Governance - Knowledge context

Governance - Knowledge context

Building with Nature is a knowledge-intensive practice. Water infrastructure is a tailor-made product that requires engineering expertise; and part of this expertise is still under development. All web pages of the BwN guideline outside of this governance section are meant to provide the new knowledge that is required for BwN projects. This governance subsection addresses the special governance challenges that are connected with working in an innovative and knowledge-intensive domain.

This chapter deals with knowledge issues in decision-making processes in general and specifically for BwN projects. BwN is an innovation on the brink of a break-through. Can an innovation process be managed, and if yes, how? It is helpful to know how innovation processes generally proceed and what factors can make the difference between a 'dead end' and a successful breakthrough of technology.

>> Read more

BwN involves integration of different disciplinary domains, for instance morphology, hydrology, physics, ecology, technical sciences, social sciences. What challenges are resulting from such interdisciplinary projects?

BwN projects require interaction with policy makers and other stakeholders. Conflicts of interests and misunderstandings can get easily out of hand. The use of technologies which still are under development cause uncertainties in BwN projects. Although project management will always be complex and in part unpredictable, guidance is provided how to understand and deal with these issues.

The present section addresses the following questions:

- How to manage innovation?
- How to integrate knowledge domains?
- What is the role of knowledge in decision making?
- How to deal with uncertainties?

The section Examples illustrates how a project developer can handle knowledge and uncertainty issues in BwN-type projects, using the Sand Engine project case study as a concrete example where several aspects of these knowledge and uncertainty considerations have been tested. Finally, under References information can be found for further reading.

5 Basic steps towards Building with Nature

Tools

Identification of ecological and socio-economic components - EcoMindmap

System Analysis

Valuation of risks and opportunities in BwN

Visualising and managing uncertainties

Projects

Governance for sustainability - Øresund Fixed Link (DK)

Knowledge - Adaptive Management Strategy

Knowledge - Systems Thinking

Adaptive Management - Melbourne Port Extension, AUS

Sand nourishment - Sand Engine Delfland, North Sea, NL

Knowledge, innovation and public policy

Knowledge can be functional in several ways. It is used to get the content right and it provides substantiation for legal procedures. Furthermore, knowledge can contribute to build up support for a project among actors and stakeholders and other parties involved (van Buuren et al, 2010). Knowledge plays an important role in different project phases. It provides a basis for:

- problem identification;
- master planning and project initiation;
- developing innovative solutions;
- developing design and planning alternatives;
- assessing designs and plans;
- project execution;
- sustainable and adaptive project operation and maintenance;
- environmentally friendly decommissioning of the project.

Integrating different knowledge domains in BwN projects

In BwN projects, multiple functions are combined into one design: nature is integrated with infrastructural goals. This ‘functional integration’ is mentioned in policy documents and managements plans, but in practice implementation proves to be problematic and runs into barriers. Barriers originate among others from the fragmentation of policy fields. The field of water policy in the Netherlands, for instance, is historically an autonomous and isolated field, which complicates integration (Wiering and Arts, 2006). The challenge of BwN projects is realising functional integration in practice.

A further challenge in BwN projects is to deal with fragmented knowledge in decision making. Knowledge is often assumed to be inherently linked to a specific policy field. Consequently, functional integration requires integrating different knowledge domains. The relation between policy fields and knowledge, also known as a ‘knowledge arrangement’, is often neglected, although its relevance is clear. In functional integration the confrontation of multiple knowledge arrangements needs to be steered towards an integrated BwN design.

Guidance

BwN-type projects often involve larger spatial scales and longer time horizons than conventional ones and hence, also more and possibly larger knowledge-related uncertainties and ambiguity.

The Guidance section addresses the following questions:

a) How to manage an innovation process?

b) How to manage interdisciplinary knowledge in BwN projects?

c) What to expect from knowledge in decision making processes?;

d) How to deal with uncertainties in a BwN project?

a) How to manage an innovation process?

Knowledge is an important driver of innovation processes such as BwN. Insights form innovation studies can help to place the use of knowledge in BwN development in an economic perspective. Key aspects in managing innovation processes are

- identifying the level of development
- organising the innovation process
- spreading the news about innovations
- steps to be taken in an innovation process

>> Read more

Technological Readiness Levels

BwN is a technology under development, and an innovation on the verge of a breakthrough. Many customers will prefer a technology that has proven itself. If a technology is new they will want to know exactly how new or how risky it is. The EU H2020 programme uses Technology Readiness Levels (TRLs) as indicators of the maturity of technologies. This indicator provides a common understanding of technology status and addresses the entire innovation chain. BwN technologies are often in the higher levels of this scale: TRL 6 and higher.

Technological Readiness Levels

TRL 1 – basic principles observed

TRL 2 – technology concept formulated

TRL 3 – experimental proof of concept

TRL 4 – technology validated in lab

TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)

TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)

TRL 7 – system prototype demonstration in operational environment

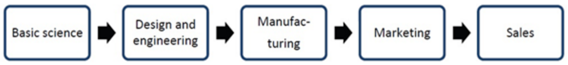
TRL 8 – system complete and qualified

TRL 9 – actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

https://ec.europa.eu/research/participants/portal/desktop/en/support/faqs/faq-2890.html

Organising the innovation process

Schumpeter was the first economist to identify innovation as an economic process. According to Schumpeter (1911) an innovator is an entrepreneur who is interested in creating something new that will improve the society he lives in. With an innovation the entrepreneur is able to gain a higher profit than the average producer. However, others will imitate a successful innovation soon, and only with repeated innovations the technological entrepreneur will be able to keep up the higher margin.

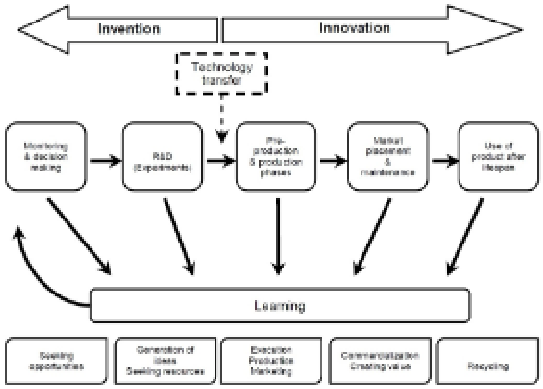


Technological push model

Theoretical models of innovation became more complex over time (Rothwell, 1992; Rothwell, 1994). Early models of how innovation takes place show a linear process: the technological push model.

Later models include market pull factors such as market needs, customer satisfaction, and risk analysis. In this model innovation does not start in the head of the entrepreneur, but in the market itself. Marketeers collect information about customer needs which can then be processed by designers. For an example see the innovation process model from Žižlavsky. In this model an invention is distinguished from an innovation: an invention is a new idea, a scientific discovery or a new technology, while an innovation is an invention that is integrated into economic and social practice (Diaconu, 2011; Žižlavsky, 2013). The model still shows the boxes from the previous models (from technology development to marketing) but has expanded this with things like learning and recycling.

Today consumers have gained more power through public product reviews. Producers have increasingly opened up to direct contact with customers. The newest model for innovation, therefore, is co-creation, in which customers are actively involved in the development of new products. See for example the coloured figure in which the technology has moved out of focus entirely.

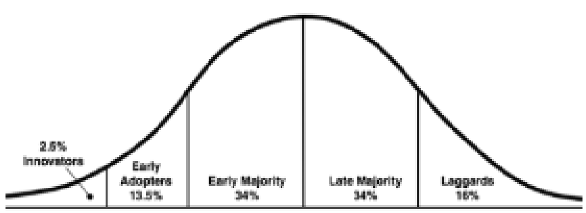


source: Žižlavsky, 2013

source: http://www.jijiplan.com/t/design-thinking-for-collaborative-city-innovation/164

Diffusion of innovations

The Diffusion of Innovations theory of E. M. Rogers (1962) explains how new ideas are adopted in a society. Not everyone responds the same to a new technology. Depending on personal characteristics people can be innovators, early adopters, early majority, late majority or laggards (see figure). BwN communications need to aim at innovators, early adopters or the early majority, depending on the Technological Readiness Level of a specific BwN technology.



source: E.M. Rogers (1962)

>> Read more

Categories of adopter groups and how they respond to innovations.

- Innovators - Innovators want to be the first to try an innovation. They are venturesome and are willing to take risks. They often develop new ideas themselves. Very little needs to be done to appeal to this population, apart from arguing that something is an inovation.

- Early Adopters - These are opinion leaders. They enjoy leadership roles, and embrace new opportunities. They are aware of the need to change and are comfortable with adopting new ideas. Strategies to appeal to this population include how-to manuals and information sheets on implementation. They do not need information to convince them to change.
- Early Majority - These people are rarely leaders, but they do adopt new ideas before the average person. They need evidence that the innovation works before they are willing to adopt it. Strategies to appeal to this population include success stories and evidence of the innovation's effectiveness.
- Late Majority - These people are skeptical of change, and will only adopt an innovation after it has been tried by the majority. Strategies to appeal to this population include information on how many other people have tried the innovation and have adopted it successfully.
- Laggards - These people are bound by tradition and very conservative. They are very skeptical of change and are the hardest group to bring on board. Strategies to appeal to this population include statistics, fear appeals, and pressure from people in the other adopter groups.

Of course a person can belong in one adopter group for one type of product, and in another adopter group for another type of product, depending on personal preferences and expertise.

For a BwN-er the message of these innovation models and theories is that innovation is not just about optimizing a technology, but also about understanding the market and about close contact with customers. Innovation can even be seen as a complex system requiring interactions with customers, suppliers, traders, competitors and various other public and private organizations.

Ingredients for successful innovation:

• A technological entrepreneur with a visionary idea based upon technical knowledge

• Exploring market opportunities for new/improved products and services

• Scientific and technological expertise for development and production engineering

• Targeting of different customer types based on the technological readyness level

• Innovation of production techniques, learning by doing.

• Learning by using and knowledge of customer perceptions for continous innovation

Innovation is not a linear process and successes are hard to predict. Even when a product is technically perfect, there is no guarantee that it is accepted by customers (Žižlavsky, 2013) Innovations also go through drastic changes in their lifetimes (Diaconu, 2011).

b) How to manage interdisciplinary knowledge in BwN projects?

The strategies for the use of knowledge in BwN projects are based on the assumption that knowledge related to different policy fields needs to be integrated. Knowledge is assumed to be inherently related to a particular policy field, which is called a ‘knowledge arrangement’: actors, discourse, rules, regulations and resources affect the process of knowledge structuring and the other way around. This leads to knowledge arrangements with different perspectives, concepts and priorities.

>> Read more

> Example of policy fields with different perspectives: the nature sector and the water sector both use the concept of ‘robustness’. For ecologists, robustness means a large nature area with a high biodiversity which is robust to disturbances. In the water sector robustness means a water body with few sensitive species so that the water body does not need too much maintenance (Veraart, 2016).

Knowledge arrangements are confronted with each other and interact in BwN projects. The strategy for using knowledge in BwN projects relates to this confrontation and interaction among knowledge arrangements. In the next section the ensuing enabling and constraining factors for realising a BwN design are identified.

>> Read more

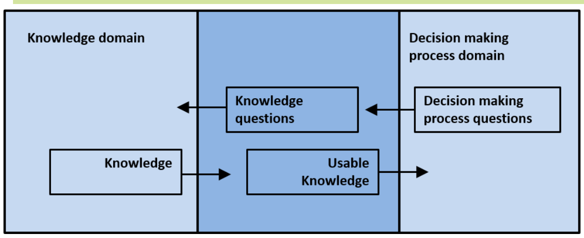
Enabling and constraining factors for interdisciplinary work

Using knowledge from different policy fields requires bridging activities. While activities bridging boundaries between policy fields can help (enabling factors), they can also have an adverse effect by emphasizing existing boundaries (constraining factors). Demarcation of existing boundaries will not result in an integrated design. Inspired by the policy arrangement approach, the enabling and constraining factors are shown in the table below.

	Enabling factors	Constraining factors
Actors	Make all stakeholders part of the bridging efforts in your project to (1) gain support for the knowledge built up and (2) to ensure an integrated approach. This requires a project architecture in which all stakeholders are involved. Stakeholders should together determine the type of knowledge to develop, assess the knowledge developed and determine the use of the knowledge. It is important that stakeholders from different policy fields are represented in this process.	*Mono-disciplinary meetings* will confirm traditional knowledge structuring. Experts will not be challenged to work in an integrated way. *Organisation of a project within one policy field:* striving for integration will be more difficult when only one policy field is involved. For example, having only water authorities in a flood defence project will constrain the development of a BwN design.
Rules and regulations	In the phase of pilot projects, find a location where the most burdensome rules and regulations are not applicable. Integrating such rules and regulations (specifically formal rules such as laws or policy documents) may be unachievable within the time span of a pilot project. Choosing a location where such rules and regulations do not apply may overcome this barrier for the time being. The Sand Engine pilot, for instance, was located outside the adjacent Natura 2000 site and furthermore it had no urgent safety target. For BwN to be truly meaningful in coastal protection, ways have to be found to combine rules and regulations from different policy fields. After pilot projects have proven their value, the barriers posed by existing regulations need to be assessed and adaptations to regulation proposed to make BwN solutions applicable more easily. For example, next to a formal guideline to assess the safety of artificial dikes, similar calculation methods need to be available to assess the safety of more natural solutions and for multifunctional constructions. For dunes such a method is available here (in Dutch).	*Separate functionalities*: rules and regulations may be directed to only one functionality. This will not support a BwN-design, the value of which is in the combination of functionalities. *Separate targets*: a BwN-design will be more difficult to realise when for each functionality strict targets are defined. In such a situation there is no room for negotiation and balancing, while the question always arises which functionality has priority.

Resources	Use financial resources from all relevant policy fields to realise the BwN project. This causes interdependency which serves as an incentive to combine goals from each policy field in the project. Apply (external or new) resources from which all policy fields involved benefit. In the Sand Engine project, for instance, an extension of the morphological model, the beach dune module, combined the nature and coastal protection domains.	*Separate resources*: if resources are separated by functionality, an integrated BwN-design becomes difficult to realise.
Discourse	Identify or develop a discourse that reflects to the various policy fields. The 'building with nature' discourse on the Sand Engine linked in to both the nature and coastal defence policy field. A discourse on coastal flood protection measures only is likely to be less interesting for the nature policy field.	*Unbalanced discourse*: if in the discourse around a project one policy field prevails, an integrated multi-functional BwN-design will be more difficult to achieve. If a project discourse is strongly biased to nature development, for instance, infrastructural goals will be difficult to integrate.

c) What to expect from knowledge in decision making processes



Conceptualisation of the knowledge-policy-interface

adapted after Turnhout (2007)

Knowledge use within projects results from interaction between the knowledge domain and the policy domain. This interaction results in context-specific knowledge ((Koppenjan and Klijn, 2004, In 't Veld 2000, Turnhout 2007). The figure represents a conceptualisation of this interface.

This section deals with

- the knowledge perception, **>>** Read more
- the knowledge opportunities **>>** Read more and
- the knowledge pitfalls in decision making **>>** Read more

Knowledge perception in decision making

Traditional perspective on knowledge in decision making

Issues on the political and societal agenda are thoroughly analysed and subsequently the best solution is chosen.

Contemporary perspective

In contemporary decision making facts and knowledge are questioned constantly. A market in demand and supply of knowledge emerged.

Different interpretations of knowledge emerge due to different perceptions by stakeholders, which can result in ambiguity. Each stakeholder may prefer a specific field of knowledge, methodology or research to be used. An environmental NGO, for instance, will be specifically concerned with effects on the ecosystem, while a flood authority may rather be concerned with the probability of flooding. Different parties may therefore value knowledge in a different way. Furthermore, tensions can emerge between different sources of knowledge. Some parties may prefer scientific or expert knowledge, developed by scientists and practitioners who strive for its general applicability and objectivity. On the other hand there is practical or lay knowledge, typically owned by local parties and based on experiences and local observations (Van Buuren et al, 2010; Hommes, 2008, Eshuis and Stuiver, 2005). Lastly, different disciplines may have different perceptions of knowledge. Research methods differ greatly between natural sciences and social sciences, for instance. The case study methodology, very common in social sciences, may not always align with the natural science approach of experimenting. The interaction between different disciplines is particularly relevant to Building with Nature projects, which strive for integration of functions. This includes opportunities, but also pitfalls, as discussed below.

Knowledge opportunities for decision making

Use of knowledge in BwN projects offers the following opportunities:

- Knowledge use leads to evidence based policy making and thus to effective solutions.

- Knowledge can lead to innovations which can be sold and implemented elsewhere.

- Social science can help to sort out conflicts.

The following strategies for realising these opportunities of knowledge in decision making are identified.

- Towards trusted knowledge
  Acquiring useful knowledge for decision making requires both acceptance and quality of that knowledge. For the acceptance of facts, a certain level of trust in the messenger (e.g. the scientist) is needed. For building trust the different actors need to meet and experience the process of project development together.

- Learning
  Learning among actors is an important tool in overcoming different perceptions of knowledge. Two types of learning are distinguished: cognitive and strategic.

  a. Cognitive learning is about nature, causes and effects of the problem, its possible solutions and their consequences.
  b. Strategic learning relates to “the parties’ consciousness of each other’s involvement and mutual dependencies” (Koppenjan and Klijn, 2004).

  Cognitive and strategic learning are both needed to create a shared knowledge base (Hommes, 2008).

Joint fact Finding

Joint fact finding is a cooperative effort of different actors to gather information and engage in scientific analysis. The method aims at preventing a difference in opinion regarding the facts. Thus joint fact finding helps in consensus building. Experiences with joint fact finding indicate that this stimulates individual and organisational competences and sometimes leads to new coalitions and new processes. **>>** Read more on Joint Fact Finding and data mediation.

Joint Fact-Finding and Data Mediation

In disputes experts often reach very different and apparently contradictory conclusions. Here joint fact-finding can make an important contribution. This technique uses consensus building to help the experts resolve their disagreements over the technical facts. Because findings are jointly developed, the outcomes are likely to be more credible, useful, and durable.

In joint fact-finding, the experts and the constituency groups implement a joint strategy for answering the key policy questions, based upon generally agreed-upon scientific methods. It is commonly understood that the experts do not have to reach agreement on every issue. Their primary goal is to clearly separate the issues upon which they can agree from those which are still subject to debate and then report their findings to the parties. Here it is important for the experts to explain their findings in ways which non-experts can understand.

Points of agreement can then provide the parties with a more informed basis for resolving the dispute. Points of continuing debate, however, will require the parties to employ strategies for dealing with uncertainty. The goal is to use areas of technical consensus to eliminate options which clearly do not advance the parties interest, and then use strategies for dealing with uncertainty to approach the remaining technical issues.

While this can often be very useful, there are limitations on how much research is appropriate. In many cases, the benefits of better information are outweighed by costs and delays associated with further fact-finding. There are also cases in which further fact finding is unlikely to be helpful, no matter how much time and money is spent. This is because the technical problem may be so difficult that experts cannot hope to find the answer.

Joint Fact Finding collaborations tend to follow a series of stages. They vary in length, but the sequence usually proceeds as follows:

1. Start. A convener appraises the situation and, if the timing and politics seem right for a focused joint fact finding effort, will discuss the idea with other partners, assign a staff member to explore it, or retain a facilitator to help assess the viability of initiating a process. Professional, neutral facilitators can help even at this initial stage by conducting a situation or conflict assessment and designing the sequence of steps needed to complete the JFF process.
2. Scope. An independent facilitator may begin by conducting a series of exploratory interviews to gather disparate views, help further define the issues, and begin to identify appropriate individuals to sit as members of the JFF working group.
3. Plan. Based on interviews, the facilitator or project manager will lay the specific groundwork for the coming conversation. This requires the recruitment and selection of JFF participants (which also can be done by or with a steering committee). This stage usually also involves the development of:
   - conflict-ofinterest forms;
   - a draft “charter” or terms-of-reference document;
   - a website for the posting of documents;
   - a proposed schedule of meetings;
   - and, in many cases, a design for meetings that invite public participation.
4. Convene. The conveners, sponsors and political leaders who have lent their names and support often start initial meetings. They may share expectations and urge JFF group members to engage their task with the highest possible degree of cooperation. Beyond that, the first part of an initial meeting is usually devoted to organisational matters and the second part to a preliminary pass at exchanging views on the topic.
5. Research and deliberate. This phase will often run over multiple sessions. The heart of JFF requires formulating and prioritising more detailed questions, exchanging information sources, bringing salient data and evidence to the table, and weighing and deliberating on that information. Some of the specifics may include working with experts to define or sharpen the questions, preparing research agendas, and assessing data collection needs. The process carves out key technical and scientific questions that are often at the heart of a controversy and maps areas of factual agreement that all parties can respect. Often, this process illuminates the reasons for disagreement and puts those areas in a proper context, thus helping to build a platform for policy agreement.
6. Align. JFF groups must eventually reach agreements and, pursuant to their charge, formulate pertinent recommendations. Reaching agreements, even if there are dissenting voices, is not always easy; however, the process is always tied to the ground rules for decision making as spelled out in the agreed--upon charter or terms--of--reference document.
7. Produce. Once aligned, JFF groups must then memorialise the work that has been done, along with their findings and their recommendations. Because wording matters, this often requires considerable editing and a series of final negotiations.
8. Deliver. At the end of the process, delivery and rollout may involve summary supplemental briefings to the project’s conveners and sponsors and, in some cases, meetings with other public officials. Honouring the work of the JFF participants and celebration are also an important part of project closure.

https://www.colorado.edu/conflict/peace/treatment/jfactf.htm

https://www.mediate.com/articles/AdlerJFF.cfm

Communities of Practice (CoP)

Experiences with BwN-related Communities of Practice lead to similar conclusions. In a CoP professionals can meet to learn about an issue together. A CoP is often created to elaborate an issue, to exchange knowledge and experiences in order to bring knowledge and expertise to broader acceptance. **>>** Read more on Communities of Practice

What is a Community of Practice?

Communities of Practice are groups of people who share a concern or a passion for something they do and who learn how to do it better as they interact regularly (Wenger, 2002). The members of a community deepen their knowledge and expertise in a particular area by interacting on an ongoing basis. Examples of Communities of Practice are a band of artists seeking new forms of expression or a group of engineers working on similar problems.

A Community of Practice can be characterised by three core dimensions: the domain, the community and the practice. If a group of people develops these three elements in parallel it constitutes a Community of Practice.

The domain

A Community of Practice is not merely a network of people. It has an identity defined by a shared domain of interest. Membership implies a commitment to the domain, and a shared competence that distinguishes its members from other people. A domain can be any kind of expertise like ‘tomato growing’, ‘urban planning’, ‘empowerment’ or ‘surviving on the street’.

The community

In pursuing their interest in a specific domain, the members of a CoP build relationships that enable them to learn from each other. They engage in joint activities and discussions, help each other, and share information. Members of a Community of Practice interact on a regular basis. The Impressionists, for instance, used to meet in cafes and studios to discuss the style of painting they were inventing together. These interactions were essential to create a Community of Practice, even though they often painted alone.

The practice

Members of a Community of Practice develop a shared practice. Together they create a repertoire of resources: methods, tools, experiences, stories, and ways of addressing recurring problems. This takes time and sustained interaction. Nurses who meet regularly in a hospital cafeteria may not even realise that their lunch discussions are one of their main sources of knowledge about how to care for patients. In the course of all these conversations, they develop a set of stories and cases that become a shared repertoire for their practice.

The concept of community of practice has found a rich and growing number of practical applications in business, organisational design, government, education, development projects, professional associations, and civic life.

Knowledge pitfalls for decision making

The following pitfalls are commonly observed when applying knowledge in decision making processes:

- A ‘reports war’ or ‘dialogues of the deaf’
  A reports war may emerge when multiple parties or coalitions disagree on the knowledge base. Parties try to convince each other by means of producing additional reports with knowledge which proves they are right. Knowledge is used here as ammunition. This approach usually does not lead to agreement among parties, but rather to many useless, one-sided reports.

- Negotiated nonsense
  Negotiated nonsense can be the outcome of a decision-making process emphasizing agreement among the parties without paying due attention to the quality and scientific relevance of the content. As a result the proposed solution may not be effective.

- Superfluous knowledge
  The decision makers or the stakeholders try to postpone the decision by asking for more knowledge. The new knowledge does not bring a decision nearer because the people involved only wanted to buy time with it. The solution is to find out what the real issues of the opponents are.

d) How to deal with uncertainties in a BwN project?

- What is uncertainty? **>>** Read more

Uncertainty refers to an incomplete and unclear understanding of the system to be managed (Brugnach et al., 2008). More conservative scientific interpretations of uncertainty state that it relates to missing insights and facts concerning choices and their effects. Irrespective of its nature or magnitude, uncertainty can become an issue of concern if it jeopardises the success of an initiative.

BwN-type projects have to deal with high levels of uncertainty. Firstly, no complete knowledge exists regarding the behaviour of the natural system considered. Secondly, BwN involves larger and more variable spatial and temporal scales as compared with traditional "hard" engineering projects. Thirdly, BwN requires an interdisciplinary approach, which implies that many phenomena and their mutual interactions, each inherently uncertain, need to be taken into account. Finally, uncertain contextual factors such as climate and weather conditions are 'driving forces' of BwN and are of paramount importance.

It makes no sense to deny these uncertainties, as they are inherent to the system and to BwN. It is better to deal with them by, for instance, considering different scenarios and introducing flexibility in the chosen solutions.

Not every uncertainty can be reduced by additional research. Some of the contextual factors, including human behaviour, are unpredictable. Modeling, though easily disputed, can support decision making, e.g. by exploring scenarios and uncertainty ranges.

Many decision makers do not like uncertainty, but they will accept uncertain information as long as the process remains manageable. Certainty has to be provided that, if things take an unexpected turn, measures can be reversed, or at least controlled through adaptive management.

- What is ambiguity? **>>** Read more

In the literature, ambiguity is considered as a special type of uncertainty. It refers to a lack of clarity what the problem is and how it should be solved, due to the presence of multiple, equally valid knowledge frames (Dewulf et al., 2005; Brugnach et al., 2011; Brugnach and Ingram, 2012). As a consequence, multiple approaches and interpretations are promoted, and there are no criteria to distinguish between more and less valid interpretations of facts. In such situations, it is tempting for actors in the power game to question facts and knowledge, and to produce rivalry facts and knowledge. Stakeholders can hire their suppliers of knowledge to deliver knowledge that is gathered from their preferred perspective. Rivalry between governmental institutions sometimes also leads to a 'reports war' or 'dialogue of the deaf'.

Additional research usually cannot solve ambiguity. Mutual understanding is improved by dialogue and negotiation, and not by additional facts. Ambiguity can be an even more important issue for BwN than incomplete knowledge.

- Three types of scientific uncertainty **>>** Read more

Following the definition of uncertainty provided above, a distinction is made between three types of uncertainty (Brugnach et al., 2008):

- **Unpredictability** – uncertainty due to unpredictable or chaotic behaviour of e.g. natural processes, human beings or social processes;
- **Incomplete knowledge** – uncertainty due to the imperfection of available knowledge, e.g. due to lack of specific knowledge, data imprecision or approximations;
- **Multiple knowledge frames** – uncertainty due to the presence of multiple knowledge frames or different but (equally) valid interpretations of the same phenomenon, problem or situation. The presence of multiple knowledge frames causes ambiguity.

When identifying the most important uncertainties in a BwN project's development process, actors need to focus on the most important factors. These are the factors that can seriously hamper development, cause budget overruns or retrenchment, influence milestone decisions or even cause the cancellation of the entire project ("showstoppers"). Uncertainties in a project using BwN design principles are numerous, an inherent characteristic of this type of projects. Therefore, one should not be distracted by the many smaller issues, but focus on those uncertain factors that may become a major concern.

Beware that there is a difference between "true" uncertainty and perceived uncertainty. Some factors are "truly" uncertain, for instance because there is insufficient knowledge available. Other issues, however, can be perceived as uncertain by some actors, while there actually is sufficient knowledge available. Yet, both "true" and perceived uncertainties have the ability to influence project developments and are therefore equally relevant. Perceived uncertainty may be an ambiguity (e.g., different views about the level of certainty of a particular factor).

- Uncertainty identification: which uncertainties are most important? **>>** Read more

Uncertainty has a meaning in policy development which goes beyond the classical scientific definition that uncertainty is just a 'deficit of knowledge'. In policy development, there are many stakeholders and actors, each with different backgrounds, values and beliefs. Therefore, multiple interpretations of an (uncertain) phenomenon are possible. As a consequence, ambiguity is often the most important type of uncertainty in BwN projects. More specifically, uncertainty becomes meaningful in policy development through its financial and social implications (e.g., swimmer safety around the Sand Engine). These are far more important than the unpredictability of weather conditions or a lack of knowledge concerning the behaviour of natural systems. BwN concerns projects with unclear temporal and spatial scales. Therefore, it is also difficult to determine which actors have to be involved in the project development process. This, in turn, can yield uncertainties if parties feel ignored and start objecting against the project. In the study of uncertainties in BwN project governance, no evidence was found that their size is important. No clues were detected in either documents or interviews that there is something like a maximum acceptable deviation or uncertainty bandwidth. Uncertainties are important if they have a potential effect on the success of a project. So: size does not matter: it is the (potential) effect of the uncertainties that counts.

- Uncertainty management: how to cope with it? **>>** Read more

Managing uncertainty is of major importance to BwN projects. The following general rules have to be regarded when choosing a strategy for coping with a particular type of uncertainty:

- **Unpredictability** – The appropriate strategy direction is to **accept that we cannot know better**. An unpredictability cannot be reduced by doing more research due to its inherent nature;
- **Incomplete knowledge** – The appropriate strategy direction is to **work on extending and improving the relevant knowledge base**. If we know more, this type of uncertainty may be reduced. However, in projects with a long-term perspective, such as BwN-type projects, there is no guarantee, since effects may manifest only on the long run;
- **Multiple knowledge frames** – The appropriate strategy direction is to **deal with the existing differences**. In this case, additional knowledge does not solve the problem. Working to reach mutual understanding will help to eliminate ambiguity.

This is elaborated in further detail in the tool Visualising and managing uncertainty.

Actually, the attitude of people towards uncertainty and its acceptability needs to change in order to make BwN successful. People tend to prefer a command-and-control approach to water engineering, with hard structures such as dikes and dams, aiming at controlling the natural system and eliminating uncertainties. This suggests full predictability of the water system and a guaranteed future state of the system. However, water engineers know that the system they build is limited for economic reasons and the natural system is capable of extremes that go beyond that design.

Contrastingly, flexibility is an inherent characteristic of the BwN approach; this means that guarantees about the future state of the system involved cannot be given. Current policy practices cannot cope with high levels of uncertainty in projects / designs. One way to change this situation might be to increase the media exposure of BwN, so as to increase its visibility to the general public. Also, raising awareness of the problems associated with climate change may make the general public realise that the adaptability of BwN solutions may be a better way to cope with higher future unpredictability of the climate.

- **The role of additional research** - Further research, a traditional strategy to reduce uncertainty, generally does not have that role in BwN-type projects. Research results can still be used to explain BwN to relevant actors, but research is less appropriate to reduce uncertainty about the natural system and its behaviour.
  Example: Swimmer safety around the Sand Engine Delfland.
  Uncertainty is caused here by the fact that natural dynamics around the Sand Engine project are to a certain extent unpredictable. By definition, uncertainty due to unpredictability cannot be reduced by additional research. Yet, in the preparation process of the Sand Engine, an additional swimmer safety study was conducted. An implicit strategic goal of such a study may be to show the public that everything has been done to reduce uncertainty to a minimum.
- **The role of monitoring** – Monitoring of the (positive and negative) effects of a BwN solution after it has been realised can of course significantly reduce uncertainties and ambiguity. For this strategy the BwN developer first has to gain enough trust to realize the project. Promising to monitor effects and to pull the plug of a project if needed, can help in gaining more trust.
  Example: Drilling for gas in the Dutch Wadden Sea was a difficult topic for many years. Nature organisations feared soil subsidence which would result in drowning of Wadden nature. In the end it was negotiated that the subsidence effects would be monitored and if subsidence exceeded a certain level, gas exploitation would be stopped. https://www.rijksoverheid.nl/documenten/kamerstukken/2016/05/30/kamerbief-gas-en-zoutwinning-waddenzee-hand-aan-de-kraan-principe (in Dutch)

In the BwN projects analysed so far, ambiguity and social implications were found to be the most important uncertainties. This means that addressing the differences between the various actors and stakeholders offers perspectives for managing uncertainties in BwN projects. Participation and cooperation are keywords, negotiation and dialogue important tools.

Start managing uncertainty as early as possible in the project development process by stimulating participation and cooperation. This will prevent framing differences, and hence ambiguity. In the Sand Engine project, for instance, there was concern about the budget and whether dredging contractors would accept a relatively low price per m^3 of sand. This potential problem was successfully coped with by early involvement of market parties, in order to prevent problems in a later phase.

Uncertainty can be a powerful tool in project development. Project opponents can use "the presence of high levels of uncertainty", or a specific "uncertain, dangerous issue" to object against promising initiatives. They may mobilise politicians that share their ideas, like in the Sand Engine case on the issues of swimmer safety. Furthermore, other experts can come up with new facts to support their case (beware: these facts can be false or subjective, but they may just as well be true!). Be prepared to recognise and further identify these problems and invest in addressing them. Avoid getting into the spiral of a reports war. Some opponents may have become so upset that they are not interested in the facts anymore, but just want to stop the project. Instead, aim at reducing the feelings of distrust and insecurity by paying proper attention to people's concerns. Use stakeholder input as early as possible to prevent these adverse dynamics.

Lessons learned regarding uncertainties

BwN initiatives will benefit from the following lessons and best BwN practices:

1. Uncertainties occur in almost every phase, but their influence on policy development is mostly indirect. **>>** Read more

   Lesson 1:

   Uncertainties concerning the technical aspects of a project, the project's functionality and its effects on the ecosystem occur in almost every phase, but their influence on policy development is mostly indirect.

   In policy development the emphasis is on the social implications of these uncertainties. Uncertainties tend to differ between project phases. Uncertainty management in a project should take this into account.
2. BwN projects, having both longer temporal and larger spatial scales are usually not yet taken into account in the policy development process. **>>** Read more

   Lesson 2:

   BwN projects have both longer temporal and larger spatial scales than traditional water engineering projects. Analyses from a governance perspective indicate that these scale differences are not yet taken into account in the policy development process of BwN projects.

   Concerning uncertainty, focus among policy makers is on the short-term (disadvantageous) effects of the BwN projects, rather than on the long-term benefits. Short-term effects of the BwN project are inherently uncertain, meaning that it is 'unfair' to judge a BwN project on these characteristics only. Furthermore, communication should aim at increased understanding and negotiated acceptance of uncertainties in BwN water engineering projects.
3. A higher level of unpredictability requires a different approach to uncertainty. **>>** Read more

   Lesson 3:

   The higher level of unpredictability in BwN-type projects means that they require a different approach to uncertainty.

   Current policy practices, however, are not accustomed to accepting high levels of uncertainty in projects / designs. Consequently, current strategies of coping with uncertainty are not likely to fit dealing with uncertainty in BwN projects. 'Doing more research', the usual response to uncertainty, is not an effective way of coping with the inherent unpredictability in a BwN project. Yet, performing social scientific studies into peoples concerns and perceptions might be a powerful instrument to manage the uncertainty in the social system that is related to the unpredictability of the natural system.
4. Use the media to expose the general public to the BwN philosophy. **>>** Read more

Lesson 4:

Use the media to expose the general public to the BwN philosophy.

For instance, establishing a clear link between climate change and the potential of BwN to provide sustainable solutions may increase the awareness of the general public that BwN solutions are really needed in the future. Furthermore, keeping up the speed in the policy decision process of a BwN project can be a key strategy to prevent endless discussions about uncertainty. Stress that monitoring and feedback enable finetuning and adjustments, if necessary.

Practical applications - examples

Pilot Sand Engine Delfland

Sand engine located in front of the Delfland coast, August 2011

Building with Nature is a form of 'functional integration': combining nature and infrastructural goals in one design. The pilot Sand Engine Delfland is an example of a project (a dynamic, moving flood defence), in which multiple functions are combined: the projects aims at contributing to nature development, increased safety and recreation development. In 2011, this concentrated mega-nourishment was completed. From the perspective of knowledge arrangements, experiences are reported on

- **>>** enabling factors,
- **>>** constraining factors for functional integration,
- **>>** uncertainty identification
- **>>** uncertainty management.

Enabling factors

Actors and coalitions

- The composition of the project team contributed to an integral approach to the design. In the project team, relevant knowledge and information were considered from multiple perspectives: hydraulic engineering, coastal morphology and ecology. Documents such as the EIA report were available to the team and all parties involved had the opportunity to respond. This setting stimulated the learning process among disciplines and different perspectives (stakeholders). In the Sand Engine project team , discussions were held on what was regarded as 'knowledge' and what knowledge development methods were appropriate to be used in the further process.
- The organization of the design process contributed to an integral development of the Sand Engine. The four design alternatives that were assessed in the EIA report resulted from integral design workshops where experts as well as stakeholders cooperated. The interaction contributed to the learning process among people from different backgrounds and disciplines. As one of the morphologists stated: 'Here I began to understand how ecologists think'.
- The involvement of the Building with Nature innovation programme in the project team. Among other things, they contributed to development of a 'beach-dune module' for the morphological model, which enabled better predictions of more relevance to nature and recreational functions. This stimulated a further integration of the safety, economy and nature policy fields.

Rules and regulations

- The goals formulated for the Sand Engine had an open character: creating temporary nature and recreation areas, stimulating natural dune growth for safety, and developing new knowledge. These goals were not translated into more specific objectives, such as desired areas of dune growth, or the type of nature or recreation desired. The open character of the project goals contributed to achieving integration as conflicts in weighing different functions could easily be avoided.
- The lenient requirements from the legal framework: for the time being, the Sand Engine is not critical to coastal safety and no specific nature objectives were identified (e.g. in terms of numbers of individuals of certain species). The only condition was that it should not negatively affect the Basic Coastline,

dune erosion buffers, or the Natura 2000 site adjacent to the nourishment. The absence of specific legal requirements facilitated the integration of functions.

Resources

- Financial resources were from two policy actors: the Province and the Ministry of Public Works both contributed to the realisation of the Sand Engine. The resulting mutual dependency stimulated cooperation between the two.

Discourse / the story about the Sand Engine

- The focus on innovation and experimenting implied acceptance of (and maybe even a desire for) uncertainties. Uncertainties legitimated the project as an experiment ("we need to do this project in order to learn from it and answer our research questions"). This experimental character of the project also promoted science-oriented monitoring and knowledge development.
- The project was communicated as a 'building with nature' project in which nature is allowed to have its course. Although there is a variety of interpretations of the building with nature concept, it did have an effect on knowledge structuring and enabled integration of functions. Parties from the nature as well as the safety policy field were able to identify themselves with this concept. 'Building with Nature' had "different meanings in different social worlds but their structure is common enough to more than one world to make them recognizable means of translation" (Star and Griesemer, 1989)
- The 'let nature have its course' approach contrasted with the focus on (cost-) efficiency in terms of contribution to the basic coastline which is common in the safety arrangement. In the Sand Engine project, employees of the Ministry of Public Works repeatedly stated that the underwater design alternative, basically a traditional shore face nourishment, should be preferred, as it was the most efficient and predictable design from a safety point of view.

Constraining factors

Below we list a few constraining factors. It should be noted that certain factors may constrain functional integration, whereas they have a positive effect on other aspects on BwN. The 'brains from Delft' discourse (referring to the civil engineering expertise from Delft University of Technology), for instance, helped generating public support, but was a constraining factor in working towards an integrated approach.

Actors and coalitions

- The preferred position of Deltares, a specialised consultancy institute which mainly operates in the civil engineering domain. During the development of the EIA inception note (author: consultancy Grontmij) and the EIA report (author: consultancy DHV), the consultants were instructed to cooperate with Deltares, which was hired under a separate contract. This emphasised the weight attributed to morphological expertise in the project, at the expense of the balance between disciplines that was actually required.
- Assessing separate effects of design alternatives in the EIA process led to 'sectoral workshops', i.e. workshops in which one knowledge discipline was represented. Such a sectoral approach constrains functional integration.
- Multiple ecological perspectives. Within the nature coalition, different ideas existed on the type of nature that the project aimed at (e.g. one ecologist valued a seal whereas another valued dune nature). In this case, the legal framework gave little to hold on to, as no nature goals were defined. The morphologists, on the other hand, operated from a common perspective. As a consequence, the nature policy field held a relatively weak position in the integration of functions.

Rules and regulations

- The EIA procedure aims at assessment of effects of the different design alternatives. This approach leads to sectoral knowledge development, not only in sectoral design workshops, but also in sectoral reports. This procedure constrained functional integration.

Discourse

- In the project, morphological expertise was highly valued and formed the basis for further knowledge development. In external communication, repeatedly reference was made to the ‘brains from Delft’ to indicate that the best engineers available were involved in the project. Contrastingly, the involvement of the ‘best ecologists’ or the ‘top of Wageningen’ (i.e. referring to the nature and agriculture oriented Wageningen University and Research) was not part of the discourse. No specific knowledge party was hired to supply ecological expertise, although individual ecologists were invited to expert sessions. This balance towards morphological knowledge constrained integration.

Uncertainty identification

In the Sand Engine case, three uncertainties were identified as potential threats to the project (Van den Hoek et al., 2012). They were categorised as ambiguities, caused by the existence of multiple (equally valid) interpretations of the situation:

- *Recreational swimmer safety:* the project should not endanger human safety. The Sand Engine's project team and the committee 'Stop de Zandmotor' ('Stop the Sand Engine') committee of opponents had a conflict regarding this topic. The Sand Engine project team believed the Sand Engine was an innovative and socially acceptable pilot project. The Committee believed that the Sand Engine was a socially unacceptable initiative with adverse effects. The uncertainty was not directly caused by the unpredictability of the (natural) system in which the Sand Engine is positioned: actually, both parties agreed that the conditions of the system are unpredictable. They disagree, however, on whether the area could be kept safe for the recreants and how this should be done.
- *Drinking water quality:* this was an essential issue for the same human safety reason. An important stakeholder of the project threatened to file an official complaint against the construction of the peninsula, which would result in a delay causing funding problems. Like in the recreational safety case, the Sand Engine's project team and the stakeholder actually agreed that there was incomplete knowledge about the effect of the Sand Engine on ground- and drinking water. Whereas the project team initially interpreted this as "not a problem", the stakeholder claimed that additional research was needed to get a complete picture of the potential effects as a basis for proper judgment of the project.
- *Attractiveness of the project to contractors:* as the budget per cubic metre sand was substantially less than that for regular Dutch North Sea nourishments, constructors might either consider the project attractive (because of the Sand Engine's unique and innovative character, which would draw world-wide attention and become a suitable marketing object) or unattractive (because it would be less profitable).

Uncertainty management

In order to cope with these ambiguities, the following strategies were followed:

- *Recreational swimmer safety:* the underlying framing difference about the effects of the Sand Engine on swimmer safety was not solved. Nevertheless, an impasse in the project development was successfully prevented by the project team: they chose an *oppositional mode of action* strategy (selecting one preferred interpretation of the problem and neglecting the other in decision making) and forced a favourable decision, with swimmer safety an acknowledged point of attention.
- *Drinking water quality*: as opposed to the swimmer safety issue, the project team was not the powerful actor in this case. Hence, they needed to choose a different strategy. The issue was first addressed by doing additional research (*rational problem solving*), which led to the adaptation of the project team’s frame (*frame accommodation*). As a result, *negotiations* led to the implementation of a pumping station to prevent problems with salt water intrusion into the drinking water reserve.
- *Attractiveness of the project to contractors:* this problem was solved by *dialogical learning*, i.e. involving potential contractors in an early process phase and engaging in a dialogue with them, thereby preventing problems in the later stages of the project development.

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