Interreg
North Sea Region
FAIR
European Regional Development Fund

EUROPEAN UNION

Adaptive asset management for flood protection

FAIR extended summary

June 2020

Introduction to FAIR

Challenges for flood protection in the NSR:

Despite the diverse character of the North Sea Region (NSR), asset managers of flood protection infrastructure face common challenges. This includes threats related to climate and socio-economic changes, along with the ageing of existing flood protection assets. Large investments are needed in order to face these challenges and to keep the NSR as safe as possible from flooding, both in maintaining existing and constructing new assets. Economic constraints mean that adaptation of existing infrastructure needs to be smarter, utilising innovations and latest knowledge, and this can both reduce overall costs and at the same time control the potential impacts. The required large scale of investments provide a unique opportunity to simultaneously improve flood protection and implement climate adaptation measures that are fit for the future; i.e. that are flexible and adaptable.

The FAIR project:

FAIR brings together flood protection asset owners, operating authorities and researchers from across the NSR to share the policy, practice and emerging science of asset[1] management. It aims to reduce flood risk across the NSR by developing and implementing improved approaches for asset management of flood protection infrastructure.

The specific result indicators for the project are:

- Increase the life span of flood protection infrastructure – through smarter maintenance and renovation;
- Reduce the life cycle costs of flood protection infrastructure – through better targeting of investment;
- Encourage the multi-functionality of flood protection infrastructure – through mainstreaming (that is, connecting) investments with other policy objectives.

[1] e.g. Abadie L M., et al., (2019). Risk measures and the distribution of damage curves for 600 European coastal cities. Environ. Res. Lett. 14 (2019) 064021 https://doi.org/10.1088/1748-9326/ab185c and Calafat F M., Marcos M. (2020) Probabilistic reanalysis of storm surge extremes in Europe. PNAS | January 28, 2020, vol. 117, no. 4, 1877–1883. www.pnas.org/cgi/doi/10.1073/pnas.1913049117

[2] https://northsearegion.eu/fair/output-library/

Connecting FAIR to practice

The FAIR framework:

FAIR provides guidance to help to address the various challenges facing those with responsibilities for managing the assets for flood protection in the NSR. It utilises a framework comprising three 'contexts' to consider the approach to and processes for asset management.

1. Strategic: corporate and long-term view;
2. Operational: focusing more on day-to-day measures and activities;
3. Tactical: ensuring effective interconnections between strategic and operational

This document provides an extended summary of the main results of FAIR, published in the FAIR end report[2] and is structured around the three contexts.

The experiences of the FAIR beneficiaries demonstrate good practices in asset management in the flooding domain, in five pilot projects. The pilot projects provide a proof of concept, which validate the application of the FAIR framework. This validation has shown that the use of the framework can help to ensure that flood protection assets are designed and used to be as multi-functional as possible, that there can readily be reduced life cycle costs of at least 5%, and a typical prolongation of the lifespan of targeted infrastructure by at least 5%.

The pilots are presented in standalone reports[3] as well as in the end report. A short description of each pilot is given in this table.

Location	Object type	Pilot case
Middelkerke, Belgium	North Sea dike	Combination of measures, including new stilling wave basin and sand dunes with beach nourishment.
Ribe Polder, Esbjerg, Denmark	Storm sluice, three locks and dikes	Reviewing and enhancing the performance of the system, taking an integrated perspective.
Hamburg, Germany	Three public defence gates	Ensuring security and effective functioning of protection of the city of Hamburg from River Elbe.
Flood Protection Hollandsche IJssel, Netherlands	Dike in combination with storm surge barrier	Improving the performance, operation and reliability of the Hollandsche IJssel Kering (barrier) and the river Hollandsche IJssel dike system.
Helsingborg, Sweden	Sea wall in densely populated urban area	Improving the flood protection of the inner part of the city of Helsingborg.

[3] https://northsearegion.eu/fair/output-library/

The FAIR framework

Although the countries in the NSR face similar challenges, there are many differences between regions and even within countries in the planning and delivery of flood protection. There are differences in terms of strategy, delivery, operation and responsibilities. Each beneficiary has to operate within unique funding processes, unique institutional arrangements, delivery and operational approaches. The FAIR project has been able to utilise the concept of three overarching 'planning and decision contexts' to consider the approach to and processes for asset management, including a strategic, an operational, and a tactical context.

The three FAIR action contexts that define the framework used in the project.

The strategic context produces the adaptive management plan for the assets, and the operational context delivers and maintains the plans' requirements. Interconnecting these is the tactical handshake that will feed information in both directions to inform both strategy as to the need for adaptations, and operational practices as to what is expected from the strategic plans.

The framework shows that each context is considered equally, rather than in a hierarchy of, e.g. strategic on a level higher than operational. The infinity shape used in FAIR represents the continuous process of individual and group asset management, and also applies to the integrated asset management process used to decide on how best to manage assets.

The FAIR project has found that there is an essential need to manage assets by connecting and aligning actions across the strategic and operational contexts, via the tactical handshake.

Definitions for the three planning and decision contexts of the FAIR framework are:

Strategic loop - the why and what?

Establish strategy and consequential long term planning processes using an overall integrated system perspective from understanding threats, asset operational effectiveness, responsive policy, standards and processes for interactions within FP asset systems and beyond the flood risk domain. Develop investment priorities to balance cost, risk and performance from an understanding of the flood risks, the opportunities associated with alternative strategies, objectives and functional requirements, and from the performance of alternative adaptation measures necessary to achieve these.

Tactical (handshake) actions - the when, where and what order?

Sustain the interconnectivity between the strategic and operational contexts, providing a means for two way information and knowledge transfer, especially about individual asset performance in the context of overall system performance, and how best to create or modify assets so that these provide the expected service by being adaptable and reliable. Ensuring that the developed strategic objectives inform the adaptive prioritisation and planning for individual and asset systems. This perspective ensures the connection between the two other AM contexts is guaranteed and fulfills the required role in the translation of asset performance to system/ network performance.

Opertional loop - the how?

Operate the assets and maintain service in compliance with strategy, by ensuring functioning through the assessment of the performance (reliability) from monitoring, based on the knowledge gained from the information collected. Where and when necessary, modify, design and construct adaptations to existing and new assets in conformity with and as informed from, the overall strategic planning context.

Strategic asset management

Strategic asset management consists of five main components, numbered 1-5 in the FAIR framework of planning and decision contexts.

1. Performance of the network

This component receives information from component D in the operational loop, via the tactical handshake. This gives the observed performance, predictions of longer term functioning/reliability essential to use in the source-pathway-receptor (SPR) analysis to reveal the performance of the assets and system as a whole and their longer term functioning.

2. Identifying threats and opportunities

Defining opportunities and threats is an important part of the continuous on-going process of asset management. It requires consideration of both external (e.g. climatic, socio-economic) and internal (e.g. asset and asset network functioning) factors. Understanding these opportunities and threats for individual assets and also system/strategic contexts, enables asset managers to plan ways to optimise investments for the operational context. It enables the take-up of opportunities (e.g. mainstreaming multi-functionality of services) and minimises the risks from threats cost-effectively (e.g. potential damage, deterioration of the asset, future accelerated sea-level rise).

3. Setting strategic asset management objectives and requirements

The strategic context aims to establish the desired role that flood protection assets play today and in the future, their performance objectives, and the likely investment needs (at a national, regional and system scale) in a way that delivers multi-value outcomes and that can be appropriately adapted as the trajectory of the future becomes better known. Strategic objectives, based on an understanding of the threats and opportunities, must seek to reflect local and national needs, align multi-institutional and stakeholder interests, set out the requirement performance objectives and should take into account funding, roles and responsibilities.

4. Understanding the performance of the system and system measures

Good decision-making relies upon an understanding of the behaviour of the whole system. This includes developing an appropriate understanding of:

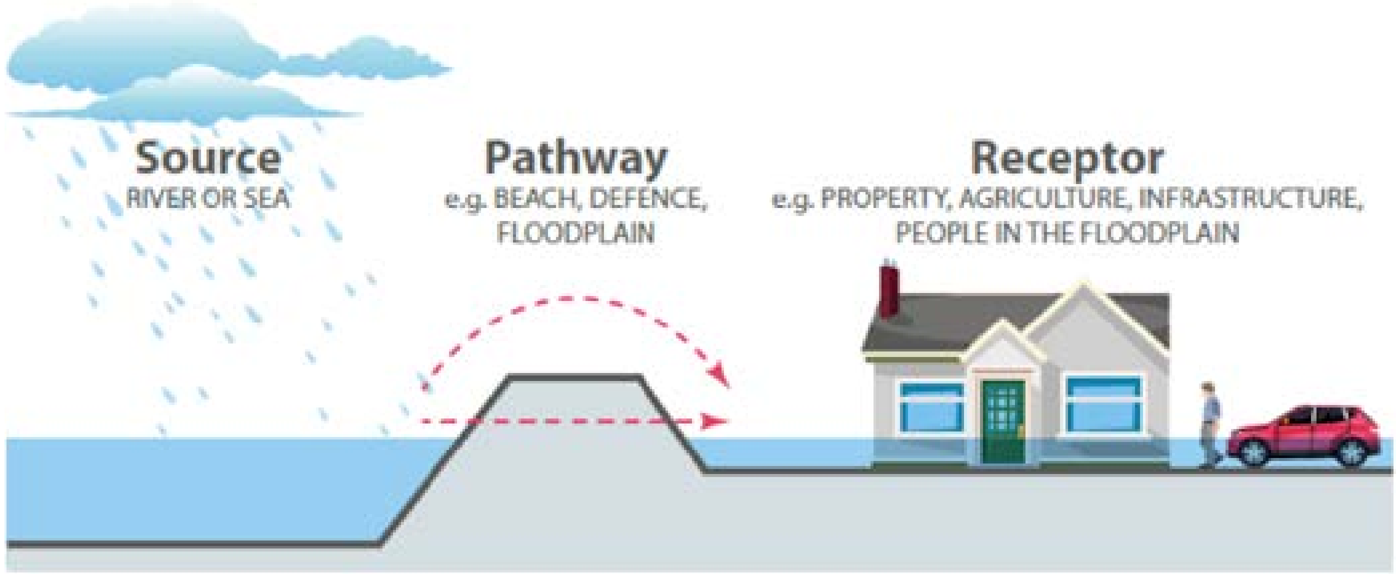
- The geographic boundaries of the system, the vulnerabilities to flooding within that system;
- The external influences that may influence the behaviour of the system over time;
- The hydrological and hydraulic functioning of the system;
- The performance of the flood protection assets in response to the loads and future climate change;
- Routine uncertainties within the data, models and model structures used to represent the performance of the system

5. Developing an adaptive asset management plan

Strategy plans should proactively plan for an uncertain future and can be modified as new evidence and insights emerge. Investments in monitoring and evaluation (assets, the loading conditions and the socio-economic setting) provide the central underpinning of the continuous process of updating both the strategy and operational delivery to ensure flood risks are well-managed and plans adapted in a timely manner.

Tool: the Source-Pathway-Receptor framework

Understanding the performance of the system can be a daunting task. To aid this process, FAIR beneficiaries have promoted the use of the standard Source-Pathway-Receptor framework (SPR).



The Source-Pathway-Receptor (SPR) framework (Redrawn from Sayers et al, 2002) [4]

The SPR framework provides a practical means of disaggregating the basic components of probability and consequence into their constituent components. Consideration is given to both the probability of the initiating event (the **source** of the flood such as rainfall or a marine storm) and the probability that flood waters will reach a particular location in the floodplain, taking account of the performance of the intervening system (the **pathway** of the flood water). The consequences should flooding occur reflects both the vulnerability of the **receptors** and the chance that a given receptor will be exposed to the flood when it occurs.

Illustrative example SPR Ribe: From static/hold-the-line thinking to dynamic planning

Traditionally, Danish asset managers have worked with fixed timeframes following national guidelines and driving operational decisions that typically lead to "hold-the-line" policies. New methods such as dynamic pathway planning are now enabling a more strategic approach to be taken. In the case of Ribe, an SPR analysis has highlighted new possible pathways for how the flood protection systems may respond, based on outside pressures on the system (climate change, urban development), planning cycles (local planning, political cycles) and socioeconomic considerations. The possible responses derive from multiple considerations such as moving the economic focus of some areas from farming to tourism, or to services. All significant assets are incorporated in the analyses and therefore they are appropriately included in the planning and decision-making process.

Integrated hydrodynamic modelling incorporating sea levels, river discharges, groundwater levels and precipitation are becoming key components in the planning toolbox, and a common understanding of the performance of all assets are important prerequisites of any future work.

[4] Redrawn from Sayers P B., et al., (2002). Towards risk-based flood hazard management in the UK. Civil Engineering 2002, 150(5), 36-42.

Operational asset management

Operational asset management encompasses all activities that ensure the individual assets and asset systems continue to perform as required and when required. Operational asset management also provides many of the data building blocks that strategic planning relies upon. Within FAIR this broad remit is considered in the aspects A-D in the FAIR framework of planning and decision contexts.

A. Measures for assets

In this component of the FAIR framework, the overall management of the assets and the measures to be adopted are defined. The measures for assets are defined and refined for each asset, using the requirements from the strategic context and passed through the tactical handshake. At least ensuring protection of assets, data and information management and preparedness for extreme events should be taken into account.

B. Design and construct

The functional requirements for the flood protection assets are implemented in the design procedures for assets. These are given as hydraulic, environmental and economic requirements or may consider a wider range of functionalities such as enabling drainage of the land behind a dike, or securing better traffic flows. In general, the key technical steps of the planning process include a review of local specific problems, the definition of design parameters for flood protection assets, the functional and constructional design of flood protection, a cross check of functionality, constructability and operational requirements and a selection of the final option.

C. Monitoring, maintenance & Operation

Maintenance and monitoring of flood protection infrastructure as well as physical operation of assets during storm events are frequently seen as the basic and most important tasks of operational asset management. Independent of the type of asset there are three main approaches to maintenance strategies: corrective maintenance, predictive maintenance and condition-based maintenance.

D. Performance of assets

The assessment of the performance is a core element in bringing together the asset (operational) and the network (strategic) oriented management of flood protection via the tactical handshake. Understanding and verifying that the performance is as required is a continuous and long-term part of the operational asset management process. A performance analysis is based on the asset condition and the targeted protection level in combination with the protected value. It should also include the performance related to multi-functionality, adaptability, cost effectiveness and possible extended lifetime of the asset. The analysis relies on information and data generated in the other operational asset management components A to C and feeds across the tactical handshake to component 1 of the strategic loop.

Tool: life-cycle costs analysis for an optimal design of flood protection assets

In life-cycle cost (LCC) analyses for optimal design the main cost-based criteria are analysed with the objective to find the solution connected to the minimum cost over the life-cycle, whilst meeting the performance requirements. Life-cycle-costs include:

i) planning and building costs;

ii) operational costs including maintenance, monitoring and inspection costs;

iii) costs of environmental impacts;

iv) repair and replacement costs;

v) decommissioning costs.

These can be divided into four categories: planned; unplanned costs; costs of ownership; and costs of usage. Life-cycle cost assessment is aimed at the selection of the most suitable and economically efficient solution from possible alternatives, fulfilling the desired requirements (functions and required safety standards for the asset at the network level) of a construction. Also consideration of any buildings' environmental impacts should be part of the LCC design process.

Illustrative example: maintenance and LCC in Hamburg

Assets, which are in round-the-clock operation (24/7), require a different maintenance strategy than those which are used only a few hours per year. For this specific case, the LSBG and TUHH developed an adaptive Maintenance Concept. The overall objective was to increase the reliability of the assets as well as reducing the maintenance costs. Furthermore, the quality of the maintenance can be sustained or even enhanced. A constant asset availability is LSBG's top priority. A well-thought-out maintenance concept, which explains the basic strategy as well as the schedules, gives the responsible people more confidence in their actions. Through standardisation, the technical framework for this can be simplified. This adaptation facilitates the easier operation and an improved long-term understanding of the assets by the operational staff.

A holistic view of the entire LCC is an essential aspect of the maintenance strategy. Important feedback from the maintenance organisation is gathered for future asset designs, in order to contribute to sustainable planning and operator concepts. The permanent improvement process is based on the goal of providing optimised and application-oriented systems. The maintenance concept developed from this describes the structure for the maintenance of the facilities in delivering the objectives. This is intended to serve as supporting guidance for all maintenance services.

Illustrative example: Dike Information System in Hamburg

In Hamburg a central module for the presentation of all relevant data of the flood protection facilities - the Dike Information System (DIS) - was developed within the FAIR project. Its goal was to provide the official supervisory authorities, planners, constructors and maintenance staff with a tool that allows them to work comprehensively. The most important aspects were to determine the data structure, to avoid redundancies, and to convert the data itself into a digital and georeferenced form, since it was often only available in paper form. The application is web- based designed. Information is thus available in the office but also on the dike, out in the field or at any other location. The city of Hamburg is currently developing a system for maintenance management that will include all assets from e.g. school buildings, cycle paths, parks and ... flood protection facilities. The information from DIS is available to this application.

This programme led to significant optimisation of the work. The process enables integrated work at one workstation without asking, searching and collecting information at different locations. This saves a lot of time and helps to reduce errors because all information is available. Importantly, the direct availability of the data enables decisions to be prepared more clearly and better. This makes it easier to avoid costly, less than optimal decisions. The process is being further developed. The data design was chosen in such a way that other applications (as front-end) can also be based on it and use the non-redundant data. With this development and the support of the FAIR project, the digital mode of operation in the flood protection of the city has been significantly improved and cost savings made.

Tactical asset management

The tactical context of the FAIR framework links the strategic and the operational loops with information and communication constantly flowing between these. It provides the link to ensure there is effective communication between strategic planning and decisions and operational activities. There is a flow of information and communication in two directions:

- From strategic to operational: The tactical context helps to link the strategic plans to establish the boundary conditions in space and time for the components in the operational context. In this 'translation' from strategic to operational delivery, prioritisation and programming are key elements.

- From operational to strategic: The tactical context ensures that knowledge about the performance of the assets (operation) as part of the overall system, is presented in an appropriate way to help the asset owner or operator to develop an adaptive asset management plan. This link from operational to strategic processes, includes the translation of performance of single assets to system/network performance.

The five primary components of the guidance used in translating strategic planning into operational processes and vice versa comprise:

- Re-evaluating the tactical handshake. The handshake needs to be made recurrently to ensure that the information such as policy and strategy is translated into delivery in operation, and that feedback is given regarding the operational feasibility of policies, and the progress with their implementation.

- Getting the right temporal and spatial scales. The strategic considerations are typically based on a larger spatial and temporal scale than the individual operational interventions. The translation in the tactical handshake includes aggregation (operational to strategic) or specification (strategic to operational).

- Enabling implementation, incorporating challenges of cross-utility and multi-functional use. Typically flood protection assets are multi-functional, meaning that different performance requirements might hold and different methods of assessment are prescribed. The tactical handshake should align and point to different requirements and desires from different functions.

- Use of appropriate metrics and assessment criteria. A major factor in the success of the tactical handshake is whether the metrics (and associated organisational processes) used for translating strategic to operational decisions are fit-for-purpose and vice-versa.

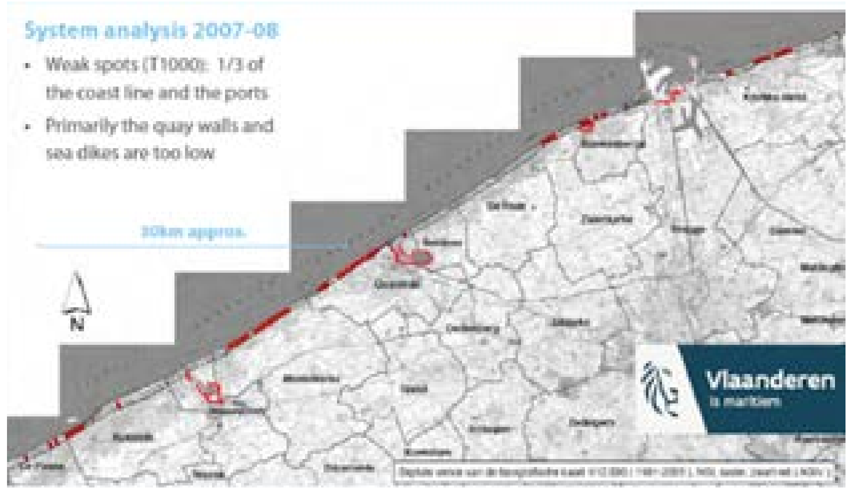
- Looking beyond the immediate management scope. A major challenge in the tactical handshake is that strategic and operational contexts of asset management may be the responsibility of different (branches of) organisations and may receive funding from separate sources. Managing diverse operators or funders is an important part of the tactical handshake.

Tool: intervention planning with ROBAMCI Tools:

ROBAMCI developed tools for Risk and Opportunity Based asset management for Critical Infrastructure (Klerk W J., den Heijer F. (2017)[5]). The tools may be used in conjunction with other assessments to derive planning and cost estimates for alternative intervention strategies. These intervention strategies provide the starting points for assessing specific intervention characteristics, such as (prescribed) maintenance frequency of individual assets. For every strategy, an optimal intervention plan can be determined in order to control the risk. The optimal strategy and corresponding prioritisation and planning process can be selected with the aid of the ROBAMCI tools.

Illustrative example Middelkerke: from strategy to asset requirements

In Belgium, the masterplan coastal safety prescribes a 6 yearly assessment of the entire coastline. The desired safety level is for a storm with a return period of 1000 years. In the 2008 assessment, one third of the coastline was found to be vulnerable (see Figure to the right). Four coastal pilot projects were allocated to address these weakest defences using different rehabilitation projects. For each project, a cost benefit analysis was carried out and different options were assessed. The cost benefit analyses and the variants were reviewed with the various interested parties, as the general funding is provided by the Flemish government, supported by funding from the local municipality for any architectural upgrades. For Middelkerke, the most cost-beneficial option was for a heightening of the beach, where the municipality proposed an expansion of the dike for tourist and economically beneficial reasons. The final selected option is for widening of the sea wall, with most of the funding from the municipality. For the other coastal projects, the preferred solutions were determined in a similar way, although, the specific requirements varied locally. For some projects, the extra cost of heightening the asset was marginal compared with the overall investment costs, and thus a lot of extra safety was achieved with little extra investment. For some of the other existing assets it was found beneficial to invest in an increase in life span; e.g. a storm surge barrier built for 100 years.



Overview of the initial weak spots along the Belgian coastline.

[5] Klerk W J., den Heijer F. (2017). A framework for life-cycle management of public infrastructure. ALCCE.http://www.robamci.nl/wp-content/uploads/2017/12/PaperIALCCE_Framework.pdf

Main outputs, outcomes and effects

The FAIR framework and its components can be used in asset management in the NSR. The FAIR pilots illustrate the beneficial effects that can result from the application of the FAIR framework. These benefits can be assessed by distinguishing different levels of results:

Outputs refer to the improved approaches, methods and guidance provided, such as the Source-Pathway-Receptor (SPR) framework[6]. The FAIR outputs enable usage by the asset owners in the context of the pilots, but also facilitate wider uptake (beyond FAIR). **Outcomes** are the improvements in existing practice, learning or other insights from the usage of the FAIR outputs. This typically means that an asset owner does something differently (behavioural change) or something better (a change in organisational maturity, see below). **Effects** relate to the broader, longer-term benefits from applying the FAIR framework. For FAIR, this will not be evident until a period of time has elapsed after the project completion.

OUTPUTS
Include: improved approaches, methods and guidance for AM

OUTCOMES
Include: improvements in AM practice by asset owners

EFFECTS
Such as reduced Life cycle cost; Increased asset Lifespan; functions provided by assets

Approach to assess the value from the application of the FAIR framework (examples shown)

The FAIR pilots illustrate how the various aspects of FAIR have come together to help to deliver more effective, efficient and practical asset management for flood protection assets. Although the pilots are from the NSR, the illustrations, showing outputs, outcomes and results, are readily applicable to other cases where flood risks are manifest and likely to be increasing.

Illustration for the operational context: flood protection Hollandsche IJssel

Outputs from FAIR: In tactical asset management, looking beyond the (immediate) management scope is of primary importance. In the FAIR pilot flood protection Hollandsche IJssel, two asset management organisations work together: the dikes along the river are operated by the regional water authority (HHSK) and the storm surge barrier is operated by Rijkswaterstaat (RWS). The dikes no longer meet the safety standard and the storm surge barrier controls the hydraulic loads on the dikes. By using a broader system approach on the entire river of the Hollandsche IJssel, HHSK and RWS together found out that the reduction of failure risk of the storm surge barrier could significantly simplify the dike reinforcement plans.

Outcomes in FAIR: By looking beyond the management scope for asset management in both organisations, HHSK was able to incorporate assets from other asset owners into the analyses. Intensive cooperation was needed and started up because of FAIR, working together on a system analysis, and taking a broad view on possible measures, such as using the flood plains, and improving the storm surge barrier.

Effects: The original costs of the dikes were reduced substantially: life cycle costs of 5%. That is: €30M savings on an amount of €600M. There is also an increase of life span of the dikes, because of using the flood plains. This may in turn result in multifunctional dikes: when heightened, the flood plains may be of use for nature.

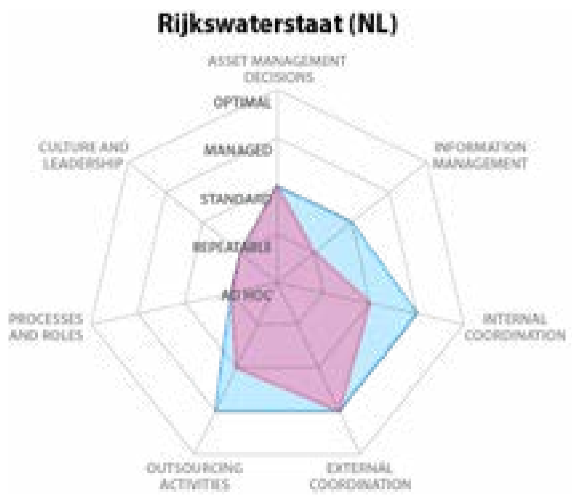
6 SPR was not developed in FAIR. But FAIR drew the beneficiaries attention to the value of adopting the approach, hence it is classed here as an output.

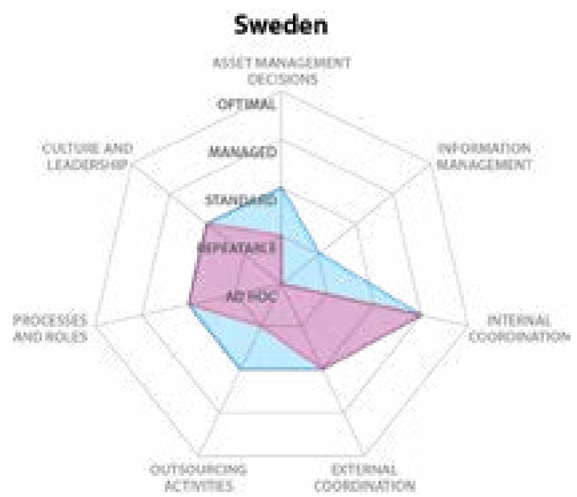
Maturity of the organisations and asset management processes in FAIR

The Framework has been used in FAIR for the beneficiaries to assess their own position regarding their internal processes for management of flood protection assets. Undertaken using a 'maturity analysis' defined for the assessment of how different dimensions or processes within an organisation are able to contribute to a set of pre-determined organisational outcomes[7], the beneficiaries were able to self-evaluate their individual progress in enhancing their asset management processes during the project. A seven-fold Infrastructure Management Maturity Matrix (IM3) was utilised:

Maturity Dimension	Description
1. Asset management decisions	The use of risk management methods and life cycle approaches in decisions at strategic and operational asset management contexts.
2. Information management	The availability and use of (standardised) static and dynamic data-bases for decision making
3. Internal coordination	Coordination and problem solving between the different departments of the organisation
4. External coordination	Coordination and problem solving between the different stakeholders of a project, including communication with users
5. Outsourcing activities	Strategy about and implementation of integrated and performance based contracting and innovative procurement methods
6. Processes and roles	Clarity, definition and implementation of job responsibilities and roles within the organisation
7. Culture and leadership	Level of knowledge, implementation and support of asset management related issues

Two maturity self-assessments were carried out to track whether or not there had been changes in maturity of each of the beneficiaries: the first, a baseline round, in Summer 2017 (red lines below), and the second, an assessment in September 2019, in the last year of the project (blue lines below). Examples for two beneficiaries are shown below, for scales from 0 - Ad hoc (centre of the diagrams) to 4 – optimal (outer limit of diagrams) asset management processes.





The maturity improvements for the Dutch beneficiaries (including Rijkswaterstaat) were the result of innovative FAIR insights, specifically on 'information management' and 'external coordination'. Leading to a shift to a system-wide and strategic perspective, from a single organisational one, over the project duration. Other beneficiary improvements were due to a number of factors including the implementation of ISO standards (e.g. ISO 55000:2014); better coordination due to management change (leadership); Investment management system implementation (government wide); greater clarity of the indicators delivered, and clearer view of the problems; helping to understand the details and costs; greater openness to innovation on the part of organisations to the ideas of specialist consultants. Overall the maturity analysis was deemed to be helpful for organisations in understanding better their existing AM processes and how these could be improved.

[7] Volker, L., et al., (2013). Asset management maturity in public infrastructure: the case of Rijkswaterstaat. International Journal of Strategic Engineering Asset Management 3, 1, 439-453.

Challenges and the way forward

In the context of flood management, an adaptive asset management approach aims to optimise the performance (i.e. value) of flood protection infrastructure at the lowest total cost to the asset owner or operator, whilst providing the best value to society as a whole. However, in reality, a compromised approach is often employed, including accepting sub-optimal performance or using cost-effectiveness as a measure. This is because there are several key challenges for the adoption of an adaptive asset management approach throughout the NSR, which are explained and addressed in the FAIR Policy Brief[8]:

- The institutional context for asset management is often fragmented
- Funding is constrained, especially for maintenance and monitoring
- Strategic planning and operational processes are often misaligned
- Decisions taken today may not account for long-term implications
- Innovation is not consistently embedded in standard practice

Several topics have been identified in the FAIR project by the beneficiaries as considered important to shape the future direction of asset management for flood risk infrastructure and for which knowledge is lacking. These knowledge gaps are addressed in the FAIR knowledge agenda[9].

Gap	Question	Brief description
A. From (big) data to information	How can we better know where assets are, their condition, and measure asset performance and deterioration, and therefore better understand asset dynamics over time?	Relates to knowledge required to determine what data has to be collected and how it has to be interpreted such that it yields the required information both on assets and the socio-economic system these assets serve.
	How can we translate Big Data on all aspects of asset management into good quality and valuable information for decision making?	Multi-disciplinary challenges require data analyses that are fit to combine different data sources.
B. From uncertain information to asset management policy	How do we take robust and adaptive decisions now with uncertain and changing information about the future?	Every flood defence manager struggles with the uncertainties when looking to the future, whilst accepting the need to live with uncertainty and build it into decision making for asset planning, design and operation.
C. From asset management policy to action	How do we manage our organisation(s) to efficiently translate asset management policy into actions?	The realisation that climate and other drivers are changing faster than the lifetime of individual assets means that existing arrangements may need to be reconfigured to adaptive ones.
D. From stakeholder to shareholder	How do we engage relevant key stakeholders in asset management as shareholders, thus creating innovative financing opportunities and (better) sharing of risks?	Asset management should focus on multi- functionality to address the multi-sectoral challenges beyond flood risk that climate change brings. This requires collaboration with a much wider group of stakeholders with a variety of different interests.
E. Engaging Society	How do we engage with society in the way needed to ensure that assets are delivered and managed in the best way?	Effective and mutually beneficial engagement with communities is more important than in the past, especially to help people to understand the need for flood risk management measures and the need to use and maintain these in response to climate change.

[8] A perspective on the future of asset management for flood protection - A Policy Brief from the Interreg North Sea Region FAIR project

[9] https://northsearegion.eu/media/13396/knowledge-agenda-v9.pdf

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Further reading

The documents relating to the FAIR project can be found on the following websites:

http://www.fairproject.org/

https://northsearegion.eu/fair/

This includes the following FAIR documents:

- End report: Results of FAIR, illustrated by examples from the pilots.
- Pilot reports: Results and lessons learned for the individual pilots in Belgium, the Netherlands, Germany, Denmark and Sweden.
- Knowledge agenda: Identified knowledge gaps in FAIR and suggestions to overcome them.
- Policy brief: Four policy recommendations to improve flood protection asset management in the NSR.

Partners

FAIR brings together Asset Owners (facing real problems and challenges) and leading scientists (with domain expertise) to share and develop innovative solutions to the management of flood protection assets. In doing so, FAIR is the first collaboration of its kind.