European Climate Adaptation Platform
Climate-ADAPT factsheet

Assessing Adaptation Knowledge in Europe: Ecosystem-based Adaptation

What is ecosystem-based adaptation?

Ecosystem-based adaptation (EbA) is 'the use of biodiversity and ecosystem services to help people adapt to the adverse effects of climate change' (CBD, 2009)[1].

EbA measures or practices use natural or managed ecosystems (biophysical systems) and processes to increase resilience to climate change and/or adapt to its impacts. EbA can also deliver a range of other benefits, such as reducing greenhouse gases (climate change mitigation) and better water and air quality.

What types of ecosystem-based adaptation measures exist?

EbA measures can be grouped according to the main land use category they are applied in and further classified depending on their characteristics, such as whether they involve changes in management, land cover or habitat changes. The sectors and categories with representative EbA measures are summarised below (Figure 1). Some EbA measures do not sit within a single category. For example, blue infrastructure measures are typically associated with urban settings, but also relate to water management. Moreover, multiple EbA measures can be applied in one area, often at catchment scales across multiple land uses.

Agriculture	Agricultural habitats	• Agro-forestry and crop diversification • Buffer strips and hedgerows	• Improved water retention in agricultural areas • Meadows and pastures	• Traditional terracing
Agriculture	Agricultural management	• Crop rotation • Low till agriculture	• No till agriculture • Green cover	• Reduced stocking density
Forestry	Forest planting	• Reforestation • Afforestation • Forest riparian buffers	• Land use conversion • Maintenance of forest cover in headwater areas	• Targeted planting for 'catching' precipitation
Forestry	Forest management	• Water sensitive forest management	• Coarse woody debris • Continuous cover forestry	• Peak flow control structures
Coastal		• Beach nourishment • Coastal managed realignment	• Dune reinforcement and strengthening • Cliff stabilisation	
Urban	Green infrastructure	• Green roofs • Rain gardens • Soakaways	• Swales • Urban greenspace • Urban forest parks	• Urban Trees & Forests
Urban / Water management	Blue infrastructure	• Basins and ponds • Channels and rills • Detention Basins • Filter Strips	• Infiltration basins • Permeable surfaces • Retention Ponds • Sediment capture ponds	• • Temporary flood water storage
Water management	River restoration	• Elimination of riverbank protection • Natural bank stabilisation • Re-meandering	• Reconnection of oxbow lakes and similar features • River restoration and rehabilitation	• Riverbed material re-naturalization • Stream bed re-naturalization
Water management	Floodplain restoration			
Water management	Groundwater restoration			
Water management	Lake restoration			
Water management	Wetland restoration			

Figure 1: Categorisation and examples of EbA measures

[1] https://www.cbd.int/climate/intro.shtml

Which types of climate hazard can EbA measures address?

EbA measures can address a range of climate hazards and offer the potential for dealing with multiple threats at the same time. This, together with other ecosystem service co-benefits, means that EbA measures can contribute to wider climate resilience and so are of interest to a variety of stakeholders.

	Agricultural habitats	Agricultural management	Forest planting	Forest management	Coastal	Green infrastructure	Blue infrastructure	River restoration	Floodplain restoration	Groundwater restoration	Lake restoration	Wetland restoration
Wind: providing protection from erosion and damage due to more frequent high winds	■		■	■		■						
Temperature change: providing shading and other cooling effects	■		■	■		■	■	■	■			
Precipitation: mitigating the impact of more intense rainfall events and flooding	■	■	■	■		■	■	■	■		■	■
Storm surge: mitigating the impact of more frequent and higher storm surges					■			■				■
Sea level rise: mitigating rising sea levels					■			■				
Water scarcity/drought: maintaining soil moisture and supply to ground and surface waters	■	■	■	■		■	■	■		■	■	■

Figure 2: Climate hazards that can be dealt with by different EbA categories

What are the biophysical impacts of EbA measures?

- EbA measures are applied in a variety of contexts and on different scales, from small plots to large river basins; this means that it is difficult to generalise their adaptation potential in a wider context.
- The co-benefits of EbA measures are important for encouraging their adoption and can even be more significant in the short-term than adaptation benefits.

The biophysical impacts of EbA measures are often context-specific, reflecting the situation, combinations and scale on which they have been applied. It is not always easy to assess the effectiveness of EbA measures in terms of climate change adaptation and resilience: ecosystem-based solutions are sometimes applied for other purposes, or on an inappropriate scale. For example, field or plot-level applications may demonstrate effectiveness in reducing water run-off, but the wider catchment level impacts required to determine flood risk reduction are difficult to assess.

There are several examples of successful EbA measures in different sectors and on different scales across the EU. However, assessing their ecosystem impacts remains a challenge. The extent to which ecosystem service co-benefits can be quantified depends on the main objective of the measure in question. For instance, agricultural measures are often applied to maintain soil health and therefore their benefit is often assessed on this basis. Blue infrastructure or water management, on the other hand, may concentrate on water quality impacts. Stated ecosystem service impacts are also sometimes conjectural or inferred from other applications of the measures.

Beyond these examples, however, it is difficult to identify common metrics for measuring the physical impacts of EbA in its various applications across Europe,ather effectivness'r adaptaiton ve title doesn't have capitals as different units are used to measure the impacts.

What are the economic impacts and the cost-effectiveness level of EbA measures?

- Implementation and operational costs are commonly available across EbA applications.
- Quantitative benefits estimates (including ecosystem services) are a major gap.
- The variety of biophysical units reported makes comparison of applications through cost-effectiveness analysis difficult.

Much of the evidence on the economic efficiency of the EbA measures is restricted to implementation costs, as these are readily available at project level. Monetary evaluations of the benefits are seldom presented. For agricultural measures, the benefits that are most often quantified include potential payments through EU Rural Development Programmes (agri-environment-climate measures) and in some cases the savings to farmers from implementation. These are important private benefits of EbA measures and drive individual decisions on their implementation.

However, the largely public benefits related to adaptation are often not quantified. Flood protection benefits could be presented in a number of ways, including a reduction in the number of properties at risk or the estimated damage costs avoided (Box 1), but there are only a number of cases where such monetisation is done. Some studies quantify benefits for cultural ecosystem services in terms of the number of recreational and educational visits (Boxes 2 and 3), though again this is infrequent. Only one case study (Box 4) presented the results of a full ecosystem services valuation exercise.

EbA measures have been applied across a wide variety of scales and this is reflected in the range of cost and benefit estimates. Information on case study area (or length of river) could be used to estimate per unit values for costs (e.g. €/ha). However, as multiple EbA measures are often implemented, comparison of such unit costs is problematic. For the same reason, cost-effectiveness analysis would be recommended for comparison of case studies rather than for individual EbA measures.

Box 1: White Cart Water project (UK)[1]

The White Cart Water is prone to flash flooding. Its water levels can rise by six metres after just 12 hours of rain, threatening vulnerable homes and businesses downstream. The scheme involves the creation of three large flood storage areas to hold back flood water and control its release.

Project actions:

- Installation of three large flood storage reservoirs, six surface water pumping stations, and two new road bridges
- 4,500 metres of new flood defence walls
- Over 7,000 new trees
- 9 ha of new, biologically diverse and robust wetlands
- Implementation cost: €63 million

Adaptation impacts:

- 7,200 homes and businesses protected
- Avoided flood damage of €13 million in 2011-2012
- Better water retention

Ecosystem service co-benefits:

- Improved carbon capture
- Better river water quality
- Extensive habitat creation

[2] http://www.covenantofmayors.eu/IMG/pdf/CovenantOfMayors_BestPracticePublication_web.pdf
www.whitecartwaterproject.org

Box 2: Tamera water retention landscape (Portugal)[3]

Tamera, a farm of 154 ha, is located in an arid region of Portugal. The area has shown trends of increasing erosion and desertification. A "Water Retention Landscape" has been created, comprising a system of lakes and other retention systems along with other structures such as terraces, swales and rotational grazing ponds.

The biophysical impacts of the project have not been fully assessed but the socio-economic effects have been estimated:

- Cost of five largest lakes: €509,000
- Increase in carbon storage of 9.4% per year (2006-2014)
- Tourism: €810,000 (2014-2050)
- Social and environmental benefits of increased water retention via market value of land: €150,000 to €400,000

Box 3: Restoration in the Comana wetlands (Romania)[4]

Reconstruction of Comana Wetland to conserve the biodiversity, the natural habitats, the wild species of flora and fauna and to assure an efficient management of Natura 2000-protected natural areas. Beyond providing improvements in habitat resilience, the main adaptation benefit is increased water retention.

The cultural ecosystem service benefits of the site include:

- 10,000 tourism and recreation visitors to protected sites per year
- 5,000 users for camping, nature walks, jogging, water sports, cycling per year
- 500 educational excursions per year

[3] http://climate-adapt.eea.europa.eu/metadata/case-studies/tamera-water-retention-landscape-to-restore-the-water-cycle-and-reduce-vulnerability-to-droughts
http://base-adaptation.eu/water-retention-landscape-restore-water-cycle-and-reduce-vulnerability-droughts-tamera-portugal
http://www.nwrm.eu/case-study/water-retention-spaces-reforestation-and-grazing-management-southern-portugal

[4] http://nwrm.eu/case-study/restoration-comana-wetlands-romania

Box 4: Slowing the flow at Pickering (UK)[5]

The town of Pickering in North Yorkshire, UK, has a history of flood events, most recently in 1999, 2000, 2002 and 2007; the last of these caused an estimated €8m of damage. A hard engineered flood alleviation scheme was proposed but deemed unaffordable under national cost-benefit thresholds. The 'Slowing the Flow at Pickering' project implemented multiple EbA measures, including low level bunds (flood basins), woody debris dams and woodland planting (in riparian zones, floodplains and farmland). The aim of the project was to show how land management measures can help to reduce flood risk from a river in the town and it is implemented in close cooperation with local stakeholders.

The surrounding catchment area (6860 ha) was extensively modelled and the estimated impacts of the project were:

- Increased water storage (bunds): 90,000-138,000m^3
- Peak flow rate reduction (riparian woodland and woody debris dams): 10.7% (range 6.7-14.7% depending on size of flood event)
- Flood peak delayed by 20 minutes

The total costs of the project was estimated at €1,580,000, of which:

- Low level bunds: €1,320,000
- Riparian woodland: €17,951
- Large woody debris dams (150): €27,782

The estimated loss of agricultural output if 85 ha of woodland planted was €36,326/yr.

In addition to providing information on the costs of the project, there was also an economic valuation of the ecosystem service co-benefits.

Based on 85 ha of woodland planting these were estimated to total €270,450/yr, of which:

- Habitat creation: €139,683/yr
- Flood regulation: €6855/yr
- Climate regulation: €123,029/yr
- Erosion regulation: €236/yr
- Education and knowledge: €16/yr
- Community development: €631/yr

[5] http://www.nwrm.eu/case-study/slowing-low-pickering-uk
http://www.forestry.gov.uk/website/forestresearch.nsf/ByUnique/INFD-7YML5R

What are the key success and limiting factors in the application of EbA?

Although a wide variety of EbA measures have been implemented, there is a common set of factors contributing to successful implementation across all EbA categories.

Key innovative approaches to success include the integration of agencies, stakeholders and their activities; the identification of multiple benefits; and the linking of these benefits to financing opportunities.

A number of messages can be identified from the assessment of EbA case studies:

- Evidence is context-specific and often not transferable. Common units should be used if possible and demonstration projects are an important tool.
- The scale of EbA implementation is important and cooperation across land owners is often needed. Incentives should be designed to encourage cooperation.
- The gap between private and social impacts needs to be recognised and explicitly taken into account in the design of incentives.
- Negative impacts and time lags before benefits are achieved also highlight the role of incentives. The use of trusted agents and stakeholder engagement throughout the planning and implementation process is also important.

A number of gaps remain in the geographical coverage of some EbA measure categories (forestry, coastal, urban, agriculture in eastern Europe) and climate hazards that are being addressed (sea level rise, storm surge, temperature change, wind). Further research is required to fill gaps or alternatively to demonstrate transferability of existing evidence in terms of contexts or relevant climate hazards.

Success factors

- Stakeholder engagement and attitudes
- Cooperation across stakeholders
- Alignment of activities across agencies including shared institutional structures
- Existing knowledge and/or on-going research and monitoring
- Demonstration of private benefits
- Demonstration of co-benefits
- Availability of finance
- Multiple sources of finance linked to multiple benefits

Limiting factors

- Lack of finance for measure implementation or land acquisition/ compensation
- Poor stakeholder engagement and negative attitudes
- Cooperation and consent across multiple landowners
- Lack of land or space constraints for implementation
- Time lags in observing benefits

What ecosystem service co-benefits are generated by EbA measures?

One of the strengths of EbA measures is that they generate significant co-benefits, in addition to enhancing climate change adaptation. Different measures are associated with different co-benefits.

EbA measures usually have positive impacts on ecosystem services. However, EbA can also have unintended negative consequences that need to be taken into account. For example, some EbA measures (e.g. water retention) can lead to an increase in insect pests (e.g. mosquitoes), which can have negative impacts on health and wellbeing or on crops. Some coastal measures may reduce public access to beaches and the shoreline. Negative impacts such as these will influence the acceptability of EbA measures and must be taken into account in both planning and implementation.

Several measures show both positive and negative impacts. This reflects potential trade-offs, which indicate where attention should be focused in order to ensure successful implementation. For example:

- Agricultural food production (crop yields, reduction in agricultural land) or wild food such as fish (improved water quality, new aquatic habitats);
- Changing types of natural habitats (move from terrestrial to coastal wetlands);
- Different recreational activities (new recreational opportunities or restricted access or activities).

Figure 3 illustrates the frequency with which ecosystem service co-benefits are associated with each EbA category. It combines the co-benefits across individual EbA measures with the colour indicating whether the impact is associated with few, most or all measures within each category. The figure does not represent the scale of impacts and care should be taken when making cross-category comparisons.

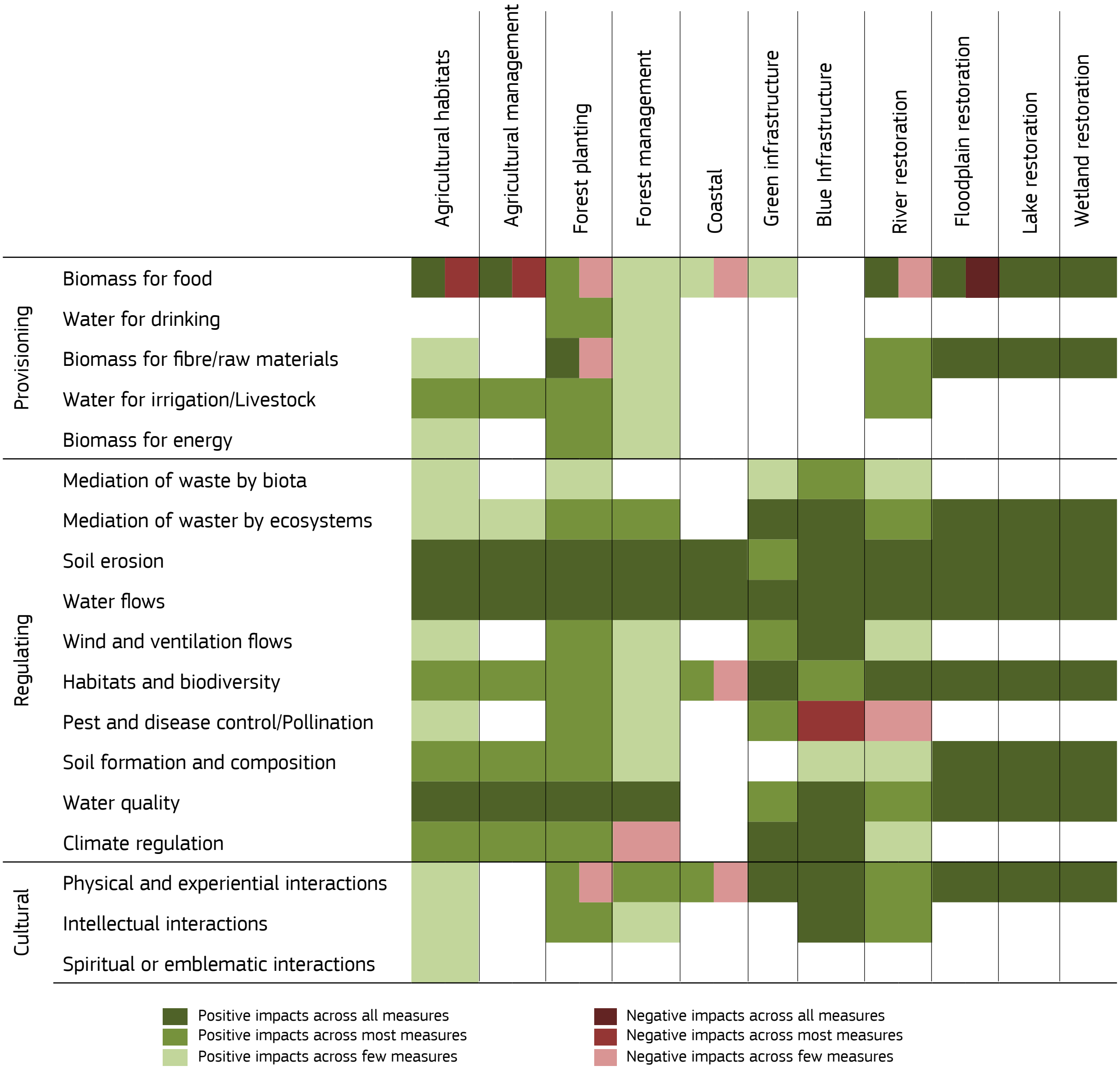

Figure 3: Frequency with which ecosystem service co-benefits are associated with different EbA categories

The factsheet is developed by the project EU Strategy on adaptation to climate change: knowledge assessments to support informed decision-making (CLIMA.C.3/SER/340202/2015/719923) carried out for the European Commission by Ecofys, UKCIP and SRUC.

The examples and case studies described in this document represent the views of the authors and are based on information gathered by the authors. The references used to develop these illustrative examples should always be considered as the most accurate and complete sources of information.

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