DESSIN

DEMONSTRATE ECOSYSTEM
SERVICES ENABLING INNOVATION
IN THE WATER SECTOR

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MS12 - First version of evaluation methodology available for testing at mature sites (progress to date)

FINAL DRAFT

Lead Author: Ecologic Institute, April 2015

The research leading to these results has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement no. 619039

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	SUMMARY

This document synthesises the progress achieved to date on the development of the DESSIN ESS Evaluation Framework.

DELIVERABLE NUMBER	**WORK PACKAGE**
MS12	WP11-WP13
LEAD BENEFICIARY	**AUTHOR(S)**
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QUALITY ASSURANCE	
N/A	N/A
PLANNED DELIVERY DATE	**ACTUAL DELIVERY DATE**
31/12/2014	08/04/2015
DISSEMINATION LEVEL	☐ CO = Confidential, only for members of the consortium

1. Introduction

This milestone document shows the progress to date on the development of the DESSIN ESS Evaluation Framework. The report is structured as a compilation of discussion papers elaborated and reviewed by the members of WP11 and WP13. These papers were used as background material to inform the WA1 coordination meeting that took place in Barcelona on 4-5 March 2015, whose main objectives, as stated in the meeting agenda (found in Annex III of this document), were:

- Overall coordination and check status of progress with WA1 activities.
- To present and discuss recent developments with the WP11 ESS Evaluation Framework.
- To get feedback from WP13 (the mature sites partners) from different issues to set up the framework.
- To have an overview of state of progress with the mature case studies.

Based on the discussions held during the meeting and a subsequent round of internal reviews, these discussion papers have been revised and integrated as the 6 chapters making up this progress report. These are:

2. **Assessing the suitability of existing analytical frameworks for evaluating the impacts of changes in freshwater ESS**
    - Is dedicated to the review and comparison of a number of frameworks available in the literature for assessing the impacts of changes in freshwater ESS and their qualification in the light of the needs of DESSIN.
3. **Testing a common set of methodological steps for the analysis of each of the DPSIR elements: an example**
    - Explores practical ways to deal with all elements of the DPSIR cycle and suggests the idea of agreeing upon a list of common methodological steps to do this. Presents an example to introduce the concept and the necessary methodological steps.
4. **Identifying relevant indicators in the mature case study sites and developing a template for selecting proxy-indicators of ESS capacities**
    - Continues the discussion on indicators by describing some ESS in more detail concerning their classification into PROVISION/USE indicators as well as process-related/structure-related indicators. Presents a list of relevant ESS and indicators for the Emscher case as an example and describes the process-related indicators in more detail.
5. **Selection of indicators relevant for economic valuation**
    - Aims to understand the necessary steps to measure the change in human welfare (in Euros) as a result of an environmental improvement due to interventions in the water sector.
6. **Sustainability assessment and ecosystem services**
    - Aims at expanding the discussion on suitable sustainability assessment tools for the purposes of DESSIN with the final goal of selecting a sustainability approach that

can best be applied to evaluate innovative solutions introduced within different mature and demo case studies.

7. **Activating the exchange between WA1-WA3**
   - Outlines a practical exercise to get the demo site owners acquainted with the methods being developed under WA1 and to cover some ground on the identification of relevant ESS, indicators, data sources and stakeholders in the demo sites.

Each chapter includes a section on next steps that is intended to facilitate the coordination of upcoming work and the measurement of progress. These next steps are related with the list of upcoming activities agreed in the Barcelona meeting and shown below (the ones completed by the time of delivery of this progress report are shown in green):

Coordination of WP11 and WP13 Activities towards Deliverable 11.2 and Deliverable 13.1

1. ALL: participants to provide comments to the meeting background papers within one week after the meeting. Comments are to be sent directly to main authors by 13.03 17:00h. All background papers to be finalised before 20th of March.

2. ECOLOGIC to provide the basis/outline for D11.2 (*Framework for evaluating changes in ecosystem services* (M24)). This will provide a picture of the structure for the final version of the deliverable, and should help align our efforts. It will be circulated for comments from all relevant partners. Once agreed upon, the outline will be populated by following the tasks listed below as discussed at the WA1 coordination meeting:

- Step-by-step guidance in the practical application of the DPSIR scheme (clarification of definitions including examples and measurement)
- Further development of the DESSIN ESS analytical framework (based on comments to background paper No.1/chapter 2 of this progress report)
- Further revisions of Ecosystem Services and DPSIR definitions in the D11.1 glossary based on OPENNESS/MARS definitions
- CICES ESS classes and relevant types and general definitions.
- Development of a template for the justification in the selection (i.e. a list of criteria for indicator selection) of DPSIR indicators. This template will be used for the presentation of relevant indicators in the D11.2/D13.1 reports. The template should contain, among other aspects, information on the selection of the specific indicator, the relevant CICES ESS types covered, data/modeling sources, scope, scale and uncertainty issues.
- The template will be coordinated by the WA1, WP11 and WP13 leaders and developed in close cooperation with WP11-13 partners and will be (in first instance) tested with State-Impact I indicators by the mature case studies owners (EG, DHI and CETaqua).
- Revision and evaluation of proposed State-Impact I indicators by all partners
- Application of economic valuation methods to measure changes in economic welfare resulting from changes in ESS (ECOLOGIC)

3. EG/ECOLOGIC to develop a template for result reporting & giving recommendations after testing the ESS Evaluation Framework at the mature sites. This will involve developing and circulating an annotated outline of the report for the presentation of the testing of the concepts of the case studies that will be the basis of D13.1 (*Quantified ESS for 3 mature sites including recommendations for application* M24).

COORDINATION ACTION: Set up of the mature sites coordination task force coordinated by WP13 lead (EG – Nadine). Telcos to be scheduled every two weeks with participation from all mature case study leaders and key WP11 participants.

4. Sustainability Assessment, IWW/SINTEF to circulate the list of relevant TRUST indicators among WP13 case study owners. The objective of the exercise is to test the measurement of sustainability aspects in the mature case studies and assess their suitability for their final selection.

5. List of the mature sites' relevant ESS and possible ecosystem service indicators to be sent to Valuation team in order to develop methods to link ESS indicators to valuation indicators.

COORDINATION ACTION: Set up of the sustainability assessment task force coordinated by IWW (Clemens).

6. Exchange exercise WA1/WA3. Agreed to circulate background information and instruction to identify relevant ESS in the demo sites and assess the data availability to describe them (following Telco of the mature sites coordination task force). Specific plans to complete this action will be discussed at the first mature sites coordination task force.

7. Other
Next WA1 coordination meeting: 23-24 (possibly noon-to-noon or noon-to-evening) June 2015. Back to back meeting (noon-to-noon) with the DESSIN 18-month-Meeting in the Emscher Region 22-23 June 2015. Optional: field trip through Emscher region at 24th afternoon or 25thmorning.

WA1 lead to discuss with Coordinator and WA2 lead schedule conflicts between MS21 Internal recommendations on the application of the ESS method (M18) and D23.1 System requirement specification and system design documents (M20).

2. Assessing the suitability of existing analytical frameworks for evaluating the impacts of changes in freshwater ESS

The final product of WA1, the DESSIN ESS Evaluation Framework, is being developed on the basis of the CICES classification and the DPSIR adaptive management scheme (see Figure 1 below). The latter was chosen as groundwork due to its potential to disentangle the biophysical and social aspects of a system under study. The DESSIN ESS Evaluation Framework, however, should be able to trace the links and interactions between these aspects across all the DPSIR elements to allow a holistic examination of the said system[1].

This chapter picked up the insights gathered in Chapter 3 of Deliverable 11.1 to expand the discussion between WP11 and WP13 on the suitability of each of the ESS analytical frameworks studied for the purposes of DESSIN. The final goal of this discussion was to select a framework which can best be applied to evaluate changes in ecosystems and their services relative to the implementation of new water technologies, and that can trace the impacts of these changes on the various elements of the DPSIR scheme. The idea is to select a framework that can subsequently be applied in practice to other working areas of DESSIN (e.g. WA2 and WA3). This can be achieved by either selecting the single best-suited framework, or by identifying individual elements of each framework that are of interest and could be incorporated into a combined framework to be branded as an original DESSIN methodology.

The purpose of the selected analytical framework

The analytical framework underpinning the DESSIN ESS Evaluation Framework must allow its users to "evaluate and account for impacts that result from changes in ESS in the water sector." This should be as transparent and robust as the current knowledge on ESS allows, and, most importantly, it should be applicable in the context of DESSIN (innovative technological implementations on freshwater ecosystems).

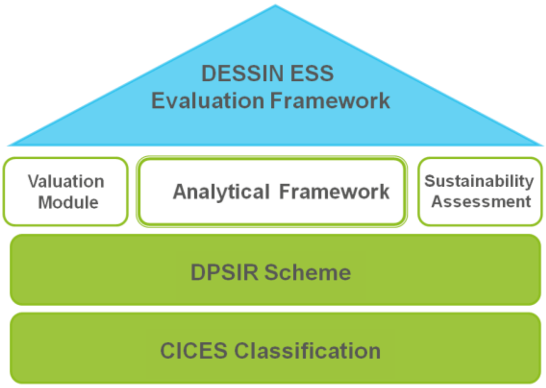

Figure 1: Components and foundations of the DESSIN ESS Evaluation Framework

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[1] In this case, the *ecosystem* as defined in page 7 of DESSIN D11.1: *The environmental system of interest within the DESSIN project (e.g. a surface or ground water body, sub-catchment or catchment).*

2.1 Existing frameworks

2.1.1 Building upon the MA and TEEB

The Millennium Ecosystem Assessment (MA) and The Economics and Ecosystems of Biodiversity (TEEB) lay out methodological frameworks to categorise ESS and reveal their links to human well-being, and they represent the first large-scale steps towards the better understanding of these issues. However, these frameworks lack the ability to identify if/how changes in ecosystems and their biophysical status impact the provision of ESS. In other words, these global initiatives were originally aimed at answering the first set of questions which arose together with the ESS concept. As the research has come further and practical application of these frameworks has been undertaken, new questions have surfaced which bring new requirements to the table. This has consequently promoted the development of new structured ways to assess and understand the interactions between the elements that make up an ecosystem.

2.1.2 Other frameworks considered within our work

A brief recap of each of the frameworks reviewed in Chapter 3 of D11.1 is shown below. These include examples of their applications whenever these were found in the literature.

Ecosystem Service Profile

This assessment framework was created to assess ecological quality by providing a flexible measure of quality which takes into account that the 'ideal' ecosystem state is largely dependent on the specific management context. It is supposed to solve the problem of practically employing the concept of 'naturalness,' which pervades existing environmental legislation and ecological quality definitions, within human-dominated landscapes and socio-environmental management schemes. This framework has been implemented within research studies, such as Nedkov and Burkhard (2012) analysis of ESS provision to use ratios of a Bulgarian sub-catchment to map flood regulating ESS. Additionally, Boithias et al. (2014) assess water ratios in a Mediterranean basin under different global change scenarios and mitigation alternatives. Lastly, Schröter et al. (2014) account for the provision and use of various terrestrial ESS in the Norwegian countryside.

Water Quality and Well-being

This assessment framework was created in an effort to make water quality assessments more meaningful to the public and interested stakeholders by providing a comprehensive and generalisable framework for describing and valuing water quality-related services. It solves the problem of viewing water solely as a final ecosystem service rather than an important contributor to many different ecosystem services, from recreation to human health. This framework has been implemented in various studies, such as a willingness to pay study for changes in lake water quality (Van Houtven et al., 2014). Gisselman (2014) conducted a study to identify, value and assess costs and benefits of restoration actions to harvest and capture algae and reed from shallow coastlands to mitigate effects of eutrophication. Jiang et al. (2013) used this framework to estimate ecological damage in Lake Taihu, China. Lastly, Bark and Schmidt (2013) followed an adapted version of this framework to estimate the effects of the Murray-Darling Action Basin Plan on changes in ecosystem services and their valuation in Australia.

TESSA

This framework was created to aid decision-makers on how change to a site, whether for development or restoration, would affect the delivery of services and the distribution of benefits among stakeholders. It fills the gap of appropriate methods and tools for ecosystem service assessments that do not require substantial resources or special technical knowledge, or rely heavily upon existing data. To date, TESSA has been used in few empirical studies, including an ecosystem service assessment (cover forests, grasslands and freshwater ecosystems) in Nepal to inform biodiversity conservation and local to national decision-making (Thapa et al., 2014). Similarly, Birch et al. (2014) conducted an assessment of a forest ecosystem in Kathmandu Valley, Nepal which included water quality and provision. Peh et al. (2014) used TESSA to evaluate changes in ecosystem service delivery resulting from land conversion of farmland into wetland habitat in Cambridgeshire, UK. Lastly, Peh et al. (2015) estimated the effect of feral livestock control on ecosystem services provided by forests in Montserrat, including water provisioning services.

RUBICODE's Framework for Ecosystem Service Provision (FESP)

This framework was initially designed to aid decision-making for biodiversity conservation by taking into account ecosystem dynamics, land and other resource constraints. The RUBICODE project collated and reviewed information on ecosystem services for terrestrial and freshwater ecosystems in Europe (Harrison, 2010). This framework solves the problem of assessing the impacts of direct and indirect drivers on ecosystem services and identifying the mechanisms of mitigation or adaptation derived from policy or management responses. This framework has limited practical application. Lavorel et al. (2009) used this framework to identify the effects of riparian buffer restoration on the provision of fish, within the RUBICODE project. Rounsevell et al. (2010) highlights case studies in which the FESP could be implemented, or fit the parameters of the framework. Samways et al. (2010) examine the possible value of the FESP framework for practical conservation using results from corridors and ecological networks in South Africa. Lastly, Carvalho-Santos et al. (2014) assessed the provision of hydrological services (water supply at the municipal level and water damage mitigation at the sub-basin level) by forests in northern Portugal.

Blueprints as Structural Templates

Though the blueprints do not qualify as an assessment framework *per se*, they do have the advantage of offering a means to consistently document work undertaken in the course of the DESSIN project. As such, the blueprints provide structural templates to guide assessment studies and allow comparability between them. Ultimately, this would enhance the knowledge base for comparisons and meta-studies, the exchange of experience and reproducibility.

2.2 Comparing the frameworks' suitability for the purpose of DESSIN

The suitability of the frameworks presented in the last section can be compared based on the premise that an analytical framework will be more effective in achieving the goals of the DESSIN if it counts with a specific set of qualities previously identified by the authors.

2.2.1 Qualities needed for the purpose of DESSIN

For it to best serve the purpose of DESSIN in general, and that of WA1 in specific, the selected analytical framework should:

- facilitate the identification and incorporation of appropriate indicators regarding both provision and use of water-related ecosystem services (Capturing water-related ESS)
- be able to encompass socio- and biophysical environmental aspects (Socio-biophysical link)
- be relatively less data intensive than others (Low data intensiveness)
- take careful consideration of spatial and temporal issues in order to ensure consistency and comparability of results (Scalability)
- be able to aggregate across ESS (Aggregation)
- identify and consider trade-offs between services and identify and avoid double-counting issues (Considering trade-offs and double-counting)
- include provisions to translate effects resulting from the implementation of technical innovations into economic value in terms of ESS (Valuation)
- allow comparison of various management scenarios (Comparability between policy options)
- be easy to communicate to and understood by multiple audiences (Communication)
- identify and address sources of uncertainty associated with the assessment of the selected ESS (Addressing uncertainty)
- suggest the involvement of stakeholders (Stakeholder involvement)
- consider the issue of sustainability (Considering sustainability)
- be based on the DPSIR concept (DPSIR-based)

While this list might not be exhaustive, an analytical framework covering all or most of the above-mentioned aspects would be a significantly close fit to what is needed for estimating the impact of new technological implementations on ecosystems and the services they provide.

2.2.2 Comparing across frameworks based on the needs of DESSIN

Table 1 below illustrates the qualities of each framework with respect to the needs listed in section 2.2.1. This resulted from combining the opinions of the members of WP11 and WP13.

Table 1: A comparison of the analysis frameworks studied in D11.1

Frameworks	**Characteristics determining suitability for DESSIN**												
	Capturing water-related ESS	Socio-biophysical link	Low data intensiveness	Scalability	Aggregation	Considering trade-offs & Double counting	Valuation	Comparability between policy options	Communication	Addressing uncertainty	Stakeholder involvement	Considering sustainability	DPSIR-based
Ecosystem Service Profile (ESP)	++	++	+-	++		++		++			++	++	
Water Quality and Well-being	+-	++		++		++	++	++		++	+-		
Toolkit for Ecosystem Service Site-based Assessment (TESSA)	+-	++	++				+-	++	++	++	++		
RUBICODE	++	++		++	+-	++	++	+-				+-	++
Blueprints as Structural Templates									++		+-		

++ denotes the framework could cover the necessary aspect/characteristic to a good extent

+- denotes the framework could cover the necessary aspect/characteristic to a limited extent

(blank) denotes the framework does not cover the necessary aspect/characteristic

According to the comparative exercise, the Ecosystem Service Profile (ESP) and the RUBICODE frameworks appear to be well suited to the purposes of DESSIN, closely followed by the Water Quality and Well-being and TESSA frameworks.

The ESP is useful for identifying provision-use balances for individual services across water bodies, sub-catchments or entire water basins. This provision-use ratio is closely linked to sustainability[2], including both social and biophysical aspects (at the conceptual level) in ecosystem service assessments. Advantageous aspects of this framework also include the ability to compare environmental systems at various points in time (e.g. between past, present, or future states) or under various management scenarios. It also includes a direct link to management practices with provision and use of ESS, does not require marked baselines[3] and allows for trade-off analysis. Economic valuation of changes in the services provided is possible through the calculation of marginal differences on the level of service provided at two points in time.

RUBICODE's Framework for Ecosystem Service Provision (FESP) has been applied to freshwater and terrestrial ecosystems in Europe. It was initially designed to aid decision-making for biodiversity conservation. As such, this framework allows comparison across competing ESS, highlighting the conflicts and trade-offs between not only multiple ESS but also multiple service beneficiaries. It builds on the DPSIR scheme with introduced elements to the ecosystem service approach and incorporates the comparison of provision-use ratios.

The Water Quality and Well-being framework links actions to measured/modelled marginal changes in water quality and their subsequent effect on changes in the value of ecosystem goods and services. An important strength of this framework in the context of DESSIN is that it focuses on identifying actions (e.g. implementation of new technologies) very early in the process of the analysis. The framework bases value estimates on marginal changes in service provision and accounts for multiple sources of value without double-counting. It integrates aspects of biophysical and economic research and models, with assessments capable of being applied to multiple scales. Additionally, the framework is sensitive to alternative land use or management decisions.

TESSA framework's assessment focuses on services that are (i) significant in biophysical, social or economic terms; (ii) sensitive to potential drivers of change; and (iii) measurable with limited capacity and resources. It guides the user through decision trees to appropriate methods for each service and provides guidance on how to communicate findings. TESSA, especially, empowers local users and non-specialists to engage in ESS assessments with demonstrated low application costs. Lastly, it allows comparison of alternative management decisions – e.g. development or restoration.

2.3 Constructing an original framework for DESSIN

While selecting one of the frameworks described and analysed in the first two sections of this chapter for its application within DESSIN is plausible, the idea of building upon several of them to construct a customised piece integrating their most salient elements has been generally well received among WP11-WP13 members. While making this "combined framework" operational would entail a more detailed effort (e.g. identifying workable links between elements, ensuring

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[2] Paetzold et al. refer here to „the more narrow ecological sense of sustainability", i.e. „the capacity for the long-term provision of services".

[3] The P:U ratio provides a snapshot of the situation at a given time. If one has two of these snapshots (before and after implementation) one could theoretically assess the changes without having a marked baseline.

compatibility among the approaches), it would also result in a more powerful tool catering for the custom needs of the project.

For this exercise, a series of steps is suggested and outlined below.

2.3.1 Suggested steps towards an original analytical framework for DESSIN

1. Start by using the ESP framework as a basis
   According to the comparative table in chapter 3, from the set of analytical frameworks considered in D11.1, the ESP is one that covers most of the aspects identified as necessary by the authors. This, in combination with its step-wise, straight forward approach, facilitates its employment as the main structure into which additional elements extracted from the other frameworks can be incorporated. The P:U ratio approach could be applied as far as feasible, however, it is expected that in certain cases other approaches will be more suitable.
2. Identify and select the most attractive elements of other frameworks, e.g.:
   - Water Quality and Well-being: incorporate the strength of marginal ESS provision analysis (relatively simple to analyse marginal changes in P:U ratios). DESSIN could also make use of the literature review on illustrative examples conducted by Keeler et al. As DESSIN aims to conduct also a monetary valuation of the ESS, the ESP framework will need to be extended by this feature - also in order to allow aggregation across ESS.
   - TESSA: Conduct the Preliminary Work & Rapid Appraisal as described in the TESSA methodology, including an early engagement of stakeholders. Incorporate the focus on services that are (i) significant in biophysical, social or economic terms; (ii) sensitive to potential drivers of change; and (iii) measurable with limited capacity and resources. Could also include the comparison of alternative states, the communication strategy to ensure accessibility of results to multiple audiences and the decision trees to ensure replicable results. Also the generic guidance on the degree of confidence for assessment methods can be applied as a way to determine uncertainty.
   - RUBICODE: make use of the comprehensive examination of indicators - especially concerning biodiversity, incorporate the strength of comparing competing ESS, for a more accurate conflict/ trade-off analysis and incorporate how services can be valued in decision-making. The DPSIR approach can be adopted and adjusted to DESSIN's needs. A list of criteria for the selection of adequate indicators could build on the "Framework to test adequacy of indicators" presented in RUBICODE.
   - Blueprints as Structural Templates: incorporate a template style to ensure comparability and consistent documentation.
3. Identify the points of convergence between the selected elements and the ESP
   Given that the ESP follows a simple step-wise approach, an optimal arrangement of the new elements to be incorporated should be feasible. This optimal arrangement of the new elements should be carefully thought through in order to ensure that the necessary inputs are available at that point in the process and that the subsequent steps in the chain will not be negatively affected/become redundant.
4. Ensure there is no conflict between the incorporated element's approach and that of the combined framework

Given that the context (either conceptual or operational) for which the new elements were conceived could be different as that of the ESP/of the combined framework, discrepancies and inconsistencies could arise. Adaptations may be necessary and should be carefully considered.

5. Conduct a brief test of the resulting combined framework on a mature site
   Once the theoretical concept and workflow of the combined framework has been laid out, a quick practical application should be conducted in order to ensure proper operation.

2.3.2 Linking the selected framework with the common methodological steps proposed for each of the DPSIR elements

Finally, the analytical framework selected (or constructed) should be integrated into the DESSIN ESS Evaluation Framework and thus facilitate the assessment of all elements of the DPSIR cycle. The common methodological steps to be followed by the users of the ESS Evaluation Framework (at first instance the mature and demo site partners) in their assessment of each of the DPSIR elements are presented in the following chapter. The alignment of the analytical frameworks to these common methodological steps is an important “fine-tuning” issue that continues to be discussed and tested within WA1.

2.4 Next steps and potential barriers

Next steps:

- Identifying the elements of the analytical frameworks which are of main interest for the purpose of DESSIN WA1: *to enable the assessment of changes in the provision of ESS relative to the implementation of new water technologies.*
- Testing the suitability of the different elements of the analytical frameworks in practice by applying them in the mature case study site assessments
- Evaluating the fit between the elements of the analytical frameworks and the common methodological steps to assess the full DPSIR cycle (described in the following chapter)

Potential barriers:

- It has become clear that there will be cases where some elements of the analytical frameworks will not be applicable due to various reasons (e.g. incompatibility with a certain ecosystem service type or indicator). This could be addressed by perceiving the set of analytical frameworks and/or their elements as a toolbox from which the user can choose depending on the individual circumstances of the case under examination.

3. Testing a common set of methodological steps for the analysis of each of the DPSIR elements: an example

3.1 The adapted DPSIR scheme for DESSIN against the backdrop of previous applications

As a reminder, Figure 2 below outlines the DPSIR scheme as applied in DESSIN. The innovative technologies to be trialled within the project are considered *Responses* that may have impacts on *Drivers* (anthropogenic activities with environmental impacts), *Pressures* (the direct effects of such activities) and *States* (the conditions of the ecosystems under study). From the resulting changes in ecosystem state, the changes in ESS (*Impact I*) will be estimated. An economic assessment of the subsequent changes in the benefits perceived by society, i.e. in the value of the goods and services derived from ecosystems (*Impact II*), will follow. Finally, this estimated change in the level of human well-being will provide insights for the conduction of a sustainability assessment to inform policy and decision-making (further responses).

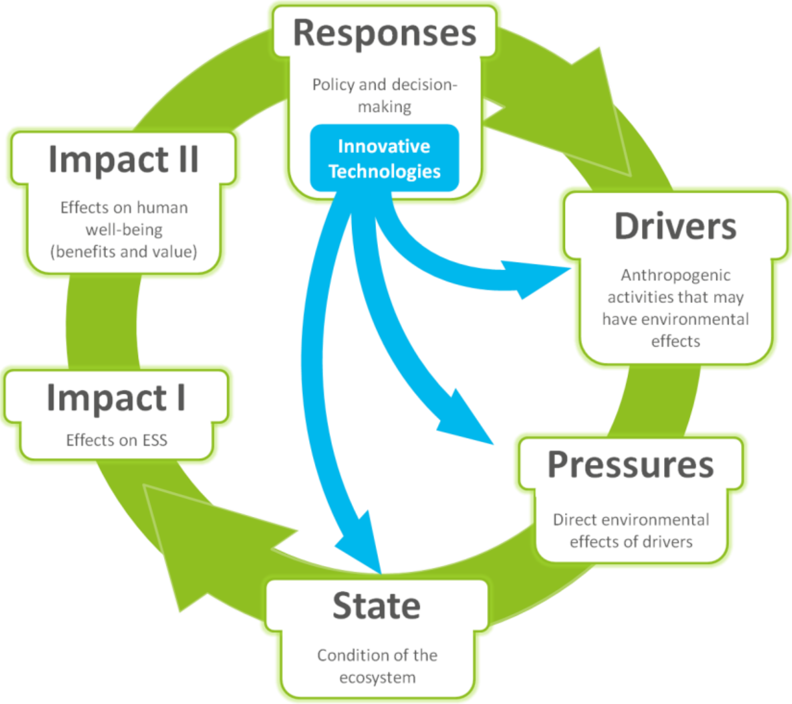


Figure 2: Conceptual approach of the DESSIN ESS Evaluation Framework (based on Müller and Burkhard, 2012, Van Oudenhoven et al., 2012 and Haines-Young and Potschin, 2010; 2013).

In addition, the definitions agreed upon and listed in the glossary of D11.1 are an important consideration.

Box 1: Relevant definitions Drivers-Pressures-State-Impact-Responses (taken from DESSIN D11.1)

The causal framework for describing the interactions between society and the environment adopted by the European Environment Agency: driving forces, pressures, states, impacts, responses

(Gabrielsen and Bosch, 2003).

Driver: An anthropogenic activity that may have an environmental effect (e.g. agriculture, industry) (MARS Project Terminology, 2014)

Pressure: The direct environmental effect of the driver (e.g. an effect that causes a change in water flow or a change in the water chemistry) (MARS Project Terminology, 2014)

State: The condition of the ecosystem under study (e.g. water body) resulting from both natural and anthropogenic factors (i.e. physical, chemical and biological characteristics)

Impact: Effects on ecosystem services (Impact I) and their subsequent effects on human well-being (Impact II) resulting from changes in ecosystem state, triggering social response. See Impact I and Impact II below (Müller and Burkhard, 2012)

- ***Impact I:*** The changes in ecosystem services induced by modifications in the state of an ecosystem (based on Müller and Burkhard, 2012).
- ***Impact II:*** The effects that changes in ecosystem services have on human well-being and on the value of the benefits perceived from ecosystem service use (based on Müller and Burkhard, 2012).

Response: The measures taken to address drivers, reduce pressures and improve the state of the ecosystem under study (e.g. restricting abstraction, limiting point source discharges, developing best practice guidance for agriculture) (MARS Project Terminology, 2014)

(The MARS Project Terminology, 2014 is based on IMPRESS, 2002)

In the work performed and planned under WP11 and WP13 of DESSIN so far, the focus of the exercise has been on understanding how to measure changes in ESS, or in other words, quantifying the relationship between the *State* and *Impact I* and, to an extent, *Impact II* (see DPSIR cycle in D11.1 for more information about the proposed DPSIR cycle). Figure 3 below illustrates this process, which focuses on the identification and selection of relevant indicators to describe possible changes in relevant ESS.

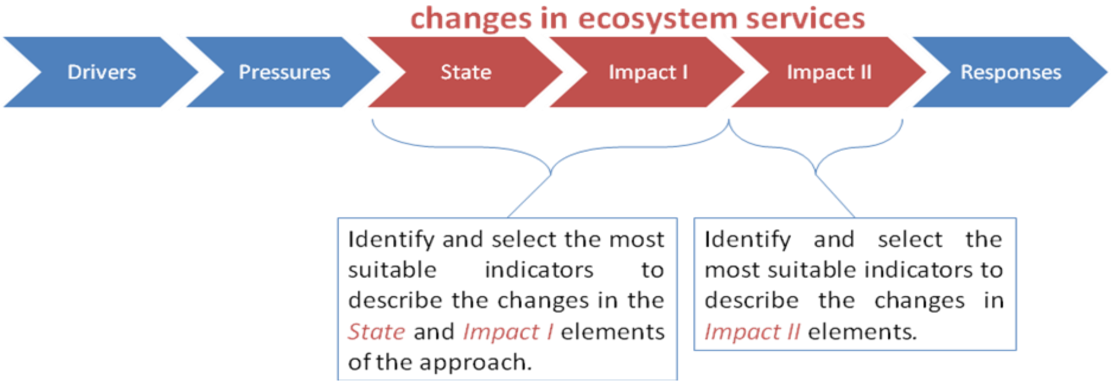


Figure 3: Starting from the key research question of the project and moving towards the rest of the DPSIR cycle

However, very little has been discussed about how to deal with the other elements of the DPSIR cycle in a practical way. This debate goes beyond the discussions about the selection of suitable DESSIN ESS analytical frameworks, as we aim to highlight here practical applications. For example, the UNEP guide on the Application of the Ecosystem Approach in integrated environmental assessments (UNEP, 2010) recommends using the DPSIR conceptual framework to indicate the possible drivers, pressures, impacts and responses associated with the ecosystem and respective services identified (see Table 2).

Table 2: Relevant ecosystem services and the DPSIR cycle factsheet

Ecosystem:			
Service identified:			
Driver	*Indicator1*	*Indicator2*	*Indicator3*
Pressure	*Indicator1*	*Indicator2*	*Indicator3*
State	*Indicator1*	*Indicator2*	*Indicator3*
Impact I	*Indicator1*	*Indicator2*	*Indicator3*
Impact II	*Indicator1*	*Indicator2*	*Indicator3*
Response	*Indicator1*	*Indicator2*	*Indicator3*

Modified from: http://www.unep.org/ieacp/files/pdf/ecosystem/Module-10-ecosystem.pdf
Note: such a factsheet should be filled for each of the relevant services for a specific ecosystem type.

Important for the consideration of the UNEP approach is the definition of the indicator that can be applied to all elements in the DPSIR cycle. The EEA defines indicators as “a measure, generally quantitative, that can be used to illustrate and communicate complex phenomena simply, including trends and progress over time” (EEA, 1999). Furthermore, “an indicator provides a clue to a matter of larger significance or makes perceptible a trend or phenomenon that is not immediately detectable. An indicator is a sign or symptom that makes something known with a reasonable degree of certainty. An indicator reveals, gives evidence, and its significance extends beyond what is actually measured to a larger phenomenon of interest” (IETF, 1996).

In this instance, we are proposing that the use of indicators is the best way to understand and communicate the different elements of the DPSIR cycle.

Once we are able to understand the causal relationships between different elements of the DPSIR cycle for all relevant ESS for a given ecosystem (or area), it is possible to draw an integrated DPSIR concept map (see Figure 4) in order to understand the issues at stake and the synergies between the relevant services and other elements of the cycle.

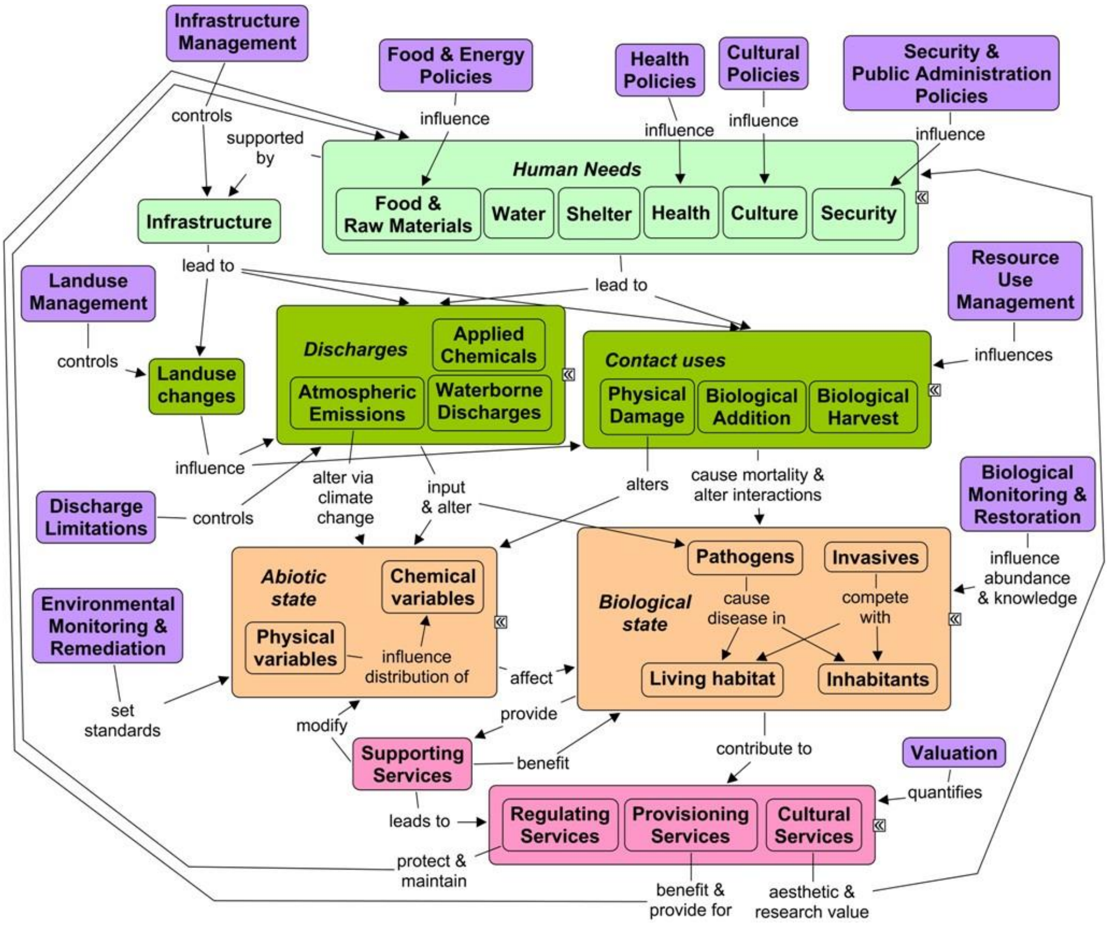
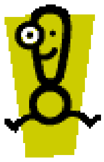


Figure 4: An example of a generic DPSIR concept map from the US EPA.[4]

*Please note the following colour codes: Light green: *Drivers*; Green: *Pressures*; Orange: *State*; Pink: *Impacts*; Purple: *Responses*.



In case you are interested in finding a bit more about the practical application of the concepts introduced above, the US EPA website has many illustrations and materials to showcase the application of these tools. You can find some of these examples in the annexes of this document. They are very informative.

In DESSIN, a relevant way forward for the assessment of each element in the DPSIR cycle could be to come up with an agreed list of common methodological steps that will be covered in the specific ESS assessments at each mature case study site as part of the work done in WP13 and later on in WA3. The idea is to focus initially on the key research question of DESSIN, which is to measure changes in ESS as a result of the implementation of new technologies. In this respect, step 1 is the identification of relevant services that will be impacted by the new technologies. The second step would be to address the *State*, *Impact I*, and *Impact II* elements of the cycle, and then moving through to the *Drivers*, *Pressures* and *Responses* elements that will also need to be covered. The idea is better reflected in the graph below (Figure 5):

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[4] http://www.epa.gov/ged/tutorial/docs/GenericDPSIR_simple_cmap.jpg

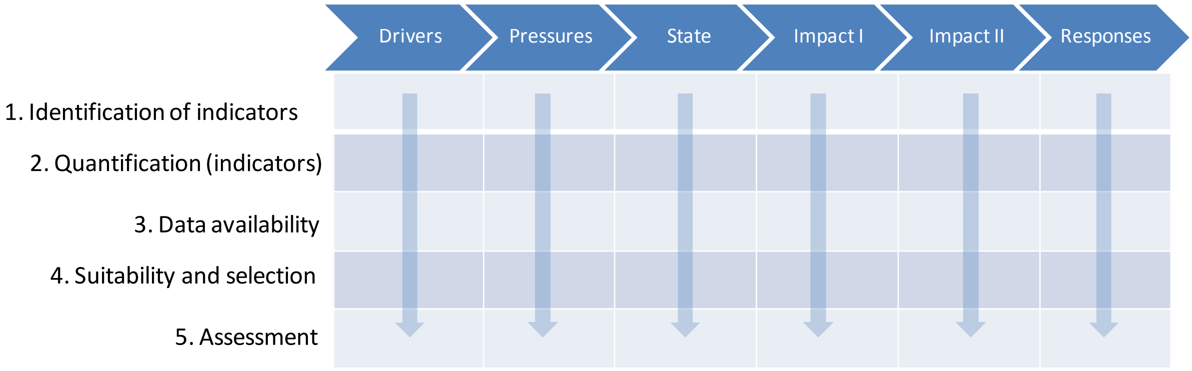


Figure 5: A set of common methodological steps to analyse each element of the adapted DPSIR cycle.

In order to conduct ESS assessments in the mature case studies that follow the proposed DPSIR cycle (see D11.1), each element of the cycle would have to be individually considered. Figure 5 illustrates that there are a series of common steps that can be systematically applied to the assessment of each individual element of the cycle. In this respect and focusing specifically on the assessment of drivers, we could argue that the necessary steps in order to properly understand this specific element of the DPSIR cycle could be similar than those that will be used to assess pressures or impacts. Some of the proposed methodological steps for discussion would be:

1. Identification of relevant indicators (DEFINITION)

2. Quantification (DEFINITION)

3. Data availability (DEFINITION)

4. Suitability and selection (DEFINITION)

5. Assessment (DEFINITION)

The above could also be seen as criteria for the selection of relevant elements for the assessment. It is also important to consider issues of scale and temporal aspects (in terms of measuring changes before and after an intervention).

3.2 An example of the common methodological steps proposed for each of the DPSIR elements

The question is how all the notions discussed above translate into practice. We have applied the above to an example on the implementation of new technologies in the Llobregat River in Barcelona. Below, an example is presented to introduce the concept and the necessary methodological steps. Please be aware that this exercise is only intended to serve as an example to apply the framework and therefore may not be accurate. The proposed steps for the application of the approach are:

- **STEP 1: Identification of DRIVERS**
- **STEP 2: Identification of PRESSURES**
- **STEP 3: Identification of STATE indicators**
- **STEP 4: Identification of IMPACT indicators**

- **STEP 5: Identification of relevant RESPONSES**
- **STEP 6: Development of a DPSIR concept map**
- **STEP 7: Development of *DPSIR* cycle indicator factsheet**

3.2.1 DPSIR FRAMEWORK APPLIED TO: Innovations to reduce trihalomethanes concentrations in the Llobregat River. Based on Honey-Roses et al, 2014

Background

1. The Aigues Ter-Llobregat (ATLL) facility in Abrera, Spain is a public water treatment wholesaler that supplies municipal providers. ATTL purchased electrodialysis reversal (EDR) to remove bromine, the critical precursor of trihalomethanes and to ensure compliance with the new water quality standards. The new EDR water treatment technology was adopted to reduce the uncertainty surrounding freshwater provision.

2. A second water treatment facility on the Llobregat River is owned and operated by the private water company Aigues de Barcelona (AGBAR) in Sant Joan Despi (SJD). AGBAR installed reverse osmosis membranes.

This technological improvement was motivated by new drinking water quality standards that reduced the permissible level of total trihalomethanes to below 100 µg/L.

STEP 1: Identification of DRIVERS

Definition: Anthropogenic activities that may have an environmental effect (e.g. agriculture, industry)

1. Mining
2. Drinking water supply: to the city of Barcelona (covering 50% of total drinking water demand)
3. Climate
4. Water treatment

STEP 2: Identification of PRESSURES

Definition: Direct environmental effects of drivers (e.g. an effect that causes a change in water flow or a change in the water chemistry)

1. WATER QUALITY
    a. The river has high concentrations of salts and bromine. Mine tailings (large mountains of salt deposits by an extractive potash mining industry) in the mid section of the river are a major source of salinity.
    b. Trihalomethanes are formed during the water treatment process when ionic bromines are mixed with chlorine. The concentration of trihalomethanes in drinking water supply are regulated because they are carcinogenic.
    c. Higher water temperatures accelerate the formation of trihalomethanes.
    d. The river has heavy nutrient loading and turbidity.

STEP 3: Identification of STATE indicators

The condition of the ecosystem under study (e.g. water body) resulting from both natural and anthropogenic factors (i.e. physical, chemical and biological characteristics)

1. Concentration of trihalomethanes µg/L – environmental standard: below 100 µg/L.
2. BEFORE AND AFTER: STATE relevant under the implementation of the technology.

STEP 4: Identification of IMPACT indicators

Effects on ecosystem services (Impact I) and their subsequent effects on human well-being (Impact II) resulting from changes in ecosystem state, triggering social Response.

IMPACT I

The changes in ecosystem services induced by modifications in the state of an ecosystem

1. Relevant ESS according to the latest version of the Common International Classification of Ecosystem Services (CICESv4.3):

   Provisioning: Water: Surface water for drinking/ Ground water for drinking

   Regulation & Maintenance: Liquid flows: Hydrological cycle and water flow maintenance

   Regulation & Maintenance: Water conditions: Chemical condition of freshwaters
2. Water quality protection and salinity: mean daily conductivity values (conductivity (µS/cm)). Conductivity, a measure of electrical current flow through a solution, is expressed in units of microSiemens (*u*S). Conductivity is the reciprocal of electrical resistance (ohms). Because conductivity increases nearly linearly with increasing ion concentration, we can use conductivity measurements to estimate ion concentrations in solutions.
3. BEFORE AND AFTER: IMPACT I relevant under the implementation of the technology.

IMPACT II

The effects that changes in ecosystem services have on human-well-being and on the value of the benefits perceived from ecosystem service use

1. BEFORE AND AFTER IMPACT II relevant under the implementation of the technology:
   - BEFORE: traditional treatment methods are incapable of removing chloride ions from the feed water when salinity values passed maximum permissible concentrations, in which case, surface water treatment was stopped altogether. These high concentrations usually occurred when the brine collector that transports mining effluents from the mines to the Mediterranean would rupture and release highly concentrated salt water directly into the river.

     Stoppage events generate a penalty cost because they oblige the treatment company to purchase water at a higher cost elsewhere.
   - AFTER:

     Health costs avoided: http://www.who.int/water_sanitation_health/dwq/chemicals/en/trihalomethanes.pdf

     Savings in buying water at a higher cost elsewhere.

     Savings in treatment costs with river restoration response: benefits that restoration projects could produce for the water treatment managers downstream based on the salinity–energy nexus and savings in water treatment costs. A reduction in mean daily conductivity values in the Llobregat River by 100 µS/cm would generate ESS worth €213,612/year. A reduction of conductivity by 500 µS/cm would generate services worth €868,546/year.

STEP 5: Identification of relevant RESPONSES

The measures taken to address drivers, reduce pressures and improve the state of the ecosystem under study (e.g. restricting abstraction, limiting point source discharges, developing best practice guidance for agriculture)

1. REGULATION: environmental standards
2. Technologies: Disinfection byproducts, such as trihalomethanes, are usually removed by modifying the chlorine process or removing the chlorine sensitive compounds
    - EDR: Uses energy to separate dissolved ions such as Br-, Cl-, and Na+, or
    - Ultrafiltration and reverse osmosis membranes.
3. Protect the river from salt pollution: Plant halophytic vegetation reducing the volume of water coming into contact with salt deposits.

STEP 6: Development of a DPSIR concept map - Example of DPSIR framework.

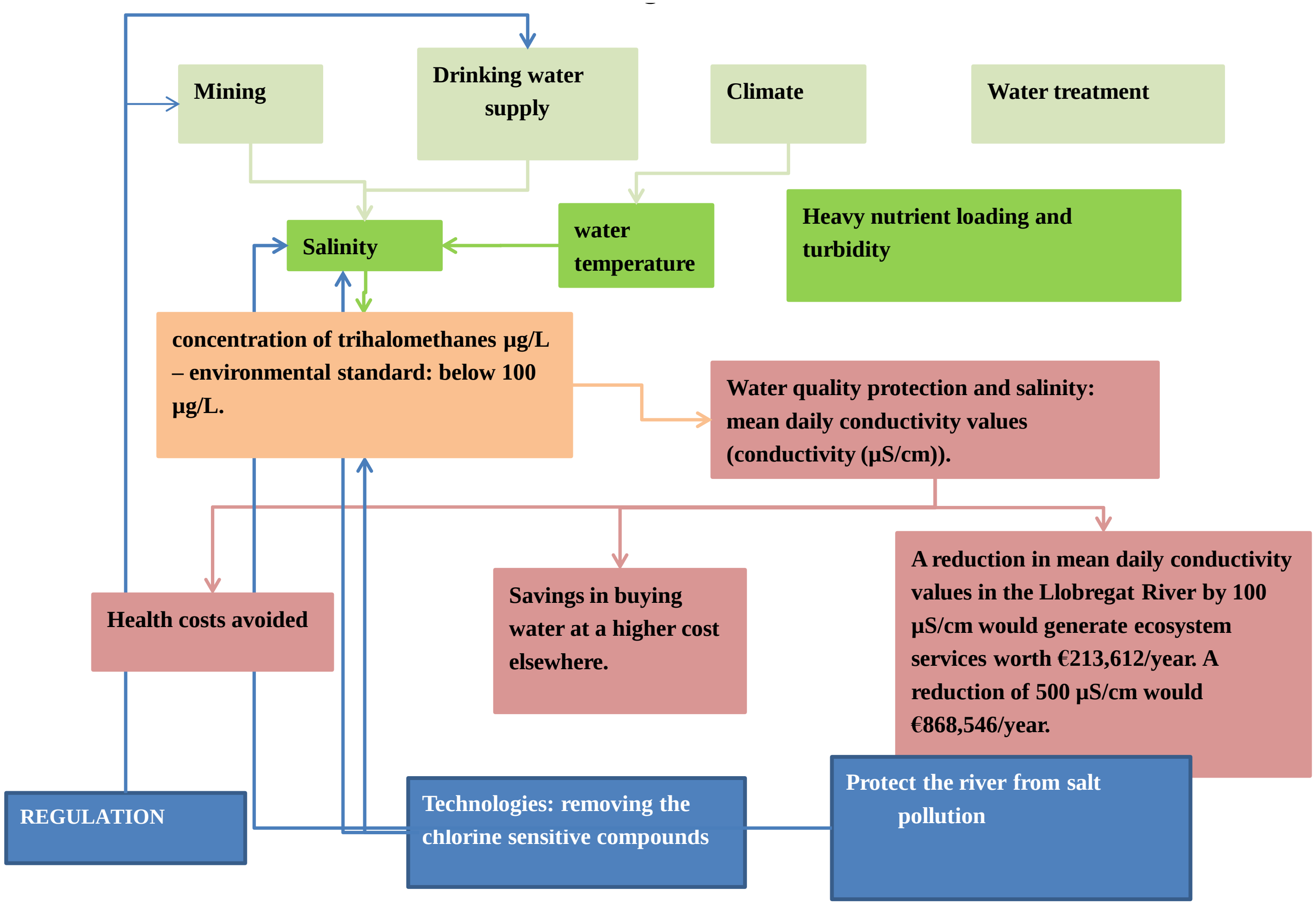


Figure 6: DPSIR concept map - Innovations to reduce Trihalomethanes concentrations in the Llobregat River.
*Please note the following colour codes: Light green: *Drivers*; Green: *Pressures*; Orange: *State*; Pink: *Impacts*; Purple: *Responses*.

STEP 7: Development of DPSIR cycle indicator factsheet - Example of DPSIR indicators

Table 3: DPSIR cycle indicator factsheet - Innovations to reduce Trihalomethanes concentrations in the Llobregat River.

Item	Factor	Indicators
Driver	Mining	Potash mining economic statistics in the area
Driver	Drinking water supply	Volume, coverage, prices
Driver	Climate	Air temperature
Driver	Water treatment	Volume
Pressure	WATER QUALITY, EQS	Salinity
Pressure	WATER QUALITY, EQS	Water temperature
Pressure	WATER QUALITY, EQS	Nutrient loading (Ammonium)
Pressure	WATER QUALITY, EQS	Turbidity
State	ionic bromines mixed with chlorine	concentration of trihalomethanes µg/L.
Impact I	Water quality protection and salinity	mean daily conductivity values (conductivity (µS/cm))
Impact II	Health protection	Health costs avoided (€/year)
Response	REGULATION	100 µg/L concentration of trihalomethanes in water
Response	INNOVATIONS	Meeting concentrations of trihalomethanes in water Cost-Effectiveness indicators
Response	ECOSYSTEM BASED SOLUTIONS	Density of halophytic riparian vegetation Cost-Effectiveness indicators

Questions for discussion at the WA 1 Meeting in Barcelona (4-5 March 2015):

- How do we include an assessment of *Drivers*, *Pressures* and *Responses* into the on-going work on *State-Impact* for DEL 13.1 “Quantified ESS for 3 mature sites including recommendations for application”? Is it necessary to deal with these elements of the DPSIR cycle in a quantitative manner?
- Should we pursue the presented approach? Is that useful or other alternatives need to be found?
- Do we need to develop guidance for application?
- Other ideas/way forward?

3.3 Next steps and potential barriers

Next steps:

- At the meeting in Barcelona 4-5 March 2015, it was decided that the basis/outline for D11.2 (Framework for evaluating changes in ecosystem services (M24)) will include a step-by-step guidance in the practical application of the DPSIR scheme.
- This would include further work on the clarification of definitions including examples and measurements. The development of templates for the selection of relevant indicators was proposed.
- In addition, it was also decided that regarding the application of the DPSIR cycle it would be necessary to deal with the elements of the cycle in a quantitative manner and that guidance for its application in the mature case studies would be required.
- Specific actions:
    - Revise the glossary of D11.1 to fit the contents of the step-by-step guidance.
    - Develop a stepwise guide/“Cookbook” on the application of the DPSIR cycle including suggestions and issues raised in this chapter.
    - Develop a list of criteria for indicator selection to be included into the cookbook in close communication with WP13.
    - Work closely with the mature case study owners of WP13

Potential barriers:

- The experimental application of the DESSIN framework in the 3 mature case studies will show the applicability and suitability of the approaches suggested. The issue of how any assessment of the DPSIR cycle would fit with selected analytical frameworks (chapter 2) still remains. Any potential assessment of the DPSIR elements can well be linked into the description of the ecosystem at hand, as required e.g. for the ESS blueprint approach and the TESSA preliminary work step.
- The following question remains: are we going to describe the DPSIR circle starting at the *State* when contamination or similar is already present and a measure/technology is to be put in place to alleviate from this stress? This might be a point for discussion in next iteration of the guidance.

4. Identifying relevant indicators in the mature case study sites and developing a template for selecting proxy-indicators of ESS capacities

For each of the mature case study sites, relevant services of the respective ecosystem have been compiled and have been considered in relation to specific measures conducted at each of the mature sites. In order to quantify these ESS bio-physically (as a first step before economic valuation), appropriate indicators are required.

In section 4.1, some ESS are described in more detail concerning their classification into PROVISION/USE indicators as well as process-related/structure-related indicators. Furthermore, a list of relevant ESS and indicators is presented for the Emscher case as an example in section 4.2. Finally, the process-related indicators are described in more detail in section 4.3.

4.1 ESS and their respective indicators classified into PROVISION/USE and Process-related/Structure-related indicators

Concept for selecting ESS indicators

Preliminary remark: The notion of ESS is an ideal concept that becomes operationalised by the use of indicators. The quality of this operationalisation depends very much on the quality of the indicators used. See

Box 2 below for definitions of the terms used in the following paragraph.

1. We describe the concept for selecting indicators to quantify the provision and use of ESS.
2. ‚Provision' and ‚use' are the two central components of the „Ecosystem Service Profile" (ESP)

   framework (Paetzold et al., 2010). Also the MAES working group as well as the RUBICODE project (Harrison et al., 2011) aim at identifying and quantifying both service provision/supply as well as service demand/need. Also within the MARS project, an approach that identifies 'Capacity', 'Flow', and 'Benefit' is suggested. Capacity and Flow can here be used synonymously to ‚Provision' and ‚use'.

   Within DESSIN, the Provision-versus-use approach can be part of the analytical framework which is to be developed using relevant elements from available frameworks produced in former studies. Suitability of the Provision-versus-use feature, however, will need to be tested in the experimental framework application in WP13. Also the additional advantage of the feature will need to be verified since the DESSIN framework is already planned to differentiate between state and Impact I and Impact II indicators, which might lead to redundancies.
3. The capacity of an ecosystem to provide services depends on its properties which are composed of the structure (i.e. the system's biophysical architecture) and processes (i.e. the interactions between the system's elements).
4. We distinguish between:

a. two types of indicators: ecosystem structure-related and ecosystem process-related

indicators

Note that the differentiation between these two types of indicators is only of relevance for the Provision indicators of the Impact I assessment.

This differentiation between indicators will be of importance when checking the criteria for indicator selection, which will be part of the DESSIN framework. One of the criteria will be to preferably apply structure-related indicators for ESS related to structures and process-related indicators for ESS based on processes. Compliance to this criterion links to bullet point 4b.

b. two qualities of indicators: direct indicators (quantifying the service directly) and proxy-indicators (e.g. quantifying selected premises or effects of the services in question).

Note also here that both the direct and proxy-indicators focus on the quantification (i.e. level) of service provision. The level of change in ESS will be evaluated by BEFORE/AFTER comparisons with regard to a measure or an innovative technology.

The idea of having two qualities of indicators is to reflect ESS as good as possible by applying the most appropriate indicators. For services that represent processes, process-related indicators are direct indicators reflecting the service. If data for those are not available, proxy-related indicators can be applied instead, however, with a lower accuracy expected. In an earlier study (Natho et al., 2013), two types of indicators - a proxy-based approach and a model-based approach for identifying nitrogen retention in floodplains – were compared for floodplains in different degrees of degradation.

Box 2: Definitions of terms (taken from DESSIN D11.1)

Term	Description
ESS provision	The actual provision of ecosystem services.
ESS use	The actual utilisation of ecosystem services by people.
Ecosystem structure	The biophysical architecture of ecosystems (TEEB, 2010).
Ecosystem processes	All interactions between elements of the ecosystem. Note: Ecosystem functions represent a specific subset of the ecosystem processes (see Ecosystem functions above).
Ecosystem structure-related indicators	Indicator of first choice when quantifying ESS related to Ecosystem structure. (to be elaborated)
Ecosystem process-related indicators	Indicator of first choice when quantifying ESS related to Ecosystem processes. (to be elaborated)

Direct indicator	Indicator that quantifies the service directly, irrespective of it being related to processes or structures. (to be elaborated)
Proxy-indicator	Indicator that quantifies selected premises or effects of the services in question and, thus, comes with higher level of uncertainty. (to be elaborated)

5. The indicator selection depends on the respective group of services: A. Provisioning services,

B. Regulation & Maintenance services, and C. Cultural services.

It became apparent that Provisioning services are related to the structures of an ecosystem and should, thus, be quantified with structure-related indicators. Regulation & Maintenance services, however, can either be related to processes or to structures and, thus, should be assessed with process- or structure-related indicators, respectively. Note that this refers only to the Provision indicators and not to Use indicators. Cultural services were found to be a special group, where Provision indicators cannot easily be applied.

The Provision-versus-use distinction might, thus, not be applicable for all services. It can nevertheless be an optional feature if regarded as appropriate for individual cases/indicators. This would allow maximum flexibility within the framework.

The issues raised in this chapter will be incorporated into the stepwise approach/cookbook mentioned in chapter 3 and into the list of criteria for indicator/method selection of the DESSIN framework.

Adopting those criteria clearly reduces the list of services that can be considered quantitatively. It remains to be discussed, how qualitatively described ESS, which might be significant in some cases, can be integrated in the overall evaluation. The main aim of DESSIN, however, is the ability to measure changes in ESS rather than assuring complete ecosystem assessments.

A. *Examples for Provisioning ESS:*

Type: Structure-related indicators

Quality: Direct indicators

CICES class:	"Surface water for non-drinking purposes"
ESS:	Surface water provision for agriculture/industry/urban use
PROVISION indicator:	Surface water flow (average annual river water supply (m3/a))
PROVISION indicator	*Type: Structure-related indicators* *Quality: Direct indicators*
USE indicator:	Surface water abstracted (average annual river water demand (m3/a))

Here it is important to note that we have an ESS which can well be resembled by structure-related indicators, as the service capacity is closely related to the structure of the ecosystem.

CICES class:	"Wild animals and their outputs"
ESS:	Fish provision
PROVISION indicator:	Total biomass of commercially relevant fish species (kg/ha/a)
PROVISION indicator	*Type: Structure-related indicators* *Quality: Direct indicators*
USE indicator:	Total biomass of angled fish species (kg/ha/a)

B. *Examples for Regulation & Maintenance ESS:*

Type: Process-/Structure-related indicators

Quality: Direct/Proxy indicators

CICES class:	"Filtration/sequestration/storage/accumulation by ecosystems"
ESS:	Water purification
PROVISION indicator:	a) Substrate turnover: N retention rate (denitrification) (kg/ha/a)
a) PROVISION indicator	*Type: Process-related indicator [1st choice]* *Quality: Direct indicators*
	b) Saprobic index (= proxy for the river's capacity to purify organic pollution)
b) PROVISION indicator	*Type: Structure-related indicators [2nd choice]* *Quality: Proxy indicators*
USE indicator:	a) N to be retained to comply with water quality standards (kg/ha/a) b) River type-specific Saprobic Index value representing at least good saprobic conditions

For water purification, which is an ESS that is closely related to processes/interactions in the ecosystem, process-related indicators like substrate turnover are the first choice. In case the assessment of these indicators is not possible, second choice structure-related indicators like the Saprobic Index can be applied alternatively. Option a) can well be assessed with simple process models.

CICES class:	"Flood protection"
ESS:	Flood protection

PROVISION indicator:	Retention volume available
PROVISION indicator	*Type: Structure-related indicators* *Quality: Direct indicators*
USE indicator:	Retention volume inside river bed required to avoid flooding i.e. to comply with legal targets (e.g. Q < HQ200)

Flood protection can well be resembled by structure-related indicators, as the service is closely related to the structure of the ecosystem.

CICES class:	“Maintaining nursery populations and
habitats” ESS:	Maintaining habitats
PROVISION indicator:	River habitat quality evaluation score
PROVISION indicator	*Type: Structure-related indicators* *Quality: Direct indicators*
USE indicator:	River habitat quality evaluation score representing at least good habitat conditions

Different to the Provisioning ESS, it is more challenging to identify appropriate Use indicators for the Regulation & Maintenance ESS. Here, the Use indicators could be represented by regulatory thresholds (e.g. good status of the WFD) or the level at which a service is favorable to or desired by people (e.g. to reduce flood risks). It will, however, be challenging to link a biophysical assessment that is not based on the concrete use of the beneficiary/end-user to the economic assessment in the following step. In order to account for this challenge, consideration of the end-user or beneficiary of the specific service should be part of the stepwise approach/cookbook of the DESSIN framework (e.g. users of the ESS “water purification” are water utilities; while those benefitting most from “flood protection” are riverside settlers, infrastructure owners, and insurance companies). Furthermore, one of the criteria for selecting appropriate indicators should be that end-user oriented Use indicators are to be applied where possible.

The focus in DESSIN is to support the business cases of the technology developers. If the technology affects certain ESS but no specific groups of people are/would be actually using the enhanced/provided service, then the enhancement of ESS becomes a weak argument for technology uptake. Therefore, this criterion is of high importance.

When Regulation & Maintenance ESS are examined, it furthermore becomes apparent that Maintenance types of ESS (e.g. biodiversity-related ESS) should rather be seen as supporting services that are prerequisites for Regulation ESS (e.g. biodiversity as prerequisite for self-purification in streams) as well as for Cultural ESS (e.g. biodiversity as prerequisite for aesthetic services or the experiential use of animals and plants). Accounting for this issue can be assured by identifying the “final ESS” or “products” from ecological systems that contribute to human well-being, as suggested by Haines-Young and Potschin (2011). This would certainly help in avoiding double-counting and should be integrated into the stepwise approach/cookbook of the DESSIN framework.

C. *Examples for Cultural ESS:*

Note: Cultural services are rather assessable via Use indicators. Proxies for Provision indicators may, however, be e.g. the suitability of an area for a Cultural service (see 3rd example). The ESP concept is, thus, not always applicable here.

Type: Structure-related indicators

Quality: Proxy indicators

CICES class:	"Physical use of landscapes in different environmental
settings" ESS:	Outdoor recreation
PROVISION indicator:	none
PROVISION indicator	*Type: none*
	Quality: none
USE indicator:	Density of bicycle pathways/ Density of bike paths weighted by users/ Number of people using the bike paths

See also Schröter et al. (2014) for examples. In this case, the 3rd Use indicator suggested would be the most meaningful one, as it is most oriented towards the end-user.

CICES class:	"Aesthetic"
ESS:	Quality of life enhancement
PROVISION indicator:	none
PROVISION indicator	*Type: none*
	Quality: none
USE indicator:	"willingness-to-pay" for real estates close to waterways

CICES class:	"Physical use of landscapes in different environmental settings"
ESS:	Outdoor recreation
PROVISION indicator:	Suitability of the area for recreational fishing
PROVISION indicator	*Type: Structure-related indicators*
	Quality: Proxy indicators
USE indicator:	Number of anglers

Here it can be noted, that the group of Cultural ESS seems to be a special group. Cultural services cannot easily be assigned Provision indicators but rather Use indicators.
Plus, as can be observed in the 2nd example "Quality of life enhancement", it is possible that a valuation method/economic assessment method such as "willingness-to-pay" becomes the Use indicator. Valuation can here be seen as a shortcut, without defining the service provision. This is an example of how it may be possible to estimate changes in value from changes in state, without necessarily computing ecosystem service indicators. In this case, however, the ESP approach cannot be followed.

4.2 Example of relevant ESS & indicators for mature site Emscher

An exemplary list of ESS relevant in the Emscher case (classified according to the CICES classification) along with suggestions for Provision and Use indicators for each of the ESS is given in Table 4. ESS and indicators to be applied in the Emscher case are given in bold; Process-related indicators in blue, and Structure-related indicators in black.

Table 4: Examples for ESS relevant for the Emscher mature site along with Provision and Use indicator suggestions.

DESSIN ESS	PROVISION indicator	USE indicator
--	--	--
Water purification	**Saprobic index value assessed (self purification)**	Saprobic index value required for good ecological status
	Physical habitat quality assessed	Physical habitat quality required for good ecological status
	Physical-chemical quality: BOD	Physical-chemical quality: BOD required for good ecological status
	Substrate turnover: N retention rate (denitrification)	Amount of N to be retained to comply with water quality standards
	Substrate turnover: P retention rate (sedimentation)	Amount of N to be retained to comply with water quality standards
Flood protection	**retention volume inside river bed**	retention volume inside river bed required to avoid flooding i.e. to comply with legal targets (e.g. Q < HQ200)
	retention volume of riparian wetlands/ floodplains	retention volume required to avoid flooding i.e. to comply with legal targets (e.g. Q < HQ200)
	retention volume of vegetated basins	retention volume required to avoid flooding i.e. to comply with legal targets (e.g. Q < HQ200)
Surface water provision	**water flow**	Minimum water flow
Biodiversity preservation and improvement	**number of type-specific aquatic species observed**	number of type-specific aquatic species required at good ecological status
	number of species of the Red List of endangered species	"high" number of Red List species
	Ecological status/potential class (WFD)	Good ecological status/potential class (WFD)
	General degradation	Low general degradation
	Shannon index	good Shannon value
	Evenness	high evenness
	Functional traits	high number of traits for intact/functioning community
Pest control: invasive species	**Number of invasive species**	low number of invasive species
Nutrient retention	***N-retention rate by soil in floodplains/ vegetated riparian buffers (denitrification)***	recommended area of vegetated riparian buffers to retain run-off
	area of vegetated riparian buffers	recommended area of vegetated riparian buffers to retain run-off
Global climate regulation	**Carbon stock (above ground biomass + soil biomass in floodplains)**	?
Local climate regulation	air cooling effect by river water	cooling effect necessary to comply with climate warming legal target (<+2°C)
	(potential) instream cooling effect by woody riparian corridors	cooling effect necessary to assure non-stressful instream temperatures to aquatic communities
Educational excursions	--	effectiveness of the education programm (e.g. enjoyment, knowledge, attitude, intentions to change behaviour)
Quality of life enhancement	--	"willingniss-to-pay" for real estates close to waterways
Outdoor recreation	--	demand of recreation infrastructure (e.g. via "willingniss-to-pay")
	--	length of bicycle pathways per capita/ density of bike paths weighted by users

Further considerations to be made for each of the ESS:

! Spatial scale (e.g. per stream section)

! Temporal scale (e.g. monthly)

! Data required & source (i.e. type of data, parameters required, and availability of data)

! Improvement via measure (i.e. Did the measure conducted at the mature sites improve this ESS?) Only those ESS that are affected by the conducted or planned measures are to be considered both in the mature case studies as well as in the demo case studies.

! Spatial considerations (e.g. Provision and Use differ in spatial extent)

! Temporal considerations (e.g. seasonal patterns in Provision or Use)

4.3 Examples of process-related indicators (based on Scholz et al., 2012)

Substrate turnover: N retention rate (denitrification)

- Denitrification (i.e. the transformation of nitrate to gaseous N_2 which is released to the atmosphere and thus eliminated from the water phase under anaerobic conditions facilitated by microorganisms) is regarded the most important process in N retention in the stream itself but also in riparian wetlands/floodplains during flood events. This process is part of the self-purification of rivers, an important Regulation & Maintenance ESS.

- An Excel-tool can calculate the N retention achieved by the stream itself based on the stream profile and the initial N concentration. This approach uses literature values for denitrification rates. The link between stream profile and denitrification rate is made via the wetted area, which is influenced by the former and influences the latter parameter.

- Also for the floodplain area, literature values for denitrification rates can be used to obtain the amount of N retained per year for the floodplain under investigation. Data required is the size of the floodplain.

Substrate turnover: P retention rate (sedimentation)

- Sedimentation of P (i.e. settlement and sorption to soil and vegetation) is regarded the most important process in P retention from river water taking place on riparian wetlands/floodplains during flood events.

- An Excel-tool can also calculate the P retention achieved by the stream itself based on the stream profile and the initial P concentration.

- With knowledge on land use of the area under investigation, from which one can derive typical vegetation types, which again represent specific levels of roughness, and in combination with literature values on P sedimentation rates, the amount of P retained per year for the floodplains under investigation can be assessed. Data required is the size of the floodplain.

N-retention rate by soil in floodplains/vegetated riparian buffers (denitrification)

- Denitrification is an important process in riparian wetlands/floodplains also at times without flooding but during and after rain events where run-off leads to nutrient input into the floodplain and the stream. The process that N is transformed and eliminated from the soil of those areas is also an ESS.

- For this case of N-retention, different types of soil (possibly derived from land use data) are assigned specific literature values for denitrification rates, allowing the assessment of the amount of N retained per year in the floodplains under investigation. Data required apart from soil type is the size of the floodplain.

4.4 Next steps and potential barriers

Next steps:

- Revise the glossary of D11.1.
- Define precisely those terms listed in Box 2.
- Develop a stepwise guide/"Cookbook" including suggestions and issues raised in this chapter.
- Develop a list of criteria for indicator selection to be included into the cookbook.
- Revise and evaluate all services and indicators (State – Impact I) suggested within the mature case studies.
- Assess ESS in the 3 mature case studies in order to test applicability of the suggested approaches.
- Identify end-user oriented USE indicators that can provide the link between the biophysical and economic assessment, i.e. Impact I and Impact II. Therefore, link the biophysical services and indicators suggested in this chapter with the economic valuation methods proposed for DESSIN.
- Identify "final ESS" among the ESS suggested for the 3 mature sites and evaluate if this helps to avoid double-counting.

Potential barriers:

- The experimental application of the DESSIN framework in the 3 mature case studies will show the applicability and suitability of the approaches suggested. Possibly, the Provision-versus-use approach will prove hard to realise for most of the services. This would make the ESP approach unsuitable for DESSIN.
- It is to be expected, that data availability restrictions might hamper the application of process-related indicators, implying that the assessment has to rely heavily on proxy-indicators.
- It will be challenging to find appropriate indicators for each relevant service (according to the criteria list), therefore, quantification and economic valuation might not be feasible. In those cases, the ESS assessment can only be a qualitative one. It remains to be discussed, how qualitatively described ESS can be integrated in the overall evaluation.
- Identifying "final ESS" might be feasible, it has, however, still to be discussed in which way the ESS that support those "final ESS" are to be evaluated.

5. Selection of indicators relevant for economic valuation

5.1 Practical steps in a valuation exercise

Economic valuation methods use value indicators in order to obtain a benefits value. These indicators represent the societal benefits of ESS. The choice of the value indicator depends on the valued ecosystem service as well as on the valuation method used.

In this chapter we aim to understand the necessary steps to measure the change in human welfare (in Euros) as a result of an environmental improvement due to interventions in the water sector. We hope this exercise will help us identify valuation techniques and related proxy indicators found in the literature for value changes in the delivery of specific ESS. The idea is to find the nexus with the indicators developed to measure changes in ESS delivery, as in the step State-Impact I.

The idea of the proposed exercise is to develop a database of existing valuation studies that can help extract information on the indicators used. In addition to displaying exact economic values (e.g. WTP/WTA – step 4), the database will also provide background information on the indicators to help inform the exercise. Indicators covered include those that measure environmental change (step 1), those that relate the change to actual societal uses of the resource (step 2), as well as economic indicators used to inform the valuation exercise (step 3). All of these three steps are used for deriving economic values (step 4). The steps are described in more detail below:

STEP 4: Value indicators - Willingness To Pay/Willingness To Accept estimates (WTP/WTA). These estimates are related to the final results of the valuation exercise. Economic valuation always aims to measure the change in human wellbeing due to changes in the provision (quality and quantity) of environmental resources. *(e.g. € per kg of Nitrogen removed). The result is very often a function of steps 1, 2 and 3 below:*

- ***STEP 1 is completed*** through the ***use/development of indicators/proxies that measure actual changes in*** 2.1) ESS, which are ***changes in provision of ecosystem services; or*** 2.2) ***changes in an environmental state.*** *For example changes in water (quality/quantity) improvements (e.g. kg of Nitrogen removed). These two are very often* the basis of the WTP/WTA values found in step 4 and they basically correspond to the environmental change that is actually valued. In the environmental economics literature, this step is often done in relation to environmental policy targets (*e.g. Nitrogen standards*) to assess the economic efficiency of policy interventions/innovations. The same could be said about the development of ESS performance indicators. Please note that this step is the link with State-Impact I indicators that are currently been developed in WP11 and WP13.
- ***STEP 2*** **Indicators used to inform the valuation exercise**. These indicators can be directly linked with the use indicators for ecosystem services. These indicators are normally collected and inform the development of baselines for the economic valuation exercise (e.g. number of visits to an improved site).

- ***STEP 3* Development of baseline indicators for the economic valuation exercise**. This type of valuation-related background indicator is dependent on specific valuation methods, meaning they are of a different nature for stated or revealed preference valuation methods (see D 11.1 for more background info about the different valuation methods). These indicators are normally developed in the study through modelling or other techniques, but do not illustrate actual values (e.g. Travel Cost Method: actual trip expenditures to improved site in relation to a baseline).

5.2 Criteria for Benefits Transfer

According to the findings of chapter 5 “Economic valuation of changes in ESS” in D11.1, it is not always necessary to initiate a new primary valuation study in a project area to determine how the wellbeing of individuals might be affected by a change in ESS. Under the scope of the DESSIN project, original valuation studies of the case study sites is not an option due to several constraints (e.g. budgets, lack of time, human resources, etc.). Fortunately, there are options to overcome this issue. If a similar valuation exercise has previously been undertaken elsewhere, estimates of its economic consequences might be usable as an indicator of the impacts for the new valuation exercise.

Such an approach is named ‘value transfer’ because the estimates of economic impacts are ‘transferred’ from one site to another. The values transferred from the study site could have been measured using any of the valuation techniques mentioned in chapter 5 of D11.1. An effort should be made to use studies that consider a similar environmental stressor as the site of interest (e.g. industrial pollution), or studies that are motivated by a similar Directive (e.g. the Water Framework Directive) and therefore share the same policy framework, or focus on areas with similar climatic/ geographical/ environmental characteristics (e.g., studies undertaken in the Mediterranean); or same ESS type to assess (e.g. water purification). The main advantage of the value transfer method is that it is quicker and cheaper than undertaking original primary economic valuation research.

Two other variants of the benefits transfer method are also important to consider: 1) a benefits function transfer from a single study, and 2) a meta-analysis, which obtains benefits estimates on the basis of regression results from multiple valuation studies (see Box 3 and Box 4 for more information about these methods).

Box 3: Benefits Function Transfer

The Benefits Transfer Function method allows the incorporation of differing socio-economic and site quality characteristics between the original study site and the policy site under evaluation. In this type of benefits transfer, only one original valuation study is typically selected. The main assumption being that the statistical relationship between WTP for improvements and independent variables are the same for both the study and policy site. In other words, BFT applications assume that preferences are the same between both locations and differences are only related to differences in socio-economic and/or environmental context variables.

Unlike unadjusted BT exercises where mean WTP at the policy site it is assumed to be equal to mean WTP values at the original site ($WTP_S = WTP_P$), BFT exercises attempt to adjust values by accounting for any possible differences (e.g. socio-economic and environmental quality variables included in the aggregated benefits function) between both sites; see Bateman et al. (2000) or Garrod and Willis (1999). Equation 1 offers a conceptual representation of the benefits function transfer approach:

Survey site: $WTP_S = \alpha_s + \beta_{s1}X_{s1} + \beta_{s2}X_{s2}$

$$\updownarrow \qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad 1)$$

Policy site: $WTP_P = \alpha_s + \beta_{s1}X_{p1} + \beta_{s2}X_{p2}$

Where s denotes the survey site, p the policy site and X_1, X_2 vectors of specific good characteristics and population characteristics for each site (e.g. income and education levels, baseline water quality levels...).

BFT is regarded as a suitable tool for the adjusted transfer of WTP estimates between different locations when the vector of attributes and socio-economic characteristics (X_1, X_2) that determine the similarities and differences between the policy and the survey site can be established. Where these differences exist and their magnitudes are known, it is possible to substitute those known variables into the survey site's original aggregated benefits function to provide valid BT estimates. This exercise involves the choice about which factors to include and which to omit in the analysis, which is usually limited by data availability.

Box 4: Meta-Analysis

The advantages and approaches to MA are outlined by Bergstrom and Taylor (2006). MA basically summarises results of existing valuation studies by estimating statistical relationships between reported original values to a set of explanatory variables which would capture the heterogeneity between and across these studies. MA has a wider purpose from that of benefits transfer by not only offering a format for predicting monetary values but it is also regarded as a very useful technique for the synthesis of relevant literature on a particular valuation topic and to test hypotheses with respect to the explanatory variables on the value construct of interest (Bateman et al, 2000).

Meta-regression analysis is the statistical tool normally applied in MA (Van Houtven et al, 2007). The first methodological step, as in any other benefits transfer exercise, consists of collecting a set of primary studies that contain a common empirical outcome, e.g. WTP for improvements in freshwater quality. The dependent variable is a common summary statistic or “effect-size”, such as a regression coefficient for a predicted WTP value. Secondly, one or more values of this statistic are drawn from each primary study (e.g. either mean WTP estimates of all the values presented in the original study or value ranges which are then adjusted to reflect current prices). The explanatory variables in the regression include characteristics of the primary data (such as reference to the water quality change in relation to baseline levels or types of uses valued), study design, valuation method, sample size, model specification, econometric methods, and other “quality” variables such as place and date of publication. Most regressors are specified as binary dummies and most of these variables are also drawn from the primary studies (which often also includes unpublished studies in the “grey literature”, working papers, government reports, student dissertations). In some analyses, the identity or characteristics of the primary investigators are used as regressors and even tests for author bias have been designed (Brouwer and Rolfe, 2008).

A fundamental issue in relation to the application of MA for benefits transfer is the minimum number of original studies necessary to carry out a proper analysis. Unfortunately, the weaker side of MA is that in order to establish meaningful statistical relationships, there is the need for a large database of relevant original studies. In addition, the selection of original studies for MA needs to carefully consider the different elicitation methods employed in the original studies. For example, the aggregation of values which were found by applying revealed preference techniques (e.g. TCM) with those that applied stated preferences methods (e.g. CVM, CE) is not recommended. This aims to ensure a common value concept in the analysis which is translated from the different concepts of value applied in stated and revealed preferences techniques. Value measures from TCM and CV/CE are fundamentally different in their nature (i.e. Marshallian consumer surplus versus Hicksian compensating surplus, respectively). Accordingly these values, if pooled together, would introduce conceptual inconsistencies.

In conclusion, due to the limited number of relevant studies, different contexts covered, methodological heterogeneity, and the impossibility of consolidating them under the objectives of DESSIN, we believe that the application of MA at this stage would raise more questions than answers. At this moment, the aggregation of mean WTP values from original studies would most certainly suffer many limitations. Most importantly, results would be conditioned to the high degree of subjectivity and manipulation, which would be necessary in order to find ways to pool these studies together.

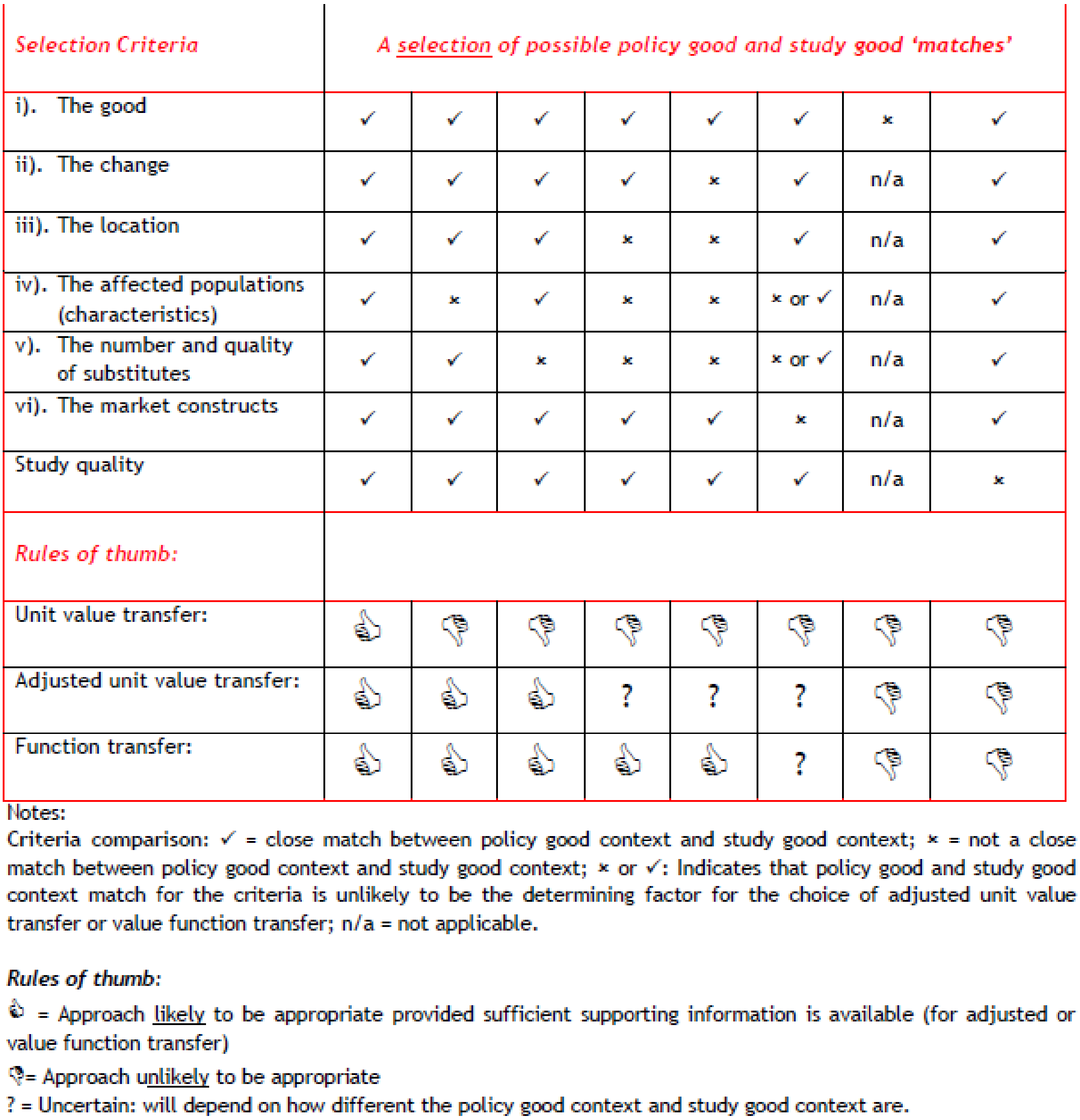
5.3 Criteria for the selection of relevant studies for benefits transfer

On the choice of the different methods that can be potentially applied to transfer values from elsewhere to another study site, there are some agreed criteria on how to decide which value transfer approach to choose depending on the availability of key background information (see table 1 below). In summary, the suitability of relevant variables between the original and the policy site to consider are:

1. The good to be valued
2. The change to be valued
3. The location
4. The socio-economic statistics of the affected populations
5. The presence of any substitute goods
6. The market construct

7. The quality of the original valuation study

Table 5: Some rules of thumb for choosing between value transfer approaches. Source: Eftec, 2009.



Selection Criteria	*A selection of possible policy good and study good 'matches'*							
i). The good	✓	✓	✓	✓	✓	✓	×	✓
ii). The change	✓	✓	✓	✓	×	✓	n/a	✓
iii). The location	✓	✓	✓	×	×	✓	n/a	✓
iv). The affected populations (characteristics)	✓	×	✓	×	×	× or ✓	n/a	✓
v). The number and quality of substitutes	✓	✓	×	×	×	× or ✓	n/a	✓
vi). The market constructs	✓	✓	✓	✓	✓	×	n/a	✓
Study quality	✓	✓	✓	✓	✓	✓	n/a	×
Rules of thumb:								
Unit value transfer:	👍	👎	👎	👎	👎	👎	👎	👎
Adjusted unit value transfer:	👍	👍	👍	?	?	?	👎	👎
Function transfer:	👍	👍	👍	👍	👍	?	👎	👎

Notes:

Criteria comparison: ✓ = close match between policy good context and study good context; × = not a close match between policy good context and study good context; × or ✓: Indicates that policy good and study good context match for the criteria is unlikely to be the determining factor for the choice of adjusted unit value transfer or value function transfer; n/a = not applicable.

Rules of thumb:

👍 = Approach likely to be appropriate provided sufficient supporting information is available (for adjusted or value function transfer)

👎= Approach unlikely to be appropriate

? = Uncertain: will depend on how different the policy good context and study good context are.

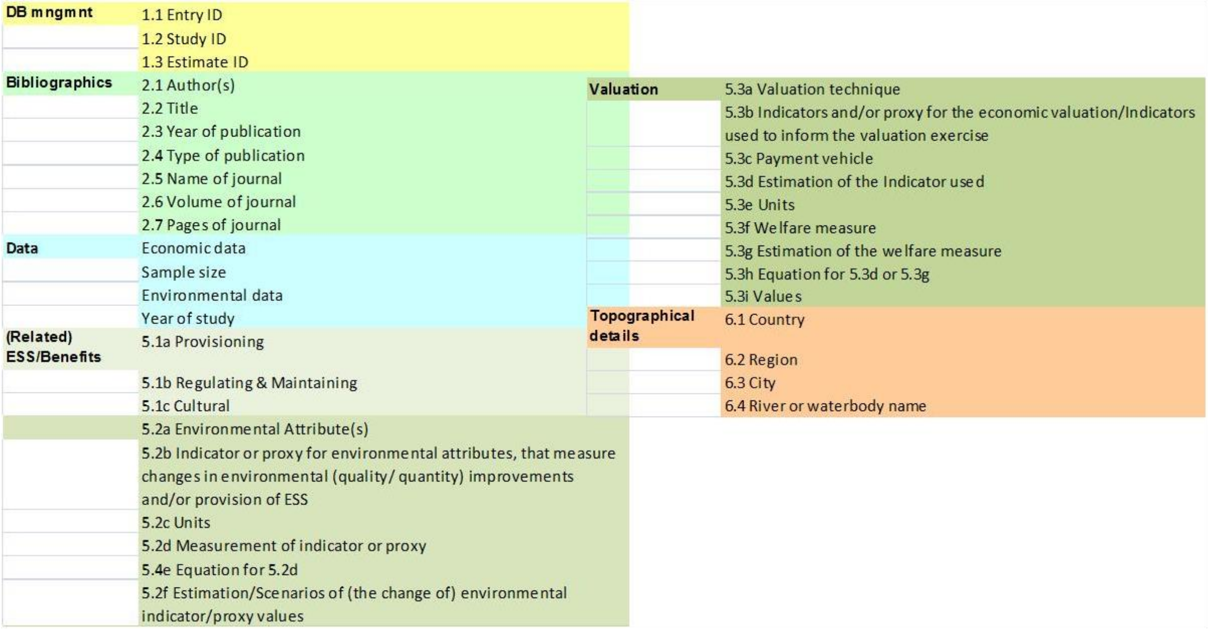
5.4 Development of an ESS relevant valuation studies database

Below are the columns that are covered in our valuation studies database. The idea is to cover those variables that will help us to understand and assess the suitability of relevant original valuation studies on changes in ESS for benefits transfer to the mature case study sites. The following are relevant aspects to consider in the review process of the valuation studies:

1. Identify relevant indicators used to measure changes in the types of ESS that are actually valued in each of the valuation studies

2. Illustrate details of the valuation method employed

3. Assess the quality of background information and statistics presented in these papers



DB mngmnt	1.1 Entry ID
	1.2 Study ID
	1.3 Estimate ID
Bibliographics	2.1 Author(s)
	2.2 Title
	2.3 Year of publication
	2.4 Type of publication
	2.5 Name of journal
	2.6 Volume of journal
	2.7 Pages of journal
Data	Economic data
	Sample size
	Environmental data
	Year of study
(Related) ESS/Benefits	5.1a Provisioning
	5.1b Regulating & Maintaining
	5.1c Cultural
	5.2a Environmental Attribute(s)
	5.2b Indicator or proxy for environmental attributes, that measure changes in environmental (quality/ quantity) improvements and/or provision of ESS
	5.2c Units
	5.2d Measurement of indicator or proxy
	5.4e Equation for 5.2d
	5.2f Estimation/Scenarios of (the change of) environmental indicator/proxy values

Valuation	5.3a Valuation technique
	5.3b Indicators and/or proxy for the economic valuation/Indicators used to inform the valuation exercise
	5.3c Payment vehicle
	5.3d Estimation of the Indicator used
	5.3e Units
	5.3f Welfare measure
	5.3g Estimation of the welfare measure
	5.3h Equation for 5.3d or 5.3g
	5.3i Values
Topographical details	6.1 Country
	6.2 Region
	6.3 City
	6.4 River or waterbody name

Table 6: “Selected” examples from the database of valuation related indicators linked to relevant services

DB mngmnt	1.1 Entry ID	76	77	86
Data	Economic data	/	/	U.K. Biodiversity, Species and Habitat Action Plans
	Sample size	75 000	/	/
	Environmental data	/	U.K. Environment Agency’s 1990-1999 national data set on blue-green algal blooms	U.K. Biodiversity, Species and Habitat Action Plans
	Year of study	2003	2003	2003
(Related) ESS/Benefits	5.1a Provisioning	/	surface water for non-drinking purposes	/
	5.1b Regulating & Maintaining	/	/	Lifecycle maintenance, habitat and gene pool protection
	5.1c Cultural	aesthetic benefits	/	/

	5.2b Indicator or proxy for environmental attributes, that measure changes in environmental (quality/ quantity) improvements and/or provision of ESS	Phosphorus	Frequency of closure (prevention of use of water for demand use due to algal blooms)	Negative ecological effects on biota (arising from changed nutrients, pH, oxygen), resulting in changed species composition (biodiversity) and loss of key or sensitive species.
	5.2c Units	mg of P/L	closure rate in %	/
	5.2d Measurement of indicator or proxy	Data from the EU Urban Waste Water Treatment Directive	The estimate of the extent and frequency of eutrophication is calculated as the number of days of closure of a water body per year.	Water species and habitats adversely affected by eutrophication listed in the U.K. Biodiversity, Species and Habitat Action Plans.
	5.4e Equation for 5.2d	/	The frequency of closure (fc) is (IbgN)/(C(S1/2 or S1)Y), where Ibg is the number of incidents of blue-green algal blooms, C is the number of water bodies affected, N is the number of days water body closed for each incident, S1/2 is the season length (days in half year), S1 is the season length (days in full year), and Y is the number of years of data.	/

	5.2f Estimation/Scenarios of (the change of) environmental indicator/proxy values	Under the EC Urban Waste Water Treatment Directive, 2540 km of water courses is designated as sensitive areas (eutrophic), equivalent to 6.35% of all 40 000 km of rivers assessed by the Environment Agency. Waters classified as grades 4 and above (>0.1mg of P/L) exceed the guideline value for eutrophic rivers in the Directive, and for 1993-1995, 51.6% of rivers were in these grades. Thus, the proportion of rivers deemed eutrophic ranges from 6.35% to 51.6%. They assumed that there were 75 000 waterfront properties exposed.	They estimate that 25% of blooms cause closure of a water body for 30 days, 50% cause closure for 15 days, and 25% cause closure for just 5 days each.	/
Valuation	5.3a Valuation technique	Damage Costs (social damage costs)	Damage Costs (social damage costs)	Damage Costs (ecological damage costs)
	5.3b Indicators and/or proxy for the economic valuation/Indicators used to inform the valuation exercise	Value of waterside properties	Value of water bodies for commercial uses (abstraction, navigation, livestock watering, irrigation, and industry). A proxy for the value of water abstraction has be derived from the charges made for licenses	The costed U.K. Biodiversity, Species and Habitat Action Plans are used as a proxy for eutrophication costs
	5.3c Payment vehicle	/	/	/
	5.3d Estimation of the Indicator used	Value loss for waterside properties, they use a value of 10% for the loss in value per property.	Reduced value of water bodies for abstraction. They used the costs occured of three paper mills from a single algae bloom.	For those species and habitats for which eutrophication was identified as a factor causing problems, the action plans were used to estimate costs.
	5.3e Units	Costs (loss in value per property)	Costs (charges made for licenses)	Cash

	5.3h Equation for 5.3d or 5.3g	The value-loss relationship is VL = Pf * VL where VL is the total value loss for waterside properties in England and Wales, P is the number of waterside properties, f is the frequency of loss of value due to some eutrophication, and VL is the value loss per average 10 m of frontage.	The value-loss relationship is VL = Vw*fc, where VL is the reduced value of water bodies for abstraction, livestock watering, navigation, irrigation, and industrial uses; Vw is the value of water for industrial, farming, and navigation uses; and fc is the frequency of closure (prevention of use of water for demand use).	The relationship for the value loss is: VL = Ce + Cm + (SCsP), where VL is the negative ecological effects on biota resulting in changed species composition (biodiversity) and loss of key or sensitive species, Ce is the average annual cost of HAP (Habitat Action Plans) addressing eutrophic lakes, Cm is the average annual cost of HAPs addressing mesotrophic lakes, S = number of Species action Plans (SAP) potentially affected by eutrophication, Cs is the average annual cost of SAPs, and P is the proportion of SAP affected by eutrophication.
	5.3i Values	13.76 (million USD)	0.7-1.4 (million USD)	10.28-14.17 (million USD)
Topographical details	6.1 Country	United Kingdom	United Kingdom	United Kingdom
	6.2 Region	England, Wales	England, Wales	England, Wales
	6.3 City			
	6.4 River or waterbody name			

5.5 Next steps

1. Complete the valuation database with a suitable number of relevant studies for key freshwater ESS types.

2. Consider revisions to the proposed columns in the valuation studies database.

- Consider an extra row for temporal scale? Or is this covered by “Year of study” – equals year of publication or which years were included in the evaluation?
- Consider an extra row for spatial scale? Or is this covered in the “Topographical details”?

6. Sustainability assessment and ecosystem services

This chapter aims at expanding the discussion within the group on suitable sustainability assessment tools for the purposes of DESSIN. The final goal of this discussion is to select a sustainability approach that can best be applied to evaluate innovative solutions introduced within different mature and demo case studies, looking at their impacts regarding changes in ESS as well as other sustainability dimensions, such as economics (e. g. investment costs, operational expenditure), social acceptance (e. g. noise, odors), or assets (“Do we need additional infrastructure? Is the system robust to host the new technology?”).

This can be achieved by either adapting sustainability assessment tools developed within the TRUST project (as proposed in the DoW) or by selecting a totally different but better-suited method from literature to be identified or to integrate elements of other methods into one basic tool/approach.

Regarding this, this chapter is an initial attempt at identifying the current state of methodological options for sustainability assessment in the broad context of ESS. While this research is non-exhaustive, the aim here is to give a rather superficial overview of the literature on sustainability assessment to open the discussion on the best-suitable methodological approach for the purposes of DESSIN.

Within the DESSIN project sustainability assessment will be included into the DESSIN ESS Evaluation Framework as counterpart to ecosystem service valuation to provide a full scale-perspective on the valuation of technologies in terms of economic, ecologic, and social aspects. In order to fit into the framework, the sustainability assessment tool chosen should somehow establish a connection to the ecological and an economic assessment of changes in ESS (WP11). As the DESSIN ESS Evaluation Framework is being developed on the basis of the DPSIR adaptive management scheme, the sustainability assessment approach should furthermore not contradict to this framework as well.

6.1 Introducing sustainability assessment

In the past there were two threads of literature: one addressing ecological sustainability as a basis for biodiversity conservation and another addressing socio-economic sustainability of human well-being. Latest concepts try to merge these threads into one comprehensive framework (Chapin *et al.* 2010). According to Gasparatos & Scolobig (2012) one key purpose of sustainability assessment is the comparison of different project or policy alternatives (Gasparatos & Scolobig 2012). Ness et al. (2007) give a more comprehensive definition of sustainability assessment:

> *“The purpose of sustainability assessment is to provide decision-makers with an evaluation of global to local integrated nature–society systems in short and long term perspectives in order to assist them to determine which actions should or should not be taken in an attempt to make society sustainable.”* (Ness et al. 2007)

It becomes obvious that there is a close linkage between ecosystem service assessment and sustainability assessment as the value of an ecosystem service can be seen as its contribution to support sustainable human well-being (Andersson *et al.* 2014, Costanza *et al.* 2014). Finally, explicit valuation of ecosystem services can help managing ecological systems by enabling better choices about ecosystems and actions to be taken (Costanza & Folke 1997, Andersson *et al.* 2014, Botero Baez 2014, Lyytimäki & Petersen 2014).

6.2 Method

This chapter is based on a literature review of sustainability assessment methods and tools that may be used for the assessment of actions influencing ESS. The literature search has been focused on peer-reviewed articles (in English) listed in Web of Science and other online databases using the key words sustainability or sustainability assessment and ESS. The resulting database of this very focused and targeted search included 38 sources for review. A list of the reviewed literature can be found in the annex. In a second step the papers, book chapters and reports were thematically grouped (Figure 7).

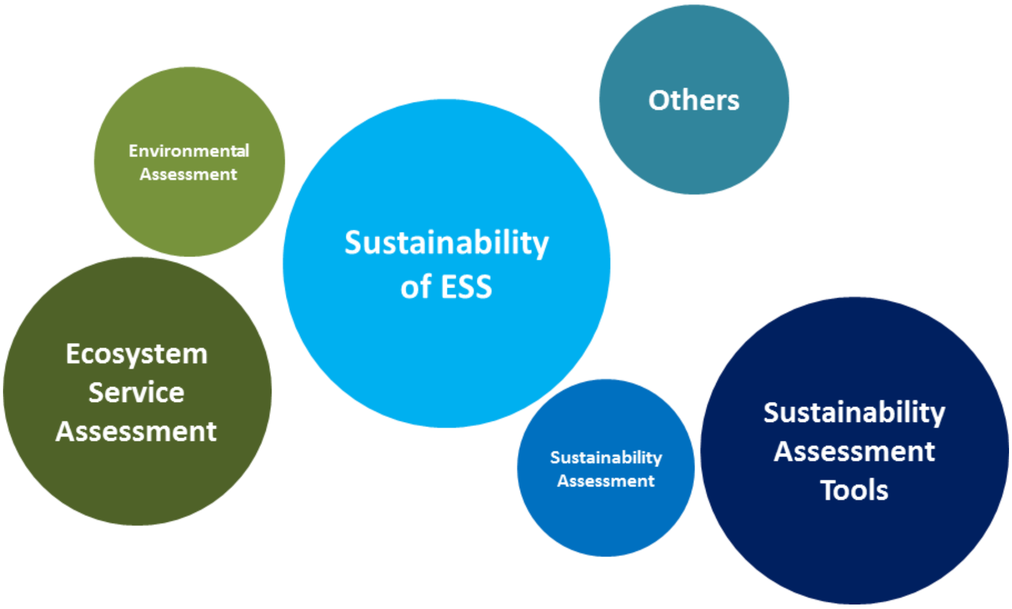


Figure 7: Subjects of the papers reviewed (circle size denotes the amount of articles found)

As this overview illustrates there are a few studies dealing with sustainability assessment tools [dark blue] and practical examples of their application [light blue] (12 papers). Most of the studies are about the global concept of sustainability for ecosystem services [turquoise] (11) or the application of ecosystem service and environmental assessment [dark green & light green] (11) as some sort of `fragmentary´ sustainability assessment tools. Based on this classification it can already be concluded that explicit sustainability assessment in the context of ecosystem services seems to be a little researched area so far.

However, the following sections summarise the results of the investigation done. According to the classification described above further explanations start with some concepts and ideas on what sustainability of ESS is about. After this sustainability assessment tools known in the context of ecosystem service change and the evaluation of actions influencing ecosystem service provision and use are described. As the choice of the sustainability assessment tool used seems to have a major influence on the quality of results, the chapter concludes with possible criteria to evaluate existing sustainability assessment tools in order to find the most suitable one for a specific application.

6.3 Defining sustainability

There are several definitions on sustainability. A very practical one concerning ESS, for example is proposed by Bateman et al. According to them in common understanding an ecosystem use is sustainable if the rate of flow extraction does not deplete stocks (Bateman et al. 2010). That is why an appropriate balance between ecosystem service provision and ecosystem service use is desired (Gao et al. 2014). But with regard to the triple-bottom-line concept of sustainability three values of ESS may be distinguished (adapted from Botero Baez 2014):

- **Social value:**
  quality of life (incl. health, safety, employment, aesthetics, cultural significance, etc.), participation/democracy, equity, social mixing/cohesion, governance, and social maturity

- **Economic value:**
  profits obtained by trade of products, materials for derived economic activities, raw materials

- **Ecological value:**
  biophysical value, future value and the value of local functioning of the system

Regarding this approach, the ideas of `weak´ and `strong sustainability´ should be discussed as well. Assuming `strong sustainability´ an action can only be considered sustainable if the value in each dimension of sustainability is increased or remains the same at least. Assuming `weak sustainability´ there can be also negative impacts in one sustainability dimension as long as the overall value is not impaired (Singh et al. 2012).

However, the focus of the sustainability assessment in DESSIN is not on sustainability of ESS themselves but on sustainability of projects and actions affecting ESS. Nevertheless, for this assessment it is important to be aware of the concept of sustainability implied within the sustainability assessment used as well. As the three dimensions (economic, environmental, social) of sustainability are overlapping and potentially in conflict, the result of the assessment is strongly depending on the degree of sustainability allowed (Olschewski & Klein 2011). In addition, sustainability assessment deals with a wide variety of information types and parameters under uncertainty. That is why assessing sustainability of projects and actions affecting ESS can be a very complex task that has to be modeled with precaution (Costanza & Folke 1997, Cinelli et al. 2014, Lyytimäki & Petersen 2014).

Besides, sustainability assessment also includes a temporal component (Lyytimäki & Petersen 2014). Thus, for being usable for the evaluation of long-term sustainability, methods for valuing sustainability have to be “integrated assessments and models of the quality, quantity, and spatial and temporal dynamics of ecosystem services and the various aspects of their connection to human well-being in the long run” (Costanza & Folke 1997).

6.4 Sustainability assessment tools

Even though tools leading to a sustainable use of ESS were already mentioned within the Millennium ecosystem assessment studies (Botero Baez 2014), according to *Constanza and Folke,* there still is a lack of valuation methods for assessing the value of an ecosystem in relation to sustainability (Costanza & Folke 1997). Although there has been a rising interest in sustainability assessment of ESS, research has mainly focused on biophysical and monetary valuation. The social dimension has been mainly neglected (Cowling *et al.* 2008).

6.4.1 Classification/typology of sustainability assessment tools

However, currently there are already multiple sustainability assessment approaches and tools suggested in literature that can be subdivided in different ways. In adaption to *Srinivasan et al.* and *Gasparatos & Scolobig*, these approaches can be categorised into three types: assessment frameworks, analytical evaluation tools and composite indicators/indicator lists (Figure 8).[5]

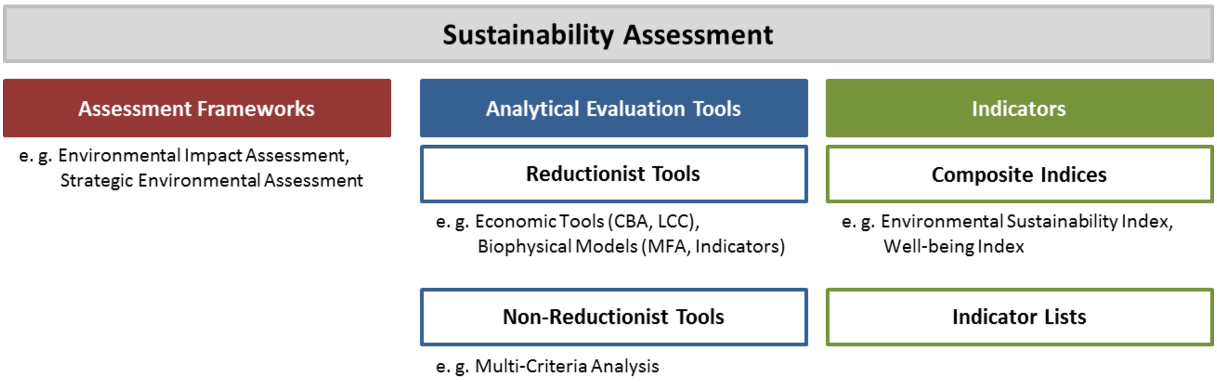


Figure 8: Classification of sustainability assessment approaches. Source: Own figure adapted from Srinivasan et al. 2011 and Gasparatos & Scolobig 2012.

The first type of assessment approach can be summarised under the term `sustainability assessment frameworks´. Sustainability assessment frameworks provide integrated and structured procedures for the comparison of project or policy alternatives with strong focus on environmental

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[5] A way more comprehensive framework for sustainability assessment tools can be found in *Ness et al. 2007*.

impacts. Usually such frameworks can be seen as guidelines including step-by-step descriptions of the evaluation process but lacking detailed evaluation methods or tools (Gasparatos 2010).

The second category includes analytical evaluation tools to conduct analysis. These tools aim to support decision making by identifying the best solution to a specific problem. Analytical evaluation tools can be further subdivided into reductionist tools and non-reductionist tools with regard to the amount of indicators, dimensions, objectives, scales or time horizon for evaluation to be investigated. Reductionist tools are much focused and therefore consider only one component in each dimension, e. g. monetary costs/benefits or resource consumption or environmental impact, in an aggregated form (Gasparatos 2010). In contrast, non-reductionist tools are based on various indicators that are weighted and balanced in a series of methodological choices.

Finally, the third category contains sustainability indicator lists and composite indices (e. g. environmental sustainability index, well-being index) that are mainly reductionist tools as well but with the difference that they normally sum up comprehensive and complex contexts in a single figure (Gasparatos 2010).

Sustainability Assessment Frameworks

There are many different sustainability assessment frameworks in literature, e.g. the “Sustainability Assessment and Management” framework developed by the *Committee on Incorporating Sustainability in the U. S. EPA*. Starting with a decision to be taken, the framework consists of eight major steps: screening evaluation, problem definition, planning and scoping, application of sustainability assessment tools, trade-off and synergy analysis, communication of results to the decision makers, decisions taken and implemented the evaluation of outcomes and stakeholder engagement and collaboration. As usual for all frameworks, “Sustainability Assessment and Management” doesn´t include specific assessment tools and a guiding on how to use them but gives hints on possible tools to be considered from case to case (Committee on Incorporating Sustainability in the U.S. Environmental Protection Agency 2011).

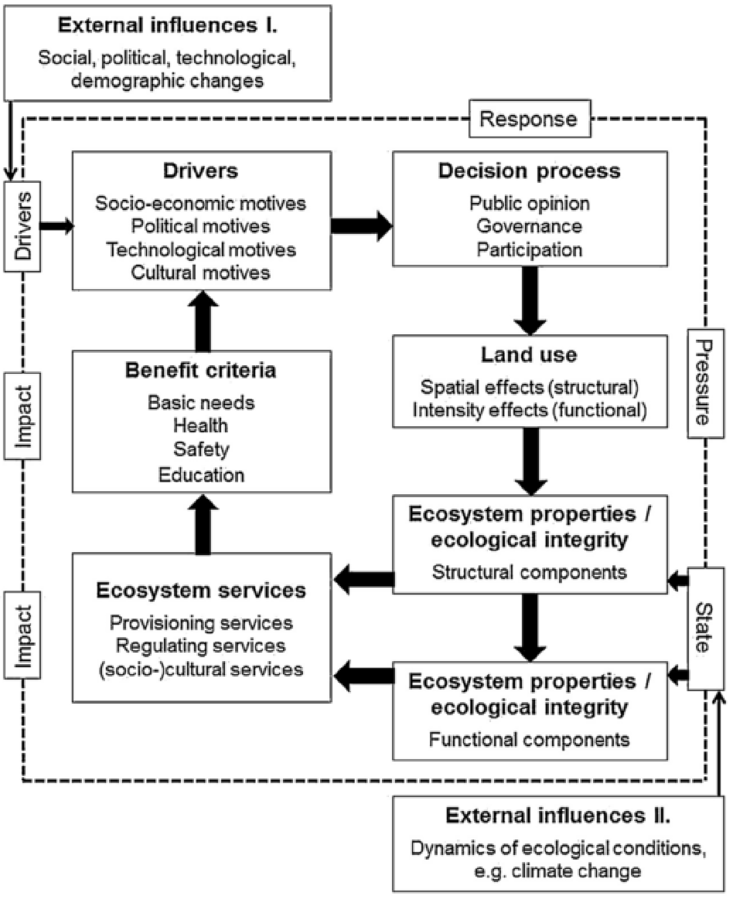
Others, like the Environmental Impact Assessment (EIA), Strategic Environmental Assessment (SEA) or the Ecosystem Services Environmental Assessment (ESEA) that have become legal requirements in several countries for projects, policies, etc. through Directives of the European Union (EU), do not consider all aspects of the classical triple-bottom-line concept of sustainability and can, therefore, not be seen as sustainability assessment frameworks in a narrow sense (Gasparatos 2010, Botero Baez 2014).

Nonetheless, there are also very few sustainability assessment frameworks developed for the application in an ecosystem service context, such as the “Schematic model of landscape analyses” proposed by *Grunewald & Bastian* (see Box 5) and the “Regional Watershed Sustainability Assessment Framework” that has been designed by *Whitman & Beall* especially for evaluations of the Spokane River Watershed (see Box 6). Another sustainability assessment approach was developed by *Costanza & Folke*. Following *Daly´s* idea of three broad goals for assessing the sustainability of ESS (ecological sustainability of human activities within the biosphere; fair distribution of resources and property rights within the current generation, between current and future generations, and between species; efficient resource allocation, including both market and non-market resources), the authors have developed a 12-step-approach for an integrated ecological-economic assessment of ESS, strongly relying on stakeholder participation (Costanza & Folke 1997).

In a wider context also the "ecosystem stewardship strategy" can be seen as such a framework, although it does not include an explicit sustainability assessment of ESS. Ecosystem stewardship seeks to establish a responsible dealing with social-ecological systems under conditions of uncertainty in order to sustain the supply and opportunities for use of ESS (Chapin *et al.* 2010).

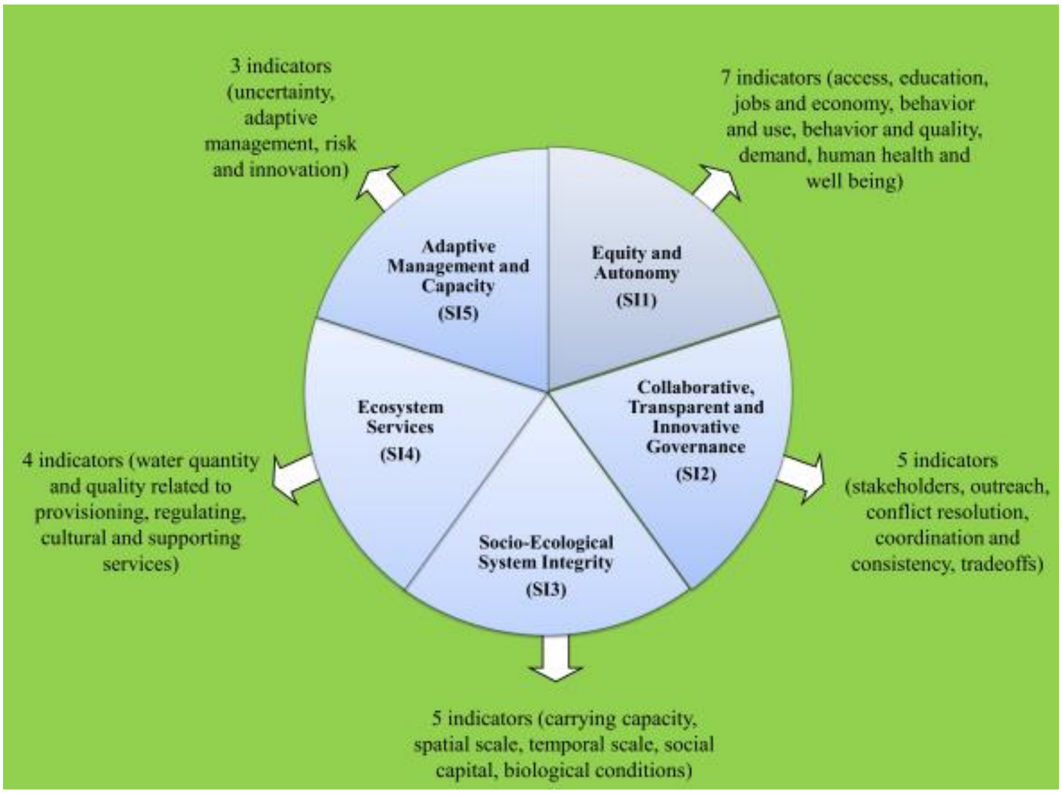
Box 5: Schematic model of landscape analyses, based on the DPSIR-approach. Source: Grunewald & Bastian 2015

Grunewald & Bastian originally developed their framework for assessing sustainable land use management in the Ore Mountains region. The concept of the framework can be seen as a modified version of *Müller´s* DPSIR (drivers, pressures, state, impacts, responses) framework. The structure of the model is shown in the figure below.



Box 6: Regional Watershed Sustainability Assessment Framework for the Spokane River Watershed. Source: Whitman & Beall 2012

The sustainability assessment framework by *Whitman & Beall* that designed for studying changes in ecosystem services is a very practice-oriented framework, containing an step-by-step assessment approach as well as indicators and proposals on valuation techniques, so that it can almost be named an \`indicator list´ as well. The framework consists of five main sustainability indices (SI) that are taken from prominent literature on sustainability (see figure below). For the specific application, the five areas were further broken down into more specific indicators specifically focused on water resources. Using a Likert-like scale, each indicator was given a score from 0 (= indicator not covered) to 3 (indicator comprehensively covered). In the end, each set of indicators averaged for an individual SI1, SI2, SI3, SI4, and SI5 score. Each category was then given equal weighting in the total Watershed Plan Sustainability Score (WPSS).



Analytical Evaluation Tools

As mentioned above, there are already several analytical evaluation tools in literature that can basically be split into reductionist, also known as mono-dimensional, tools and non-reductionist, also known as multi-dimensional, tools.

Reductionist Tools

Reductionist tools can again be subdivided in monetary, ecological or social assessment tools whereof economic tools are the most widely used. Common examples of monetary tools are Life Cycle Costing (or: Whole Life Costing) (LCC) and Cost-Benefit-Analysis (CBA).

CBA is a well-tested monetary tool that goes back to the early 1970s (Gasparatos 2010). In the context of ESS policy evaluation and the assessment of economic impacts of ecosystem change it has already been applied in several regions of the world. The main advantages of CBA are in its expediency, democracy, value-neutrality and inescapability of trade-offs. Nonetheless, Wegner & Pascual highlight that under certain circumstances CBA can generate inaccurate estimates leading to misguided policy decisions (Wegner & Pascual 2011). The main reason for that relies on the fact that within CBA there is a compensability of the monetised values in each category (Gasparatos 2010). CBA also shows some greater weaknesses regarding the evaluation of large-scale ecosystem change (Wegner & Pascual 2011). But in the end CBA especially convinces through its standardised procedure and its clear results that are easy to interpret. Using CBA the impacts of policy options or actions on the ecosystem flow are quantified through a monetary metric (positive changes as benefits, negative changes as costs). The resulting monetary values are then aggregated to a net present value (NPV). If the policy or action passes the *Kaldor-Hicks* compensation test, i.e. NPV> 0, it is ranked by its NPV in relation to the other options. In the end the alternative with the highest NPV should be selected in order to maximise the increase in social welfare (Pearce *et al.* 2006, Wegner & Pascual 2011).

To assess environmental sustainability, plenty of tools such as Material Flow Analysis (MFA), Life Cycle Assessment (LCA), Ecological Footprint (EF), Ecosystem Service Footprint (ESF), Ecological Network Analysis (ENA) or Environmental Assessment, have been developed (see boxes 7-9) (Gao *et al.* 2014, Schaubroeck *et al.* 2012). These tools mainly account for the amount of resources invested in the production of a good or service. Decisions are finally made based on the approach `the less - the better´ (Gasparatos 2010).

In LCA, the total environmental impact of resource extraction and emissions during a product's life cycle is quantified (Schaubroeck *et al.* 2012). Although it does not take into account the concept of limited resources and the carrying capacity of ecosystems, it can be used for the assessment of changes in ESS as well. But the application is hindered by its enormous requirements. At least in the context of cultural services, such as tourism activities, LCA as well as EF have been identified as a useful method for the assessment of ecological sustainability (Castellani & Sala 2012).

ENA is an indicator-based approach that assesses indicators on total ecosystem´s functioning. If there are alterations of ecosystems (damage to ecosystem quality or disruption in energy and matter flows) they can be shown by changes in the values of those indicators. Although the choice of indicators has not been standardized yet, in general, these ecological network indicators are good and robust estimators of the network functioning. The whole approach includes seven steps: system identification and selection of system boundary, compartmentalisation, selection of energy-matter flow currency, identification and quantification of flows, data balancing, construction of an input-output table, and calculations of indicators. However, currently the application of ENA is merely known for the assessment of damages to aquatic systems or the assessment of energy and matter flows in industrial systems (Schaubroeck *et al.* 2012).

Environmental assessment is also very well-known in the context of ecological sustainability evaluation. It can basically be defined as "procedure that ensures that the environmental implications of decisions are taken into account before the decisions are made" (European Commission 2015). Therefore, environmental assessment includes all types of methods and tools for evaluating ecological impacts based on the EIA or the SEA framework (s. a.). Although the application of environmental assessment can be documented with numerous examples, there are also some problems that can appear in its application (e. g. lack of consistency and quality in screening, lack of early and effective scoping, ineffectual collection and use of baseline information within the assessment, lack of consideration of reasonable alternatives)(Baker *et al.* 2013).

A more concrete example of a sustainability assessment tool addressing ecological sustainability is the *MUSIX* (Micro-level Urban-ecosystem Sustainability IndeX) model proposed by *Dizdaroglu & Yigitcanlar*. The MUSIX model is based on the *DPSIR framework* (s. a.) and provides a methodological approach for identifying parcel-scale indicators to monitor impacts of changes in urban ecosystem components. Enabling this, the tool aims to detect the sustainability performance of a residential area. MUSIX therefore focusses on six main issues of urban development (hydrological conservation, ecological protection, environmental quality, sustainable mobility and accessibility, sustainable design of urban environment, and use of renewable resources) and provides a set of core indicators in each category (Dizdaroglu & Yigitcanlar 2014).

Box 7: Application example of Life Cycle Assessment and Ecological Footprint Analysis. Source: Castellani & Sala 2012

In 2012 *Castellani & Sala* performed a comparative study about sustainability evaluation of tourism activities using the methodologies of Ecological Footprint Analysis and Life Cycle Assessment. Due to the fact that LCA is more comprehensive in terms of coverage of impact categories but disregarding the carrying capacity of the system/limit of resource assessed by EF, the authors aimed to provide a robust and detailed sustainability assessment using both methods. Hence, EF and LCA were applied for two case studies (a holiday and a hotel structure) in Northern Italy. The final comparison of results showed that there is a correlation between the two assessments that was caused by the overall high influence of energy and fossil fuel consumption.

Box 8: Example of a complex ecological based sustainability assessing system. Source: Zhang et al. 2011

Zhang et al. developed an adapted form of previous ecosystem services value (ESV) assessing systems. The new ecological based assessing system for cropping systems incorporates geographical information system (GIS) and remote sensing (RS) technology. Based on ESV assessing criterions, the final computational approach consists of two major parts: net primary production (NPP) and universal soil loss equation (USLE). The complex system was successfully tested by assessing the sustainability of an area along the Huai river watershed.

Box 9: Application example of the FESF model. Source: Gao et al. 2014

The freshwater ecosystem service footprint model (FESF model), based on the concept of ecosystem service footprint proposed by *Burkhard*, was designed by *Gao et al.* to addresses the sustainability and capability of regional freshwater provision and consumption. By enhancing the accuracy of water provision and consumption calculations and revealing a spatial-pattern of freshwater ecosystem service footprint at the watershed scale, the model overcomes shortcomings of the traditional water footprint model. The approach was tested in the Beijing–Tianjin–Hebei freshwater supply area in China and found to be "a reliable and helpful model for researchers to understand the regional freshwater situation" (Gao et al. 2014).

As mentioned above, there is still a huge lack on reductionist assessment tools focussing on the social dimension of sustainability. This becomes apparent by the fact that none of the tools that focus on the social dimension were found in the investigated papers.

However, none of these reductionist tools is likely to be comprehensive enough to analyse impacts on all pillars of sustainability, so that in any case a suite of these tools would be required to assess sustainability of an action (Committee on Incorporating Sustainability in the U.S. Environmental Protection Agency 2011).

Non-Reductionist Tools

With regard to the triple-bottom-line concept of sustainability, evaluating sustainability can simply be seen as assessing the value of an action based on its contribution to the goals of sustainability. So in the end the valuation of sustainability may also be seen as a multi-criteria decision problem in which the single dimensions of sustainability are weighted according to the goals and worldviews of the society (Costanza & Folke 1997).

Therefore sustainability assessments can also be based on Multi-Criteria Decisions Analyses (MCDA) that enables a project evaluation in terms of multiple objectives with different prioritization and metrics (Wegner & Pascual 2011). For this purpose all classical MCDA methods, that are flexible in use, transparent and structured in their approach, and able to deal with uncertainty (e. g. MAUT, AHP, PROMETHEE, ELECTRE and DRSA), can be used (Wegner & Pascual 2011, Cinelli et al. 2014). But the main problem in implementing such a system remains in the identification of weightings for the three dimensions of sustainability. According to *Sen*, this can only appropriately be reached through public discussion (Sen 1995). However, again some MCDA methods seem to be more suitable for sustainability assessment than others. The utility based approaches MAUT and AHP, for example, are simple to understand and well-tested for many purposes, but in the context of sustainability they are only usable if the concept of weak sustainability is assumed. In contrast ELECTRE, PROMETHEE and DRSA are non-compensatory approaches and therefore suitable for decisions based on the idea of strong sustainability. In the end, according to *Cinelli et al.*, DRSA seems the easiest method due to its "straight-forward set of decision rules" (Cinelli et al. 2014).

However, MCDA is well-tested in the context of sustainability evaluations. Thus MCDA should be considered in most sustainability assessment cases (Cinelli et al. 2014).

Another non-reductionist tool is the Net Ecosystem Service Analysis (NESA) which is somehow a similar approach to CBA. The approach for the evaluation of net changes in ecosystem services is based on existing ecological and human use quantification methods (e. g. Habitat Equivalency Analysis (HEA)) in order to identify possible impacts on human well-being over time. In contrast to CBA, these values of provision and use can also include non-monetary metrics which makes the model flexible in data needs. Besides it is not necessary to quantify the overall stock value of a resource. If there is a positive change in the benefit caused by ESS in reference to the baseline scenario, the action is considered to be potentially sustainable. In some cases an action may also evoke both positive and negative impacts that have to be interpreted by the user (Nicolette *et al.* 2013).

Martín-López et al. and *Castro et al.*, as well, propose a methodological approach that incorporates valuation in the three dimensions of ESS (biophysical, socio-cultural, and monetary) from both the supply-side and the demand-side (Figure 9). Therefore in a first step the ecosystem delivery is quantified from a biophysical perspective. Afterwards the demand of ESS is analysed via preference based and monetary valuation techniques. In the end, the results within the different value-domains are compared to each other in order to explore similarities and major trade-offs. The main advantage in this approach is that biophysical and socio-cultural properties can be compared in a spatial context without complete monetisation of ESS (Martín-López *et al.* 2014, Castro *et al.* 2014).

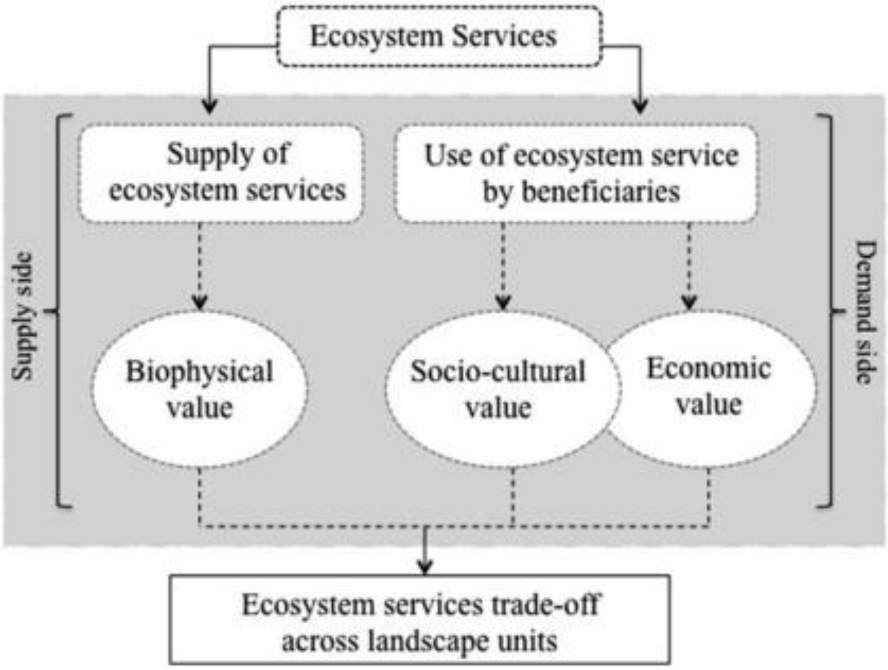


Figure 9: Overview of the research approach of Castro et al. and Martín-López. Source: Castro et al. 2014.

Although all multi-dimensional sustainability assessment tools described above are based on quantitative evaluations, this is not required for all non-reductionist tools by definition. There are also few methods dealing with qualitative assessments of the social-ecological system (e. g. Downing et al. 2014).

Indicators

The last group of sustainability assessment tools are the indicator-based approaches. In the context of sustainability assessment indicators (or metrics) are significant key variables that adequately and precisely characterise the ESS considered. In general, indicators are “relatively easily detectable, and at the same time they provide an above-average explanatory value with respect to the underlying problem” (Grunewald & Bastian 2015). Thus, sustainability indicators are meant to simplify, quantify, analyse and communicate the complex and complicated information on sustainability in order to assess and evaluate the performance of actions taken, providing information on improvement as well as warning information on declining values for the various dimensions of sustainability. This should help decision makers to formulate strategies and communicate the achievements to the stakeholders. The development of a suitable indicator system should be case-specific. In general two approaches for sustainability indicator selection can be distinguished (Singh et al. 2012):

- `Top-down´ approach: Experts and researchers define the overall structure for achieving sustainability that is subsequently broken down into a set of indicators.
- `Bottom-up´ approach: Based on systematic participation of various stakeholders key sustainable development indicators are selected from a list of various indicators proposed.

Construction of composite indicators can be a very complex process due to the fact that it involves the selection of various methods, tools, and techniques. That is why composite index systems are strongly influenced by weightings and aggregation methods. The same is true for non-reductionist sustainability assessment tools. But regarding this, multivariate techniques (e. g. principal component analysis) can provide help (Singh et al. 2012).

Indicator systems can be provided for each sustainability dimension at its own as well as for a certain definition of sustainability as a whole. An example of a highly complex indicator suitable for measuring ecosystems ecological sustainability in a certain status is *ecosystem integrity*. This indicator is strongly connected to an ecosystem approach that relies on the “variables energy and material balance in connection with the structural characteristics of whole ecosystems” (Grunewald & Bastian 2015). Well-known examples of indicators for human well-being are the World Health Organization’s Quality of Life measure (WHOQOL), the Genuine Progress Index (GPI), the Happy Planet Index (HPI), the Human Development Index (HDI), the Life Satisfaction Index, and other different indices of Quality of Life (QoL) (Yang *et al.* 2013).

But in the past decades there have also been several attempts to establish linkages between different indicator types, e. g. social and environmental indicators, such as *Holmberg & Karlsson*´s concept of socio-ecological indicators (SEIs), the sustainable development indicators proposed by the UN Commission on Sustainable Development or *Precott-Allen*´s `barometer of sustainability´

(further examples with corresponding sources can be found in: Singh et al. 2012). However these indicator systems still lack a connection with the concept of ecosystem service.

A more comprehensive approach of sustainability indicators with regard to ESS is the one by *Yang et al.* They developed a quantitative index system to measure human well-being and assessing its external drivers in the context of ESS assessment. The proposed index system is based on five sub-indexes (basic material for good life, security, health, good social relations, freedom of choice and action). Because of its close link to the MA the system that was developed for assessing the consequences of the 2008 Wenchuan Earthquake may also be adaptable in other contexts (Yang *et al.* 2013).

Aside from all these classical valuation tools *D´Amato et al.* propose a set of ecosystem service indicators for corporate sustainability reporting according to the GRI framework. But as these are strongly focused on corporate sustainability and plantation-based forestry, the proposed indicator set will not be considered within further explanations (D´Amato *et al.* 2014). Although the described approach of developing an indicator set for the evaluation of ESS may be adapted for working with the TRUST tools (see section 6.6).

6.4.2 Criteria for sustainability assessment tool selection

As described above there are many different sustainability assessment tools. Some of those are linked to ESS. Since each of these tools implies a different valuation system, choosing the appropriate assessment tool for a specific assessment study is not straightforward. In most cases the evaluation tool is chosen by the analyst(s) with regard to time, data or budget (Gasparatos & Scolobig 2012). The values of other affected stakeholders are not taken into consideration (Gasparatos 2010, Cinelli *et al.* 2014). Hence, in some cases the choice of a certain approach is only driven by familiarity and affinity with this certain approach. This can be hazardous since if the chosen sustainability tool does not fit to the situation there is a high risk of distorted evaluations of sustainability (Gasparatos 2010). Although, according to *Gasparatos & Scolobig*, guidelines and criteria on how to choose between sustainability tools are still lacking (Gasparatos & Scolobig 2012), some criteria can already be found in literature:

Table 7: Examples of criteria for sustainability assessment tool selection.

Criteria	**Description/Meaning**
Accuracy of problem description	As sustainability assessment is strongly depending on weightings of the three dimensions (economic, environmental, social) it is necessary to make the valuation issue as explicit as possible (Sen 1995).
Aspects of sustainability covered	Which aspects of the sustainability are measured by the indicator/tool (Singh et al. 2012)?
Compatibility with DPSIR approach	Possibility to link/integrate the tool into the DPSIR approach
Data availability	As data unavailability is a common weakness of indices, sustainability assessment should be based on tools with data requirements that can realistically be met. Otherwise sustainability indicators or indices are not capable of measuring all dimensions of sustainability in an appropriate way (Mayer 2008, Carpenter et al.

Criteria	Description/Meaning
	2009).
Efficiency	At the same time sustainability assessment tools should be efficient in time and costs for data collection (Nicolette et al. 2013).
Forward-looking	As existing ecosystem management tools often use historic conditions that are no longer achievable in the future as a reference point, sustainability assessment tools should try to overcome this issue and be more than just a status quo evaluation. (Chapin et al. 2010).
Life cycle perspective	Possibility of including the life cycle of the assessment target (Cinelli et al. 2014).
Results	Sustainability “tools should be capable of delivering quantitative assessments of impacts to the greatest extent feasible” (Committee on Incorporating Sustainability in the U.S. Environmental Protection Agency 2011).
Simplicity	Especially sustainability indicators should simple enough to be applied consistently in different case studies (Carpenter et al. 2009, Singh et al. 2012).
Scientific demand	Additionally the approach should be also “science-based, technically defendable, and provide sufficient information for decision-making purposes” (Nicolette et al. 2013).
Transparency	“It is desirable to have relatively transparent methods that can be easily explained.” (Committee on Incorporating Sustainability in the U.S. Environmental Protection Agency 2011).
Uncertainty	Sustainability assessment tools should be able to deal with uncertainty (Committee on Incorporating Sustainability in the U.S. Environmental Protection Agency 2011).
Use of qualitative and quantitative information	It is not necessary to quantify all ecosystem services provided, but it is necessary to identify the services that will change by an action, and the level of change in comparison to the baseline condition (Nicolette et al. 2013, Cinelli et al. 2014).
Further generally applicable requirements for sustainability indicators to be considered: policy relevance, highly aggregated statements, normative indication, independence, orientation toward a guiding model, spatial comparability, comparability over time, ability to integrate, possible data collection, quantifiability, verifiability, reproducibility, validity, representativeness, sensitivity, agreeability, methodological transparency, and clear effect assignment (Müller 1996).	

6.5 Conclusions

Preliminary conclusions

- There are several frameworks, methods, and tools available but not all are suitable for an application in the context of ESS.
- As the general framework for sustainability assessment in DESSIN will be given, sustainability assessment frameworks as presented in section 6.4 seem to be out of focus in a first step. But a later integration/link of the sustainability approach into the DESSIN framework should already be considered and prepared.
- Reductionist tools do not fulfil the general requirement of a comprehensive view on sustainability and could therefore only be applied as combinations of two or three

reductionist approaches (one for each sustainability dimension).

- In general, MCDA methods have very extensive data requirements that may exceed the data availability of the case studies within DESSIN. Weighting of criteria is a very huge issue that probably can´t be appropriately done to everyone´s satisfaction.
- As composite indicators face the same problem of weighting as MCDA, an indicator list would probably be the best approach for sustainability assessment within DESSIN. Besides, this is the approach that fits best to the TRUST tools.
- The focus of the sustainability assessment approach for DESSIN should be to assess the sustainability of innovative solutions looking at different impact dimensions, not limited to the impact on ESS.

6.6 Next steps

1) Definition of key requirements/criteria that DESSIN´s sustainability indicators should fulfil
2) Suitability check of TRUST indicators/criteria (Start with Emscher mature case study)
    - Which TRUST indicators/criteria are influenced by the preliminary ESS indicators described?
    - Which TRUST indicators/criteria can be adapted? Which can be left out? Where are criteria lacking?
    - Do we need all five TRUST sustainability dimensions or is the triple bottom line enough?
3) Targeted literature check for complementary indicators/criteria to be added to the remaining indicator/criteria list. Are there results in WP12 relevant for sustainability assessment as well?

7. Activating the exchange between WA1-WA3

Based on the discussions held in Athens during the WA2-WA3 coordination meeting, a more active exchange between WA1 and WA3 is seen as necessary. The main goal of this is to get the demo site owners acquainted with the methods being developed under WA1 and cover some ground on the identification of relevant ESS, indicators, data sources and stakeholders. It will also serve as a feedback loop to enhance the applicability of the DESSIN approach and further its development.

In response to this feedback, WA1 has conceived a practical exercise that should help the demo site owners visualise their case under the light of the preliminary components of the DESSIN ESS Evaluation Framework.

7.1 Objective of the exercise

This exercise aims to provide the demo site owners with a “beta-tester” experience by:

1. providing background explanations of the different elements that integrate the preliminary version of the DESSIN ESS Evaluation Framework (Glossary of terms, CICES catalogue, adapted DPSIR scheme, DESSIN analytical framework, first indicators tested in the mature sites)
2. allowing them to test the concepts and methodologies hands-on at their own sites
3. activating a communication channel to gather their feedback on the experience

Ultimately, the completion of this exercise should result in a prioritised list of ESS for each pilot site as well as an indication of the data available for the description of these services. Facilitating this overview at such an early stage will hopefully allow WA3 to make the necessary arrangements and preparations to facilitate their assessments of changes in ecosystem services and ensure a successful application of the DESSIN methodology.

7.2 Proposed methodological steps for the exercise

Step 1	Prioritising the list of ESS in the pilot according to the purpose of the intervention/relevance to the area: the prioritisation of ESS is mainly dependant on the type of technology being implemented and its capabilities (in terms of influencing ESS) and the actors being affected by the change in ESS. • Identify range of potential ESS that the technology could enhance according to the proposed technology and the context of the pilot • Identify range of potential adopters (i.e. actors who would take up the technology because they would ultimately obtain a return from investment) and beneficiaries (i.e. actors who would support uptake but not adopt the technology themselves) • Based on the points above, identify the key ESS that the technology could enhance, and associated key beneficiaries and key adopters
Step 2	Discussing about the accessibility of information to assess each ecosystem service and evaluating this using a scale from 1 to 5 based on expert opinion (where 1 is highly accessible and 5 is not accessible). Listing the sources of information that will be used next to each proxy.
Step 3	Brainstorming on potential substitute proxies to assess the ecosystem service for which accessibility is low.
Step 4	Plotting the results of the exercise on a Relevance-Accessibility matrix and presenting it to WA1 and WA3 partners.

7.3 Next steps

- Discuss specific plans and responsibilities to complete the exercise at the first telco of the mature sites coordination task force.
- Circulate background information and instruction to WA3 on how to identify relevant ESS in the demo sites and how to assess the data availability to describe them.

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Annex Chapter 3: The US EPA guidance on the practical application of the DPSIR cycle

The US EPA offers in their website guidance into the application of the DPSIR framework. See. Tutorials on Systems Thinking using the DPSIR Framework[6]

The DPSIR framework was originally developed as a framework for identifying indicators for environmental health or public health problems (DPSEEA). Once a conceptual model is agreed upon, metrics can be identified across all levels of the DPSIR, and either evaluated separately or combined to form indices related to environmental concerns, economic concerns, or social concerns. Below is a selection of relevant examples that can be found in the website.

BOX 1: Wetlands example

Problem – Wetlands provide numerous ecosystem services that contribute to human well-being, including habitat for wildlife, stock for fisheries, flood and storm surge protection, recreational opportunities, carbon sequestration, and improving water quality. Yet wetlands are subject to numerous stresses, including development, hydrologic modifications, invasive species, pollution, land-use changes, and resource exploitation.

A DPSIR framework can be used to link stressors to their impacts on ecosystem services, and to highlight the causes of stresses and potential management actions.

The Wetlands DPSIR was created by highlighting concepts from the generic DPSIR concept map which were applicable to wetlands.

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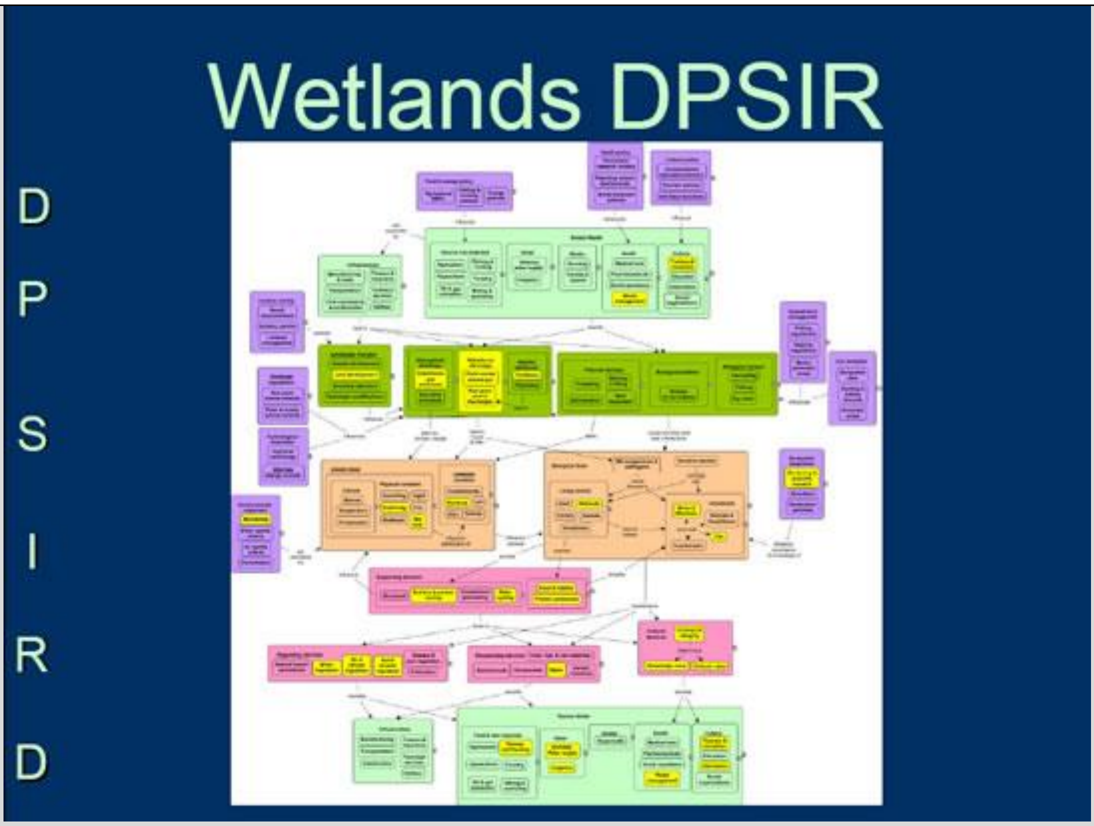
[6] http://www.epa.gov/ged/tutorial/index.htm



Wetlands DPSIR

Key *Drivers* whose activities were creating pressure on the wetland ecosystem included

- Waste management
- Tourism and recreation

Key *Pressures* were identified as

- Land development
- Greenhouse gas emissions
- Waterborne discharges
- Fertilizer use

Key abiotic and biotic variables within *State* included

- Hydrology
- Sea Level
- Nutrients
- Birds & mammals
- Fish

Impacts to human well-being derived from wetland ecosystems included

- Nutrient & carbon cycling
- Water cycling
- Food & habitat for wildlife
- Primary production
- Water regulation
- Air & climate regulation
- Soil & erosion regulation
- Provision of water

- Ecological integrity
- Knowledge value
- Cultural value

Wetland ecosystem services were considered to have direct benefits for socio-economic *Drivers*, including

- Fishing and hunting sector
- Drinking water supply
- Irrigation
- Waste management
- Tourism & recreation
- Information sector

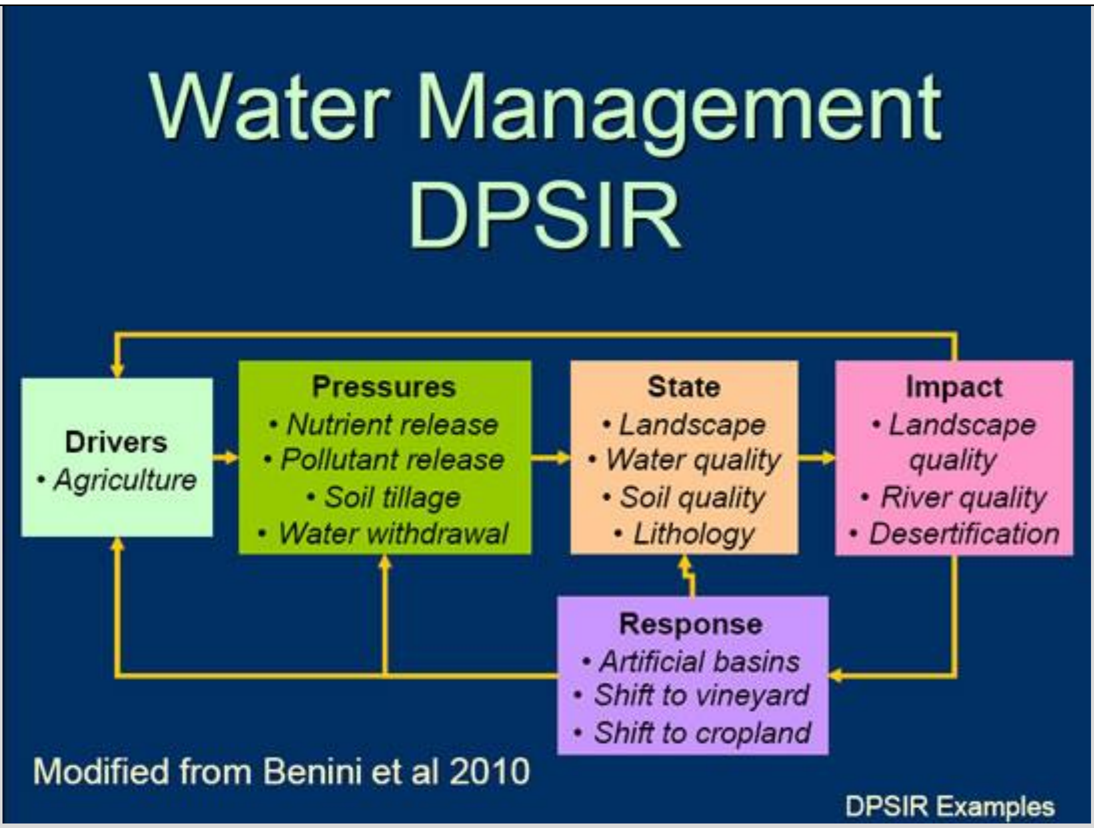
The key Response identified was to conduct monitoring and scientific research.

BOX 2: Water management

Benini and colleagues used the DPSIR framework to evaluate indicators associated with shortage of water in the river and the modification of the landscape structure in the Lamone River basin of Northern Italy.

The effect of different management scenarios on the indicators was evaluated using Multi-Criteria Decision Analysis. This allows decision-makers to examine situations where different stakeholders have different concepts of what is important and what outcomes they desire. A software program, called MULINO-Decision Support System, was used by the authors; it adopts DPSIR as a reference framework to integrate socio-economic and ecological modeling techniques.

Benini and colleagues used the DPSIR framework to derive the conceptual model for management of the river basin. This process defined the key elements to be included in the model evaluation of management scenarios.



Water Management
DPSIR

Drivers
- Agriculture

Pressures
- Nutrient release
- Pollutant release
- Soil tillage
- Water withdrawal

State
- Landscape
- Water quality
- Soil quality
- Lithology

Impact
- Landscape quality
- River quality
- Desertification

Response
- Artificial basins
- Shift to vineyard
- Shift to cropland

Modified from Benini et al 2010

DPSIR Examples

The decision indicators included loss of agricultural income, loss of agricultural surfaces, number of artificial basins, hydrological balance, and presence of a riparian buffer. The various indicators are combined using additive weighting to give a score for each possible management action.

Benini, L., V. Bandini, D. Marazza, and A. Contin. 2010. Assessment of land use changes through an indicator-based approach: A case study from the Lamone river basin in Northern Italy. Ecological Indicators 10:4-14

BOX 3: Set of indicators for evaluating sustainability of Giant Panda Sanctuaries in Sichuan, China

Wei and colleagues used the DPSIR framework to identify key issues and a set of indicators for evaluating sustainability of Giant Panda Sanctuaries in Sichuan, China. The Sichuan Giant Panda Sanctuaries are large areas of protected habitat in Southwestern China, covering almost 1 million hectares. Local farmers account for approximately 86% of the total population within the area. Local authorities have been making efforts to protect World Heritage sites. A set of indicators for assessing sustainable development will facilitate monitoring and determine whether sites are being properly managed.

The DPSIR Framework was used to generate policy relevant indicators for evaluating sustainability of Giant Panda Sanctuaries. The authors used the DPSIR framework to identify key factors which could be monitored to indicate sustainable development of Giant Panda Sanctuaries.

In addition, the authors used the DPSIR framework to generate a tentative list of sustainable development indicators which could be used to monitor management activities.

In addition to natural physical drivers, including climate change, key socio-economic *Drivers* and their corresponding indicators, included:

- Heritage protection & conservation: type and value of protection incentives, area under conservation
- Community development: urbanization level, population growth rate
- Tourism Activities: % employment in tourism, contribution of tourism income to local GDP

These socio-economic drivers create *Pressures*, and their corresponding indicators, on the state of the ecosystem through

- Demographic dynamics: net migration rate
- Waste emissions: rates of greenhouse gas emissions, rates of sulphur dioxide emissions

Changes in the *State* that can be monitored include

- Eco-environment: Soil degradation index
- Community living conditions: Access to safe drinking water, life expectancy

Changes in the ecological and environmental state can have *Impacts* on indicators of

- Heritage security: landscape fragmentation, bamboo coverage, distribution of panda sanctuaries
- Social progress: public perception of condition

Long-range management actions, or *Response*, may be quantified by

- Monitoring: construction of a monitoring network, investment in monitoring
- Thematic planning: quantity & quality of plans, implementation of plans
- Awareness, training, and education: sales promotion, percent of population trained

Reference: Capacity building: share of protection and pollution treatment investment in GDP; funding of programs launchedWei, J., Z. Yountao, X. Houqin, and Y. Hui. 2007. A framework for selecting indicators to assess the sustainable development of the natural heritage site. Journal of Mountain Science 4:321-330.

Annex Chapter 6

	Author, year	Title	Content
Ecosystem Service Assessment	Bateman et al., 2010	Economic Analysis for Ecosystem Service Assessments	The flow of ecosystems services and their contribution to welfare bearing goods is considered under varying basic conditions and methods for valuing resultant benefits are reviewed and illustrated via a case study of land use change.
	Castro et al. 2014	Ecosystem service trade-offs from supply to social demand: A landscape-scale spatial analysis	This paper provides quantitative studies that assess and map the relationship between the supply and social demand of ecosystem services.
	Deal and Pallathucheril, 2009	Sustainability and Urban Dynamics: Assessing Future Impacts on Ecosystem Services	In this paper a three-step approach to assessing the impact of future urban development on ecosystem services is described: 1) characterize key ecosystem resources and services, 2) forecast future land-use changes, and 3) assess how future land-use changes will affect ecosystem services. The approach is illustrated by describing how it was used in two regions in the state of Illinois in the United States.
	Downing et al., 2014	Coupled human and natural system dynamics as key to the sustainability of Lake Victoria’s ecosystem services	To disentangle drivers and dynamics of change in this complex system, the authors built a qualitative model of Lake ViKtoria´s social-ecological system, then investigated the model system through a qualitative loop analysis, and finally examined effects of changes on the system state and structure in order to analyze the system as a whole.
	Gao et al., 2014	Freshwater ecosystem service footprint model: A model to evaluate regional freshwater sustainable development—A case study in Beijing–Tianjin–Hebei, China	On the basis of the concept of ecosystem service footprint proposed by Burkhard, in this paper, a new methodological approach that addresses the sustainability and capability of regional freshwater provision and consumption is introduced.
	Grunewald and Bastian, 2015	Ecosystem assessment and management as key tools for	In this paper, a framework for assessing sustainable land use management, and to demonstrate it by way of examples of successful implementation in the Ore Mountains

	Author, year	Title	Content
		sustainable landscape development: A case study of the Ore Mountains region in Central Europe	region is presented based on such important ecological approaches as the concepts of ecosystem research, ecological indicators, ecological integrity, and ecosystem services.
	Matín-López et al. 2014	Trade-offs across value-domains in ecosystem services assessment	One of the key challenges for ecosystem services research is to develop a comprehensive methodological approach in which biophysical, socio-cultural and monetary value-domains can be explicitly considered and integrated into decision making processes. This paper operationalizes a methodological approach for ecosystem service assessment on the basis of value pluralism.
	Nicolette, J. et al.	A Practical Approach for Demonstrating Environmental Sustainability and Stewardship through a Net Ecosystem Service Analysis	In this paper a practical approach for demonstrating the environmental sustainability of an action through ecosystem service analysis is presented. The overarching premise of the approach is that human well-being is directly related to changes in ecosystems and associated services. The approach evaluates the net change in ecosystem services, and hence human well-being, and is termed a net ecosystem service analysis (NESA).
Environmental Assessment	Baker et al., 2013	Ecosystem services in environmental assessment — Help or hindrance?	The paper presents a critical analysis of the potential role of ecosystem services within environmental assessment, including both strategic environmental assessment and environmental impact assessment.
	Castellani and Sala, 2012	Ecological Footprint and Life Cycle Assessment in the sustainability assessment of tourism activities	This article presents a comparative study about sustainability evaluation of tourism activities, including LCA of a holiday and a hotel structure in Northern Italy.
	Potschin and Haines-Young, 2012	Landscapes, sustainability and the place-based analysis of ecosystem services	The aim of this paper is to describe the strengths of the place-based approach. In particular the paper argues that a place-based approach can help better understand issues of multi-functionality, the valuation of natural capital and the role of landscape in framing debates about ecosystem services and sustainability.

	Author, year	Title	Content
Sustainability of ESS	Anderson et al., 2014	Cultural ecosystem services as a gateway for improving urban sustainability	The paper discusses why cultural ecosystem services may serve as a useful gateway for addressing and managing nature in cities.
	Cairns, 1995	Ecosystem Services: An Essential Component of Sustainable Use	This articles deals with five assertions on sustainable use of ecosystem services.
	Carpenter, 2009	Science for managing ecosystem services: Beyond the Millennium Ecosystem Assessment	This paper discusses the need for research considering the full ensemble of processes and feedbacks, for a range of biophysical and social systems, to better understand and manage the dynamics of the relationship between humans and the ecosystems on which they rely.
	Costanza and Folke, 1997	Valuing Ecosystem Services with Efficiency, Fairness, and Sustainability as Goals	The paper is divided in three sections: ecosystem valuation in a broader context, assumption of fixed tastes and preferences and coevolutionary nature of preference formation. A Two-Tiered Decision Structure and an approach for Integrated Ecological-Economic Modeling and Assessment is presented.
	Gable, 2004	A Large Marine Ecosystem Approach to Fisheries Management and Sustainability: Linkages and Concepts towards Best Practices	This technical memorandum addresses interdisciplinary aspects of fisheries assessments as linkages for adaptive management and sustainability of large marine ecosystems (LME). Management and the ecological aspects of fish stock populations in the United States Northeast Continental Shelf ecosystem are examined for prospective and emerging “best practices” from a synthesis of the scientific literature.
	Hirokawa, 2011	Sustainability and the Urban Forest: An Ecosystem Services Perspective	This article argues that urban forestry is a local opportunity to engage in an exercise of self-determination and local identity. Urban forestry requires an investigation into the ties between the community’s environmental, economic, and social needs, a realization of the potential of space and natural infrastructure, and a manipulation of the services provided by trees.
	Lyytimäki and Petersen	Ecosystem services in integrated	This paper discusses the challenges of developing and using integrative concepts

Author, year	Title	Content
2014	sustainability assessment: A heuristic view	aiming to comprehensively cover the functioning of socio-ecological system by using the example of ecosystem services.
O´Shea, 2012	Ecosystem Services and Corporate Sustainability: In Theory and Practice	This Master's Project includes results of a comprehensive literature review, analysis of ecosystem services tools, and a survey of over eighty outdoor industry companies that suggest that ecosystem services theory is ahead of corporate sustainability practice. Nonetheless, the findings support emerging trends and demand for increased corporate ecosystem valuation.
Olschewski and Klein, 2011	Ecosystem services between sustainability and efficiency	Environmental scientists of different disciplines sometimes use the same words—such as sustainability or efficiency—with distinct meanings. This essay aims to define clear terminology and a mutual understanding of these.
Richardson, 2010	Ecosystem Services and Food Security: Economic Perspectives on Environmental Sustainability	The article examines the role of ecosystem services in rural food security through the lens of its three dimensions, and highlights the tensions that stem from household-level interactions and uses.
Sidle et al., 2013	Broader perspective on ecosystem sustainability: Consequences for decision making	Although the concept of ecosystem sustainability has a long-term focus, it is often viewed from a static system perspective. Because most ecosystems are dynamic, the authors explore sustainability assessments from three additional perspectives: resilient systems; systems where tipping points occur; and systems subject to episodic resetting. An example of sustainability assessment of ecosystem goods and services along the Gulf Coast (USA) is given and mountain road development in northwest Yunnan, China is discussed. Ecosystems reset by natural disasters is also represented by the example of 2011 Great East Japan Earthquake and resulting tsunami and repeated major earthquakes and associated geomorphic and vegetation disturbances in Papua New Guinea.

	Author, year	Title	Content
Sustainability Assessment	Rad et al., 2012	Including Ecosystem Services in Sustainability Assessment of Forest Biofuels	With increasing demand for forest biofuels the pressures on ecosystem services from forestry practices will increase. This paper discussed the need for identification and assessment of tradeoffs between different uses of provisioning and other ecosystem services and establishing management practices considering such tradeoffs.
	Whitman and Beall, 2012	Connecting a Region through shared Ecosystem Services: A Regional Watershed Sustainability Assessment Framework for the Spokane River Watershed	This poster provides a sustainability assessment framework for the Spokane River Watershed.
Sustainability Assessment Tools	Cinelli et al., 2014	Analysis of the potentials of multicriteria decision analysis methods to conduct sustainability assessment	This review paper presents the performance of five MCDA methods (i.e. MAUT, AHP, PROMETHEE, ELECTRE and DRSA) in respect to ten crucial criteria that sustainability assessments tools should satisfy, among which are a life cycle perspective, thresholds and uncertainty management, software support and ease of use.
	Committee on Incorporating Sustainability in the U.S. Environmental Protection Agency, 2011	Sustainability and the U. S. EPA	In chapter 4 elements of sustainability assessment and management and exemplary sustainability assessment tools are described.
	Dizdaroglu and Yigitcanlar. 2014	A parcel-scale assessment tool to measure sustainability through urban ecosystem components: The MUSIX model	This paper introduces one attempt of developing an urban sustainability assessment frameworks in developing a comprehensive assessment tool—i.e., Micro-level Urban-ecosystem Sustainability IndeX (MUSIX). Being an indicator-based indexing model, MUSIX investigates the environmental impacts of land-uses on urban sustainability by measuring urban ecosystem components in local scale. The performance of MUSIX is demonstrated in a pilot test-bed—i.e., in Gold Coast, Australia.

Author, year	Title	Content
Gasparatos, 2010	Choosing the most appropriate sustainability assessment tool	This paper explores the implications that arise with the selection of specific sustainability evaluation tools.
Gasparatos and Scolobig, 2012	Improved ecological network analysis for environmental sustainability assessment; a case study on a forest ecosystem	This article presents an overview of sustainability assessment tools (incl. assumptions and implications) and makes proposals for tool selection.
Schaubroeck et al., 2012	Improved ecological network analysis for environmental sustainability assessment; a case study on a forest ecosystem	To assess the environmental sustainability of industrial products and services, tools such as life cycle assessment (LCA) have been developed. To better quantify of resource extraction and emissions during a product's life cycle, the concept of ecological network analysis (ENA) was adapted and applied to a forest ecosystem.
Singh et al., 2012	An overview of sustainability assessment methodologies	This article provides an overview of various sustainability indices applied in sustainability domain. The paper also compiles the information related to sustainability indices formulation strategy, scaling, normalization, weighting and aggregation methodology.
Wegner and Pascual, 2011	Cost-benefit analysis in the context of ecosystem services for human well-being: A multidisciplinary critique	This paper provides a critique of the cost-benefit analysis tool for ecosystem services policy evaluation.
Yang et al., 2013	Going Beyond the Millennium Ecosystem Assessment: An Index System of Human Well-Being	Due to the complexity of the linkages between ES and HWB, there are still many knowledge gaps, and in particular a lack of quantitative indicators and integrated models based on the MA framework. To fill some of these research needs, a quantitative index system to measure HWB is developed, and assessed the impacts of an external driver – the 2008 Wenchuan Earthquake – on HWB.

	Author, year	Title	Content
	Zhang et al., 2011	An ecological based sustainability assessing system for cropping system	Incorporating the geographical information system (GIS) and remote sensing (RS) technologies, an initial idea of the crop sustainability assessing system was proposed, based on ecosystem services value (ESV) assessing criterions. To test the efficiency of the proposed system, an assessment was thus conducted along the Huai river watershed.
Others	Botero Baez, 2014	Strategic Environmental Assessment mainstreaming Ecosystem Services. The role of Stakeholders - Sustainable development through high levels of involvement and participation	This paper aims to find the challenges, benefits and opportunities of increased engagement of stakeholders by conducting three cases of SEA from different countries, interviews to expert academics and practitioners, and general trends drawn with data from a survey among experienced environmental professionals
	Chapin et al., 2010	Ecosystem Stewardship: Sustainability Strategies for a Rapidly Changing Planet	Ecosystem stewardship is an action-oriented framework intended to foster social-ecological sustainability of a rapidly changing planet. Recent developments identify three strategies that make optimal use of current understanding in an environment of inevitable uncertainty and abrupt change: reducing the magnitude of, and exposure and sensitivity to, known stresses; focusing on proactive policies that shape change; and avoiding or escaping unsustainable social- ecological traps.
	D´Amato et al., 2014	Linking forest ecosystem services to corporate sustainability disclosure: A conceptual analysis	This paper (1) summarizes results of a literature review of the impacts and dependencies of plantation-based forestry on ecosystem services; (2) identifies the existing and missing links between the corporate sustainability indicators and the ecosystem services framework; and (3) proposes a set of possible ecosystem services indicators for corporate sustainability reporting.

	Author, year	Title	Content
	Nicolaus and Jetzkowitz, 2014	How Does Paying for Ecosystem Services Contribute to Sustainable Development? Evidence from Case Study Research in Germany and the UK	This paper provides an empirical investigation on participatory and deliberative structures in already existing PES initiated by non-state actors. Based on the assumption that playing an active part in scheme design facilitates the consideration of justice and fairness, case studies from Germany and the UK present interesting results on the involvement of conflicting interests and their argumentation in the design process. Summing up these findings, the authors conclude that paying for ES rarely contributes to sustainable development in and of itself, but deliberatively designed schemes provide a formal setting to take aspects of justice into account.

Annex III: Final Agenda of the WA1 Coordination Meeting in Barcelona, Spain, 04-05 March 2015

	Meeting description
Meeting	**Title: WA1 coordination meeting** Place: Cetaqua, Centro Tecnológico del Agua Date: 4th-5th March 2015 Author of the meeting: Manuel Lago and Gerardo Anzaldua (ECOLOGIC) Location: Carretera d'Esplugues 75, 08940 Cornellà de Llobregat
Attendants	*See attendants list in a separated document*
Objective of the meeting	• Overall coordination and check status of progress with WA1 activities. • To present and discuss recent developments with the WP11 ESS evaluation framework. • To get feedback from the mature sites partners from different issues (bullet points) to set up the framework. • To have an overview of state of progress with the mature case studies. • To present drafts of D12.1 and D12.3, and exchange on main results and lessons learned • To launch activities for D12.3 *"manual for practitioners and policy-makers on best practice and constraints to innovation uptake".*
Background documents	*List (proposed titles)* for *Coordination of WP11 and WP13 Activities* *1. The selected DESSIN ESS analytical framework (ECOLOGIC)* *2. An example of the common methodological steps proposed for each of the DPSIR elements (ECOLOGIC).* *3. Identification of relevant indicators in the mature case study sites (EG/UDE)* *4. Developing a template for selecting proxy-indicators of ESS capacities (UDE)* *5. Selection of indicators relevant for economic valuation (ECOLOGIC)* *6. Sustainability assessment (IWW/SINTEF)* *7. Plans to engage with WA3 demo sites (ECOLOGIC)* *8. Draft D12.1 on governance factors, including draft storylines of innovation uptake in the three mature sites, and draft comparative analysis (ECOLOGIC with input from KWR and SINTEF)* *9. Draft D12.2 on financing mechanisms conducive to innovation uptake in water sector (CETaqua)* *10. Note on Task 12.4 "linking best practice in governance and financing with ESS framework" and D12.3 "manual for practitioners and policy-makers on best practice and constraints to innovation uptake (ECOLOGIC)* *Please note that the documents should have a practical remit (know how type of guidance documents) and conclude with a set of questions that the authors would like to discuss at the coordination meeting. Presentations at the meeting should be based on these documents. The documents need to be sent by the 25th of February the latest to manuel.lago@ecologic.eu and gerardo.anzaldua@ecologic.eu . Ecologic will circulate the documents with the final version of the agenda for the meeting by the 27th of February the latest.*

Agenda	**DAY ONE: Coordination of WP11 and WP13 Activities** 13:30-13:45 – **Coffee reception** and **welcome** (CETaqua) 13:45-14:00 – **Objective of the WA1 coordination workshop** (ECOLOGIC), round of introductions/expectations for the meeting (ALL) 14:00-14:30 – **Presentation** (ECOLOGIC /IWW/EG) **of progress in WP11/13**, reminder overview of relevant tasks, milestones and deliverables. 14:30-18:00 – WP11 "Development of an evaluation framework (to account) for impacts of changes on Ecosystem Services". 10 mins presentations on plans/progress by topic followed by 15 mins Q&A sessions. These presentations will be based on background papers developed for the meeting. Topics: • *Introducing the selected DESSIN ESS analytical framework (ECOLOGIC)* • *The way forward: presenting an example on the common methodological steps proposed for each of the DPSIR elements (ECOLOGIC)* • *Identification of relevant indicators in the mature case study sites (EG/UDE)* • *Template for selecting proxy-indicators of ESS capacities (UDE)* • *Selection of indicators relevant for economic valuation (ECOLOGIC)* • *ESS + Sustainability assessment (IWW/SINTEF)* *15:30 – 15:45 Coffee break* 18:00- 18:20 - further discussion, agreements and list of actions 18:20-18:30 – **Wrap up. Evaluation of DAY ONE and expectation of DAY TWO.** 20:30 – **Social dinner (Balthazar Restaurant)** -- From 10:00 to 13:00 Opportunity for targeted **Bilateral meetings on specific tasks. Please inform organisers if interested.** **PROPOSED BILATERAL MEETINGS** 11:00-12:15 Mature/Demo case study owners get together. Exchange of info and experiences. Thinking ahead: link with the assessment of the demo site. Location: CETaqua 10:00 – 12:00 WP12 meeting (KWR, Ecologic and SINTEF). Location: CETaqua

DAY TWO Coordination of WP11 and WP13 Activities (cont) and Coordination of WP12 Activities

09:00 – 09:15 – **Presentation** (EG) of progress in WP13 "Testing & refining the ESS evaluation framework by using mature sites", reminder overview of relevant tasks, milestones and deliverables.

09:15 – 10:45 - Presentations on the state of progress with the mature case study sites. Each presentation will aim to follow this layout:

- *a description of the mature site (focusing on progress since previous meetings about the details of the implementations and their (potential) impacts.) and the technical/management/innovative measures already conducted at the site (e.g. Emscher conversion, RTC in Aarhus, …): description of the situation before and after the measure; description of the future scenarios that are to be considered in WP13 (of which the application of new technologies could be a part of)*
- *a list of the main ESS of relevance ACCORDING to the CICES list*
- *an overview of data available to describe the main ESS of relevance listed (kind & format of data)*
- *time and spatial scale considerations*
- *sustainability considerations*
- *Brief statement to each mature site's specific task (e.g. various stages of restoration for Emscher, model based real-time DSS system for Aarhus). Further, mature site owners could already identify potential barriers to the proposed ESS assessment framework/s and application of the Evaluation Framework and include this in the presentations/discussions.*

09:15 – 09:45 – Overview of progress towards the selection of relevant indicators in the Emsher mature case study (EG). 20 mins presentation + 10 mins Q&A

09:45 – 10:15 – Overview of progress towards the selection of relevant indicators in the Aarhus mature case study (DHI). 20 mins presentation + 10 mins Q&A

10:15 – 10:45 – Overview of progress towards the selection of relevant indicators in El LLobregat mature case study (CETAqua). 20 mins presentation + 10 mins Q&A

10:45 – 11:00 – Coffee break

11:00– 11:30– further discussion, agreements and list of actions

11:30– 12:00 – Plans to engage with WA3 demo sites (ECOLOGIC)

Coordination of WP12 Activities
12:00-13:00 – **Presentation** (ECOLOGIC) of progress in Task 12.1 (submitted Milestone); Task 12.2 (interviews campaign, storylines); Task 12.4 (timeline). **Presentation** (CETaqua) of progress in Task 12.3. **Round of feedback and comments.**

13:00-14:00 –LUNCH

14:00-15:30 – **Presentations** for Task 12.2 of Ebro (ECOLOGIC), Aarhus (SINTEFF), Emscher (KWR) and comparative assessment for DL12.1 (ECOLOGIC). **Open discussion** on results.

Objective of session: to present results and lessons learned on governance factors conducive to innovation uptake. In particular:

- *For each mature sites (Aarhus, Ebro, Emscher): overview of the focus of each mature sites, data collection performed, key results and lessons learned*
- *For the comparative assessment: presentation of draft analysis and lessons learned across mature sites*

The discussion aims to exchange views on key results and messages for D12.1.

15:30-16:00 - **Presentation** (CETaqua) of Task 12.3 and DL12.2. **Open discussion** on results.

Objective of session: to present results and lessons learned on financing mechanisms conducive to innovation uptake. In particular:

- *To present the structure of D12.2*
- *To present progress on data collection, analysis and lessons learned*

The discussion aims to exchange views on key results and messages for D12.2.

16:00 -16:30 – **Presentation** (ECOLOGIC) of Task 12.4 and DL12.3. **Discussion** on linkages with WA3 and WA4, and next steps.

Objective of session: to launch activities for D12.3 "manual for practitioners and policy-makers on best practice and constraints to innovation uptake". In particular:

- *To present options on the objectives and target audience of D12.3*
- *To present a potential timeline of activities for the delivery of D12.3*

The discussion aims to exchange views on objectives and target audience for D12.3, and amend/agree next steps.

16:30-17:00 – **Next steps**: deadlines, responsibilities, wrap up of agreed list of actions. **Evaluation of DAY TWO**.

OPTIONAL: Friday 6th of February
Friday morning informal car visit to El LLobregat case study area. *Maximum number of participants 8. First come first basis.*
-For those interested, please confirm interest to the organisers by the 20th of February- Marta: mhernandezga@cetaqua.com

The research leading to these results has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement no. 619039

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