Integrated System-based Asset Management 2

A methodology for sustainable nature-based water management

EcoShape

Contents

Summary

Integrated System-based Asset Management (ISBAM) is a methodology aimed at achieving sustainable water management, while contributing to accelerating the international sustainable development ambitions and European Green Deal objectives. This methodology is based on three principles:

1. **Acts at a landscape scale, including both the natural and socio-economic system;**
2. **Integrates management of multiple assets and functions within the landscape context;**
3. **Embraces and leverages upon the natural dynamics of the system, providing resilience and adaptability towards future (climate change related) challenges.**

In a typical deltaic landscape system, assets include dikes, sluices, saltmarshes, dunes, agricultural land, navigation channels and roads. Following the ISBAM methodology, these assets are mutually connected and aligned with the natural and the socio-economic dynamics of the landscape. They are multi-functional, providing a broad range of benefits. They fulfill a wide range of primary, secondary and trade-off objectives of many stakeholders, in line with national and international ambitions. They realize a long-term best value for the region towards climate adaptation, resiliency and true sustainability.

ISBAM is a system-wide methodology in managing water assets that results in sustainable and long-term benefits. It focuses on connecting and promoting the collaboration of responsible authorities and agencies in managing the overall combined performance of their assets, while refraining from the day-to-day asset management practice. A system-based approach includes Nature-based Solutions (NbS). NbS have demonstrated to deliver multiple direct and indirect system benefits. At this stage NbS have been tested frequently in pilots. However, the step from pilot to upscaling and mainstreaming requires a broader landscape approach. The ISBAM methodology is thus also critical to achieve mainstreaming of NbS.

Several barriers still exist for ISBAM, the most important of which are governance and financial aspects. Examples of key barriers include the:

- Vertical governance structure of current asset-management, with an emphasis on single-asset performance management instead of on the system performance and benefits;
- Translation and fair sharing of costs, benefits and values across the different stakeholders, especially when dealing with multiple and less tangible (ecosystem) benefits;
- Consequent separate allocation of budgets;
- Legal and permit restrictions;
- Lack of methods for evaluation of risk and uncertainties related to integrated and nature-based systems.

This paper presents an approach to achieve ISBAM as a standard methodology in water management. This includes two intersecting pathways: establishing ISBAM at a program level; and mainstreaming ISBAM across programs. In line with the previous paper about ISBAM published by EcoShape in 2021, this approach follows the EcoShape enablers. Of those technical, adaptive monitoring and management, multi-stakeholder and business case likely predominant in the establishing trajectory at program level. Capacity building and, potentially, institutional embedding prevail at mainstreaming level.

Establishing ISBAM is described in this paper using two ongoing programs that include ISBAM characteristics as examples: the Eems-Dollard 2050 and the Dutch Dynamic Coastline Conservation programs. These programs highlighted various relevant lessons learned, including the:

- Need to define a simple compelling story based on urgent and impacting needs;
- Importance of long-term commitment;
- Central role of adaptive management and innovation through research and development;
- Development of adaptive pathways, from coarse evaluation to refinement steps and from pilots to upscaling;
- Necessary attention for governance and socio-economic aspects that drive the success of the programs beyond technical solutions.

Further, this paper identifies six steps to achieve mainstreaming of ISBAM. Mainstreaming begins with defining an overarching and long-term landscape vision, leveraging on the available experience within previous and ongoing ISBAM-like programs. It continues with promoting the right mindset within the relevant actors. It provides support for upscaling ongoing programs and to define new programs along the ISBAM principles. It facilitates the connection of the programs with national and international ambitions and thus with funding. It disseminates lessons learned nationally and internationally at the relevant forums.

A deeper analysis of ongoing ISBAM-like initiatives is a logical next step beyond this paper to maximize uptake of lessons learned and to build a solid knowledge base, delivering a robust inventory of experience. At the same time, close engagement with key members of these initiatives, through discussion and dedicated (training) sessions will further disseminate the ISBAM mindset and accelerate application of this methodology in new or ongoing programs.

While system-dynamics are being embraced in current programs, most solutions are still based on the static nature of human development and infrastructures that characterized the last few centuries (e.g.: dikes, delta cities and coastal industrial centers). This might lead to lock-in situations that have troubles to deal with changing conditions. A critical feature of the ISBAM mindset is accepting to work with and no longer against nature, embracing the full dynamics of the system proactively, building a society that synergizes human development and natural changes to cope with, in fact leveraging on, the (climate-related) changes ahead. It is indeed necessary to transition to innovative nature-based approaches to live sustainably beyond 2050 into the next century.

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1. Introduction

During the COP21 in Paris in 2015 and very recently in 2021 during the COP26 in Glasgow, world leaders confirmed their commitment to undertake ambitious efforts to rapidly mitigate climate change and to the Sustainable Development Goals, General Assembly of the United Nations 2015[1]. Sustainability and climate are nowadays undoubtedly central themes in our lives and society. Back in 1987, the United Nations defined sustainability as:

Meeting the needs of the present without compromising the ability of future generations to meet their own needs.

Sustainability is generally described with three pillars: environmental, economic and social. Europe embraces sustainability within the Green Deal, through actions on climate, energy, agriculture, industry, environment and oceans, transport, finance and regional development and research and innovation[2]. As a practical classification system to manage the Green Deal ambitions, Europe is developing the EU Taxonomy, which defines six environmental objectives, including climate mitigation and adaptation, reuse of natural resources, zero pollutions, healthy water ecosystems and biodiversity[3]. It is apparent how sustainability expands beyond single objectives and demands for integration of sectors and functions. International and European commitments directly influence European Member States sustainability policies and development strategies. Different transition pathways towards sustainability are in full development, also in the Netherlands, such as those towards sustainable energy, agriculture, use of space, biodiversity and ecosystems. For example, the Netherlands explicitly embraced the objective of reduction of greenhouse gas emissions with 49% in 2030 and 100% in 2050 and a reduction of use of primary ground resources of 50% in 2030[4]. Further, as in most developed countries, the Netherlands is facing the need of renovating its aging infrastructures. The current predictions of climate change and sea level rise only increase the urgency of these transitions[5].

As key element towards sustainability and climate adaptation, international and European policies explicitly mention Nature-based Solutions (NbS) [6]. Rijkswaterstaat (the Dutch executive agency of the Ministry of Infrastructure and Water Management) embraced NbS in parts of its infrastructure development and renovation philosophy (Calliari et al., 2019). Since more than a decade, under the leadership of EcoShape – Building with Nature (BwN), different NbS have been studied and tested in the field in the Netherlands (EcoShape, 2021a), such as the Sand and Mud Engine, the Hondsbossche Dunes, the Marker Wadden and Marconi Buitendijks. Many of these successful examples are still at pilot scale. Rijkswaterstaat, as well as various other public and private organizations, are currently developing strategies and policies to facilitate upscaling and mainstreaming of NbS.

Development of effective nature-based and sustainable solutions must embrace the driving natural and socio-economic processes characterizing a system which is generally broader than a single structure or asset. The development of a sustainable salt marsh in front of a dike requires an understanding of the surrounding hydrodynamic processes, of the native vegetation and biota, but also of the flood safety requirements of the dike itself, the development plans of the city or hinterland, the available financial resources, just to name a few. Similarly, while dikes are critical for water safety, they detach the water body from the areas behind it. This may cause land subsidence since the areas are cut from regular sediment supply, affecting the system as a whole. As a result, agricultural lands may become less productive, groundwater becomes saltier and cities start to sink.

International and national sustainability ambitions, the Netherlands' most urgent challenges in the field of sustainable development and lessons learned from more than a decade of BwN experience unequivocally call for integration and a system-based landscape approach. Based on this urgency, in 2020 and 2021 Rijkswaterstaat and EcoShape defined the first concept of Integrated System-based Asset Management (ISBAM), which resulted in the 2021b paper. The 2021 paper defined ISBAM as a key approach to transition to sustainable and resilient water infrastructure from an asset management perspective and, consequently, to mainstream NbS. That paper also described the barriers and enablers of ISBAM, discovered through interviews with key stakeholders. It also provided three recommendations to achieve mainstreaming of ISBAM:

1. Formulation of a clear vision and a roadmap;
2. Demonstration of ISBAM in a program, preferable leveraging on existing programs;
3. Embedding it in the Dutch water sector.

1. un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E
2. ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en
3. eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32020R0852
4. government.nl/topics/climate-change/climate-policy
5. puc.overheid.nl/PUC/Handlers/DownloadDocument.ashx?identifier=PUC_147989_31&versienummer=1
6. eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2021:82:FIN

The 2021 paper and its recommendations were discussed in a webinar co-hosted by Rijkswaterstaat and EcoShape in July 2021[7]. These activities resulted in increasing support for the ISBAM concept.

This current paper is a natural follow-up of the 2021 activities, with the main objectives being to:

- Advance the ISBAM concept, providing a vision and roadmap for upscaling and mainstreaming, in line with the first recommendation of the 2021 paper;
- Discuss the concept with key stakeholders and increase the support for it, in the Netherlands and internationally.

This paper sharpens the definition of ISBAM, providing basic principles and proposing a list of ongoing programs that match these principles (Section 2). It illustrates the critical ingredients and steps to upscale and mainstream ISBAM (Section 3) and it recommends concrete actions for the future (Section 4).

This paper is largely based on two working sessions organized with key public, private and academic Dutch stakeholders involved in the various programs listed in Section 2, who provided critical insights and review. These sections were facilitated by a visual thinking approach, which resulted in the illustrations of this paper. This paper leverages primarily on experience and lessons learned from The Netherlands, but it is intended for a broader application of its findings and the ISBAM methodology.

7. ecoshape.org/en/integrated-system-based-asset-management-webinar/

2. The ISBAM Concept

ISBAM is a methodology that:

1. **Acts at a landscape scale, including both the natural and socio-economic system;**
2. **Integrates management of multiple assets and functions within the landscape system context;**
3. **Embraces and leverages upon the natural dynamics of the system, providing resilience and adaptability towards future (climate change related) challenges.**

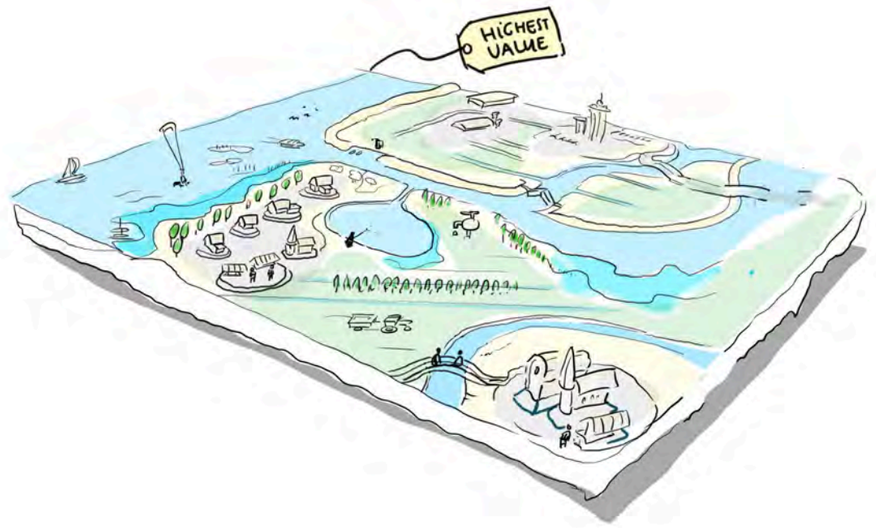

Figure 1.Visualization of a typical Dutch estuarine system landscape, with different assets and water providing a critical interconnecting role. ISBAM manages assets integrally, seeking for highest value for the area.

ISBAM results in sustainable and long-term benefits, which focus on connecting and fostering collaboration of responsible authorities and agencies in managing the overall combined performance of their assets, while refraining from the day-to-day asset management practice.

Today, as for many civilizations of the past, water is a logical binder of socio-economic activities in a landscape. While internationally valid, this especially applies for the Netherlands. Rivers, estuaries and coasts connect natural flows, support human activities and at the same time represent a constant threat, even more so with climate change. The water sector is therefore a logical center of gravity for implementing system-based methodologies.

1. ISBAM acts at a landscape scale, including both the natural and socio-economic system

ISBAM sets the focus to think from a broader landscape perspective. For example, a typical Dutch system may include an estuary and its surrounding land, which extends beyond the current dike line (Figure 1).

Before the dikes were constructed, water, together with its sediment and nutrient loads, used to periodically flood the land beyond the present dikes, maintaining the natural dynamic equilibrium of the system. A system includes specific socio-economic activities which historically developed in the landscape. Political and governmental organizations, specific legislation, community cultural background and economic activities are all elements that determine the characteristics and the dynamics of the system.

Traditionally the focus is on a specific and limited area of a system, generally the extent of a single asset or project. Dikes are typical separation lines, with a river on one side and land on the other. Often the natural or technical and engineering aspects are detached by the socio-economic aspects, especially from the local stakeholders' perspective. The same holds for the natural and human-induced developments, such as land-subsidence and sedimentation and erosion trends.

ISBAM acts on a landscape scale. The scale or the spatial coverage is dictated by the characteristics of the system (always intended as natural and socio-economic system) and the objective to be achieve within a specific time horizon. System spatial coverage can be (a portion of) a watershed, an estuary, but also provincial boundaries or economic hubs. Objectives are, for example, flood safety, counteracting subsidence or sustainable agriculture. It is also important to recognize that a system isn't typically isolated or confined in nowadays societies, but always intrinsically embedded in a wider context that influences it.

2. ISBAM Integrates management of multiple assets and functions within the landscape system context

Assets include man-made as well as natural environments and vary for example in functions, characteristics, lifetime and size. Each asset typically has a specific primary function. For example, dikes have the primary function of protecting from floods; roads, good transportation; and agricultural land, effective agricultural production.

Traditionally assets are managed independently from each other. Different assets fall under the responsibility of different agencies or organizations. In the Netherlands and with specific focus to the typical Dutch context, dikes fall under the combined responsibility of the central government and regional water authorities, agricultural land is privately owned and governed by a municipality and (inter)national policies, cities fall under the municipal government, and ports are governed by a (mostly public owned) agency. Some nature areas are managed by different organizations (including NGO's) and protected by (inter)national legislations and agreements, while economic assets are generally owned by private parties. Sometimes, specific responsibilities related to the same asset fall under different organizations. For dikes, the Dutch High-Water Safety Program (HWBP) is tasked with constructing and strengthening dikes, while the different regional water authorities are responsible for the long term management. Independent management of different assets may result in the realization of merely single or limited functions, overdesign and disconnection.

ISBAM acts on a landscape scale

Balancing or integrating the management of different assets at a landscape scale has various advantages. It allows for realizing broader objectives, such as flood protection and nature enhancement when a saltmarsh is constructed in front of a dike. It also allows improving the design of each asset, for example by constructing a lower dike behind the saltmarsh which connects the areas in front and behind the dike while still guaranteeing flood safety. A system approach works both ways: it can create additional system-wide benefits, and results in additional benefits to a single asset. An integrated broader vision further permits better long-term planning and coordination of supply and demand. It finally allows proactive alignment with international, European and global ambitions.

3. ISBAM embraces and leverages upon the natural dynamics of the system, providing resilience and adaptability towards future (climate change related) challenges.

A landscape system is intrinsically dynamic (EcoShape, 2021c). Dynamics include natural dynamics, such as seasonal variation, weather events or, nowadays, climate change. It also includes social dynamics, such as stakeholders' perspectives or political changes, and economic activities at landscape scale, which may change over time.

Traditionally, humans have created static systems that combat rather than embrace natural dynamics. Assets are designed without accounting for larger system dynamics, often through 'gray' rigid solutions that create lock-in situations over time. Not embracing natural dynamics results in less optimum design and realization of limited functions. Further, sea level rise of one meter or beyond and more intense precipitation may mean that raising dikes, maintaining a fixed shoreline, counteracting subsidence, maintaining sufficient fresh groundwater and constraining water within the currently channelized rivers may no longer be feasible or economical.

Infrastructures design and water management should proactively embrace and indeed leverage upon these dynamics, creating a landscape that can adapt to natural-climate and socio-economic changes. This is more urgent in longer term perspective, for example beyond 2050, when climate change and socio-economic development will likely require different solutions. Spatial planning and asset management need to create landscapes that are sustainable, safe and resilient under future circumstances. Dikes or shorelines may be strategically relocated to let nature slowly and naturally rebuild land. Some agriculture may transition to saline agriculture. New houses may be built to withstand periods of floods. Nature and natural corridors need to be fully integrated with human economic activities. ISBAM facilitates the realization of this future sustainable vision.

ISBAM, Building with Nature and Nature-based Solutions

BwN is a conceptual approach for creating, implementing and upscaling NbS for water-related infrastructures, with proactive use of natural and socio-economic processes of the system (EcoShape 2021a). EcoShape defines four characteristics for NbS: dynamic, multi-functional, context specific and innovative. As explained in the 2021 paper (EcoShape 2021b), these characteristics are largely aligned to the ISBAM methodology, which is therefore essential to implement and mainstream NbS at landscape scale.

Existing barriers for ISBAM

Various current Dutch and international initiatives are already developing along these three principles typical of ISBAM. These include for example the Dutch Eems-Dollard 2050 (ED2050)[8], the Programmatische Aanpak Grote Wateren (PAGW) [9], the Integrated River Management[10] and the Grensmaas[11] programs in the Netherlands. Internationally, programs such as the Solent coastal management plan[12] also express aspects of ISBAM. These programs have a focus that is at least regional. At a higher level they manage assets that fulfill multiple functions integrally and they try to embrace the systems dynamics.

While these examples are critical to pave the way, ISBAM is not yet a recognized norm or a starting point. Those initiatives represent promising examples, often triggered by a compelling ambition and significant effort of key individuals. A more in-depth analysis of how specifically these programs relate to ISBAM is necessary and it is a recommended next step. According to the stakeholders involved in these initiatives, existing key barriers to ISBAM include governance, financial, legal and technical considerations, with the former two probably representing the highest barriers to overcome. In more detail, the main barriers identified are:

Governance:

- The vertical governance structure of current asset-management, with organizations (and budgets) structured on single (or limited) objectives, responsibilities and single-asset performance, instead of the system performance and benefits.
- The lack of integrated thinking within the various organizations, with fragmented responsibility, tasking and limited collaboration across departments.
- The fact that in integral solutions, the weakest link tends to determine the progress of the entire program.

Financial:

- The translation to costs, benefits and values, their unfair subdivision across the different stakeholders and the unclear definition of ownership (for example of CO2).
- The separate allocation of maintenance and capital budgets.

Technical:

- The lack of methods and assessment frameworks for evaluation of risk and uncertainties related to integrated and nature-based systems.

Legal:

- The legal and permit restrictions.
- Uncertainties in liability.

8. eemsdollard2050.nl
9. helpdeskwater.nl/onderwerpen/water-ruimte/ecologie/programmatische-aanpak-grote-wateren-pagw/
10. english.deltaprogramma.nl/regions/rivers
11. grensmaas.nl/
12. northsolentsmp.co.uk/

3. Establishing and Mainstreaming ISBAM

This paper defines two trajectories to achieve landscape scale integrated asset management:

1. **Establishing ISBAM**
2. **Mainstreaming ISBAM**

Establishing ISBAM assures that ISBAM is concretely implemented at program level. Mainstreaming ISBAM happens across programs, aiming at the ISBAM methodology to become a standard in all relevant programs nationally and internationally. In Figure 5 each column represents a specific program, the activities related to building a new column represent Establishing ISBAM, the architrave connecting the columns indicates the trajectory towards Mainstreaming ISBAM through six steps.

Establishing a new program may include different phases and scales. It is often desirable to start with a pilot, which is smaller but representative of the larger scale, then scale up to a system scale. Each specific program is designed and optimized for a specific system. It is focused on specific objectives, stakeholders, geophysical and socio-economic models. It experiences specific enablers and barriers and undergoes a specific scaling-up process. While specific to a system, the different ISBAM programs express common features.

Figure 2. The enablers for BwN as defined by EcoShape (2021a).

Mainstreaming provides connection and support for the programs. This connection ideally ensures that new and existing programs can benefit from the lessons learned from other existing ISBAM programs. It supports existing programs in the process of upscaling by providing preferred access to central support and financial resources. Furthermore, it may facilitate the link between existing programs and national and international ambitions. It creates the fertile ground for ISBAM.

The 2021 paper connected mainstreaming of ISBAM to the enablers for BwN developed by EcoShape, in the order presented in Figure 2. In line with the two pathways identified in this section, the first four enablers have a greater weight in the establishing pathway, while the last two enablers are more important in the mainstreaming pathway.

Following this structure, establishing ISBAM is described through the lessons learned of ongoing ISBAM-like programs (Section 3.1). Mainstreaming ISBAM is presented through six overarching steps (Section 3.2).

Enablers aid in the creation, implementation and upscaling of ISBAM

3.1 Establishing ISBAM

Through the programs mentioned in Section 2 that manifest ISBAM principles, the ED2050 and the Dutch Dynamic Coastline Conservation (DDCC) programs offer practical lessons learned that are typical for the establishing phase of ISBAM. These are used as examples in this paper.

Eems-Dollard 2050

The Eems-Dollard is one of the last two natural estuaries in the Netherlands. The still intact connection between river and sea makes it a habitat for unique flora and fauna. The same region is characterized by important economic activities for the country, such as ports, industry and agriculture. Relatively large human settlements are present in connection to these economic activities but also to tourism and recreation. A key sign of the conflict between economic activities and the natural ecosystem is the increase in the turbidity level of the water of the Eems-Dollard, due to the significantly decreased sedimentation capacity of the estuary. This appears to be caused mainly by the combination of the need of deeper navigation channels (i.e. dredging) to facilitate access to ever bigger ships and historical land reclamation in large parts of the estuary, which result in little opportunities for natural siltation. Turbidity levels are currently higher than formulated in policy agreement, such as the Water Framework Directive. Research indicates that a potential solution for the water quality issues can be reached by structurally reducing the amount of fine sediment in the estuary[13].

As part of the ED2050 program, various pilots have been initiated and partially executed to explore the technical, financial and legal feasibility of various solutions to beneficially use Eems-Dollard sediments. Two of these applications include the use of ripened sediment as building material for dike reinforcement (Figure 3) and to raise low lying and still subsiding lands with high groundwater levels, increasing salinity and continuous oxidation of peat layers. In parallel to these pilots, the program VLOED, also under the ED2050 umbrella, was initiated with the main objective to assess the technical, economical, legal and governance feasibility to scale-up these two applications (sediment for dike reinforcement and for raising agricultural land) at a regional scale.

Figure 3. Locations for the Clay Ripening pilot project in the Province of Groningen (NL): near Termunten (Clay Ripening location Delfzijl) and on the salt march (Clay Ripening location Kwelder). The areas in red and white show where the sediment was collected (Zeehaven Kanaal and Breebaart polder); the green areas show the sections of the clay ripening site (Clay Ripening location Delfzijl and Clay Ripening location Kwelder).

13. ee-eemsdelta.nl/assets/pdf/dossiers/natuur-en-landschap/Eindrapport%20MIRT-onderzoek_Eems-Dollard.pdf

Dutch Dynamic Coastline Conservation

The Netherlands has a long tradition of sand nourishments to maintain the coastline and protect the country from the sea. However, this has not always been common practice. The DDCC program to protect the Dutch coastline was developed in the 80's, based on an understanding of the sediment budget and the observed natural evolution of the coastal zone (Figure 4).

The realization that there was a negative sediment budget along the coast and that the entire coastline was retreating resulted in a simple but elegant approach to stop the erosion on a system-scale, instead of only halting local erosion after for example storms, which did not solve the system-wide long-term problem.

A reference coastline (BasisKustLijn, BKL) was established in 1990 with the goal to maintain the coastline at this location through pro-active sand nourishments. This program was embedded in legislation and had a long-term financial commitment, which enabled the project to think long-term and focus on continuous improvement through research and innovation. Over time, the program has evolved through improved system understanding, resulting in improvements in the management practices as well as creating more benefits for nature and society. A detailed (historic) overview of dynamic coastline conservation is provided in Brand et al. (2022). Lessons learned regarding ISBAM are given below, based on discussions with the authors of the referred paper.

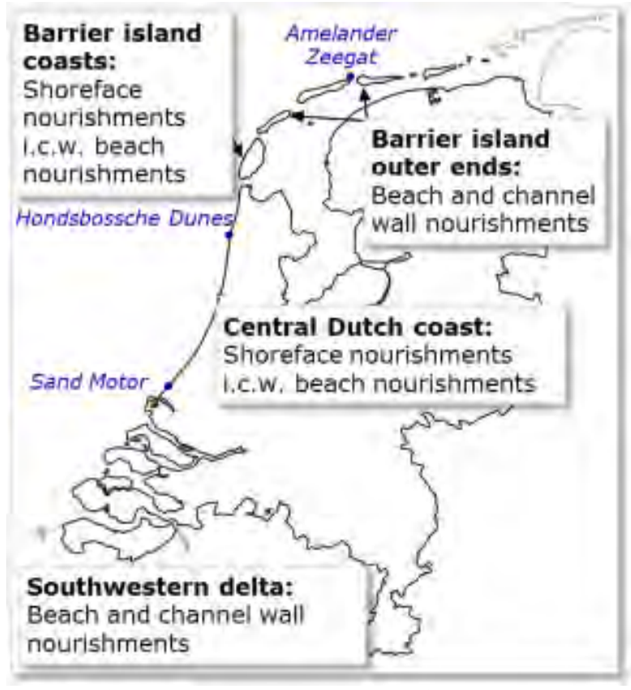

Figure 4. Overview map of the Netherlands with the most common type of nourishments per region taken from Dutch experience with sand nourishments for dynamic coastline conservation (Brand et al., 2022)

Elements of ISBAM

These programs effectively show key elements of the ISBAM methodology. Extracting sediment from the Eems-Dollard estuary and using it for dike reinforcement or to raise subsiding agricultural land is a system-based process. The same holds for the design, implementation and management of a significant stretch of the Dutch coastline and adjacent dunes and habitats. They encompass a larger area, including natural and socio-economic aspects (Criterium 1). Socio-economic evaluations and activities are carried out in parallel to technical feasibility and implementation. The programs are founded on stakeholder's dialogue and needs. They are managed by a collaboration between different national and regional government organization with active involvement of industry and academic partners.

These programs integrate multiple assets and deliver multiple functions (Criterium 2). Sediment is dredged from the harbor of Delfzijl and used, after ripening, to reinforce the Dollard Dike. While the main ambition of the ED2050 is to improve the ecological quality of the Eems-Dollard estuary by decreasing its turbidity, the beneficial use of dredge sediments for dike strengthening and raising agricultural land contributes to flood safety and sustainable agriculture. Use of dredge sediment for this purpose contributes also to safe navigation. For the DDCC program the primary function of flood safety is integrated with habitat and ecosystem development, recreation and drinking water storage in dunes. In addition, the implementation of new solutions such as the Dutch Sand Engine has created additional features and benefits, such as a kitesurfing hotspot, dune habitat and a living lab, as well providing a long-lasting source of sand off the coast.

These programs embrace the dynamics of the system (Criterium 3). Both programs analyzed the natural morphological and ecological dynamics. They identified human-induced problems within the eroding coastline and the turbid estuary. They consider system-wide opportunities to use the sediment beneficially relocating it strategically within the water system or on land. They also embrace the socio-economic and governance system, as these solutions touch on different stakeholders with different priorities and interests. In addition, the indirect less measurable benefits created within the programs also contribute to 'higher system level' and international ambitions such as improving biodiversity, contributing to climate mitigation and adaptation and circular use of locally available resources, specifically sand and mud.

The assets of the system are integrally interconnected as the dike reinforcement depends on the dredging cycle of the harbor but also on the availability of a ripening basin elsewhere on the land. Similarly, the DDCC connected shoreline conservation with dune rejuvenation and management in the hinterland. Assets are thus integrally managed within a natural and socio-economic system, through dialogue and committed partnership between the stakeholders involved. Both the ED2050 and the DDCC programs build on the unique dialogue between local, regional and national governments, businesses, nature and environmental organizations. They jointly hold themselves responsible for developing a healthy ecosystem within the Eems-Dollard estuary that is in balance with economic development. As the project develops, the stakeholders themselves bring different objectives to the table that can be achieved through mutual collaboration, automatically increasing the impact of the program[14].

> *Programs exist that effectively show key elements of the ISBAM methodology*

14. Eems-Dollard 2050 Partners: Province of Groningen; Dutch Ministry of Infrastructure & Water Management; Dutch Ministry of Management and Agriculture; Municipalities of Eemsdelta, Oldambt and Hogeland; Regional water authorities Hunze en Aa's and Noorderzijlvest; the Waddenfonds; nature organization Het Groninger Landschap; Groningen Seaports

Lessons Learned

Listed below are some key lessons learned from these programs. These can be interpreted as a number of actions to overcome the barrier mentioned in Section 2.

A clear shared ambition:

- A project needs to have a clear common ambition, a compelling and simple story, a tangible objective and defined system. In the ED2050 case, this is the ecological quality of the Eems-Dollard; in the DDCC this the formulation of a Basiskustlijn (reference coastline) to prevent the structural retreat of the coastline.
- This ambition is driven by an urgent and important need. For the DDCC, the erosive state of the coastline was the triggering factor. For the ED2050, this was the decrease in ecological value of the estuary.
- Partners should formulate their ambition and commitment in a binding document or policy, to use as a roadmap to keep the partners together when they encounter major decisions or challenges along the way. During execution, it is important to have a well-working Plan-Do-Check-Act (PDCA) cycle, where there is a clear link between policy, assignment, monitoring and management, into evaluation/policy advise.
- Expand the ambition of the program and the objectives within scope, seeking to connect with a broader range of financial streams.

From coarse and small to fine and large:

- The program partners should work from "coarse to fine", focusing first on the most important roadblocks and opportunities and then working out the details.
- When starting from scratch, pilots are essential in the development of the program to enable the structural implementation of new solutions. In addition, pilots provide evidence and convince the various stakeholders. Shortly after the initiation of pilots the scale-up process should starts in parallel, so as not to lose momentum.

Time and long-term commitment:

- It takes time to set up a well-functioning program. For example, to determine the right reference coastline, it took approximately 5 years. It is important to invest upfront to develop a solid program.
- A large and multi-year (e.g. 10 year) financial plan is necessary, where clear objectives can be defined and achieved through different strategies, while maintaining a flexible and adaptive approach.

Learning by doing and adapt:

- Long-term commitment, necessary for maintenance, provides also room for learning by doing. The research and development and innovation component has been essential for the growth of the DDCC program, resulting in more benefits over time.
- A comprehensive monitoring strategy, that covers the technical but also socio-economic aspects, is necessary to be able to adapt the program based on new information.
- Monitor potential developments in the regions that are outside the control of the program but that may influence its outcomes.

Governance and socio-economic challenges require the most attention and effort

- Recognize that the most difficult challenges, and therefore the focus of the program, lie in the governance, economic and social aspects, especially in the support from the community, the line-up of finances and potential legal challenges. Technical aspects exist but can generally be solved.
- Act proactively and develop inclusive business models that highlight (high) value (instead of low cost) and define the (financial) responsibilities for fairly distributing the costs and benefits of the less tangible ecological and social benefits, such as water quality, a decrease in CO2 emissions, robust infrastructures, use and ownership of locally available resources, and circularity.
- Develop ownership or responsibility for the costs and benefits early on, especially identifying who should bear the costs or secure revenue from the less tangible (ecosystem) benefits.
- Develop a transparent process towards all relevant stakeholders, engaging local stakeholders actively in the program and the business case, and showing the added value of the program for their specific situation (e.g. improving their agricultural soil and a better income).
- Find ambassadors at all levels (coalition of the willing), organizing active communication about the project in the region and lobby activities versus the potential financiers.

3.2 Mainstreaming ISBAM

The examples of programs described in Section 3.1 prove that programs with ISBAM characteristics already exist at different stages of development, providing important experiences and lessons learned. Mainstreaming ISBAM intends to support this systems approach, with the aim of making ISBAM a standard methodology for asset management in regional and national water management that is in line with national and international sustainability ambitions.

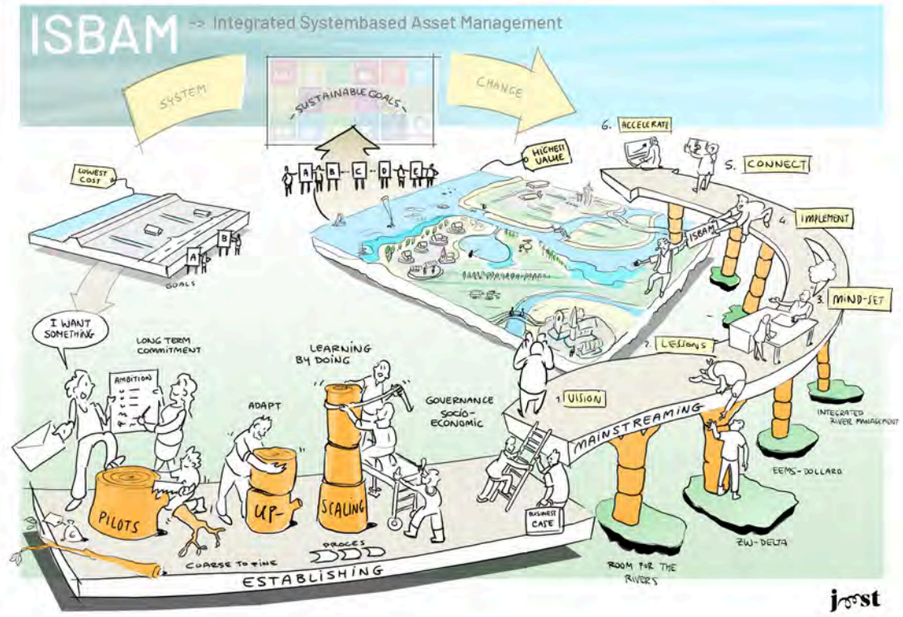

Figure 5. Representation of establishing and mainstreaming ISBAM. ISBAM determines a transition from single-asset, single-objective lowest cost asset management (top-left) to system-based multi-asset, multi-objective and highest value regional integrated water management (top-right). Within establishing ISBAM, each ongoing or new program provides a lab of experience and lessons learned to achieve specific objectives in cooperation with different stakeholders (bottom-left). Mainstreaming ISBAM provides the connections between programs to facilitate this transition. Six steps are defined in this paper along this roadmap (bottom to top right).

Mainstreaming ISBAM begins with defining a broad and long term (national) vision above and across program levels (e.g.: embracing landscape management as a key pillar for water management), leveraging on the available experience within the ongoing ISBAM-like programs. It continues with promoting the right mindset within the relevant sectors. It provides support for upscaling ongoing programs and defining new programs according to ISBAM principles. It facilitates the gradually more explicit connection of the programs with national and international ambitions and thus with possible additional funding. It disseminates achievement at selected (international) moments or events to accelerate integrated system-based management to become a norm. ISBAM is not meant to be the sole responsibility of a single central organization.

However, it can help when there is a leading party that has an urgent system challenge to solve to facilitate the development of an ISBAM program and create the spark. ISBAM is about solving system-wide challenges together while at the same time improving asset management. Following this reasoning, six steps are defined to achieve mainstreaming.

Step 1) Define a broad landscape-wise vision based on the leading principles for ISBAM (Define)

This paper defines ISBAM as a methodology that:

1. Acts at a landscape scale, including both the natural and socio-economic system;
2. Integrates management of multiple assets and functions within the landscape system context;
3. Embraces and leverages upon the natural dynamics of the system, providing resilience and adaptability towards future (climate change related) challenges.

A first step is to define a broader and integrated long-term vision that goes beyond a specific program and aligns with the three guiding principles of ISBAM. This vision leads water management towards sustainable development.

Step 2) Collection of lessons learned from ongoing initiatives (Gather)

This paper lists different relevant program aspects of ISBAM. This paper further elaborates on the ED2050 and DDCC programs as concrete examples of establishing ISBAM, highlighting some key lessons learned. Other programs may be at different stages of implementation and extend to different scales. It is important to collect these experiences and to define common enablers and barriers. The EcoShape enablers framework (EcoShape 2021a) provides a good framework to structure lessons learned, as demonstrated in the 2021 paper (EcoShape 2021b). It is recommended to expand this analysis to (some of) the programs listed in Section 2 of this paper to obtain more insights in the enabling factors for mainstreaming.

Step 3) Connect and influence the mindset of key asset managers (Spark)

Those in charge of creating programs and managing the different assets will benefit from embracing the ISBAM mindset. Because ISBAM means integration, it is key to connect different initiatives and especially the stakeholders who are responsible for these initiatives. For that, it is important that asset managers and decisions makers are aware of the consequences their decisions have on the long-term performance of the system. It prevents the occurrence of lock-in situations and additional costs in the long run. Here owner- and stewardship of the system plays an important role, since someone must take the initiative to connect and influence asset managers and decision makers. This additional investment will provide long-term benefits. This paper, based on two brainstorm sessions between key experts involved in ISBAM-like initiatives and in asset management, is a first step and example towards mind-setting. It is important to identify and proactively connect key stakeholders within relevant public, private but also financial organizations to disseminate and promote the ISBAM mindset and, at the same time, adapt it and improve it to specific needs and local settings.

Step 4) Implement ISBAM in selected ongoing and future initiatives (Do)

As a consequence of Step 3, initially few and then more and more programs should be implemented following the ISBAM methodology proactively, consciously and explicitly, in line with the establishing ISBAM approach. These programs should be explicitly connected to share lesson-learned to inform and accelerate mainstreaming.

Step 5) Connect ISBAM-programs to national and international ambitions (Expand)

ISBAM programs should be explicitly and concretely connected to national needs and international ambitions, such as renovating aging infrastructures, sustainable agriculture, protection of biodiversity, circularity or zero-emissions. These ambitions should therefore be explicit objectives of an ISBAM program. It should also be made explicit – preferably in a quantitative way - how the results or outcome of such programs effectively contribute to those ambitions. This will force a focus on quantification of, above other, less tangible services, such as resilient and green infrastructure, circularity or biodiversity. Quantification of services and the development of business models to calculate these benefits on a life-cycle basis is critical to unlock financing toward these programs from public, financing or private organization and thus, in general, to support solutions needed to meet national and international ambitions and promote further mainstreaming of ISBAM.

Step 6) Provide a common forum and develop standards (Accelerate)

A good way to accelerate uptake of innovative methodologies is to communicate results and facilitate exchange of information beyond the involved organization. Lessons learned should be proactively communicated, for example in specific sessions of relevant international events. This is critical to accelerate establishment of ISBAM as a preferred methodology for water management nationally but also internationally.

Making ISBAM a standard methodology for sustainable water management

4. The Way Forward

Section 3.2 provides six steps towards establishing and mainstreaming the ISBAM methodology. Some of these steps are already taken in some ongoing projects or programs (Step 1 and partially Step 2). In the near future, it is recommended to further proceed with Step 2 and Step 3, with Step 4 and Step 5 as follow-up steps. Step 6 can only be defined when the previous steps are taken.

It is important to emphasize that an integrated system-based approach to asset management operates at a higher level and focuses on bringing together and optimizing different assets from different stakeholders and the combined performance of their functions. It is complementary to the more specific asset management approaches that apply to a single asset group, such as Iampro [15] or ISO 55000 standards.

A deeper analysis of ongoing ISBAM-like initiatives seems a logical next step to maximize uptake of lessons learned and to build a solid knowledge base, which can benefit from the enablers approach as developed by EcoShape. This step should include active participation of key members of these initiatives, for example, asset managers or program leaders. This step should result in a robust inventory of lessons learned. In addition, it would be beneficial to expand this analysis across borders.

At the same time, close engagement with key members of these initiatives allows initiation of Steps 3 and 4. Collecting lessons learned can easily be coupled with mindset forming, through discussion and dedicated (training) sessions (Step 3). It also allows inviting specific initiatives to explicitly connect with ISBAM (Step 4).

Proceeding programs (like ED2050 and DDCC) will continuously develop new experiences. Especially in these programs it is important to continue investing in system-based knowledge development, on the natural but also socio-economic aspects. The six steps are therefore not a linear process, but more an iterative process: a kind of spiral, which adapts and improves with each cycle .

Finally, it is important to state that a crucial feature of the ISBAM mindset is the conscious choice to work with and not against nature, proactively embracing the dynamics of the system. This results in building a society that synergizes human development and natural change, in effect taking advantage of, the (climate-related) changes ahead. It is thus vital to transition to innovative approaches that move beyond optimization of our built society, to live sustainably beyond 2050 into the next century.

A crucial feature of the ISBAM mindset is the conscious choice to work with and not against nature, proactively embracing the dynamics of the system.

15. https://www.iampro-portaal.nl/

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