

Large-scale river restoration pays off: A case study of ecosystem service valuation for the Emscher restoration generation project



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ABSTRACT

Though the Ecosystem Service (ESS) approach is considered promising for integrated ecosystem management, its operationalisation is hampered by the lack of agreed evaluation instruments. To demonstrate the suitability of a structured ESS evaluation, we conducted a case study estimating the impact of the restoration of the Emscher River and its tributaries on the provision, use and benefit of ESS. The Emscher restoration is a large-scale project with immense temporal and financial efforts. To assess the values generated by this restoration, we applied an ESS evaluation framework and quantified the regulation and maintenance ESS 'self-purification capacity', 'maintaining nursery populations and habitats' and 'flood protection' as well as cultural ESS such as aesthetic, recreational, educational and existence values. Final ESS were monetized using economic methods, e.g. 'damage costs avoided', 'contingent valuation' and 'benefit transfer'. We estimated a *market value/direct economic impact* of 21,441,572 € per year as a result of the restoration. Furthermore, a *non-market value* for people who care about the local environment of 109,121,217 € per year was determined, representing the benefit with 'non-use value' from the Emscher restoration. Our case study demonstrated the successful application of the structured evaluation framework in practice. Its implications and limitations are discussed.

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1. Introduction

One of the most extensive river restoration efforts is currently taking place in one of the most populated areas in Europe. The Emscher restoration is a large-scale restoration project in the "Ruhr Metropolitan Area" in the federal state of Northrhine-Westphalia, Western Germany. This area is one of the densest urban agglomerations in Europe. In a 30-year project that started in 1990, the Emscher River and its tributaries are re-converted from highly modified open wastewater channels with concrete beds into near natural stream systems. For this, an underground sewer network of 423 km length is constructed to separate waste and river water. Subsequently, the concrete shells are removed,

the channelization reversed, stream profiles widened, and secondary floodplains created. This intergenerational project is worldwide unique in its spatial and temporal scale and associated with the immense costs of approx. 5.3 billion Euro.

Justifying such expenses requires achieving ecological goals as set by the European Water Framework Directive (WFD; [European Commission, 2000](#)). Besides the improvement of ecological criteria, also human benefits result from such restorations. Thus, it is important to communicate the value of restored streams and surrounding areas beyond purely ecological criteria. Required to this end are methodologies to quantify how humans benefit from this project. The Ecosystem Service (ESS) approach represents a viable concept to assess material and immaterial values for human well-being provided by ecosystems. The first large-scale assessment of ESS, the Millennium Ecosystem Assessment ([Millennium Ecosystem Assessment, 2005](#)), illustrated how the ESS approach can visualize the value of nature and the costs of its overuse and

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degradation. The ESS concept is now widely recognised as an integrative approach that can capture different policy objectives in a single assessment and therefore, its application for a sustainable management of ecosystems is increasingly desired by policy makers (Anzaldúa et al., 2018). Aims set by the European Union via the European Biodiversity Strategy 2020 (European Commission, 2011) enforce this, as they require the EU member states to evaluate ecosystems and their services via an approach that is being elaborated by the MAES initiative (MAES, 2016; MAES, 2018).

However, a lack of agreed evaluation approaches, ESS classifications and consistent definitions has, so far, hampered the uptake by practitioners and policy makers (Daily et al., 2009). To guide a structured evaluation of ESS, concrete practical guidance via operational frameworks is required but currently lacking. Furthermore, case studies that serve as best-practice examples are needed. Particularly, case studies on freshwater ESS are necessary to advance the ESS approach also in the context of water management. The present study represents such a case study and offers an integrated evaluation of a large-scale river restoration using a structured ESS assessment method (Anzaldúa et al., 2016).

This freshwater case study was elaborated within the European research project DESSIN (Demonstrate Ecosystem Services Enabling Innovation in the Water Sector, 2014–2017). DESSIN has developed an evaluation framework (Fig. 1) as a guided approach for evaluating changes in ESS resulting from the implementation of management measures, e.g. mitigation and restoration measures. Essentially, the DESSIN ESS Evaluation Framework compares the situation before and after the implementation (Anzaldúa et al., 2016). It consists of a biophysical, an economic and an add-on sustainability assessment and is framed by the Driver-Pressure-State-Impact-Response (DPSIR) adaptive management cycle of the European Environmental Agency (Smeets and Weterings, 1999), merged with the ESS-cascade concept (Haines-Young and Potschin, 2010) as presented by Müller and Burkhard (2012).

Understanding the relationships between the five DPSIR elements is central for investigating the effects that responses have on alleviating man-made pressures on the ecosystem or improving its state. The state of an ecosystem again affects ESS provision and the human well-being resulting from it (Fig. 1; definitions according to Anzaldúa et al., 2018). Feedback flows between the single

DPSIR elements exist as it is a continuous circular progress. Especially in urban ecosystems, complex interactions between stressors and impacts need to be understood by assessing the interactions among nature, technology and human society with its synergies and trade-offs (see Fig. 2).

The DESSIN ESS Evaluation Framework differs from existing frameworks as discussed by Anzaldúa and colleagues (2018). For instance, the IPBES Conceptual Framework as presented by Díaz et al. (2015) gives a structure for analysing the interference between society, nature and ecosystems and nature's benefit to people, focussing on supranational to global geographical scales. In contrast, the DESSIN framework provides guidance for analysing the difference in values of a system before and after a human intervention (like a restoration measure) and is meant to analyse this intervention and its effect on ecosystems at regional scales.

It offers a structured guidance but also gives its user a high degree of freedom in combining diverse sets of ESS, indicators, assessment methodologies and analytical tools. The latter range from basic scientific and sociological data to complex effect modelling. Integrating these and complementing them with DESSIN's sustainability assessment results in a broad holistic perspective. This way, further aspects not addressed by the ESS evaluation but important for decision-makers are covered by the sustainability assessment.

The framework can be applied to ESS as classified in the Common International Classification of ESS (CICES; Haines-Young and Potschin 2013) and the Final Ecosystem Goods and Services classification system (FECS; Landers and Nahlik, 2013). The latter classification system separates intermediate (IESS) from final ecosystem services (FESS), depending on the presence or absence of direct service beneficiaries. Those ESS that are only provided by the ecosystem but *not* directly used or otherwise appreciated by humans are IESS (e.g. water purification), while those ESS being provided by the ecosystem and directly used or otherwise appreciated by humans are FESS (e.g. the actual use of pure water for drinking). This distinction was also suggested earlier in the UK National Ecosystem Assessment (2011) and by Boyd and Banzhaf (2007). The distinction is used in the DESSIN framework by defining the beneficiaries of the ESS as “any persons, organizations, households or firms whose interests are positively or negatively affected by either the direct use or presence of the ESS that are changed by the proposed

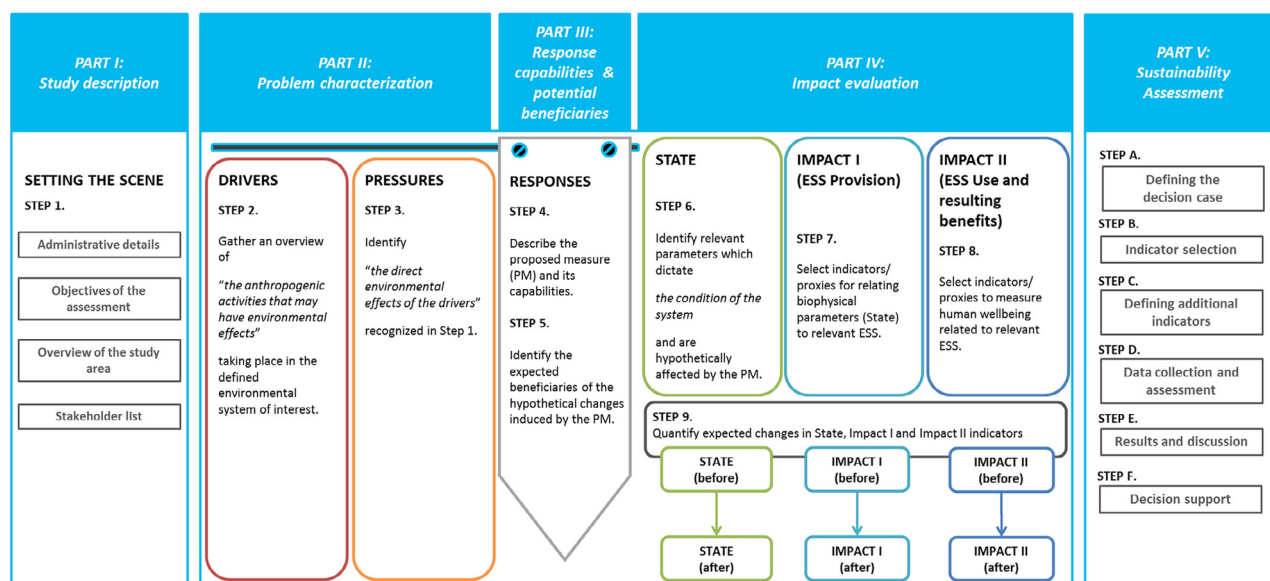


Fig. 1. Procedural steps for the application of the DESSIN ESS Evaluation Framework (from Anzaldúa et al., 2018). ESS = Ecosystem services, PM = proposed measure. Note: The position of Steps 4 and 5 depends on whether the proposed Response affects the Drivers, Pressures or State of the system.

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