Interreg
EUROPEAN UNION
2 Seas Mers Zeeën
PROWATER
European Regional Development Fund

Designing climate resilient landscapes for water

A participatory approach to (spatial) planning for climate adaptation measures

December 2021

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The PROWATER project has received funding from the Interreg 2 Seas programme 2014-2020 co-funded by the European Regional Development Fund under subsidy contract No 2S04-027. Interreg 2 Seas is a European territorial cooperation programme for the United Kingdom, France, the Netherlands and Belgium (Flanders).

This report represents Output 1 of the project PROWATER : 'Collective approach to (spatial) planning for adaptation measures' (Work Package 3 - Practice).

Citation: Stacey Freya, Bauer Katharina, Staes Jan, Broeckx Annelies, Vande Velde Katherine, Deleye Lien, Vermeulen Inge, Santbergen Leo (2021). Designing climate resilient landscapes for water – A participatory approach to (spatial) planning for climate adaptation measures. Output 1 of the PROWATER project, Interreg 2 Seas programme 2014-2020, EFRD No 2S04-027.

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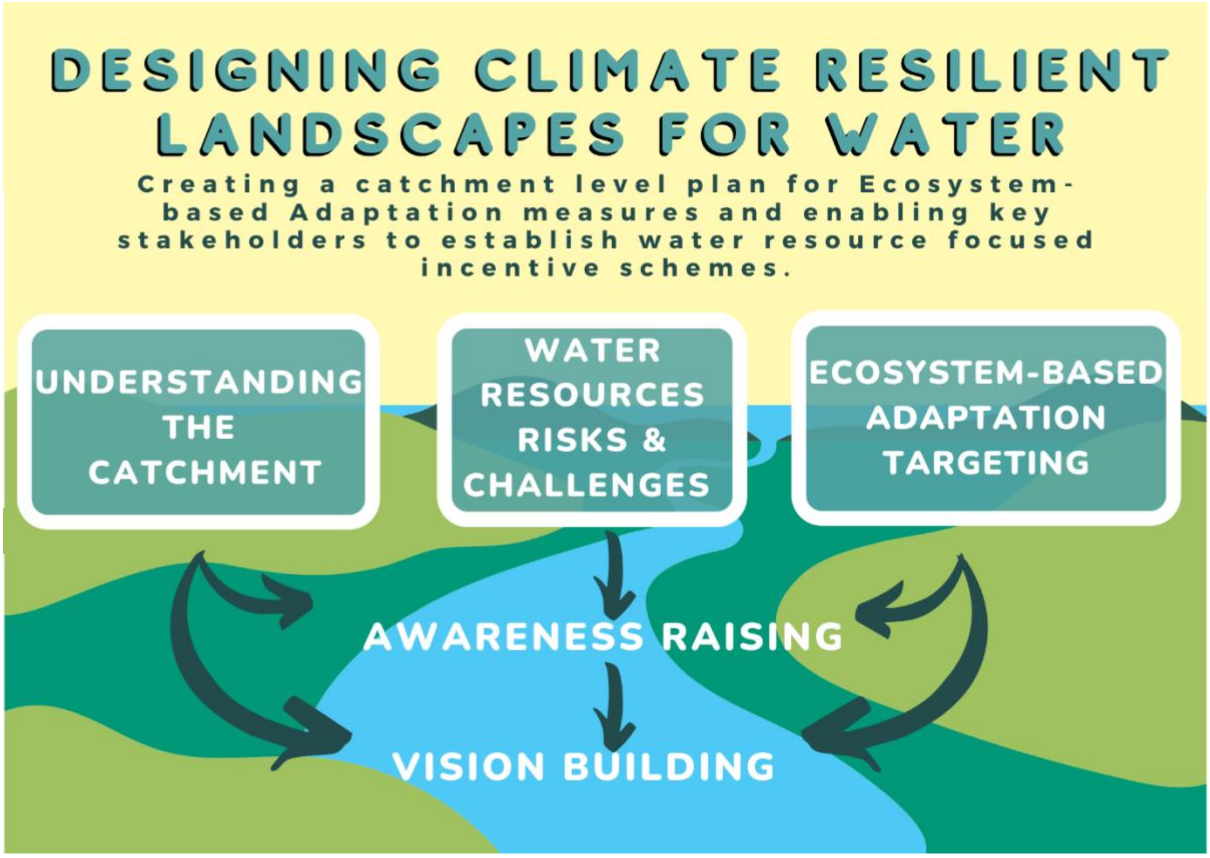
SUMMARY

The challenge for landscape management and planning is to restore a natural diversity of ecosystems and create (semi-)natural opportunities for ecosystem service development that can compensate for climate changes and anthropogenic impact. This is known as 'Ecosystem-based Adaptation (EbA)' and it requires a new perspective for land-use planning that includes spatial objectives for the multitude of ecosystem services that need to be generated on the limited land surface available. A participatory approach to this landscape scale planning for EbA relies on (early) engagement with all relevant stakeholders and can be obtained by following the phases described in this report:

- understanding the catchment
- identifying water resource risks & challenges
- identifying & engaging stakeholders
- Ecosystem-based Adaptation targeting (vision building)
- Ecosystem Service quantification (vision building)

However, the process is not linear and phases can feed into each other. Resulting implementation of EbA should be monitored and where needed adjusted.



INTRODUCTION

The aim of PROWATER is to build resilience against droughts, water scarcity and extreme precipitation events. Restoring ecosystems and enhancing natural processes can increase resilience to droughts, water scarcity and extreme precipitation by improving the retention and infiltration capacity of the landscape (i.e. 'Ecosystem-based Adaptation' or EbA). The resulting ecosystem services (ES) (i.e. retention and infiltration of rainwater in our landscapes) will improve long term stability of groundwater levels and result in less extreme fluctuation in river flow.

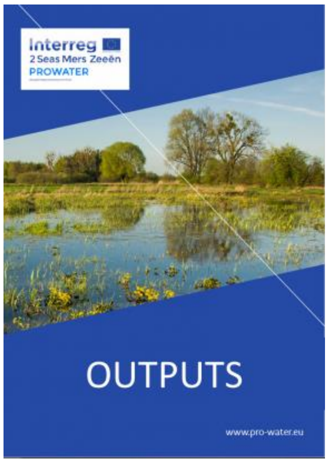
Thus, the challenge for landscape management and planning is to restore a natural diversity of ecosystems and create (semi-)natural opportunities for ecosystem service development that can compensate for climate changes and anthropogenic impact. This is known as 'Ecosystem-based Adaptation (EbA)' and it requires a new perspective for land-use planning that includes spatial objectives for the multitude of ecosystem services that need to be generated on the limited land surface available. Random implementation of EbA measures in the limited available land surface in our catchments will not be effective.

A participatory approach to this landscape scale planning relies on (early) engagement with all relevant stakeholders. In the PROWATER project we have focused on two main stages of participation, the first is the 'awareness raising' which highlights the current and future water resource challenges and introduces EbA measure as an important part of the solution. The next phase is the 'vision building', where the focus is more on presenting the evidence for the suitability of EbA measures as options within the catchment and the potential collective impact of a network of measures.

The steps included in the 'vision building' phase can form the baseline for the establishment of rewarding schemes targeted at increased water retention and infiltration in our landscapes.

For more information on establishing an ecosystem services-based rewarding scheme targeted at increased infiltration and retention of water in our landscapes, please refer to PROWATER Output 2 'Common approach and action plan to implement the rewarding scheme for EbA'.

This report presents includes future prospects and (policy) recommendations when it comes to setting up a rewarding scheme targeted at increased infiltration and retention of water in our landscapes.



LEARN MORE ABOUT OUTPUT 2 HERE[1]

Participatory spatial planning for EbA measures at the landscape level can be split into the phases described in this report: understanding the catchment, identifying water resource risks & challenges, identifying & engaging stakeholders, Ecosystem-based Adaptation targeting and Ecosystem Service quantification. However, the process is not linear and phases can feed into each other. Resulting implementation of EbA should be monitored and where needed adjusted.

[1] https://www.pro-water.eu/output-library

1 UNDERSTANDING THE CATCHMENT

Although EbA measures are efficient and cost effective they really require landscape level planning and implementation to deliver their full potential in tackling water resource challenges. River catchments provide the ideal unit of scale for this planning process.

This first step to building a catchment level plan for EbA measures is to understand the geographical and human contexts in which the catchment sits. This builds the basis of the following steps in our approach and helps water resource challenges to be targeted with specific EbA measures.

Geographical & hydrological context

The type, condition, and location of the natural capital elements within a catchment influence when, how, and where water moves. This controls the quantity and quality of water available to humans as a resource. Geology, soil type, topography and land use are all key factors alongside climatic conditions which determine hydrological behaviour (I.e., runoff, interflow and baseflow) within the catchment. As features are usually not uniformly distributed through catchments, there are multiple processes present. However, catchments can usually be described as either runoff or groundwater dominated.

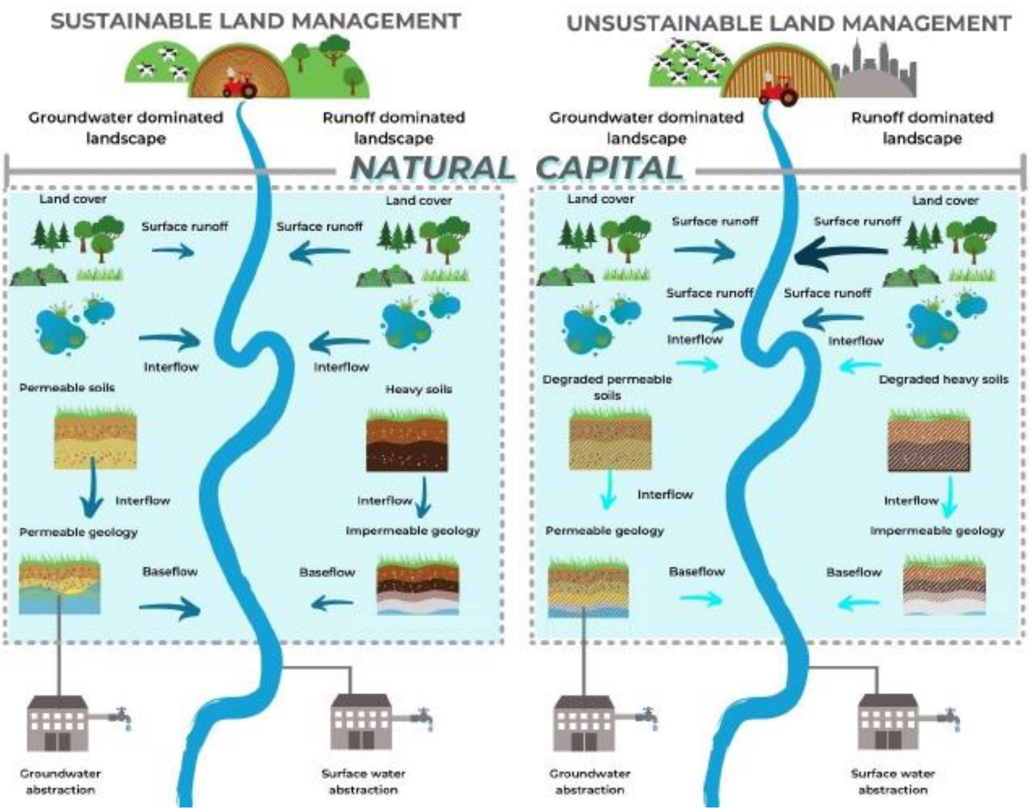


Figure 1 - This diagram demonstrates how unsustainable land management affects the hydrological function of different soil types. On permeable soils urbanisation, poor soil management and land use change reduce the amount of water reaching underground aquifers via interflow. As a result, less water is available for abstraction and to supply rivers via base flow, while surface runoff increases, raising the risk of flooding and reducing the amount of time that water is held in the landscape. Impermeable soils do not support aquifer recharge under normal conditions, so the main effect of these changes is a greater increase in the amount of surface run off, causing 'flashy' catchments that rapidly respond to rainfall. These rivers have a greater probability of flooding and are vulnerable to extended periods of low rainfall (cf. PROWATER report D3.2.1 [2]).

[2] https://www.pro-water.eu/sites/default/files/2022-03/D3.1.1_Report on risks and challenges to water supply.pdf

Considerations for the geographical & hydrological context of a catchment:

What are the dominant natural capital elements of the catchment?

- Geology
- Soil type
- Topography
- Land use & Land cover (LULC)

What condition are these dominant natural capital features in?

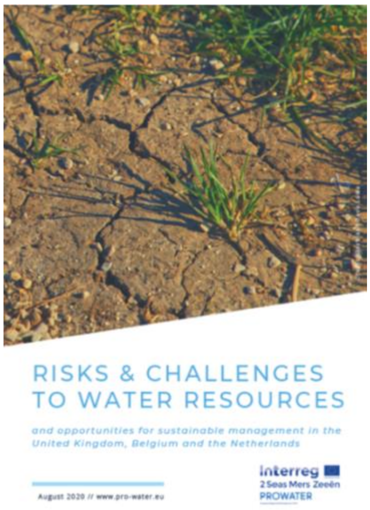
What are the dominant hydrological processes? (cf. Figure 1)

- Runoff dominated catchment / Groundwater dominated catchment

To learn more about the importance of the geological and hydrological context, please read pages 13-19 of the PROWATER report 'Risks and challenges to water resources and opportunities for sustainable management in the United Kingdom, Belgium and the Netherlands'.

The geographical and hydrological characteristics define the type of landscape(s) (in the catchment), i.e. runoff dominated or groundwater dominated. Depending on the type of catchment different EbA measures should be considered in the vision-building process.

DOWNLOAD THE REPORT HERE[3]



[3] https://www.pro-water.eu/sites/default/files/2022-03/D3.1.1_Report on risks and challenges to water supply.pdf

Geographical & Hydrological context- Otter catchment, Devon.

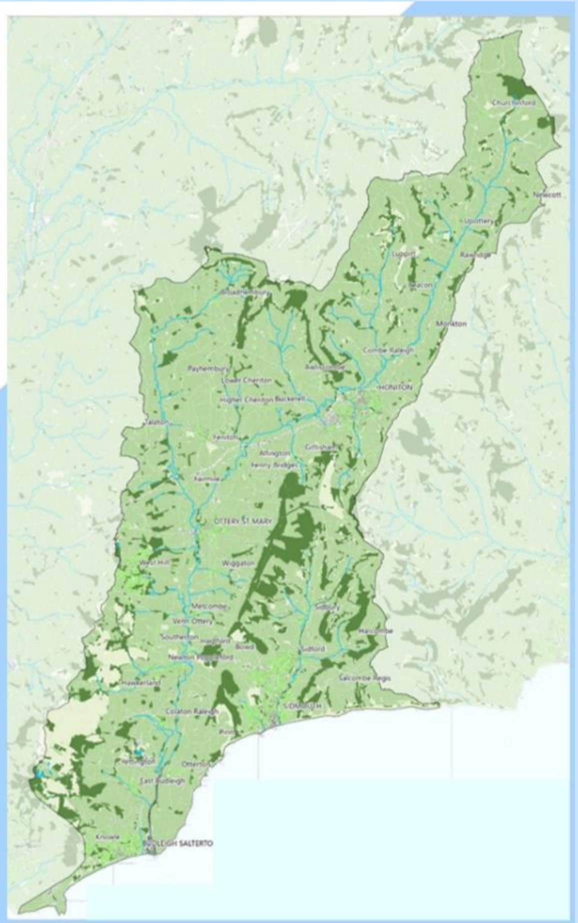
An example from West Country Rivers Trust.

There are distinct geological layers of 'clay and flint' on the hilltops called 'clay caps', lying above steep porous greensand escarpments with emergent spring lines that flow onto mudstone geology lower in the valleys. The clay and flint soils of the catchment tops are in poor, compacted condition from intensive farming and use throughout the year. The greensand is typically wooded with mixed broadleaf trees, with soils that are typically in good condition as these areas are steep and hard to farm so have not been compacted. The spring-lines at the bottom the greensand are key source of summer flows for the various tributaries of the Otter. There is a relatively rapid hydrological response, although the lower reaches are characterised by sandy-loam soils above the Sherwood sandstone and large pebble-bed geology.

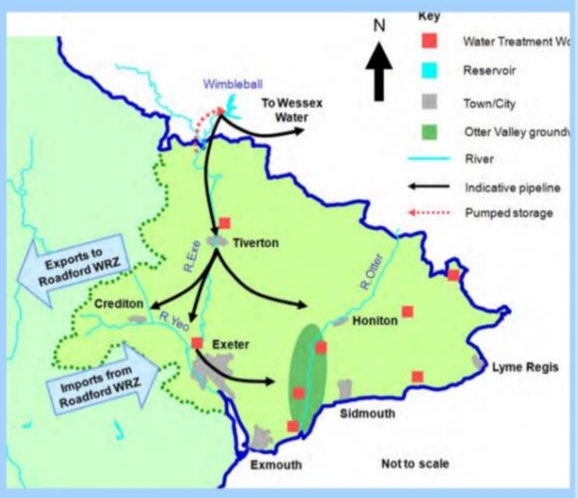
The Otter catchment is considered to have some of the most vulnerable soils combined with farm practice that creates a compaction-runoff problem. This is considered to be a key problem behind the issue of surface water flooding further down the catchment, with a heavy sediment load. The runoff from these 'clay caps' is then flows rapidly over the steep greensand slope with little time for infiltration in these porous soils. Elevated flows are also thought to be responsible for considerable hydro-morphic change in the river system, causing excessive erosion and widening of the channel. Overly wide channels during low flows are then less resilient, giving rise to stagnation and poor water quality and biology. Ecosystem based adaptations could be implemented within the catchment to reduce the risk of flooding and improve the resilience of the groundwater supply for drinking water.

The otter catchment comprises the most significant aquifer in Devon and Cornwall, with 23 boreholes from which South West Water abstract for public drinking supply from the sandstone to conurbations such as Lime Regis. The sandstone pebble beds are highly protected with SSSI/SAC/SPA designations supporting rare species such as damselflies that are attracted to 'wet seepage flushes' in the catchment.

There is mainly intensive dairy farming, with typically 2 cuts of silage on a lot of the agricultural land in this catchment, with some maize being planted – a typical rotation being grass, maize, silage on be 'freely-draining soils'. The clay caps were being sheep-grazed in places, without allowing the land to rest in the winter.



Otter catchment land cover.



South West Water water resources map.

Human context

It is important to explore the economic and societal challenges within the catchment area at this early stage to enable water resource challenges to be linked with other key issues through the planning process.

Involvement of regional spatial planners and government institutions in this mapping and planning process is crucial to get a good sense of short-term and long-term strategic objectives for land use and land cover in the catchment.

Considerations for the human context of a catchment:

What Land Use and Land Cover (LULC) characteristics impact water resources?

- Key industries/employment sectors within or dependent on the catchment
- Key land uses within or dependent on the catchment
- Key land covers within or dependent on the catchment
- Historic landscape features

What national and regional policies impact (the management of) water resources?

- Protected aquatic/wetland habitats/species within or dependent on the catchment
- Water Framework Directive status (high, good, moderate, poor and bad)
- The type of LULC classifications
- Ownership

What are the current development and management plans (linked to national and regional strategic objectives)?

- Development and infrastructure provision
- Water resource management
- Managing risks to communities from flooding and drought
- Nature conservation

2 UNDERSTANDING WATER RESOURCE RISKS & CHALLENGES

Building on the key information put together in the previous phase, this step is about understanding the current water resources position within the catchment and exploring how this may be affected in the future by climate change, population, and economic growth. It is important in this step to ensure that all the issues as they are perceived by different stakeholder are gathered here.

Water companies/providers, major water users, and regulatory bodies are the key audiences to engage with during this process to complete this step. The information is often already synthesised and easily available (e.g. by regional water resource groups).

Considerations to understand water resource risks & challenges :

What are the main abstraction sources for drinking water, for industry and for agriculture?
(Reservoir / River / Channel / Deep aquifer / Shallow aquifer / Etc.)

What are key threats, leading to deprivation of water resources for drinking water, for industry and for agriculture?

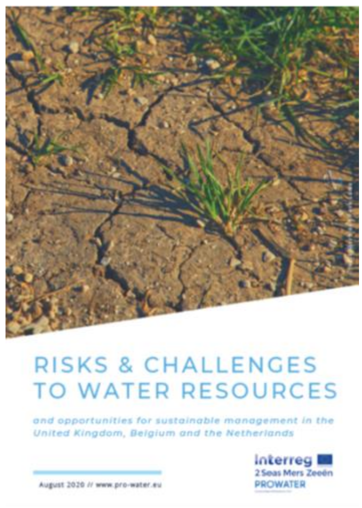
What is the current and projected supply/demand balance in the catchment? (drinking water, industry, agriculture, the environment)

What is the environment's need for water within the catchment?

What are the key threats, leading to flooding within the catchment?

To learn more about the risks and challenges identified for the 2 Seas regions and examples for the specific catchments targeted by project partners, please read the PROWATER report 'Risks and challenges to water resources and opportunities for sustainable management in the United Kingdom, Belgium and the Netherlands'.

The report summarises risks to water resources and sets out how EbA measures such as soil management, wetland restoration, river valley restoration and forest conversion can increase the resilience of catchments to climate change and increasing demand for water.



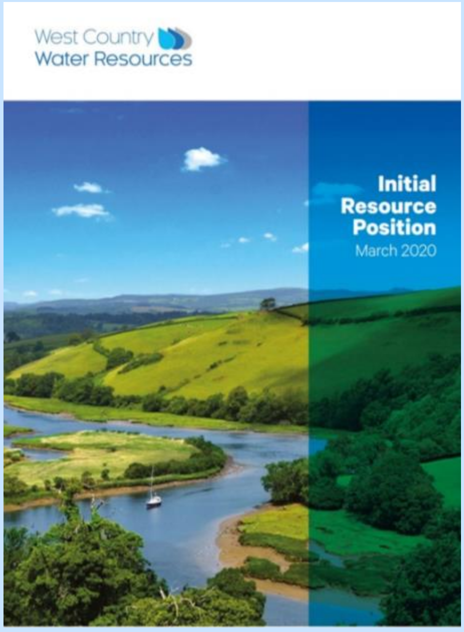
DOWNLOAD THE REPORT HERE[4]

4 https://www.pro-water.eu/sites/default/files/2022-03/D3.1.1_Report on risks and challenges to water supply.pdf

Understanding water resource risks and challenges.

In the UK, regional water resource groups have been set up. In these groups, organisations responsible for water supplies worked together to understand the water needs for England from 2025 to 2050 and beyond.

Five regional groups bring together the water companies that operate in each of England's regions an other major water users. The regional groups will each produce one plan. It must consider how the region will be resilient to a range of uncertainties and future scenarios. It must identify a set of options that provide the best value to customers, society and the environment rather than simply the least cost. Together the 5 plans must meet the national need.



The plans need to address the following:

- Increasing resilience to drought
- Greater environmental improvement
- Reducing long term water usage
- Reducing leakage
- Reducing the use of drought permits and orders
- Increasing supplies

3 IDENTIFYING AND ENGAGING STAKEHOLDERS

All the knowledge gathered on the catchment characteristics, its water resource risks and challenges will help create a mandate for action on water resources across the catchment. It provides the context in which the case for using EbA measures sits. The next stage of the engagement process, the ‘awareness raising’ is where the mandate for action is communicated to the identified stakeholders.

The success of this ‘communication campaign’ relies heavily on a comprehensive stakeholder analysis exercise. In order to target the engagement to specific audiences it is helpful to segment stakeholders according to certain characteristics. Depending on this segmentation, different communication tactics (audience-message-channel) may be implemented in the communication campaign.

For PROWATER, we segmented stakeholders in function of potential rewarding schemes for EbA measures (cf. PROWATER output 2[5]). We identified potential buyers, sellers, and those stakeholders who hold the knowledge and understanding of the area to help inform the process (brokers).

- Buyers : who will benefit from the EbA measures?
- Sellers : who owns/manages the land where the EbA measures were implemented?
- Brokers : who holds the knowledge to inform (spatial) planning and EbA?

Throughout the mapping and planning process, it is important to keep track of existing rewarding schemes (e.g. Payment for Ecosystem Services or PES schemes, subsidy schemes, etc.) that could apply to the implementation of EbA measures targeted at water infiltration and retention in the catchment. Especially schemes that take into account the importance spatial prioritization when deciding what EbA measures to plan for and implement in the catchment. Additional sources of funding can convince buyers and sellers to invest (time) in EbA measures.

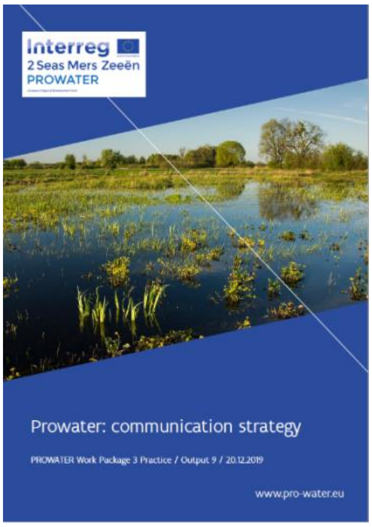
Considerations to identify and engage stakeholders:

Which stakeholder should be informed and/or involve the vision-building for EbA?

For more information on how to segment stakeholders and tailor communication to them, please read PROWATER Output 9 ‘Communication Strategy’.

This comprehensive Communication Strategy developed by PROWATER will:
1) guide and support readers as they seek to build a participatory long term vision for EbA measures in their regions
2) allow the readers to monitor and evaluate the participatory processes being undertaken and deduce the lessons-learnt

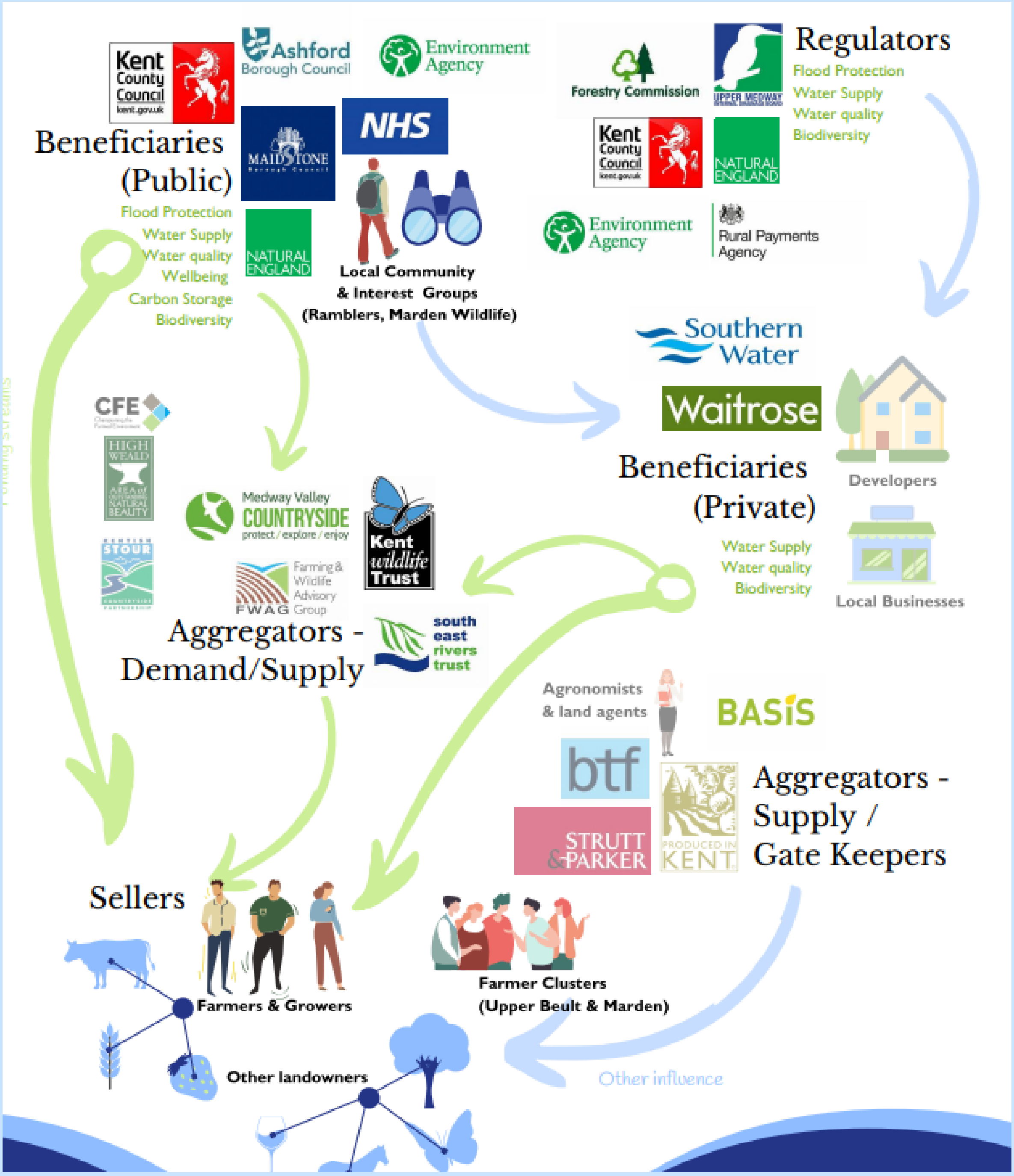
DOWNLOAD PROWATER OUTPUT 9 HERE[6]



[5] https://www.pro-water.eu/output-library
[6] https://www.pro-water.eu/prowater-communication-strategy

Stakeholder analysis exercise for participatory vision building

An example by South East Rivers Trust and Kent County Council: the Beult catchment stakeholder map.



Summarise the mandate for action based on all the knowledge gathered on the catchment characteristics, its water resource risk and challenges.

What specific EbA measures could apply to the area and how do the costs compare to the benefit?

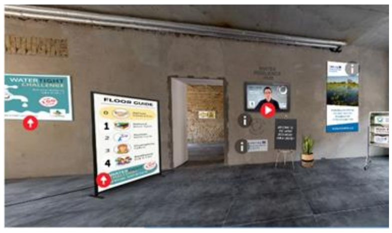
What are other key catchment issues? Highlight issues that can be solved by the same EbA measures that target increased infiltration and retention.

- Diffuse agricultural pollution
- Biodiversity loss
- Other?

Learn more about the stakeholder engagement tool developed by PROWATER partner Westcountry Rivers Trust, after the Water Resilience Summit.

This was an open conference with multiple short talks from water resilience champions across a range of sectors with opportunities for the audience to ask speakers questions. An interactive questions wall was also used throughout the event to collect general questions and comments from the audience which were then answered after the event and circulated to the attendees as part of follow up correspondence. Following the live event an online information hub was created using the talks recorded on the day and multiple sources of further information on similar topics. This online library was created using Thinglink software, an education technology platform for creating accessible, visual learning experiences in the cloud.

VIEW THE SH ENGAGEMENT TOOL HERE[7]



What are existing rewarding schemes (e.g. Payment for Ecosystem Services or PES schemes, subsidy schemes, etc.) that could apply to the implementation of EbA measures targeted at water infiltration and retention in the catchment:

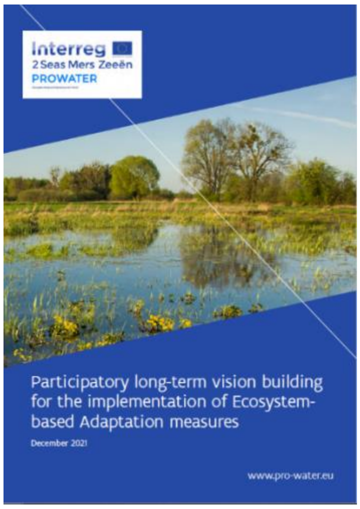
- Environmental Land Management Schemes (ELMS)
- Agri-environment schemes
- Existing water company schemes
- Nutrient trading schemes targeted at measures that also impact water quantity
- Carbon trading schemes targeted at measures that also impact water quantity
- Private investments

[7] https://www.thinglink.com/mediacard/1358113688577376257

For a summary of the methods used throughout the PROWATER project to engage with different stakeholders please read PROWATER report 'Participatory long-term vision building for the implementation of Ecosystem-based Adaptation measures'.

PROWATER held a number of interactive workshops with potential buyers, brokers and sellers across the 2 Seas region. These contributed to awareness raising and vision building for EbA measures targeted at increased infiltration and retention in the landscape.

DOWNLOAD THE REPORT HERE[8]



Stakeholder engagement in participatory vision building processes for EbA in Southeast England

A perspective from South East Rivers Trust, South East Water and Kent County council, based on the PROWATER workshops on participatory vision-building for EbA.

The workshop 'Water Resources and Climate Change' was attended by farmers and horticultural growers within Southeast England.

Please read the PROWATER report 'Participatory long-term vision building for the implementation of Ecosystem-based Adaptation measures'[9], and the separate workshop report[10] for more details.

The day-long interactive in person workshop, was broken in two sessions. In the morning, focus was put on regional impacts of climate change, starting with a presentation on the current understanding of the impact of climate change on Kent and examples from farmers and producers in the region. In group discussions following this, the role of farming and opportunities to increase resilience to climate change on farms was discussed. In the afternoon, focus was put on incentive mechanisms and actions to enable higher uptake of Nature-based Solutions targeted at climate adaptation, again using a mix of presentations and discussion groups. Additional information was gathered through a survey using multiple-choice questions.

[8] https://www.pro-water.eu/sites/default/files/2022-06/D3.2.1_Participatory long-term vision building for the implementation of EbA_0.pdf
[9] https://www.pro-water.eu/sites/default/files/2022-06/D3.2.1_Participatory long-term vision building for the implementation of EbA_0.pdf
[10] https://www.pro-water.eu/sites/default/files/2022-03/PROWATER%20Water%20Industry%20and%20NBS%20workshop%20report.pdf

There was a high level of agreement from all participants that soil and land management had a big impact on water retention in the landscape. Almost all farmers also indicated a high level of willingness to be innovative in protecting the resilience of their business and achieving improvements for the environment. However, they also indicated that they did not always know where to get information on adapting their practices to climate change from.

Stakeholder engagement in participatory vision building processes for EbA, across borders

A perspective from the waterboard Brabantse Delta, the Flemish Government, the province of Antwerp and the University of Antwerp, based on the PROWATER workshops on participatory vision-building for EbA in the Mark river catchment, situated in Flanders and the Netherlands.

Please read the PROWATER report 'Participatory long-term vision building for the implementation of Ecosystem-based Adaptation measures'[11] for more details.

The series of participatory Flemish-Dutch cross-border workshops was digitally attended by Local authorities, Regional authorities, Umbrella organisations, Lobby groups, Consultants. It delivered important conclusions and recommendations for successful stakeholder engagement in an international context:

- Physical features and resulting water system processes are valid across borders and cannot be argued with, increasing willingness to accept the resulting recommendations. The water system map (with A, B and C type locations) applied to the 2 Seas region for PROWATER, is a spatial prioritisation tool that helps to understand the physical features and resulting water system processes across borders. This biophysical context combined with land use, land cover and social data then determines the different recommended actions for EbA measures, using the catchment (river basin) as the appropriate scale for spatial planning.
- We recommend using a common baseline for spatial prioritisation of EbA measures across borders (e.g. PROWATER water system map combined with land use, land cover and social data) and to acknowledge downstream and upstream asymmetries within the catchment during the planning process. This can then result in clear, unambiguous communication (by trusted brokers such as 'The Bosgroepen') to landowners and site managers about the most appropriate Ecosystem-based Adaptation measures according to the location in the landscape..
- Communication about the need for and effectiveness of Ecosystem-based Adaptation will strengthen support and uptake of EbA measures. This requires time and capital investments.
- During workshops, participants talked about cross-border water authorities as a possible approach. Organisations on either side of the border have a different governance system with different jurisdictions across institutions. We have to find a way to counter (further) fragmentation of jurisdictions related to water management to facilitate stakeholder collaboration.
- The Payment for Ecosystem Services (PES) concept and other incentive schemes for EbA implementation are still abstract to the individual entrepreneurs that depend on the ecosystem services to make a living. Investing in new demonstrations of ('outcomes based') PES schemes and strengthening PES schemes with existing best practice incentives can help translate the PES concept into an attractive business-model.

[11] https://www.pro-water.eu/sites/default/files/2022-06/D3.2.1_Participatory long-term vision building for the implementation of EbA_0.pdf

- Given upstream-downstream asymmetries, a shared river basin redevelopment fund may help to overcome political issues of one country investing money in another country, without receiving return on investment themselves (be it financial or in the form of the targeted ecosystem services).
- Incentives to engage stakeholders need to be complemented by regulation where necessary. Delivering the full potential for EbA measures will require clear, innovative and bold land use planning as well as management.

Stakeholder engagement for (spatial) planning of EbA

A perspective from Pidpa, a Flemish integrated water company, based on their own motive for engagement within PROWATER.

Pidpa understands the importance of nature and good land management around water abstraction sites as no other, as these can have an impact on the drinking water quality and quantity for years to come. Thus, PROWATER's aim to facilitate Ecosystem-based Adaptation to improve water infiltration and retention in landscapes, and as a result counter climate change impacts on drinking water resources, matched with Pidpa's strategic objectives.

Moreover, drinking water companies pay taxes on the amount of groundwater they abstract to provide drinking water. These funds could be used as an incentive for land owners to invest in Nature-based Solutions that contribute to increased infiltration and retention. PROWATER is investigating opportunities for the application of Payment for Ecosystem Service (rewarding) schemes targeted at implementing Ecosystem-based Adaptation.

When the University of Antwerp and the province of Antwerp presented their knowledge on EbA and the possibility for additional ERDF funding, Pidpa realised that EbA implementation was possible on its own land, in collaboration with a private land owner. The development of the Water System Map would also be an added value in drafting rainwater and drought plans for the municipalities where Pidpa is the sewer manager. As a result of Pidpa's engagement in the PROWATER project, the water system map is now used in every newly drafted rainwater and drought plan.

Stakeholder engagement for (spatial) planning of EbA

A perspective from waterboard Brabantse Delta (WBD), a Dutch water management authority, based on their own motive for engagement within PROWATER.

Due to very positive prior experiences with Flemish-Dutch-British cooperation (within the Interreg 2 Seas Triple C project), the waterboard's direction decided to respond positively to the Flemish request for a new cooperation on the Interreg 2 Seas PROWATER project.

Moreover, the waterboard's own strategic objectives fitted well with the project. There is a growing consensus on the need for Nature-based Solutions targeted at improved water infiltration and retention in the landscape to counter the impacts of heatwaves, drought periods and extreme precipitation events, all exacerbated by climate change.

The timeline fitted well with the project as they just started an innovative participation process with volunteers (citizens and entrepreneurs) who wanted to work on a new water vision for the region, with a large focus on Ecosystem-based Adaptation. The volunteers aimed at acceleration of nature and water quality restoration investments by means of Nature-based Solutions, e.g. for adapting to climate change, in the Mark River Valley close to Breda City and the Flemish-Dutch Border. This approach perfectly seemed to fit in the PROWATER objectives for demonstration sites.

Additionally, WBD's water policy department had started the preparation of its new water management programme for the 2022-2027 period. The Payment for Ecosystem Services (PES) approach, included as a work package in PROWATER, sounded very interesting with regard to the needed adaptation of the development, use and management of water-landscapes to climate change. Furthermore, the Flemish experiences with ecosystem services (through partnership with the research lab ECOBE at the University of Antwerp) and the British PES-practices were an important trigger to join the PROWATER partnership.

In the implementation phase, stakeholder engagement needs to continue to make sure the EbA measures are successfully implemented. Depending on the context (implementation on private and/or public land) different approaches may be recommended.

Stakeholder engagement throughout the implementation phase

A perspective from Pidpa, a drinking water company in Flanders (Belgium), based on their experiences within PROWATER demonstration sites for EbA.

It's good to have an independent/neutral consultant present at the discussions with private land owners since this person will not only represent the buyer (in this case Pidpa) but also the seller (the private land owner).

To involve private land owners, personal contact can be very important. Having someone present at the table with knowledge of the area, its history and maybe the private landowners themselves has been an advantage to acquire the remaining parcels in Grobbendonk. The initial plan of the personal meeting was to come to an agreement for collaboration since the private landowners were not willing to sell in the past. The idea of the fen restoration was presented to the private land owners after which they proposed to sell their land. This shows the importance of making time for the private landowners to have a personal meeting, with experts on nature conservation and restoration (like a forester and consultant of the regional landscapes), explaining the initial idea and giving them the ability to decide what they are willing to do.

It's best to avoid too much time between meetings since the momentum is easily lost if it's been too long since there was contact.

Stakeholder engagement throughout the implementation phase

A perspective from waterboard Brabantse Delta, a regional authority for water management in the Netherlands, based on their experiences within PROWATER demonstration sites for EbA.

To transition from land and water management towards a more Nature-based including climate change adaptation objectives, we need to prioritise ecosystem service delivery in areas with the highest potential to deliver them. This often requires significant changes in land management and land cover (e.g. to implement EbA measures) on both public and private land. One important lesson from the Markdal project (including the initial PROWATER demonstration site for the waterboard) is that active involvement of (well-experienced) local stakeholders helps to gain support for the necessary land cover and land use changes (from involved private and public land owners).

In a multi-stakeholder, cross-border and participatory process, involved regional and local authorities (including the waterboard) have to learn to adapt their old (traditional) policies and practices to make a private-public cooperation process successful. Both, the volunteer network and the authorities learn to acknowledge each other's roles, talents and expertise and to implement these in a participatory process, based on shared ownership.

The volunteer group of the Markdal project, started a complicated but very promising process with several process agreements and different authorities involved. Such an ambitious cross-border catchment development and management project takes time and does not develop without hurdles to overcome:

- In multi-stakeholder processes a way forward can be to step back for a while in order to develop process conditions for shared fact finding, shared vision building and shared actions. At present, the partners within the Markdal project are reconsidering the best way forward in a time out moment.
- In future projects, involved authorities, actors and volunteer groups should design a participatory planning approach with more intensive communication and facilitation with all involved authorities and stakeholder groups from the start of the project.

4 ECOSYSTEM-BASED ADAPTATION TARGETING

Spatial prioritisation

Using EbA to build resilience against droughts, water scarcity and extreme precipitation events focuses on the following principles; to promote infiltration in elevated upstream areas by improving soil permeability (reducing runoff and interception), retaining runoff and groundwater in headwater wetlands and landscape depressions, and retaining water in valley systems by meandering and rewetting.

To provide guidance to the spatial planning of EbA measures across a catchment, the PROWATER project developed a ‘water system map’ for the 2 Seas region, including catchments in the Netherlands, England, Flanders and France. This spatial prioritisation tool displays how the landscape functions from a hydro-geomorphic point of view. It highlights the different hydro-zones (recharge areas, headwater wetlands -including upstream landscape depressions- and permanently wet areas) and identifies hotspots of hydrological functioning that are conditional to sustain system functioning.

When interpreted with soil type and topography information this can inform the type of EbA measures that are suitable in these area to be restore or support the key hydrological processes. Restoring functional ecosystems (through EbA measures) in these hotspots within the landscape would provide an increases resilience to system disturbances.

The water system map for Europe is a tool that enables spatial planning for EbA measures at the catchment level and across borders for catchments in the United Kingdom, the Netherlands, Flanders and France.

To learn more about what EbA measures to (spatially) plan for depending on the hydro-zone and natural capital present in the catchment, please read pages 22-30 of the PROWATER manual ‘The water system map for Europe A spatial prioritisation tool for climate change adaptation measures‘.

The manual helps readers interpret the hydro-zones highlighted by the water system map and select what EbA measures to consider and plan for based on the type catchment (runoff dominated vs. groundwater dominated) to increase resilience to climate change and other pressures on water resources.

CONSULT THE WATER SYSTEM MAP HERE[12]

DOWNLOAD THE MANUAL HERE[13]

[12] https://www.pro-water.eu/the-water-system-map-for-europe

[13] https://www.pro-water.eu/sites/default/files/2022-06/O3.1_The Water System Map for Europe - A spatial prioritisation tool for climate change adaptation.pdf

To learn more about other spatial prioritization approaches for EbA, please consult the PROWATER report 'Review of spatial prioritisation methods for Ecosystem-based Adaptation measures to drought risks'[14].

Refining spatial targeting & EbA opportunities

While the exact design of EbA measures is very site specific and would need to be developed in combination with existing land usages and on the ground investigation, some further analysis can help create a suite of practical options which can then be used in the next phase of planning.

Once the hydrological processes within the catchment have been visualized via the interpretation of the water system map alongside topographical and soil data, this can be aligned with other existing spatial planning data. Integrating EbA opportunities in this way will maximise the additional benefits that can be achieve through these investments. The additional resources available will depend on the location of the catchment but may include Habitat Network maps, NFM opportunity maps, and Hydrological connectivity models.

The water system map in use – Spatial planning in the Neteland

In a case study of for spatial planning within the Neteland (Flanders), the province of Antwerp used the water system map to visualise the ecosystem services that could potentially be delivered in the landscape. The aim of the case study was to look for opportunities in 5 surrounding municipalities, to compensate for the ecosystem services lost due to additional development in an already densely populated city. A coalition of 5 municipalities would have shared benefit of these planned opportunities for ES provisioning.

Using the water system map the province of Antwerp could show the coalitions of 5 municipalities which area's deliver services and the range of services that are delivered. This broadened their mind that services are much wider than only carbon storage or clean air. They were especially interested in the water system map as it provides site-specific information on important areas for water infiltration and water storage and shows easy interpretable gradations in measures and where specific measures could benefit the water system.

The visualisation and explanation they received based on the water system map resulted in a different and improved focus. Water infiltration, health through contact with nature and heat reduction by creating more green area's became important goals. A direct result was the information campaign "Tegelwippen". Eight municipalities organised a competition between them, with their citizens, to deliver the removal of the largest area of concreted surface with their citizens.

The user (province of Antwerp acting as a broker) considered the water system map to provide several benefits in the spatial planning process:

- clear and site-specific information.
- The same colour leads to nuanced recommendations: I.e., different measures dependent on land cover and land use (if it lies in a built-up, nature, or agricultural area) and depending on the type of catchment.
- The categorisations give information on different ecosystem services on one map, including infiltration and water retention.

[14] https://www.pro-water.eu/sites/default/files/2022-04/D2.1.1_Spatial_prioritisation_methods_EbA_measures.pdf

- The map shows what the water system looks like and what (Ecosystem-based Adaptation) measures it needs to deliver its full potential of ecosystem services.
- You can't argue with the water system and the science backing the visualisations, so the map is easily accepted. This generates a high level of willingness to implement nature-based solutions.
- By ranking the alternative recommended measures in specific sites, stakeholders feel a freedom to choose within their regular processes which measure are implemented. This generates a high level of willingness to implement nature-based solutions.

Despite this, the user also observed some room for improvement:

- sometimes stakeholders are not convinced that restoring the natural water system is the way to go, e.g., because they believe in technical solutions. By broadening the visualisation to a wider range of ecosystem services (more than water infiltration and retention) there is a bigger chance one of the services may convince them to implement nature-based solutions.

When using the water system map for spatial planning purposes, the user recommends aiming high: i.e., when explaining about the different measures it is important to mention which of the possibilities has the biggest effect. Compromises will always be made so it is good to also mention second and third best measures.

The water system map in use – Water management programme 'Chances for hydrological restoration'

Inspired PROWATER (amongst others), the Ecosystem-based Adaptation philosophy and reasoning of the water system map as a spatial prioritisation tool has been included in the waterboard Brabantse Delta's water management programme 'Chances for hydrological restoration' (see Meijer et al., 2021, 'Kansen voor hydrologisch herstel', Chapter 3). The awareness raising was already taking place for some time but has further been strengthened thanks to PROWATER.

The aim of the project was to compile an opportunity map for water system restoration, based on the concept of the water system map. This opportunity map can help area advisors and landowners to derive targeted measures that contribute to a more robust water system. To simplify the water system map, areas with coherent land use were considered one opportunity and classified as either short term, short term with restrictions or long term opportunities.

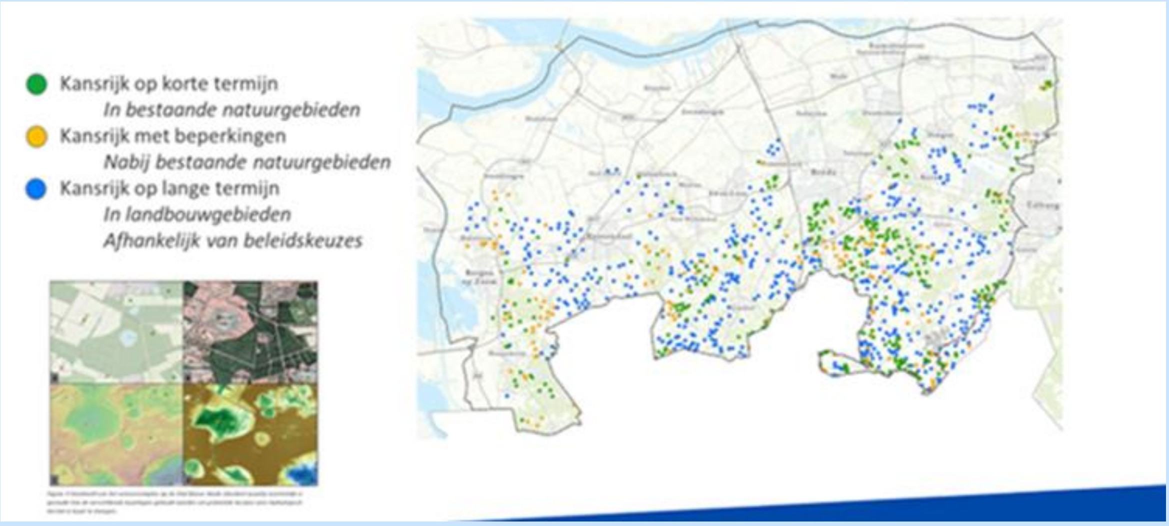
The user (Bosgroep Zuid Nederland acting as a broker) considered the water system map to provide several benefits in the spatial planning process:

- the concept explains in a comprehensible manner where the water system can be effectively restored (i.e. where specific EbA measures can have a positive impact on the water infiltration and retention capacity in the landscape)
- the map guides the user to a range of recommended EbA measures that can improve the water system (rather than only one recommendation)

On the other hand, there are some possible downsides:

- the choice between multiple recommended EbA measures may mean that the less effective measures are eventually implemented (resulting in a limited contribution to water system restoration).

- the water system map does not indicate the extend of land cover or land use change needed to significantly impact the ground water levels. However, this is beyond the scope of the water system map. The aim of the water system map is to identify where in the catchment specific EbA measures can have a positive impact on the water infiltration and retention capacity in the landscape.



Map indicating chances for hydrological restoration developed by the Bosgroep Zuid Nederland acting as a broker by order of the waterboard Brabantse Delta.

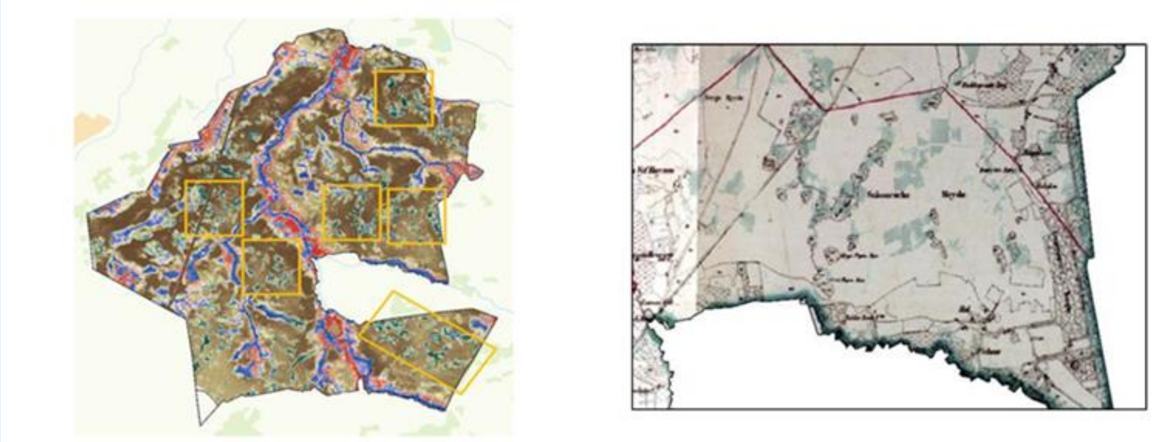
The water system map in use - Opportunities for EbA measures in the municipality Hoogstraten

A special interdisciplinary trainee project team, as lead by Steffi Deprez (waterboard Brabantse Delta), worked out opportunities for EbA-measures in the territory of Hoogstraten municipality (in collaboration with the city Hoogstraten and Regionale Landschap de Voorkempen). The project team applied the PROWATER water system map, interviewed stakeholders and organised a workshop.

The knowledge (e.g. based on water system map) and willingness to cooperate are present. The major challenge is to include farmers and develop an attractive business model with them to invest in EbA-measures. Existing financial instruments may hinder successful Payment for Ecosystem Service scheme-implementation. However, it is not only about financial incentives. Raising awareness and providing farmers with knowledge and opportunities to take part in SMART local scale water management activities are very important as well.

The user (waterboard Brabantse Delta acting as a broker) considered the water system map to provide useful insights on the potential in the landscape for targeted ecosystem services : water infiltration and retention. The stakeholders present acknowledged the sense of urgency to invest in EbA-measures to cope with increasing water scarcity issues. Every stakeholder acknowledged the possible benefit from targeted ecosystem services.

The explicit framing of spatial planning and water resource management in terms of EbA (building with nature) and ecosystem services was not standard in the working of the waterboard Brabantse Delta. Implicitly, there were and continue to be examples that do work in that spirit. However, in the next few years, partly triggered by the PROWATER findings, we want to explicitly link more examples to the biodiversity and building with nature agendas of the waterboard.

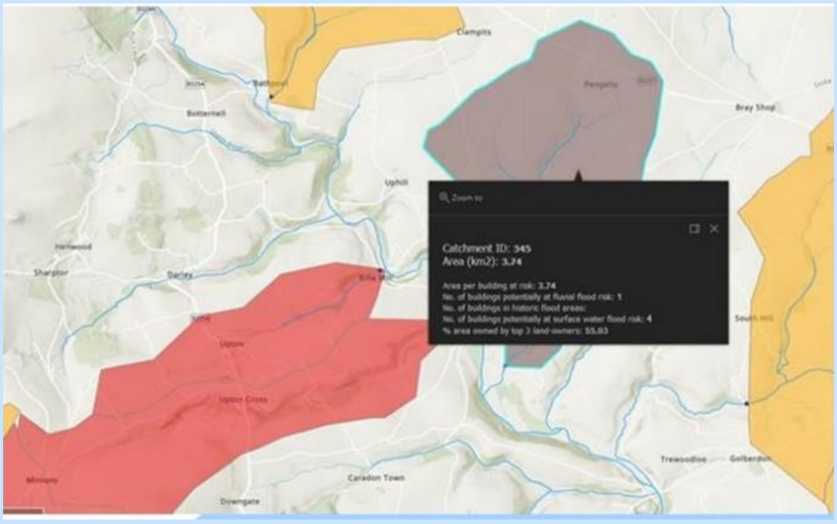


Water system map applied to the municipality of Hoogstraten on the left.

Refining spatial targeting

An example by Westcountry Rivers Trust of how budget limitations can influence the targeting of EbA measures in the Little Stour catchment.

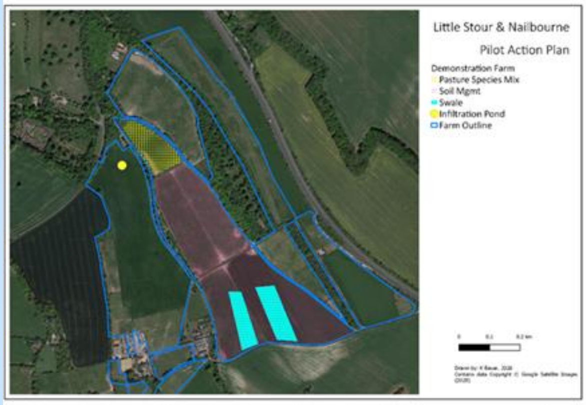
Hard engineering flood mitigation measures often entail considerable expense and are not always possible in some locations. Where such measures are impractical, there may be opportunities for natural flood management (NFM) measures (i.e. EbA measures) at smaller scale and lower cost that also bring additional benefits to biodiversity and the aesthetics of the landscape. However, the scattered and fragmented locations of properties at flood risk and the limited accessible funds necessitates identifying only the largest clusters of flood risk properties with the smallest upstream micro-catchments to deliver optimal impact with the resources available.



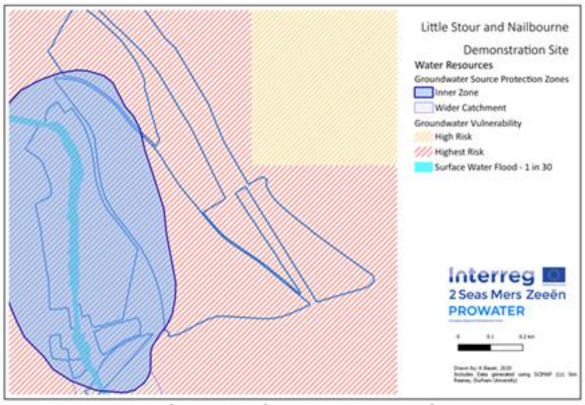
The process for identifying the highest-impacting locations of NFM measures across Devon and Cornwall involved several steps. The first step was to identify watercourses with an upstream watershed less than 10 km^2 in size, then to identify properties adjacent to these watercourses that overlapped with fluvial flood zones. Next, pour points were placed on the watercourses in front of the furthest downstream flood risk properties. These pour points were then used to delineate the micro-catchment boundaries. Penultimately, the micro-catchment area was divided by the number of flood risk properties within it to calculate the area per property at risk for each micro-catchment. Those with the lowest area per property indicated higher potential for small-scale NFM measures to benefit the greatest number of flood risk properties. Lastly, additional factors, such as Water Framework Directive classifications and previous engagement with farmers, were considered alongside the area per property at flood risk to prioritise a small number of micro-catchments to target NFM.

Refining EbA opportunities

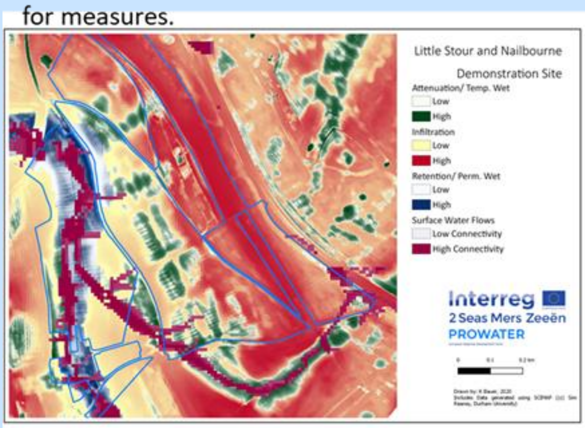
An example by Southeast Rivers Trust of measure design in the Little Stour catchment, Southeast England.



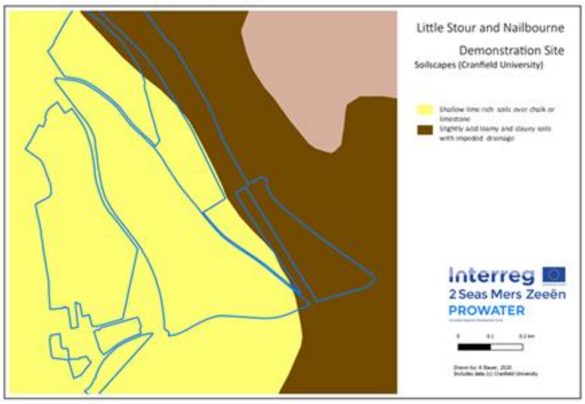
Map 1: Satellite image showing land cover and indication of land use, alongside opportunities for measures.



Map 2: Groundwater abstraction catchments and vulnerability to pollution, alongside risk for surface water flooding.



Map 3: Water systems maps identifying retention/infiltration areas alongside modelled surface water flow pathways.



Map 4: Soil types dominant on the farm. Clay soils (brown) create runoff, while chalk soils (yellow) are well drained.

In this example, a number of spatial datasets have been combined to further inform the design of nature-based solutions on the demonstration site in the Little Stour.

The top left shows a satellite image of the site, indicating land cover and use as well as options for measures identified. On the top right, the map highlights the level of groundwater vulnerability due to the likely presence of solution features in the chalk which can act as direct pathways to the groundwater body and so create a risk of pollution. They are also locations where a high proportion of water is likely to reach the aquifer, and as such could be highly valuable for increased recharge. The map also shows the boundaries of 'source protection zones', which are the estimated catchment areas for abstraction points. Bottom right shows the two dominant soil types on the site, chalk and clay. On clay, little recharge is likely to happen and most rain will become runoff, whereas the chalk soils are thin and permeable. Finally, bottom left shows the water systems maps created by Antwerp University alongside surface water flow paths modelled using Scimap.

Understanding not only the potential for where drier/wetter areas are likely to be located, but also how that land is currently being used, where water is likely to come from, and whether it is likely to run off or infiltrate, helped identify potential attenuation as well as infiltration measures. Infiltration measures were located on the chalk soil, intercepting potential flow paths to spread water further over the area of increased recharge. To ensure water quality was protected on the areas vulnerable to pollution, it was important to design measures in a way that could mitigate or treat any potential pollution risk, such as from nutrients or animal manure.

5 QUANTIFICATION & MONITORING

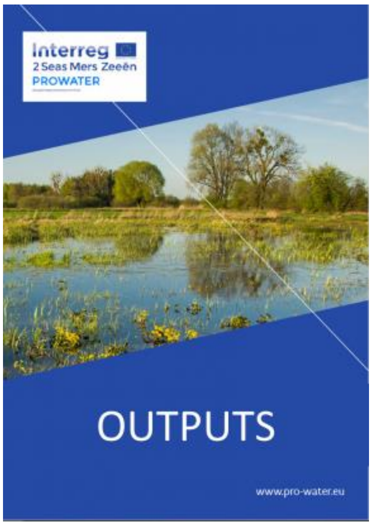
Quantification of benefits and co-benefits

The (business) case for EbA in spatial planning can be strengthened by quantifying the targeted ecosystem services (ES) or benefits resulting from planned or implemented EbA measures. This is an important yet challenging step in the participatory (spatial) planning process for EbA, as it helps gain support for large scale investments and implementation of EbA measures.

Moreover, quantifying the co-benefits delivered by EbA measures (i.e. ES in addition to the targeted ES) is key to clarify the possible design of incentive schemes and drawing in wider funding sources by building business cases and identifying the saleable ecosystem services.

To provide guidance to the participatory (spatial) planning for EbA measures across a catchment and the design of possible rewarding schemes, the PROWATER project developed a ES quantification tool for the 2 Seas region, including catchments in the Netherlands, England, Flanders and France.

PROWATER developed a tool that enables the quantification of Ecosystem Services (ES) resulting from EbA measures based on modelling (PROWATER Output 4). The tool can be applied at the local level, at the catchment level and across borders for catchments in the United Kingdom, the Netherlands and Flanders.



Currently, the ES quantification tool models the impact of EbA measures (and resulting land use and land cover change) on:

- Water provisioning (or 'water yield')
- Water evaporation
- Water runoff
- Water infiltration
- Water retention
- Carbon content in soil

The tool may be expended by more ES indicators in the near future.

LEARN MORE ABOUT OUTPUT 4 HERE[15]

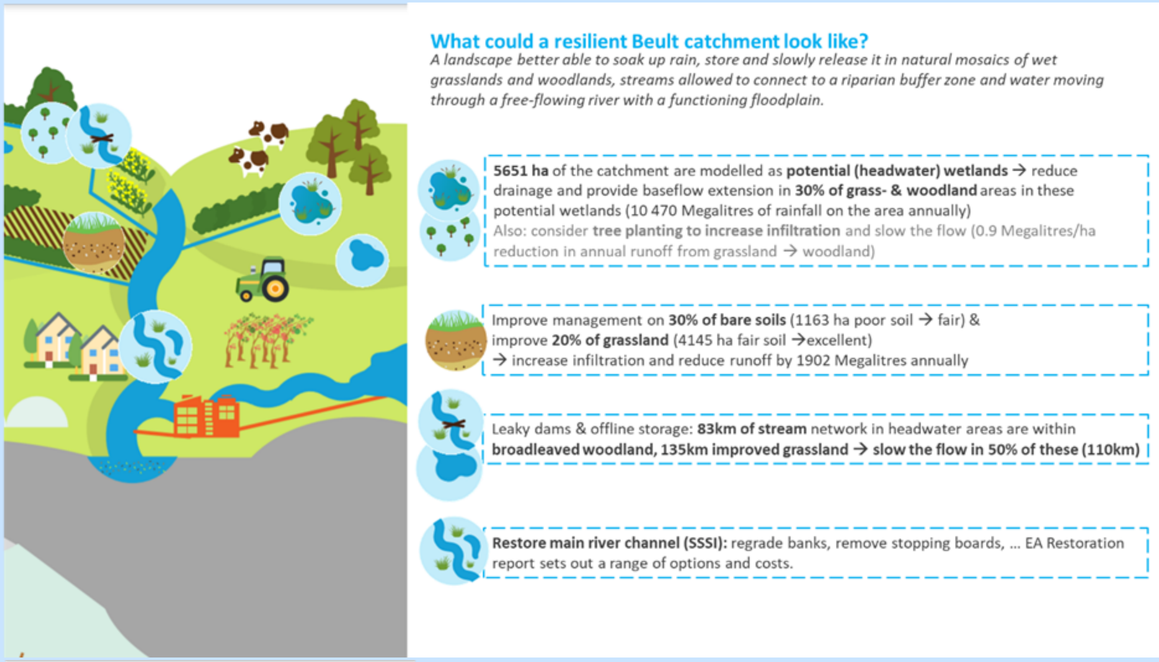
To learn more about other quantification approaches for EbA, please consult the PROWATER report 'Review of quantification methods for ecosystem services of Ecosystem-based Adaptation measures to drought risks'[16].

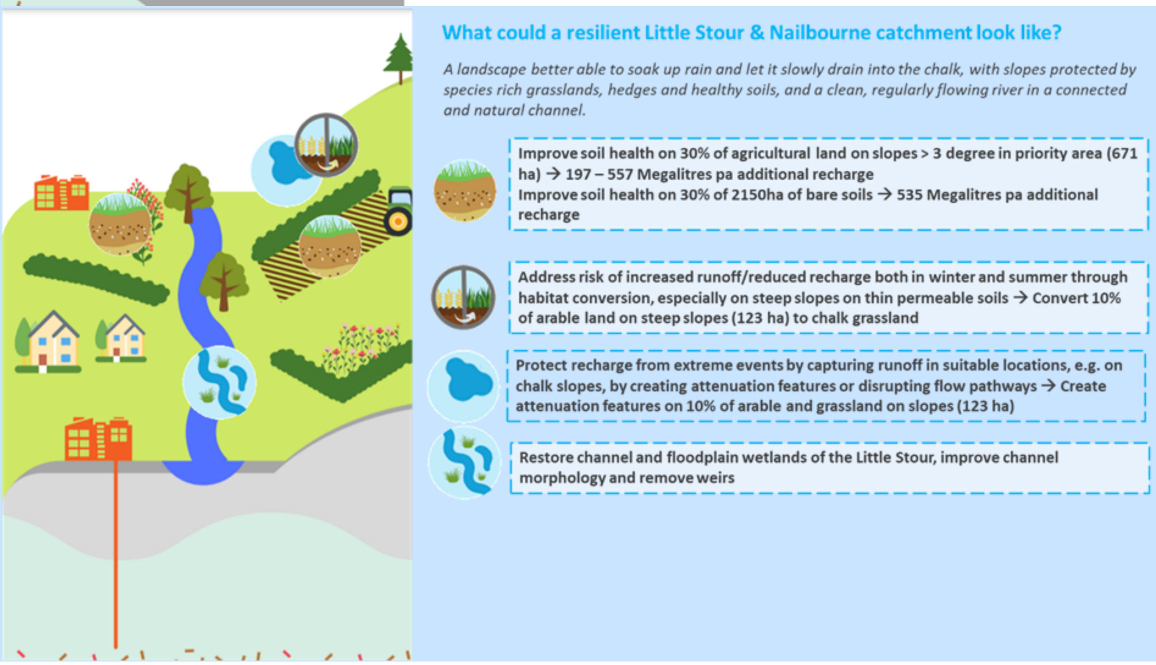
[15] https://www.pro-water.eu/output-library
[16] https://www.pro-water.eu/sites/default/files/2022-03/D2.2.1_Quantification_methods_for_ES_of_EbA_measures.pdf

Quantification of benefits and co-benefits

An example by South East Rivers Trust in the Beult, Little Stour and Nailbourne catchment in Southeast England.

To understand the potential impact of the uptake of measures at a catchment scale, the InVEST tool (https://naturalcapitalproject.stanford.edu/software/invest) was used to understand how improvements in land management and habitat change could affect recharge and runoff. A scenario for change was based on understanding the current landscape, the opportunity for improvement (using the water systems maps developed by the University of Antwerp alongside a natural capital mapping approach developed by the South East Rivers Trust) across the catchment and an assumed proportional uptake of measures. An estimate of the impact of catchment scale change for the Stour and Beult catchments is shown below.





Human pressures, such as land use changes, soil sealing, groundwater abstractions and drainage have had an enormous impact on the hydrological system, leading to increased peak flows, declining groundwater levels and a decreased natural water availability. In combination with climate change, threatening water security will become a key. Also, other ecosystem services, such as soil nutrient retention, soil carbon sequestration and biodiversity are affected. When strategic water reservoirs and/or aquifers are sufficiently replenished, drought periods and associated water demands can be bridged. However, the replenishment of these strategic water reserves has become insufficient because our landscapes have been degraded and are not adapted to deal with extreme weather. The objective is to implement ecosystem-based adaptation measures that increase the retention and infiltration capacity of the landscape by restoring ecosystems and enhancing natural processes. With PROWATER we focus on specific types of measures that improve soil permeability through agricultural soil management, reduce interception through forest conversion/management practices, promote and prolong water storage in floodplain wetlands, promote deferred infiltration through restoration of upstream depressional wetlands and remediate soil sealing impacts through infiltration ponds.

It is crucial to assess the impact of these EbA measures on the ES related to PROWATER in order to develop deliberate and correct guidelines for the future implementation of these measures. Besides their key impact on water regulation and provision, these measures may deliver many additional benefits. For many ecosystem services, their supply is driven by (complex interactions of) ecohydrological processes.

The table below gives a concise overview of the general impact of the EbA practises on the different ecosystem services. However, it must be stressed that the impact of each measure depends a lot on the local context (soil type, geology, environment, topography). The effectiveness of a measure therefore always depends on its context. For example, conversion from coniferous to deciduous woodland on naturally wet soils will obviously not result in infiltration. Also, wetland creation will not result in groundwater recharge if the subsoil has a too low permeability and improving soil quality of the topsoil will have limited effect if subsoil is compacted. The table thus provides general insights into the effects that the measures can have on the various services.

Ecosystem services / EbA measures PROWATER	Water regulation		Water purification (nitrogen removal)	Nutrient storage in soils	Erosion prevention	Climate regulation		
	Water retention	Water infiltration				Carbon	Methane	Nitrous oxide
Conversion from coniferous to broadleaved forest	Medium positive (relevant)	[1] Medium positive (relevant)	Low positive (less relevant)	Medium positive (less relevant)	Medium positive (less relevant)	[2] Low negative (less relevant)	[3] Low negative (less relevant)	[3] Low negative (less relevant)
Conversion from forest to heathland/grassland	[1] High positive (relevant)	[4] High positive (relevant)	Neutral (less relevant)	Medium negative (less relevant)	Medium negative (relevant)	[5] Medium negative (relevant)	Neutral (less relevant)	Neutral (less relevant)
Improving soil permeability (conservation tillage/cash crops) [6]	High positive (relevant)	High positive (relevant)	Low positive (relevant)	Low positive (less relevant)	High positive (relevant)	Medium positive (relevant)	Low positive (less relevant)	Neutral (less relevant)
Restoration permanent wetlands/re-meandering [7]	High positive (relevant)	Low positive (less relevant)	Medium positive (relevant)	Medium positive (less relevant)	Medium positive (less relevant)	Medium positive (less relevant)	Medium negative (less relevant)	Medium negative (less relevant)
Restoration of temporary wetlands	High positive (relevant)	High positive (relevant)	Medium positive (relevant)	Low positive (relevant)	Medium positive (less relevant)	Medium positive (less relevant)	Medium negative (less relevant)	Medium negative (less relevant)
Runoff collection through infiltration ponds or weirs in ditches	Medium positive (relevant)	Medium positive (relevant)	Medium positive (relevant)	Low positive (relevant)	Medium positive (less relevant)	Low positive (less relevant)	Low negative (less relevant)	Low negative (less relevant)

Impact		Relevance for PROWATER
Low positive	Neutral	Relevant
Medium positive	Low negative	Less relevant
High positive	Medium negative	

1 The effect depends on the type of soil. Forest cover and interception have a positive effect on heavy soils, as they buffer extreme precipitation events and promotes infiltration. In contrast, sandy soils in general reduce infiltration.

2 Conifer trees have dense canopies that intercepts a certain portion of light which causes a lowering of soil temperature. This reduces in turn slow down decomposition which leads to an accumulation of organic matter and increased carbon sequestration (Barsoum and Henderson 2016).

3 Processes responsible for methane and nitrous oxide emissions vary in time and space and depend on soil texture, topography, precipitation and nitrogen limitations (Díaz-Pinés et al. 2018).

4 The effect is strongly dependent on the soil type, scale of planting, forest design and replaced landcover. The effect mentioned in the table is the case for sandy soils, but is different for chalk soils. Conversion from broadleaved woodland to grass has a little impact as the uptake of root water can be maintained, even during drought periods (Calder et al. 2002; Nisbet 2005).

5 The C stock under grassland can be at the same level as under forest, provided that the grassland is permanent and natural grassland or either extensive grassland with livestock.

6 Deep compaction is not taken into account in PROWATER but must be investigated as it can be a problem.

7 Restoration of permanent wetlands and rivers involves several measures and mostly include riverbank stabilisation, which has a positive effect on water quality, nutrient storage in soils, erosion control and carbon sequestration.

Monitoring and evaluating the impact of EbA on ecosystem services

Resulting implementation of EbA should be monitored and where needed adjusted. Monitoring is very site specific and therefore the best method of monitoring an EbA depends on several variables. It is essential to design the monitoring plan at the time that the EbA measures are being designed to ensure the best possible data, such as factoring in where equipment or records will be taken. In many cases, it may be necessary to monitor before the installation of measures, depending on the quantification means. Although each site is different there are some really useful resources with many examples of how measures can be monitored, such as:

- Catchment Science. Fieldscale monitoring handbook (Atkins)[17]
- Monitoring and evaluating the DEFRA funded Natural Flood Management projects[18]

Monitoring In the Campine region *(Flanders)*

Small-scale depressions, also called upstream depressional wetlands (UDWs) are natural depressions in the landscape where water collects and which are not originally connected to watercourses. Such systems mainly receive local supply of runoff water and shallow soil water that collects on less permeable soil layers. Due to relatively small catchment area and topographical position, these areas are naturally characterized by a high fluctuation in water levels. This creates possibilities for deferred infiltration which recharges groundwater reserves and increases base flow during subsequent periods of drought. Most of these landscape depressions were already drained centuries ago, mostly for agricultural purposes. With climate change and an increasing prevalence of extremely wet and extremely dry periods, the natural buffering capacity of such landscape depressions is becoming increasingly important. After all, the landscape depressions offer opportunities to collect and retain runoff water locally. A large part of that water will then slowly infiltrate and thus replenish groundwater reserves.

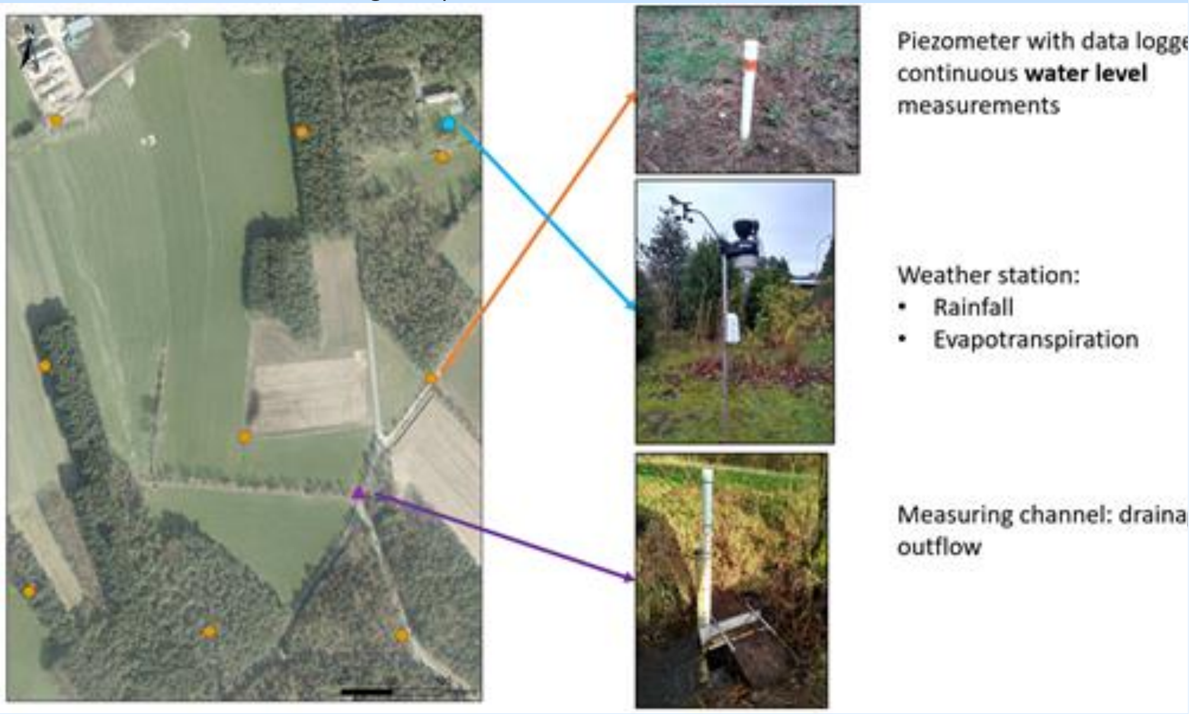
The study consists of the long-term monitoring of the water balance of several UDWs. By monitoring groundwater level, precipitation, evapotranspiration and drainage outflow, infiltration is estimated. Knowledge of soil conditions (soil permeability) is used to estimate groundwater dynamics. In combination with the monitoring data, models can be developed of an UDW, in order to estimate the potential of certain EbA's.

Water regulation functions of three drained upstream depressional wetlands (UDWs) are currently being monitored in the Campine region in Northern Belgium. The monitoring setup exists of three components:

1. Ground water levels are being monitored using pressure transducers in piezometer wells. The water levels are registered every fifteen minutes.
2. Weather stations are used to collect hourly rainfall data and several hourly parameters (air temperature, solar radiation, relative humidity and wind speed) to estimate evapotranspiration using standard formulas (Penman-Monteith equation).
3. The drainage outflow in the ditch is being monitored using a measuring channel in the at the end of the drainage ditch. A pressure transducer measures the water surge every fifteen minutes near the threshold at the end of the flume. The pressure is compensated for air pressure and is converted to hydraulic head. Using standard formulas, the discharge is calculated.

[17] https://catchmentbasedapproach.org/learn/catchment-science-fieldscale-monitoring-handbook/
[18] https://catchmentbasedapproach.org/wp-content/uploads/2018/11/NFM-MonitoringObjectivesFINAL-v18.pdf

An illustration of the monitoring setup is shown in FIG X



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Monitoring In Southeast England

In South East England, monitoring has aimed to integrate into a natural capital approach by taking account of the condition of natural assets and the provision of water. This gives an understanding of not only how flows of services from the habitat or natural asset are changing, but also the underlying state of the habitat that determines its contribution and resilience.

An overview of how this fits together is given in the table below.

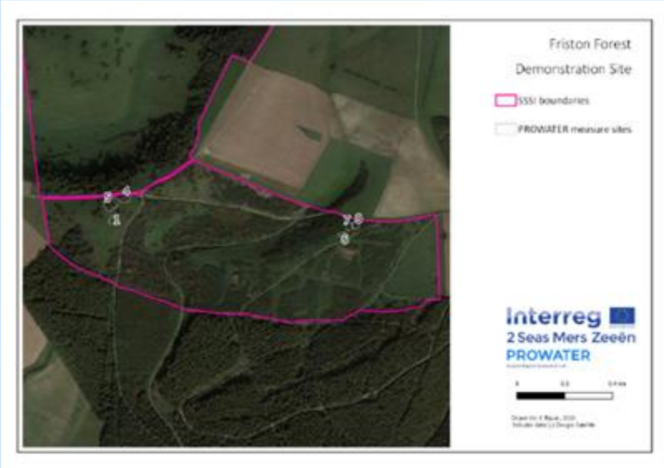
Asset	**Location**	**Hydrology**	**Nutrient & chem status**	**Vegetation**	***Ecosystem Process: Water provision***
Headwater streams/ wetlands*	Impermeable catchment Headwater zone (could also include active floodplain wetlands)	Extent of artificial drainage Naturalness of flows	Nutiient status	Vegetation next to waterbodies	Flow towards abstraction
Semi-natural grassland	Chalk aquifer Permeable soils Abstraction catchment Topography	See soil (Evapotranspiration)	See soil	Species diversity Proportion of bare ground	Drainage to groundwater (infiltration)
Soil	In relation to river Groundwater catchment Topography	Structure, compaction, & water retention capacity	N, P, K, C OM		Drainage to groundwater (infiltration)
Freshwater	Upstream of abstraction / dependent ecosystem	Naturalness of water regime	WFD chem. status	Vegetation next to waterbodies	Flow towards abstraction

On the Friston Forest site, monitoring focused on the process of water provision in the chalk aquifer, and the impact of habitat restoration on this process. Chalk aquifers are some of the most important sources of drinking water in the area, and understanding the impact of land cover on recharge to them can be challenging. Typically, the chalk is covered by thin soils, and uptake of water from plants or interception of rainfall in the canopy are key factors limiting recharge. However, the groundwater body is many meters below surface. While observation boreholes are available, attributing change in water level in an observation borehole to a change at the scale of a few hectares (which is the scale of delivery in the pilot) is difficult.

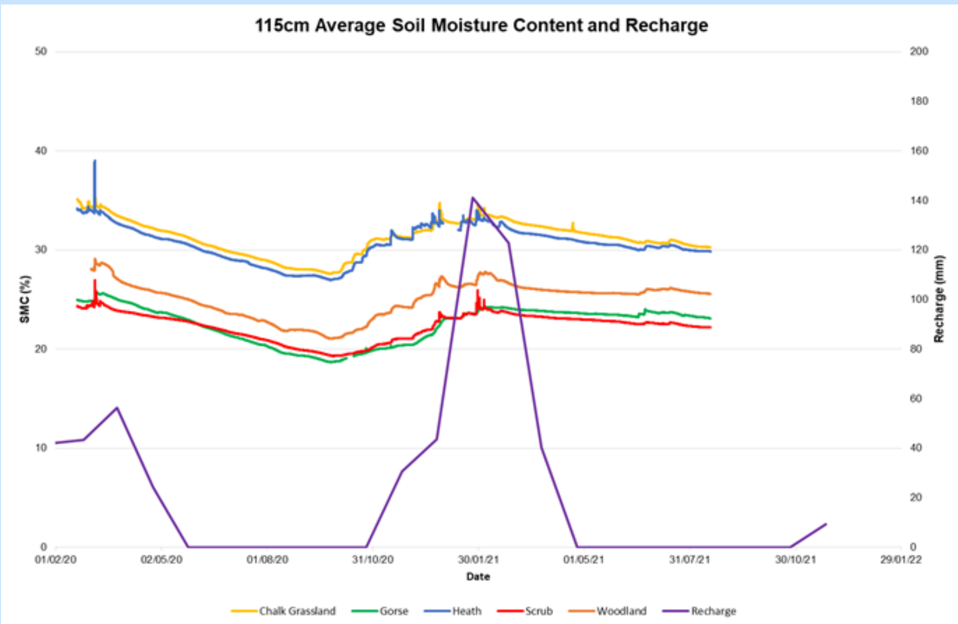
The project team decided therefore to put focus on monitoring the best available proxy for recharge on a site level, looking at soil moisture profiles alongside rainfall and weather data. 3 soil moisture profile probes were installed on a total of 9 sites, comprising three habitat types and a measure and control area. Additionally, porous pots were included across the different habitat types. These allow monitoring of nutrient levels in soil water.

Monitoring set up:

Habitat	**Measure (habitat change)**	**Control (no change)**
Gorse	3 Soil Moisture Probes	3 SMP, 3 Porous pots
Scrub	3 SMP	3 SMP, 3 PP
Decid. Woodland	3 SMP	3 SMP, 3 PP
Chalk Heathland	-	3 SMP, 3 PP, Weather Station
Chalk Grassland	-	3 SMP, 3 PP



The soil moisture profile probes measure volumetric water content every ten centimetres to a depth of 1.2metres. They record data every 15 minutes and so allow understanding of the drainage process and profile. Going to a depth of 1.2m means that the probes are likely to reach into the chalk, beyond the root zone of the vegetation above it. This means that water at this depth is likely to drain towards the chalk aquifer, rather than be taken up again by plants.



Figuur 1 Comparison of average soil moisture content at 115 cm depth on the Friston Forest pilot sites. Data prepared by Steve Howe, South East Water.

The graph above is a first output from the monitoring, showing the average volumetric water content of soil at a depth of 115cm for each of the different habitats. This clearly shows differences between different types of habitats.

Key References:

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