in detail in Sect. 7.3 of this chapter.

A brief description of the five phases of the master planning framework is given below and represented graphically in Fig. 7.4:

- **Inception/Scoping:**
- Inception is the first step in adaptive planning. It defines the boundary conditions, establishes the objectives and specifies the limitations. This requires the involvement of all decision makers and setting up the circumstances or enabling conditions under which a solution or plan is created for the decision makers to discuss. The analysis includes a thorough investigation of the existing policy mechanisms, institutional frameworks, problems, measures of success and the available data.
- **Situation Analysis:**
- It focuses on data collection and modelling. Using the conditions and frameworks from the previous step, the natural resource, socio-economic and administrative system are described. These systems components are usually captured in models, in close collaboration with stakeholders to ensure the same understanding of the system.
- A structured analysis is needed to identify present and future problems, which provide the necessary tools to identify measures to address these problems. E.g. a scenario analysis is made, often linked to socioeconomic development pathways and climate change, to prepare for problems that may arise in the future.
- **Strategy Building:**
- The most promising measures are combined into strategies, which are assessed in detail. The results are a set of selected strategies that are presented to

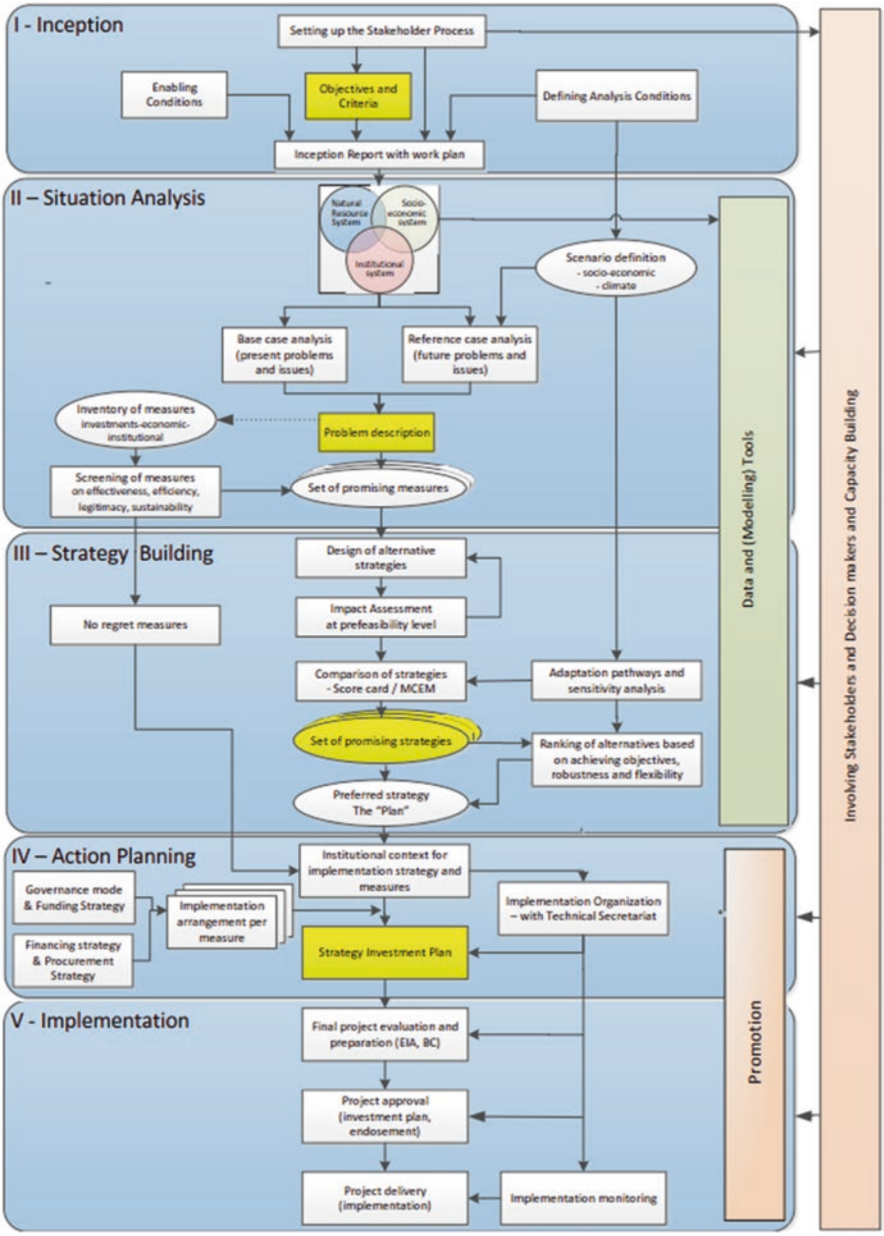

Fig. 7.4 Master planning framework. (Adopted from Deltares 2020)

decision-makers to select a preferred strategy (*in the section below, the adaptive management analysis for the selection and evaluation of alternative strategies will be further discussed*).

- **Action Planning:**
- After the selection of the preferred strategy, this phase focuses on its translation to concrete actions. The involvement of various stakeholders needs careful planning and coordination. Action planning is not intended to be static or prescriptive, it leaves room for decision-makers to further discuss and taking into account their own responsibilities. This last point is key, as this stage should assign concrete actions. This phase includes the funding and budgetary requirements for implementation.
- **Implementation:**
- This phase focuses on the implementation of the strategies selected according to the action plan devised. It includes the actual creation of construction measures and its subsequent monitoring and evaluation.

7.2.2 Towards the Strategic Planning of NBS for Adaptive Management

Anticipating future uncertainties in the system, the strategic planning process incorporates a number of elements that allow decisions to be adapted to a new situation in the future. In the situation analysis step, scenario definition presents an important exercise in exploring possible futures that will affect the system to varying degrees. When building strategies, these are checked for their flexibility and robustness in view of these future scenarios and adaptive pathways can be defined. The latter set out pre-defined routes of response when changes in the system are manifested. More general for the purpose of NAS, the implementation of NBS can bring a high degree of uncertainty related to their functioning regarding the future socio-ecological systems under climate and other changes as well as their possible impacts. There is therefore the need for adaptive capacity of the planning and management itself (see box below).

> When there are many plausible scenarios for the future, it may well be impossible to construct any single static policy that will perform well in all of them. It is likely, however, that the uncertainties that confront planners will be resolved over the course of time by new information. Thus, policies should be adaptive - devised not to be optimal for a best estimate future, but robust across a range of plausible futures. Such policies should combine actions that are time urgent with those that make important commitments to shape the future and those that preserve needed flexibility for the future. (Daniels and Walker 2001)

Management of Uncertainty in Planning and Implementation of NBS

A review of NBS literature by Dourojeanni (2019) identified a wide range of drivers and barriers that enable or impede the implementation, uptake and mainstreaming of NBS and natural assurance schemes. Roughly, the barriers can be categorized into 4 groups: (1) institutional and regulatory barriers, (2) absence of clear evaluation of NBS performance, (3) funding and financing barriers and (4) knowledge and acceptance barriers. The set of barriers are intimately related to uncertainties, which can be classified in barriers related to uncertainties in the natural and technical system and those related to political-legal, economic/financial and institutional issues, i.e. the social system.

To capitalize on the drivers of NBS implementation and overcome barriers hindering their integration in climate adaptation plans, management of uncertainty is key (Dourojeanni 2019; Van Cauwenbergh et al. 2020). Considering the risk context, planning will target the present and future risks and develop strategies for both mitigation and adaptation. Strategies are developed to achieve the goals and are a combination of management interventions that can be either infrastructural (e.g. flood protection through building of dikes or hydro-forestry measures), economic (e.g. water pricing, pollution taxes) or institutional (e.g. water allocation schemes, pollution control, land use planning). In order to operationalize these goals, we propose the framework of planning as a systematic procedure to generate a synthesis of information in such a manner to gain insight into the nature and consequences of possible management strategies. For a detailed discussion on management of uncertainty within the NAIAD project refer to Van Cauwenbergh et al. (2020).

7.2.3 *Towards Implementation: Financing Framework for Water Security*

The implementation of NBS requires bringing together the diversity of value expectations between authorities, proponents and investors to translate NBS strategies into implementable projects. In this regard, the 'D7.3 Handbook for the Implementation of Nature-based Solutions for Water Security" (Altamirano et al. 2020), the Financing Framework for Water Security (FFWS) (Altamirano 2017) for structuring NBS implementation arrangements (*Chap. 9 Altamirano et al., this volume*). The FFWS guides the design of an implementation arrangement – choosing from a wide range of project delivery and finance options that vary from purely public governance options up to the creation of markets for private initiatives. In a nutshell, the FFWS adapted to the implementation of Ecosystem-based DRR defines a process for defining funding and governance structure of a NBS strategy for a sustainable financing and implementing strategy. In this regard, the 'D7.3 Handbook for the Implementation of Nature-based Solutions for Water Security differentiates between funding and financing. Funding refers to the question of who ultimately will pay for the investments made. Funding could come from three generic sources: Taxes, Tariffs and Transfers (3 T) (OECD 2009). Financing, on the other hand, refers to mustering the up-front resources needed to be repaid over time by the funding. This simple but fundamental clarification avoids the mistaken idea that private/commercial (i.e. repayable) finance could be a substitute for a shortage of internally generated project revenues. Upon this clarification, the FFWS for implementing Ecosystem-based DRR develops five business cases to evaluate public investment, following the Five Cases Model of the UK HM Treasury (Government of the United Kingdom 2018).

– **Strategic** – is there a compelling case for change?
– **Economic** – does the recommended measure optimise public funding?
– **Commercial** – is the proposed measure achievable and attractive in the marketplace?
– **Financial** – is the spending proposal affordable?
– **Managerial** – how will the proposal be successfully delivered?

The five business cases for the context of Ecosystem-based DRR elaborates on the expected levels of risk reduction to be sustainably delivered, the type of transaction to govern the service delivery, and the enabling institutional setting. Hence, the Handbook details the process where NBS proponents make explicit:

(i) how the implementation of NBS measures enables a paradigm shift towards resilient and sustainable economic growth (Theory of Change[1]) in a given institutional setting;
(ii) a hierarchy of services and their levels at which specific target groups are willing to pay using 3 T;
(iii) the characterization of these services as economic goods susceptible to be transacted as public procurement, markets or other hybrid organizational forms;
(iv) the funding of revenue inflows and the costs outflows of the project, for identifying the need and opportunities for front-end financing; and,
(v) the project owner in-house and procurement capabilities, to make predictable cashflows by delivering on-time and maintaining levels of service over the project life cycle.

The implementation of the FFWS requires a deep understanding of the institutional enablers and constraints. An institutional understanding of the contextual embeddedness proves the professional criteria to assess the feasibility of implementing 3Ts, the availability of financing instruments, and the contracting and procurement possibilities.

[1] Theory of Change is a comprehensive description and illustration of how and why a desired change is expected to happen in a particular context. It is focused in particular on mapping out or "filling in" what has been described as the "missing middle" between what a program or change initiative does (its activities or interventions) and how these lead to desired goals being achieved.

7.3 Tools and Methods Used in the Planning Phases

7.3.1 Why Do We Need Tools for Planning?

Each step of the planning framework results in specific decisions (see Fig. 7.5). To support these decisions, various tools and methods are available for specific steps of the planning framework including e.g. existing decision-support methods such as multicriteria decision analysis. This section gives an overview of some of the tools and methods that can be used in the planning steps. We also explain how, and which tools and methods were applied for different Case studies (*see Chaps. 10, 11, 12, 13, 14, 15, 16, and 17, this volume*).

It is important to point out that in a multi-stakeholder context, each stakeholder is likely to have his or her objectives, value system and preferences (*e.g. Chap. 5 Giordano et al., this volume*). As the planning process progresses, and strategies and measures become more detailed, new questions will be raised reflecting the different perspectives from each of the partners. Whatever be the planning step, some stakeholders may base their decision on technical information and will thus rely on advanced technical tools and expert knowledge to interpret indicators. Meanwhile, understanding the perspective of other stakeholders is required to push forward the planning and overcome the divergent phase typical in strategy building. Simplified decision support tools, developed by experts that are both educational yet and as rigorous as possible, are often needed to share technical knowledge, explore possible strategies and enter the convergent phase where misunderstanding and misalignment are hopefully overcome to find possible trade-offs. Multi-criteria and decision aid methods may help this convergent phase in the decisions of each stakeholder. (Tacnet et al. 2019) provide descriptions and examples of the different tools

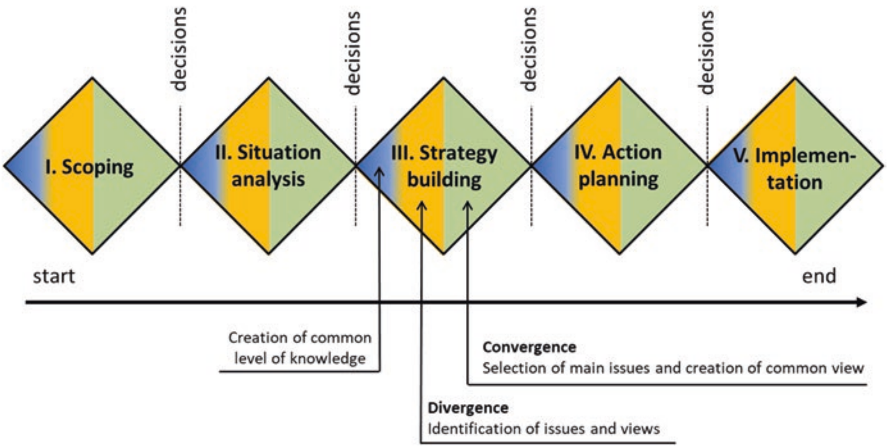

Fig. 7.5 Steps of planning framework ending with decisions by stakeholders, each step experiencing phases of knowledge creation, divergence and convergence toward new decision and next step. (Adopted from Deltares 2020)

available ranging from simple and educational, to advanced or for aiding decisions and communication.

7.3.2 Finding the Right Tool at the Right Phase

At each step of the planning framework, various questions must be addressed to end up with concrete decisions. This requires a great variety of methods and tools which have to be carefully selected to address the needs decision makers and stakeholders have, while considering the capacity available (e.g. data, technical expertise, communication support) and potential bias and trade-offs with methods/tools. Below we illustrate with some examples how methods and tools with varying levels of participation can be used in the different planning steps of NAS.

7.3.2.1 Inception/Scoping

The definition of objectives (e.g. risk reduction, ecosystem services), along with evaluation criteria to monitor and evaluate those objectives, is of utmost importance for the final configuration of NBS and NAS in the plan. Objectives are often derived from a mix of policy prescriptions (e.g. Sendai, EU WFD, Climate Adaptation Strategy etc.) and issues on the ground. The way in which objectives are articulated should ideally be supported by a participatory process.

Stakeholder interviews and workshops can be conducted to agree on objectives and prepare a comprehensive workplan specifying all the activities that need to be carried out further to achieve the defined objectives. Some of the participatory tools and methods that can be used for stakeholder workshops are serious gaming, fuzzy cognitive mapping, system dynamics by means of Group Model Building or Mediated Modelling to mention just a few. For a complete overview of the participatory modelling methods and tools used in NAIAD, refer to Tacnet et al. (2019). For a general view of the most used methods and tools used in the context of participatory modelling, refer to Voinov and Basco-Carrera (2018).

7.3.2.2 Situation Analysis

This step should provide the decision makers with a complete understanding of the natural resources, socio-economic and institutional systems; existing and potential future problems and possible measures and interventions for further analysis. The tools and methods that can be used to achieve this can be more top-down or expert-based (e.g. hydrological modelling, hydraulic modelling, damage modelling, forest fire models, social network analysis, and institutional analysis) or explicitly involve stakeholders in the generation of system understanding (e.g. system dynamics). For a more comprehensive overview of possible methods and tools for situation analysis refer to Deltares (2020).

7.3.2.3 Strategy Building

A strategy is built when decision makers have an optimal combination of potential measures that contribute to achieving the defined objectives. From several alternatives, a preferred strategy is chosen based on an overview of the expected effectiveness of its constituting measures considering previously agreed objectives, and assessed using criteria and indicators. To assess a strategy (e.g. a combination of grey/green infrastructure with regulatory incentives and community-based operation), a combination of biophysical and socio-economic methods and tools are used to provide the indicator scores of alternatives (*Chap. 8, Altamirano el al., this volume*). Given the important role of NBS in NAS, this integrated assessment will consider ecosystem services. To support the interpretation of integrated assessment feeding from different models and tools, a meta-model can be used. To select the preferred strategy, cost-effectiveness, cost-benefit analysis and multi-criteria analysis are relevant tools (see Tacnet et al. 2019) and can involve stakeholders (e.g. Van Cauwenbergh et al. 2018). In addition different methods and tools can be used to support the negotiation and management of potential conflicts when making these sometimes controversial choices.

For adaptive planning, decision makers can use adaptive pathways methods such as Decision Trees and Dynamic Adaptation Policy Pathways (DAPP) to enable them to consider future uncertainties for making decisions, and as a result ensure that the preferred strategy is robust or flexible to address possible futures (Deltares 2020; Tacnet et al. 2019).

7.3.2.4 Action Planning

To operationalize the preferred strategy and assure the decisions on paper can be implemented on the ground, action plans need to be defined. These plans list a number of concrete actions, services and their instrumentalization by means of governance, funding, and financing strategies, and procurement strategies. Given the multiple and varied stakeholder involved in the implementation and (more so) operation of NBS in NAS, their involvement in defining the rules and responsibilities is crucial. In that sense, the definition of business cases for public and/or private investments can be supported by system dynamic models using Group Model Building or Mediated Modelling. In general, this step can be supported by tools for partnership development and consolidation.

7.3.2.5 Implementation

For a smooth implementation and monitoring and evaluation of NAS, some level of collective action is needed. Participatory monitoring and citizen science can support collective action and increase overall awareness and ownership to support long lasting implementation. Given the intrinsic uncertainty in NBS and NAS, their planning and implementation should be seen as an adaptive process in which decision makers and stakeholders can continuously assess the situation and determine the best way to proceed, either moving forward or moving backward if necessary. This cyclic and iterative process can be supported using participatory monitoring and evaluation.

7.3.3 Linking Case Studies to the Planning Framework

Varied disciplines should always be involved to work in parallel, i.e., in a multi-disciplinary approach, and perform their assessment and work in tight collaboration, i.e. an interdisciplinary approach. When integrating stakeholder and lay knowledge into an assessment, the latter becomes a trans-disciplinary approach. To our experience, richer results and assessments emerge from those trans-disciplinary approaches. However, an extra effort is needed in terms of communication, clarification of concepts and capacity building between stakeholders and experts involved. In our vision, integration relies on trans-disciplinary approaches and thus a clear understanding of all the methods used, and their potential bias toward certain value systems is necessary.

In the next section we describe a representative example of the different disciplines and methods used in the different Case studies. At the start, a great variety of methods and tools were identified to support the design, operation and monitoring of natural assurance schemes and specific activities associated to DRR and the planning phases. These tasks were performed by a NAS case study team, composed of different experts, decision makers and in some instances the stakeholders themselves. Depending on the case study context, specific NBS purposes and local conditions, each case study team co-defined the models, methods and tools to be used for each activity. It is therefore important to highlight that the participatory or collaborative modelling approaches and methodologies used, conform a Natural assurance toolbox. It was then up to each case study to decide which combination of tools, methods and approaches to use in each activity.

The disciplines included in the natural assurance Case studies are broadly categorized into three assessment pillars (biophysical, economic and social) and the integration consists of:

Geography	Economy
Ecohydrology	Decision sciences
Hydrology and hydraulics	Sociology
Civil engineering	Political sciences
Safety and reliability analysis	Climate science

Most Case studies made use of hydrological and hydro-dynamic modelling to assess the biophysical system. In Lez, Lodz, Lower Danube and Copenhagen Case studies the modelling was combined with the collection and use of spatial data (*see Chap. 14, Le Coent et al., Chap. 10 Scrieciu, and Chap. 17, Jørgensen et al., this* *volume*). The Eco-Actuary tool was used for monitoring and modelling ecosystem services in Lower Danube and Copenhagen Case studies (*see Chap. 4 and Chap. 12 Mulligan et al, and Chap. 10 Scrieciu, and Jørgensen et al., this volume*). Other Case studies like Brague, made use of a wide variety of biophysical modelling tools: numerical modelling, hydraulics and wildfire modelling, in combination with hydrological and hydro-dynamic modelling (*see Chap. 13 Piton et al., this volume*). Decision-making methods and safety reliability approaches were used to design a framework for NBS' effectiveness assessment. A whole chain ranging from NBS' physical to economic features has been proposed providing results through a pluri-disciplinary cost-effect-consequence analysis.

In terms of economics and decision sciences, cost-benefit analysis and to a lesser extent multi-criteria decision analysis are the predominant methods used to develop Natural Assurance Schemes. NAS Case studies with a higher advanced Technology Readiness Levels (TRL) such as Medina del Campo and Rotterdam were able to advance further the five business cases; going beyond the economic business case towards the financial and commercial business cases. In specifics, both Case studies applied the NAS canvas to develop the business model (i.e. commercial business case). Rotterdam also applied the participatory value evaluation (i.e. participatory budgeting) to refine Life Cycle Costs (LCC) calculations. Finally, both applied the FFWS to develop suitable implementation arrangements (i.e. funding, financing and procurement) (*see Chap. 8 Mayor et al., Chap. 9 Altamirano el al. and Chap. 16 Dartee, this volume*). Other Case studies with a lower TRL like Lez and Thames also applied LCC (*see Chap. 14 Le Coent et al. and Chap. 12 Mulligan, this volume*).

Finally, all Case studies used methods and tools for involving decision makers and/or stakeholder in the different modelling and planning activities. Participatory modelling was used in all Case studies except for Lez, which used a participatory scenario planning method. In the Thames Case study, participatory monitoring was also used to obtain data for the development of Eco-Actuary (*see Chap. 4 Mulligan et al., this volume*).

In sum, participatory modelling including some monitoring was widely spread throughout all Case studies and in all planning phases. The study shows that those Case studies that focused primarily in the first planning phases of designing a natural assurance scheme, spend considerable time and efforts modelling the biophysical system. For strategy building, most Case studies made use of multi-criteria decision analysis and cost-benefit analysis, which both helped decision makers and stakeholders to define possible measures and build strategies. Action planning, however, requires additional methods and tools that relate to business models and implementation arrangements that define funding and financing strategies. It can be observed that these implementation arrangements require a high level of TRL, such as the Medina del Campo and Rotterdam Case studies.

Figure 7.6 provides an overview of the various disciplines and methods applied in natural assurance Case studies. An exemplary case of the application of the strategic planning framework and the use of models and tools for the case of Medina is presented in the next section.

7.4 Lessons Learned and Recommendations

Showcasing how to manage water-related risk with strategies mostly relying on NBS is a key objective of natural assurance schemes in the nine Case studies located across all Europe (*detailed in Chap. 2, this volume*). NBS are potentially powerful measures to use because these solutions provide multiple benefits, risk mitigation being only one of them. Each Case study site being peculiar and given the variety in scales from cities to entire catchments, there is not a one-NBS-strategy-fit-all. To identify which NBS strategy fits a given site, is a complex and often iterative process, involving multiple actors. To help guide this process, we propose the structure of strategic planning containing several standard steps well known by planning experts. These steps are not to be taken as a strict and sequential structure for the planning and design of NAS, but as a comprehensive recipe of elements needed to gain the necessary information and support to identify and implement NAS. As such, the proposed framework is applicable to different contexts across the globe. Importantly, the choice of methods and tools to support the decision process needs to be tailored to the capacity, needs and (political and other) preferences in a given context.

Whereas the multiple benefits related to NBS strategies provide an advantage over conventional or “grey” strategies, the drawbacks of NBS are their intrinsic uncertainty, difficulties in measuring the co-benefits and explicit role for a broader range of stakeholders. However, engaging all relevant partners is necessary and the use of multiple and transdisciplinary knowledge proves to be more efficient in the long run than top-down approaches tailored by experts who may miss key concerns of particular stakeholder groups. In addition, specific attention must be paid to checking that required functions for NBS are fulfilled: to reduce risk, physical effectiveness is the first mandatory objective to reach. In most cases, NBS will be used in combination with others more classical “grey” techniques within hybrid strategies. For the design of natural assurance schemes, participatory approaches from the water resources management field, need to be merged with approaches coming from the risk reduction community and the climate change adaptation community.

Among the key success factors for the natural assurance schemes in the Case studies discussed here, we found (Fig. 7.6):

- Alignment of key stakeholders and their objectives must be crystal clear;
- Project boundaries and responsibilities of partners must be stated;

Commitment of key stakeholders (champions and personal ambition).

Efforts to meet these success factors or facilitate their emergence in early stages of the decision process, will increase the projects’ likelihood to go to full implementation. And whereas their absence might not impede a project to go ahead initially, our experience is that it will slow down full implementation or emerge at a later stage.

Our results also point to some important implications for NBS uptake. For one, we saw that decision support models and tools were only marginally used during the planning and implementation process in the case studies. Findings suggest that for

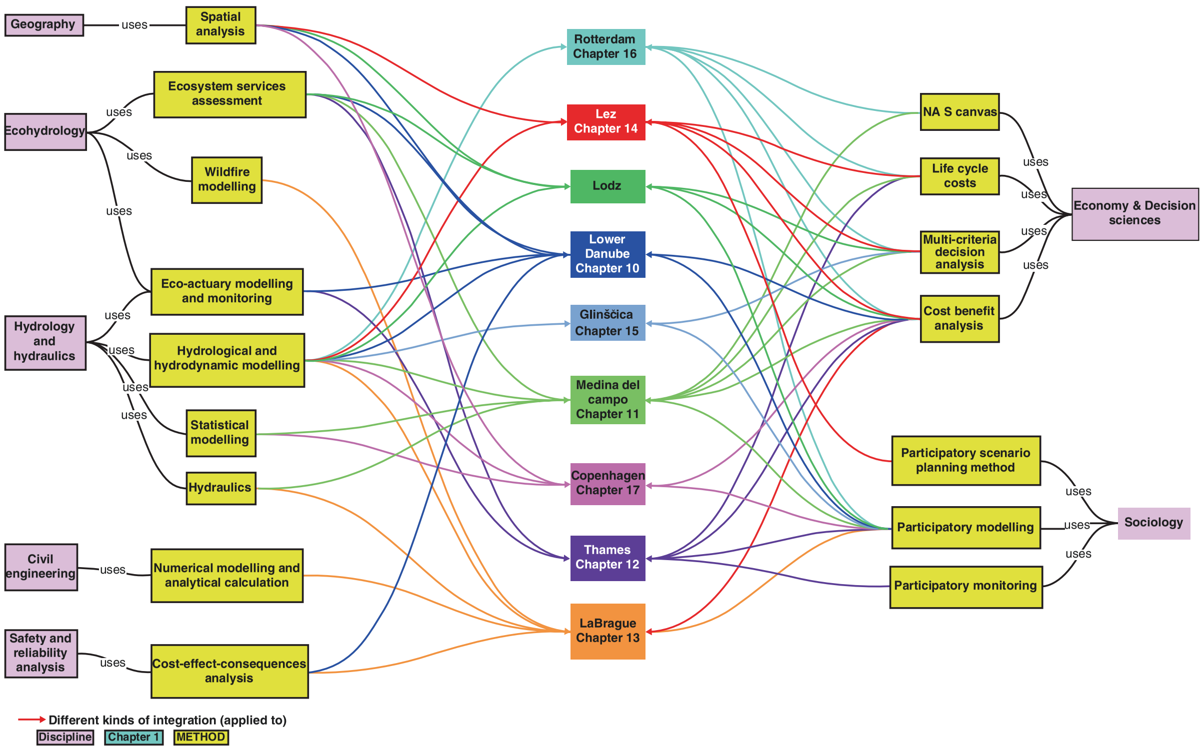

Fig. 7.6 Overview of the integration of disciplines and methods used in the natural assurance Case studies Thirdly, when an important (dis-)benefit of a NBS strategy is identified, be it a co-benefit or the main benefit – which is a matter of perspective –a rigorous assessment should be performed regarding the related improvement or alteration (dis-benefit). In our experience, this might require advanced models or extensive surveys. The experts applying these methods should then tailor the communication of results to the audience: with higher levels of detail for other experts and targeted stakeholders and in a more educational way with simpler indicators for other stakeholders. In the Brague case study (Chap. 13, this volume) for instance, the engagement and support of the French Water Agency, which is key for funding, was conditional to the outlook on a significant improvement of the river's ecological status

NBS uptake it is far more important to have willingness and commitment from the key stakeholders. Nevertheless, the need for evidence might arise towards upscaling, calling for support by above mentioned methods and tools. In our experience, when used, these tools were considered useful by the stakeholders involved.

Secondly, we found that co-benefits can be a driver for success when the funding is available, a clear owner of the NBS project exists and there is a concretized level of service. In the case of Rotterdam, the case study which was the most advanced has been fully implemented, the NBS' ability to generate cheaper water supply for the sport arena nearby, leveraged the needed support for funding and ownership, with flood reduction and recreational value as co-benefits functioning as leverage for the willingness and acceptability of the project by other stakeholders. In cases where the added value of the NBS is not clearly linked to an existing operator (entity that directly receives the benefits and can take care of the Operation and Maintenance of NBS to deliver the agreed service), co-benefits might have to play a stronger role and it remains a question whether these co-benefits can do that. In all case studies where full cost-benefit analysis could be performed, co-benefits, i.e., all benefits other than risk reduction, outnumber in value the mere avoided damages. Thus, co-benefits might weigh more than risk reduction in the final decision balance. It is therefore worth paying attention to co-benefits, involving stakeholders willing to optimize the strategy to increase co-benefits while still meeting the risk reduction objectives. Natural assurance schemes as previously defined, based on our case study learning would therefore benefit from incorporating both the risk reduction element as well as the co-benefits identification through co-design, as key elements for success (*see Sect. 7.1 on the conceptual framing*).

Despite the low TRL level of this case study and the project being at its starting phase, an advanced eco-hydrological assessment was performed to assess how various strategies improve or alter the functionality, artificiality and adjustments of the river hydrology and morphology. The assessments were then aggregated in a unique indicator, the Morphological Quality Index (MQI) (Rinaldi et al. 2013), ranging between 0 (river totally altered) and 1 (fully natural river). While the French Water Agency was interested in the details, the mere improvement in MQI score was also helping other stakeholders understand where particular strategies were better than others regarding the environmental perspective. Indicators such as MQI can ultimately be used by decision makers in multi-criteria decision-making methods, after weighting of criteria, to trace and explain how decisions were taken. Transparency in these decision phases helps finding and maintaining the engagement of stakeholders (and potential future support).

Finally, we made several observations on the aspect of integration that underlies successful planning and implementation of NBS. Case study analysis shows a reality where objectives and related indicators are driven by sectoral interests. This makes that what is defined as a benefit or co-benefit depends on the viewpoint of the stakeholders involved. In the Rotterdam case, the decision-making on the NBS was defined by the leading organization (related to mandate and funding) and the clear risk/benefit cycle (involving the Evides water company and Sparta football club stadium) proved crucial to facilitate that decision-making (see point above). The case shows that institutional coordination is a key barrier to implementation (and that this is happening even within the municipality). Finally, we observed that in order to mainstream the NBS, evidence of performance across (co) benefits is needed. However, little to no monitoring incentives or interest exists. Learning across different NAS and mainstreaming of NBS in NAS requires considering financial feasibility, the soundness of economic incentives as well as monitoring and evaluation from the start of a project.

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