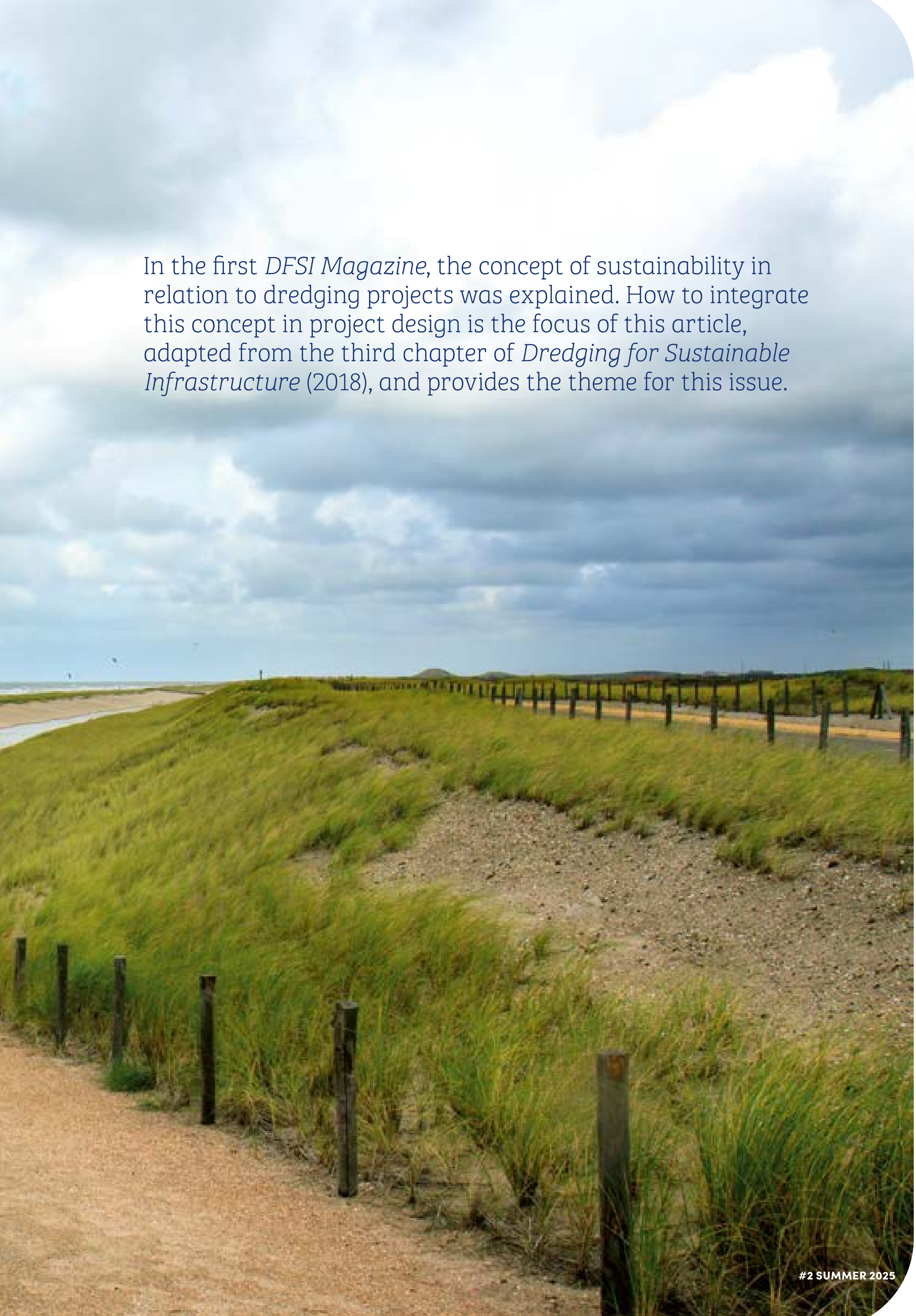
Sustainability in project initiation, planning and design: **how to design more sustainable infrastructure**



In the first *DFSI Magazine*, the concept of sustainability in relation to dredging projects was explained. How to integrate this concept in project design is the focus of this article, adapted from the third chapter of *Dredging for Sustainable Infrastructure* (2018), and provides the theme for this issue.

Sustainability and added value

It is necessary to realise that development of sustainable designs, and in particular the aspect of adding value, starts with the clear definition of project objectives. Both the primary functional objectives of the infrastructure, and the additional objectives related to the broader range of services for sustainability in the project area, should be taken into account.

Holistic view on water infrastructure

Traditionally water infrastructure projects focused on a single functional requirement only, such as protection from flooding for a dyke or accessibility for ports and waterways. Today, we realise that a dyke is also a landscape element that can provide added value for the environment (e.g. habitat, diversity, productivity) as well as society (e.g. recreation, cultural). Similarly, ports and waterways are landscape elements, located at the highly dynamic interface of land and sea, that can provide opportunities for birds foraging/resting at tidal ats and embankments, or for migratory fish that travel between rivers and the ocean.

Approaching the project design process from a more holistic point of view generally influences the choice of the system boundaries and stakeholders to involve.

The Sand Engine, a 2-kilometre-long sandy peninsula built in 2011 to ensure the long-term safety of the Delfland coast while creating space for nature and recreation, has turned into a popular kitesurfing spot in the Netherlands due to its shallow, flat water and consistent wind.

This in turn can result in different types of solutions, which deliberately incorporate ecosystem benefits. For the dykes discussed here, this could lead to the implementation of more mildly sloped vegetated foreshores for wave height reduction rather than the harder and steeper dyke reinforcements that are more traditionally used. For ports and waterways this can lead to accommodating more dynamics of tidal flats and channels in estuaries or the creation of habitats that provide shelter for migratory fish. The designs thus obtained align better with the natural system and are likely more acceptable to stakeholders that find these aspects important.

The broader range of services for sustainability in the project area and the additional objectives that can originate form that should be introduced as early in the design process as possible. Only then will there be maximum degrees of freedom in design choices . Doing so guarantees their full consideration throughout the design process and enables the development of truly sustainable solutions with added value for the environment, the economy and society. Later in the design process the various design alternatives will have to be evaluated for selection. It could be that at the end of the design process an alternative with a more narrow objective emerges as the preferred option. But at least all design alternatives will have been evaluated at a similar level of detail, enabling a fair comparison. When additional objectives are introduced too late in the design process, only marginal changes to the already considered design options can usually be achieved.

For this, early engagement of key stakeholders is crucial. They can provide important input on what is considered to be relevant in the given project area. Furthermore, they can help to specify the functional requirements as well as the preferred additional services the project would be expected to provide. The earlier such integral perspectives are included in the development process, the more influence they may have on the final outcome.

To actually put this approach into practice, a fundamentally different way of thinking, acting and interacting is needed:

Thinking – Thinking does not start from a certain design concept focusing on the primary function, but rather from the natural system, its dynamics, functions and services, and from the vested interests of stakeholders. Within this context, one seeks optimal solutions for the desired infrastructural functionality.

Acting – The project development process requires different action, because it is more collaborative and extends beyond the mono-disciplinary delivery of engineering objects. The natural and socio-economic components embedded in the project will take time to develop afterwards, and one has to make sure they function as expected. Post-delivery monitoring and projections into the future are an integral part of the project. This also creates opportunities to learn a lot more from these projects than from traditional ones.

Interacting – Sustainable project development is a matter of co-creation between experts from different disciplines, problem owners and stakeholders. This requires a different attitude from all parties involved and different ways of interaction, in interdisciplinary collaborative settings rather than each actor taking away their task and executing it in relative isolation.

The process of infrastructure development

In order to influence the design process effectively it is important to understand a few things about the process of infrastructure development, which, albeit iteratively, generally goes through a number of consecutive phases.

Initiation – The Initiation phase deals with a first definition of the problem or opportunity at hand and the scoping of potential solutions. Most influence can be exerted in this phase.

Planning and design – Where the Initiation phase focused on the problem definition and project scope, the more detailed planning and design phase deals with developing alternative strategies within this given scope and handles the selection of the preferred alternative(s). Compared with the Initiation phase the degrees of freedom are reduced..

Construction – In previous phases the problem definition, project scope, project strategy and design have been addressed. The construction phase encompasses the project execution approach. As the most important design choices are now fixed only incremental improvements to the design itself can now be achieved. The incremental improvements, however, may still provide win-win opportunities for other local interests (e.g. recreation, nature development).

Operation and maintenance – The design process obviously should be extended as far as the operation and maintenance phase. Considering maintenance aspects early on in the design process may optimise the design and reduce life-cycle cost significantly. Furthermore sustainable design considerations may lead to forms of adaptive management and development that generate additional environmental and cost benefits.

Although there is room for improvement of a design in any phase, the earlier the approach is embraced in the project development process, the more significant

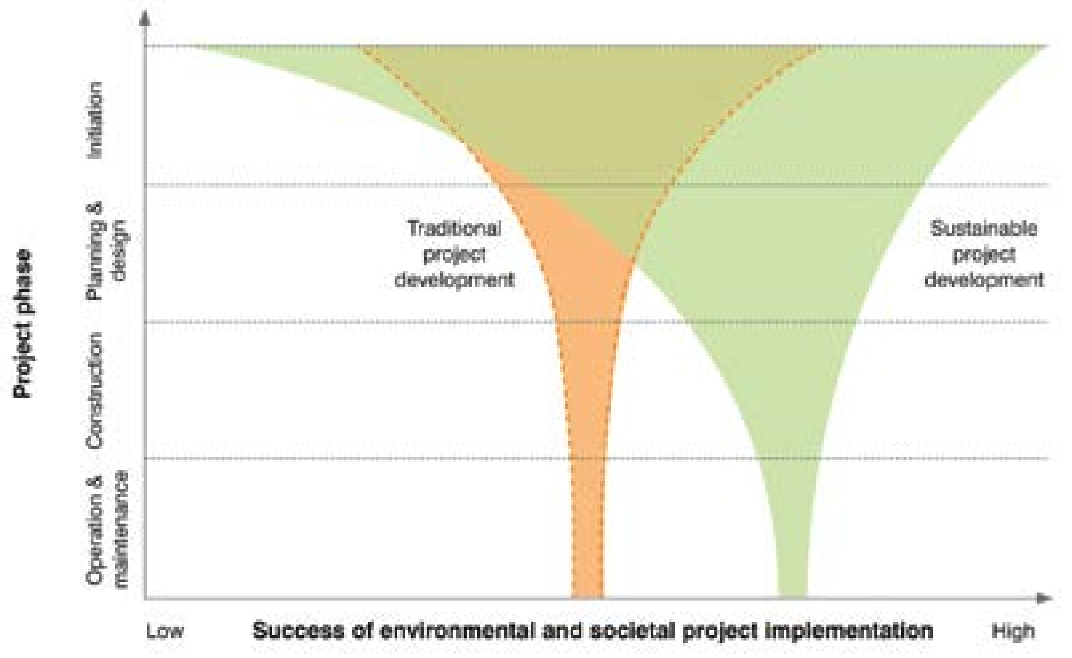


FIGURE 1
Reduction of degrees of freedom during consecutive stages of project development. Adopting a broader approach that allows for prolonged stakeholder inputs, a sustainable project development is likely to result in a more successful environmental and societal project implementation.

its potential impact. Ideally several alternatives are detailed simultaneously from the start, allowing selection of the most suitable option later in the process. Rapid selection of a preferred solution early on in the design process may initially be perceived as an efficient work process – however, as time proceeds the design enters a restriction and narrowing of options, like a journey down a funnel, and it becomes increasingly difficult to change direction when necessary. These reduced degrees of freedom of various design funnels are illustrated in Figure 1. Once inside such a funnel, it becomes very difficult to fundamentally revise a design.

A late redesign may lack societal support or may fail to qualify for the required environmental permits. Application of sustainable design principles helps to avoid the occurrence of such awkward situations, and the associated unexpected cost increases in the later stages of the project development process. Considering the major impact of decisions taken in the early stages of project development, it is crucial that all key stakeholders, with different perspectives, are involved from the very first start of a project development.

Different perspectives on infrastructure design

For the design process, it is important to think from different perspectives. In general:

The (natural) environmental perspective – In any project, a good starting point to look for added value is the natural environment or ecosystem in which the project is to be embedded. Each environment is unique, with its own characteristics, values and associated opportunities.

The project perspective – Each phase of a project generally comes with a specific scope/goal. As such it represents the starting point for considering opportunities to add value.

The governance perspective's – The governance context, i.e. the complex set of legislation, regulations, institutional arrangements and decision-making processes, etc., is a third perspective from which opportunities to add value have to be developed.

Different actors have different preferential perspectives when starting design iteration. An ecologist, for example,may take the natural environment as a starting point and consider what kind of human use the environment can support – if any. A project proponent might reason from a functional project goal where a certain trigger or ambition is formulated, and the challenge is to fit this into the environment in the most sustainable manner. A civil servant might reason from the governance perspective and analyse what kind of design is feasible from a regulatory and decision-making perspective. The challenge is then to come up with a design that fits with the governing regulations and would be acceptable given the political landscape.

Involving these different perspectives (the (natural) environmental perspective; the project perspective and the governance perspective) throughout the project development process, enriches the final design and broadens the base of support with stakeholders.

Design process for sustainable infrastructure

Strategic scoping

A starting point in any design process is to think about the strategic scoping of the challenge at hand. It might be tempting and even seem logical to take the expected final solution (i.e. the project that will be built) as a starting point for the definition of the objectives. Though perceived as a short-cut to rapid success at first glance, such a focused, solution-driven approach is often found to generate resistance in society, which may even jeopardise the

BOX 1

Project success through realisation of integral objectives

The Sigma Plan, established in 1977 in response to a major storm surge flood in 1976, was developed by the Flemish government as an integrated river basin management plan to protect the areas surrounding the Scheldt river and its tributaries from flood risk. The plan combined grey infrastructure measures such as stengthened dyke protection with green measures to make more “room for the river” and to support conservation and biodiverstiry objectives. The flood risk of more than 20,000 ha of land are adrdressed under the Sigma Plan and around 3,000 ha of natural habitiats will be restored by 2030.

While the Sigma Plan's main purpose is flood control, it is based on an integrative perspective on river management, which acknowledges a variety of river functions including flood protection, nature development, shipping and recreation.This integral development of functions and values has been the leading principle throughout the entire project development. The concept of ecosystem services was used to enable integral evaluation of project benefits and impacts. An open communication strategy involving intensive stakeholder engagement was adopted to maximise public acceptance and support. Besides safety against flooding and improved navigability, the project has resulted in important, non-hydraulic outcomes, such as nature areas, cultural values and economic activities.

Depoldering in the Kalkense Meersen along the river Scheldt, carried out by the Sigma Plan.
Photo © Vilda YvesAdams Sigma Plan Kalkense Meersen.

The development of sustainable infrastructure solutions with added value for nature and society **involves interplay of physical, ecological and governance processes.**

continuity of the complete project. A narrow definition of the project objectives consequently limits the range of solutions that is taken into account. Instead, the integral problem at hand in its broadest sense should be taken as a starting point for the definition of solutions and project objectives. In other words, be careful not to focus on solutions too early.

Conceptual design

Pilot experiments and projects have played an important role in the development of knowledge and experience for the conceptual (and detailed) design of sustainable infrastructure solutions. A five step approach for sustainable design (see box 2) can be used in the conceptual as well as the detailed design of infrastructure projects.

To illustrate the use of this approach in practice, box 3 presents a hands-on interpretation of these steps for a straightforward dredging project.

Detailed design

The process described in box 2 and 3 has been called a process of "objectification", underlining the need to specify clear objectives on the one hand, and

BOX 2

Five step approach towards design of sustainable infrastructure

Step 1 Understand the system (including ecosystem services, values and interests).

- The system to be considered depends on the project objectives. The project objectives are inuenced by the system (problems, opportunities);
- Information about the system at hand can/should be derived from various sources (e.g. historic, academic, local etc.); and
- Look for user functions and ecosystem services beyond those relevant for the primary objective.

Step 2 Identify realistic alternatives that use and/or provide ecosystem services.

- Take an alternative perspective and change more traditional reactive perspectives into proactive ones utilising and/or providing ecosystem services; and
- Involve academic experts, field practitioners, community members, business owners, decision makers and other stakeholders in the formulation of alternatives.

Step 3 Evaluate the qualities of each alternative and preselect an integral solution.

- More value does not necessarily imply higher construction cost;
- Dare to embrace innovative ideas, test them and show how they work out in practical examples;
- Perform a cost-benefit analysis including valuation of natural benefits; and
- Involve stakeholders in the valuation and selection process.

Step 4 Fine-tune the selected solution (practical restrictions the governance context).

- Consider the conditions/restrictions provided by the project (negotiable/non-negotiable); and
- Implementation of solutions requires involvement of a network of actors and stakeholders.

Step 5 Prepare the solution for implementation in the next project phase.

- Make essential elements of the solution explicit to facilitate uptake in the next phase (appropriate level of detail varies per phase);
- Prepare an appropriate request for proposals, terms of reference or contract (permitting);
- Organise required funding (multi-source); and
- Prepare risk analysis and contingency plans.

Guidance on the conceptual design of basic dredging projects

In planning for dredging projects, the main (functional) purposes/goals of the project will be leading the focus of the conceptual design, together with possible environmental and societal constraints to the project. Usually the main purpose of a project is either excavation (a deepening needs to be made) or placement (dredged material is needed somewhere).

- **Excavation –** When excavation is the main driver for the works, a decision will need to be made where to place the dredged material. Placement in open water or on land is usually controlled or regulated by national, regional and international rules and legislation.
- **Placement –** When placement of dredged material is the main objective, like for reasons of land formation or product use, a main design item will be where to excavate, where to take the material from? Often material borrow or mining sites can be identified after thorough investigations, while prevailing laws and regulations nee to be obeyed to. Landscaping of sand mining pits may help to improve the ecological value of the area after completion of the dredging works.

In both cases, the characteristics of the natural system (Step 1) will play an important role in the development of alternatives approaches (Step 2) for excavation and placement. In most cases it will be preferable when material from an excavation project can be used for a nearby placement project. That way the objectives of two operations can be combined. Such beneficial use of dredged material will normally deliver both economic as well as environmental benefits, as will appear from the evaluation of benefits and costs (Step 3).

BOX 3

the isolation of design components that can become objects of study on the other, both with the aim to rationalise the project development process. Its application in practice generally involves the following stages:

1. Define the concept's strategic objective and identify crucial individual design components;
2. For each design component specify operational objectives, boundary conditions and performance indicators;
3. Check if design components individually achieve their operational objective(s);
4. Check if design components collectively achieve the strategic objective as intended in the conceptual design phase; and
5. Check how the final solution fits in the local governance context.

Key elements for successful sustainable infrastructure development

The described conceptual and detailed design steps are generally undertaken in an iterative manner throughout the project development process; both diverging and converging repeatedly. During diverging activities alternative solutions can be developed and proposed. These are often intuitive processes where decisions can be guided by professional judgement. During the converging activities decision-making should increasingly be guided by an evidence-based approach: what are the costs, what are the anticipated benefits, how will the solution achieve its objectives in practice and how can this be monitored properly? For the primary objectives of water infrastructure developments a proper evidence base is often available in the form of empirical data and well-tested models. For the additional objectives that are associated with sustainability, this is often not yet the case. Uncertainties have to be dealt with during the proces of designing a sustainable infrastructure project.

Key elements to facilitate such a design proces are:
- multi-disciplinary collaboration;
- stakeholder engagement;
- alignment with legislation, regulations and institutional arrangements; and
- good contractual arrangements for design and realisation.

Added value through multi-disciplinary collaboration

The development of sustainable infrastructure solutions with added value for nature and society involves interplay of physical, ecological and governance processes. The combination of these disciplines can yield new opportunities, which will improve the feasibility of hydraulic infrastructure projects (engineering perspective), in sensitive environments (ecologist perspective), while meeting societal wishes and legislative constraints (governance perspective). Setting up collaboration between representatives of these disciplines is already challenging of itself, yet it becomes even more challenging when you realise that the development and implementation of new, innovative solutions typically generates its own resistance.

Sustainable infrastructure solutions developed over the last years (e.g. Sand Engine Delfland the Netherlands, mangrove-protected shorelines Demak Indonesia, Amazonehaven Rotterdam the Netherlands, Horseshoe Bend Dredging Atchafalaya River United States, amongst others) have shown that it usually takes several years of intense collaboration to achieve the realisation of a project in practice. The experience gained from these projects allows for the formulation of generic guidance for setting up successful, multi-disciplinary collaborations:

1. Integral approach – Set up a project team that covers all relevant disciplines. The team should at least represent engineers, ecologists, policy makers and legislators; note that developing a better solution in itself is not enough, it should also be feasible within the existing legislative framework and acceptable to society. Missing out on key disciplines, even if only of secondary importance at first glance, may initiate risks and uncertainties that in the longer run can seriously hamper a project.

2. Knowledge level – Make sure all members of the team bring in sound expertise from their own discipline and are sufficiently familiar with the project or case study at hand. Integrated design of innovative solutions relies on the capability of making scientifically-robust, in-depth assessments of each key discipline. Requiring a minimum level of expertise for all members strongly facilitates interaction amongst team members and smooth decision-making during for instance integral design workshops.

Close engagement of key stakeholders **is fundamental to the success of a water infrastructure development.**

3. Attitude – Besides a thorough understanding of individual disciplines, true multi-disciplinary collaboration also requires team members to be open-minded towards other disciplines. Awareness of the broader scope will help enormously in identifying and exploring innovative solutions at the interface of different fields. A similar attitude is also needed for the translation of third-party requirements into boundary conditions for more detailed mono-disciplinary studies, and vice versa the translation of the outcomes of these expert studies into meaningful findings for the broader project context.

4. Interaction – Multi-disciplinary collaboration inherently implies interaction between professionals of diverse background. Make sure sufficient time is allocated to familiarise with the other team members and become acquainted with different habits and cultures. Most notably, collaboration between hands-on professionals with a strong focus on solutions and rapid outcomes versus consensus-oriented professionals who put high value on a balanced process resulting in broadly supported solutions deserves attention. Needless to say the long time needed to arrive at a balanced compromise solution is perceived to be totally different by the two groups of professionals. The importance of a careful process of team building can therefore not be underestimated.

Early involvement of all key actors is a prerequisite for success. In addition, the design process should be open and transparent in every project phase, and the integral design workshops should be populated with the right participants. Once these aspects are in place, careful process management is needed to guide the project development process to a successful end.

Stakeholder engagement

Sustainable infrastructure projects operate on the boundaries of physical, ecological and socio-economic domains. As a consequence a multitude of interests and backgrounds are involved in the successful development of such projects. This is why they are usually complex and of high exposure. Thoughtful management of these interests – as well as combining them as much as possible in a specific design – is essential for project success. Effective incorporation of interests can only be achieved by careful engagement of stakeholders. Today, more and more projects are developed in a stakeholder-inclusive way. However, due to their novel and innovative nature, sustainable solutions can encounter resistance, as unfamiliarity often triggers a conservative response. Attentive identification and involvement of stakeholders can help make dynamic, sustainable solutions feasible.

Stakeholders can be defined as "any group or individual who can actively affect or be affected by the project development". As such, stakeholders can be anything from individuals affected by a project through to large-scale NGOs whose organisational goals are related to aspects of the project. A practical approach for stakeholder analysis is available, which essentially relies on a systematic identification and classification of relevant stakeholders, followed by the assessment of their interests and power.

Step 1: Stakeholder identification

The decision which stakeholders should be involved in a project development process is a strategic choice. In general, people

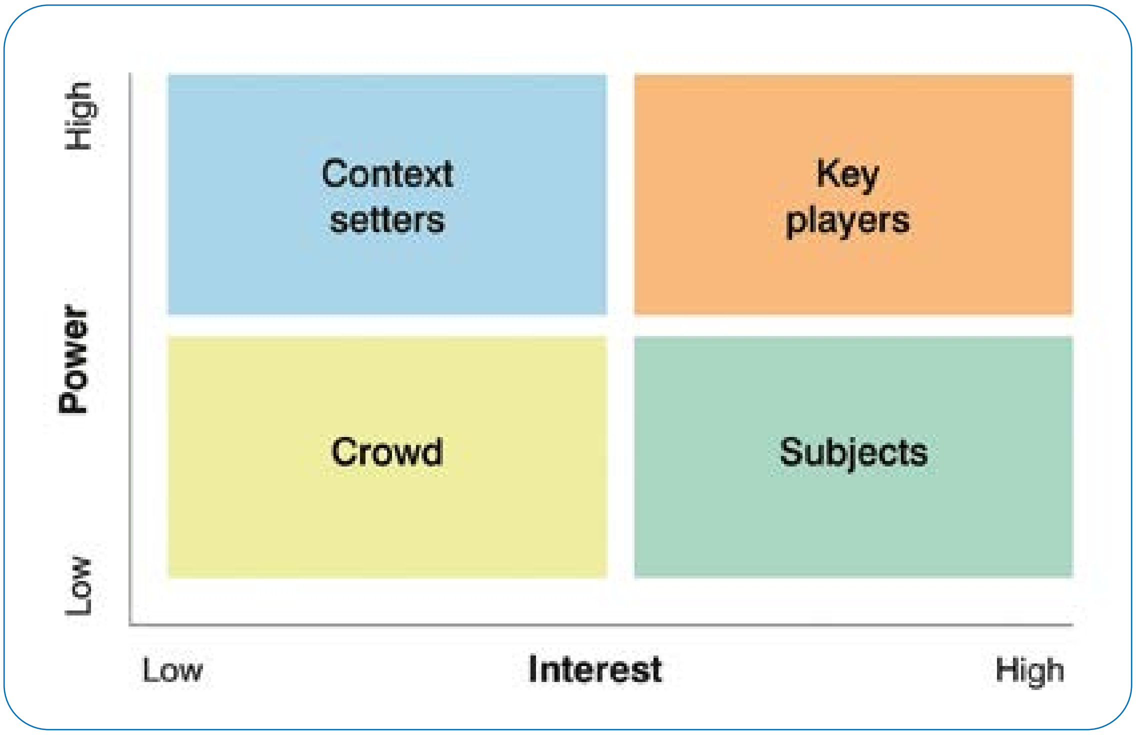


FIGURE 2
Classification of stakeholders via interest-power matrix.

should be involved if they have information that cannot be gained otherwise, or if their participation is necessary to assure successful implementation of the initiative. Normally, stakeholders are identified through structured brainstorming sessions by the project initiators, taking into account both existing networks as well as new actors gained from public hearings. Considering the innovative nature of sustainable water infrastructure solutions, it is suggested to be very open-minded about involving interested stakeholders, including those you may initially not think of. They may turn out to be the deciding factor for project acceptance and a driver for project success.

Step 2: Stakeholder assessment

In participation processes, a large number of stakeholders can be present. Not all of these stakeholders have the same attitude towards the project, and they are not equally important either. Therefore, it is important to identify the role of different stakeholders in the envisaged project development, so that specifuc management strategies can be utilised for their involvement. Stakeholder analysis can easily be done using stakeholder matrices, such as "power versus interest" or "problem-frame versus stakeholder".

By combining interest and power, it is possible to map each actor in one of four positions in a matrix (i.e. key players, context setters, subjects and crowd) and prioritise them according to their importance for the project (see Figure 2).

Step 3: Strategies for stakeholder engagement

Generally speaking, stakeholders wish to be involved in the process of project development. However, not all stakeholders are equally concerned with the project. Close engagement of key stakeholders is fundamental to the success of a water infrastructure development, which justifies a substantial effort to ensure their involvement. Open stakeholder engagement is supported and recommended, however, it is also recognised to be costly and time consuming so, inevitably, resources will need to be focused on the main groups. It is helpful to categorise the stakeholders and adopt different engagement strategies for each category. The position in the interest-power matrix (Figure 2) provides a basis to decide which action to take. It is important to realise that the four different stakeholder groups identified in Figure 3 have a very different position and attitude towards the project. For that reason, different strategies should be followed to ensure appropriate involvement:

Key players (high power, high interest): Important to keep them fully involved and satisfied with the project plans. These are stakeholders with high power and high interest. Their involvement can relate to the actor's own interest as well as the project developer's interest in what the actor can add to the project in terms of relevant knowledge, perspectives and resources. These are the people to fully and intensively engage in the processes and as such warrant and require the most effort. They should be actively involved in the project development and consulted regularly.

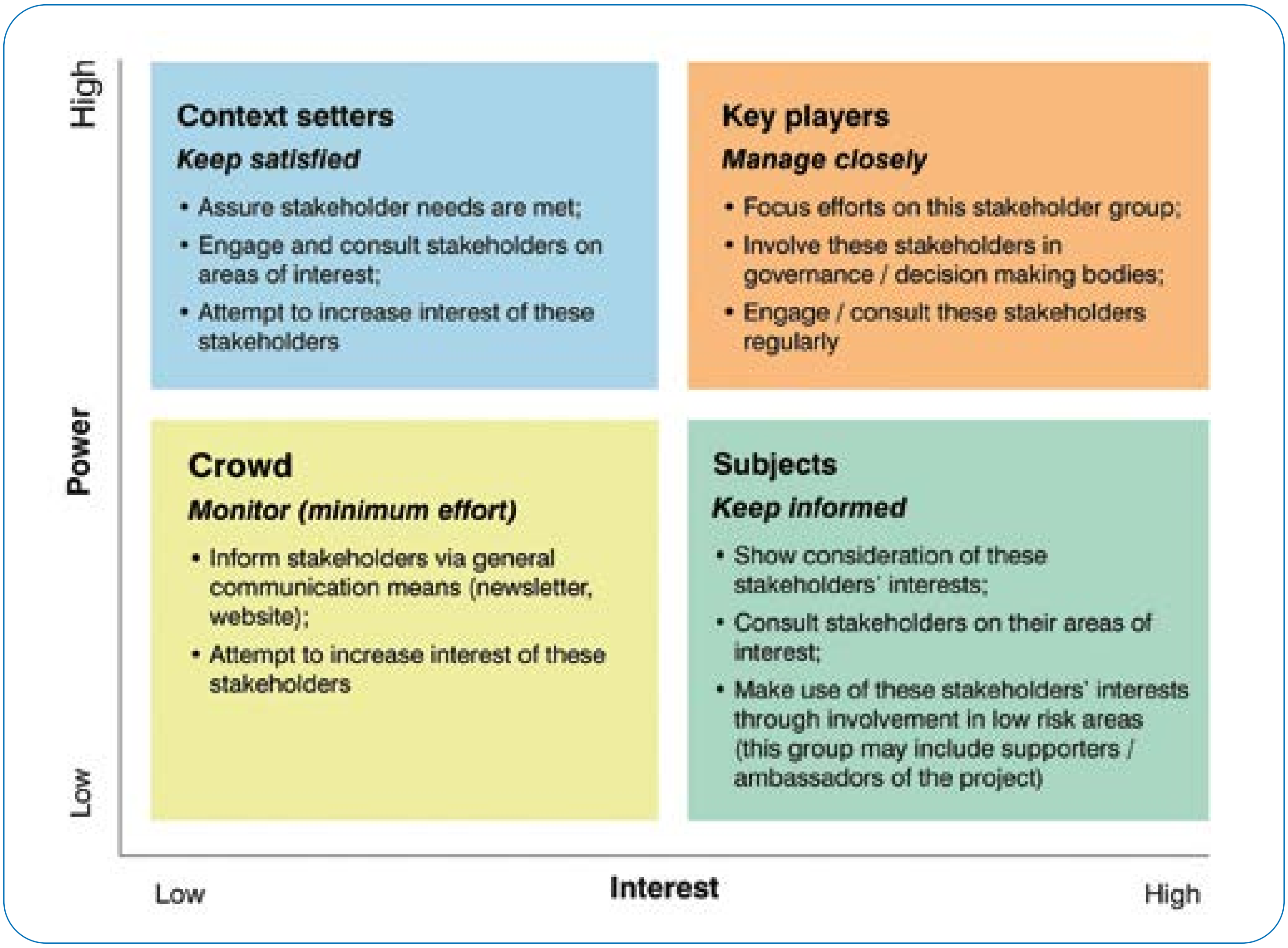


FIGURE 3
Strategies for stakeholder engagement.

Context setters (high power, low interest): Keep included and well informed. These are stakeholders with high power but less interest. Their power provides part of the context in which a development is pursued. It is important to invest enough effort to keep them included. When possible, try to increase their level of interest as this is of benefit to all.

Subjects (high interest, low power): Keep informed. These are stakeholders with low power but high value. Often these actors can be helpful with identifying opportunities for further improvement of the design for the project and often include supporters/ ambassadors to the project.

Crowd (low interest, low power): Monitor. These are stakeholders with low power and low interest. These should be monitored and informed passively via general communication means (website, newsletter). When possible, try to increase their level of interest. The identification of stakeholders that might become key players is especially crucial to a project's success. They have a high political interest and are powerful enough to stop the project completely or make sure that it succeeds. Economic interests are often secondary to the position actors take.

Legislation, regulations and institutional arrangements

Environmental legislation and regulation (or at least their interpretation) can pose an impediment to successful implementation of sustainable solutions, for instance, if they are exclusively focused on reducing environmental impact in a way that reduces opportunities to create environmental gains. This was often the case with many earlier regulations on sediments that originated from dealing with sediments that were subject to high levels of contamination. Sediment quality is much improved in many areas today. However, the past regulatory focus has led to circumstances where excessive concern is sometimes focused on very low levels of contamination, making it economically and/or logistically infeasible to use that sediment beneficially to create much needed aquatic habitat.

On the other hand, a well-developed system of environmental legislation can encourage the development and implementation of sustainable infrastructure solutions. Such a system guides the development of sound project requirements which realistically reect the perspectives of project proponents, contractors and other stakeholders. A good example comes from the London Convention, which requires countries to consider beneficial use of dredged material prior to granting a disposal licence. In the UK for instance, this was successfully implemented through the Marine Management Organisation for offshore disposal activities. In that sense, the regulatory regime in the UK is an enabling factor for the implementation of sustainable infrastructure solutions.

As nature-inclusive solutions promote the development of rich communities of ora and fauna, future maintenance of the infrastructure becomes a potential concern if that maintenance will be constrained due to the presence of the very communities of ora and fauna that the project produced. This circumstance could make maintenance more complex and costly, thus reducing the motivation to include nature-inclusive components as part of sustainable strategies for infrastructure projects. Similar considerations apply to the maintenance of land reclamations during the period before they are actually put into use. If habitat improvement leads to the introduction of rare vegetation and/or species, it might hamper future use of the infrastructure asset. In such a case, early discussion and formal agreements amongst partners, regulators, sponsors and other stakeholders should be encouraged to alleviate such concerns, and hence to avoid hampering the sustainable solution.

In addition, it is not just legislation and regulations that can impede the process, rigid institutional arrangements can also obstruct the implementation of sustainable infrastructure solutions. The other way around advancing practice related to sustainable, for example Nature-based Solutions (NbS) can

BOX 4

Options for water related infrastructure project procurement

Commonly used contract arrangement for the implementation of hydraulic infrastructure projects:

1. Design-only/Build-only – This is the traditional model, where project development and design is done solely by the project proponent, supported by engineering consultants. Contractors are only involved when the plan is finished, and the scope is fully detailed. Contractors compete on price only, possibly with bonus points to be gained for quality elements such as planning, risk management, minimisation of societal impacts and others (so-called Best Value Procurement). Generally there is little scope for early contractor involvement.

2. Design and construct, with early contractor involvement – In this model, contractors are already involved early in the design phase, taking over the design responsibility from the project proponent. Usually, the preferred contractor is already selected however there is also the possibility of multiple tenderers and a competitive dialogue process. During project procurement, market parties compete on their ability and competence to develop and design water infrastructure, in combination with cost-effective realisation. Being able to identify, assess and control risks is vital.

3. Performance-based contracting (PBC) – Performance-based contracts are often applied for maintenance of acess channels to ports, where the contractor is responsible for a guaranteed draught over a longer period of time. Payment is done for delivering this result instead of payment by volume of dredged material. Payments are linked to meeting clearly defined performance indicators regarding the depth of the waterway. A PBC requires higher quality standards for the contractor than a traditional contract. Potential advantages include increased efficiency, lower costs, and room for the contractor to develop and introduce innovative solutions. Considering the role and responsibility of the private sector in PBC, this contract form can be considered a stepping-stone towards the PPP model.

4. Public-private partnership (PPP), alliance contracts – In this model, project proponents, consultants/designers and contractors truly collaborate during all the phases of a project preparation, design,engineering and realisation. The model predicts the sharing of risks and opportunities; it particularly works for situations where projects have large uncertainties in the final solution.It is seen in concession contracts where the PPP or contractor collects the toll for vessels using a navigation channel in return for the contractor keeping the channel to the required depth. This model is no longer associated with a fixed price but often a toll arrangement; the procurement process often starts with a frame of reference that just indicates the qualities and values that are of relevance to successful project realisation.

Rigid institutional arrangements can also **obstruct the implementation of sustainable infrastructure solutions.**

help improve institutional practices across multiple levels of government and other organisations.

Least but not last, it is important to pay attention to financial arrangements. Also this aspect should be adressed early on in the process of project development. As sustainable solutions usually address multiple objectives and governmental responsibilities are often spread across different agencies and/or departments, integral solutions can also demand for integral financing schemes. In the Netherlands for instance, truly integral financing of a sustainable solution to guarantee safety against flooding with simultaneous benefits for nature and recreation would require participation of at least the national Ministry of Infrastructure and Water Management as well as regional and local public bodies, such as the province, council and the water board. Setting up such arrangements can be time consuming.

In summary, it is essential to identify possible project enablers and/or impediments related to legislation, regulations and institutional arrangements at the earliest stage possible, and to actively engage the actors involved in all successive steps of project development.

Contractual arrangements for design and realisation

Application of sustainable development principles in hydraulic infrastructure projects can introduce new challenges for successful project procurement. Two key issues play a role in that respect:

1. Evaluation of integral costs and benefits – Sustainable solutions usually address more than one objective, and aim to include extra benefits for nature and society next to the primary function of the proposed infrastructure. This implies such solutions cannot be evaluated on the basis of monetary costs alone, but require a broader, more integral evaluation. Project contracting on the basis of Most Economically Advantageous Tender (MEAT) offers a good basis for that.

2. Handling project risk – As previously stated, sustainable solutions are inherently associated with a degree of risk. These risks can cover a variety of issues, including fears on future natural development, its operational effectiveness during the lifelime of the infrastructure, the outcome of the envisaged cost-benefit analysis and the societal acceptance of innovative, sustainable solutions. Whereas the more traditional arrangements (Build-only, Design and construct) aim to assess and allocate risk between the parties prior to contract award, new arrangements like early contractor involvement and alliance contracts (public-private partnerships (PPPs) aim to settle these on the basis of increased knowledge and insights developed during project preparation. Setting up and operating of either early contractor involvement or an alliance type contract relies on open collaboration and demands a different procurement process. Guidance for the latter is provided in box 5.

Further information on procurement and contractual arrangements in relation to water infrastructure projects can be found in IADC Facts about Procurement (2008), Alliance Contracts (2008) and Early Contractor Involvement (2013).

Considering the integral and innovative nature of sustainable infrastructure projects, the selected contract arrangement should allow the involvement of specialists from different backgrounds (knowledge institutes, consultants, government, contractors) during the early stages of project development. This can be achieved through all arrangements listed in box 4, albeit that early contractor involvement generally offers more direct benefit and flexibility than the traditional procument approach. Furthermore, it is important to assess the preferred contracting method early on in the process of project development, as this will govern the degrees of freedom available to introduce nature-based elements in the project design and timings for when this should be achieved.

Check out the *Dredging for Sustainable Infrastructure* book.

Implementation of public-private partnerships

Projects with key risks, especially those that are difficult to assess upfront generally benefit from early contractor involvement. Doing so requires a fundamentally different approach and attitude as compared to the more traditional procurement arrangements. The following guidance can be taken into account:

1. **Think about procurement early and proactively:**
   - Focus on the procurement process and contractual framework right from the start.
   - Contact the authorities at an early stage to discuss the needed perspective with regard to (organisation of) procurement.
   - Aim for a clear and shared perspective with regard to the envisaged procurement process and the roles of public and private in every project phase.
   - Anticipate the consequences of different options for each of the project phases.
   - Anticipate the consequences for the required contractor arrangement and act accordingly.

2. **Keep an overview of the procurement process. In the most ambitious model the process might include four phases:**
   - In the first phase, shortlisting of project participants with a lead party that outlines the situation in a short document, based on analysis, and shows his/her ability not only to identify and manage risks (which are a traditional procurement criterion) but also to understand mutual perspectives and connect opportunities to de-risk such risks. The latter might even include relation management working towards consensus between contracting parties and all stakeholders.
   - In the second phase, the detailed planning will proceed with close collaboration between the contractor and the authorities.
   - In the third phase, the actual procurement will take place. This starts with the pre-selection. Interested suppliers will position themselves on price, knowledge, competences (including management of perceived risks and perceived opportunities). After the pre-selection the procedure continues with one or two selected consortia. Next steps are not so much about competing but about negotiations. Showing competences in perceiving, connecting and handling opportunities is of equal importance to perceiving and handling of risks. Avoiding delays requires starting the procedure early or imposing strict deadlines.
   - In the fourth phase, final decision-making takes place followed by construction.

3. **Realise effective management of the procurement process. Effective handling of the process as described requires:**
   - Settlement of sound functional requirements based on system engineering as necessary (instead of technical specifications). Sound functional requirements at least include spatial and time boundaries. In a layered perspective these criteria should anticipate subsequent steps in working towards specifications for implementation.
   - Though sound functional requirements should be sought after, also procedures for incremental changes of functional requirements should be described with regard to their consequences for the cooperation and procurement processes.
   - Define and describe the process: clearly state who is responsible for what, the set of performance indicators as agreed upon, how compliance to performance indicators is measured, the allocation of risks over partners and the pain and gain settlements. Be aware that these monitoring, verification and counting schemes should be regularly updated while the early contractor involvement arrangement works itself through the project phases.

4. **Feasibility of innovative procurement. Some further issues to take into consideration:**
   - As the traditional model of procurement suits single-organisation contractors very well, the more innovative procurement procedures with demanding criteria will often require consortia of organisations that pool expertise, competences and available resources. For innovative projects involving sustainable solutions (and associated uncertainties), the definition and application of such criteria for contractor selection requires careful attention.
   - Making the added value for nature and society "tangible and verifiable" is a prerequisite for reordering roles and responsibilities during the project phases. This includes both added values with regard to an integral perspective (serving multiple goals), as well as the economic perspective demanding optimisation of total costs during construction and over the project lifelime.

BOX 5