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SEVENTH FRAMEWORK PROGRAMME

REFORM

REstoring rivers FOR effective catchment Management

Deliverable Title **D 2.3 Analytical framework ecosystem services**
Valuing the ecosystem services provided by European river corridors – an analytical framework

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Summary

An analytical framework is developed for the estimation of ecosystem services delivered by restored and non-restored river corridors, i.e. the active river channel and its accompanying valley floor. The Millennium Ecosystem Assessment approach towards ecosystem services is adopted, but with a focus on final services, i.e. only those services are quantified that provide a net benefit to societal beneficiaries. A long list of services potentially provided by European rivers is provided and linked qualitatively to a river style typology developed in D2.1 by Gurnell and colleagues to present the major services potentially provided by European rivers and their floodplains.

The appropriate spatial scale for a quantification of services provided is defined as that of a reach, hence the method should cover extents of ~ 10 km and grains of ~ 100 m. From the reach, aggregation upwards to segments and catchments is feasible. The consolidated land cover classification of CORINE can serve to provide the mappable units but requires additional fine-grained detail to specify the different habitats (or landscape elements, as specified in EUNIS) present in a reach as a mapped unit. The analytical framework starts from the mapped mosaic of habitat units within a reach and lists the potentially delivered services by each habitat. Subsequently, the exercise is re-iterated to assess whether a service is only provided at a larger scale by a combination of landscape elements, or the full length and width of the floodplain and stream that can only be appreciated as a landscape. Then services are summed across the reach, generally as fluxes in biophysical units, and brought under the same denominator of economic value using benefit transfer functions. For several cultural services that have no market, direct field surveys using questionnaires are proposed. Such economic valuation methodologies for different services are briefly justified and procedures are outlined.

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1. Introduction

This report aims to develop an analytical framework that can be used during field assessments of ecosystems services provided by European river corridors, and their value to society. The value of such ecosystem services may be derived explicitly from existing markets, implicitly from observed or stated preferences, or be perceived as high though not quantified in monetary terms. The framework will be tested and applied in the restored flag-ship case study rivers identified in WP4 of REFORM. It should, therefore, also allow a differentiation between restored and not restored sections of a river and its floodplain.

This report first briefly highlights our perspective on ecosystem services as final services, and clarifies the choice for a particular perspective on ecosystem services. It offers a long list of services potentially provided by rivers and links these to the typology proposed in D2.1. The remainder of the report then focuses on the methodology. It settles the spatial scale and resolution required, then highlights the line of reasoning to work through the analytical framework step by step, and concludes with an overview of the economic toolbox necessary to value ecosystem services.

This report serves to fulfil task 2.5 of REFORM, and we specify below how we have accomplished (right column) the task elements phrased in the Description of Work (left column).

Task description	Approach
Building upon understanding of the characteristics of European rivers and floodplains gained in WP1 and other tasks in WP2, this task explores the ecosystem goods and services that European rivers of various types may offer.	Instead of 'goods and services' we apply the MEA classification of ecosystem services (chapter 2).
Devise a generic overview of ecosystem services potentially provided by river networks and floodplains in Europe.	This generic overview is provided in table 3 and accompanying text. A long list of services potentially provided is compiled in annexe 3. Conditions for their delivery are briefly explained.
Define a framework of analysis based upon a matrix of river types defined in Tasks 2.1 and 2.2, and MEA-type ecosystem services and deduce approaches that can quantify the biophysical/geochemical fluxes and stocks that are responsible for the delivery of final services that are of benefit to society.	The framework is a matrix of landscape elements versus services, rather than river types, since the basic unit of analysis is the reach in wp2 and wp4. A variable abundance of these landscape elements composes a reach in each river type.

2. Ecosystem services: what do we mean by it?

The notion that the world's ecosystems provide an undervalued resource base to humanity has been well established since the report of the Club of Rome was issued in the early 1970s (Meadows et al. 1972; Westmann, 1977; Costanza et al. 1997; Turner et al., 2000; Balmford et al. 2002). Since the Millennium Ecosystem Assessment (MEA, 2005), the concept of ecosystem services has gained great popularity among policy makers, conservationists and scientists across the world. Still, each of these may well have a different interest and agenda (Tallis et al. 2008). Fisher et al. (2009) demonstrate this popularity with a massive increase in research output on this topic as witnessed from published papers.

Ecosystem services are seen as those benefits obtained from an ecosystem that enhance human welfare (MEA, 2005). This notion of benefits that enhance human welfare implies an anthropocentric and economic perspective on value. This economic perspective on value is probably more easily quantifiable but also more restricted than the wider view of welfare embraced by the MEA (2005). This latter includes well-being, and also lists security, basic material for good life, health, good social relations and the freedom of choice and action as key constituents. Quantifying and attributing economic values to services is a complex and interesting research effort in itself (e.g. MEA 2005; Wallace 2007; Fisher et al. 2008, Bateman et al. 2010). The more recent National Ecosystem Assessment of the United Kingdom (UK-NEA, Watson and Albon, 2011) equally mentions well-being and economic prosperity side-by-side. The European Environment Agency (EEA) has issued a framework for 'ecosystem capital accounting', that is designed to align well with the UN system of national accounts and so uses a strictly economic interpretation (Weber, 2011).

Although the framework of the MEA (2005) is generally embraced wholeheartedly as a valid starting point, ecologists and economists alike continue to argue for better operationalisation and more rigorous quantification of ecosystem services (Kremen, 2005; Boyd and Banshaf, 2007; Wallace, 2007; Ansink et al. 2008; Tallis et al. 2008; Daily et al. 2009; Carpenter et al. 2009) and they propose revisions of the framework (as in TEEB, De Groot et al. 2010). The current project REFORM aims to contribute one such an effort at more rigorous quantification, in this case for Europe's river corridors.

An important contribution to operationalisation is made by Wallace (2007), who argued that welfare or the societal benefit acquired from a service should only be valued when and where it was enjoyed by humanity as a benefit, and labelled this 'final services' whereas all other services, that occur whilst an ecosystem functions as it happens to, are íntermediate services'. Supporting services are therefore not 'final', they contribute to the provision of a service in the other categories. Haines-Young and Potschin (2010) labelled this the 'service cascade' and placed ecosystem functions and processes as intermediate services at different levels. Like Watson and Albon (2011), we adopt this final service perspective since it does provide a clear link between ecosystem and society. This implies that all intermediate services are incorporated in the final service that does contribute to human welfare. The latter can be valued economically or otherwise from a rate per area and per time. A transparently strict accounting at the final services level prevents double counting. Environmental economists provide the toolbox needed for this estimation (e.g. Bateman et al., 2010). The contribution by an intermediate service to a final service could be marginal or crucial, and direct or indirect.The importance of a particular intermediate service may be back-tracked by a form of path analysis, source apportionment, or possibly by a comparative thought experiment ("what if we were without this..").

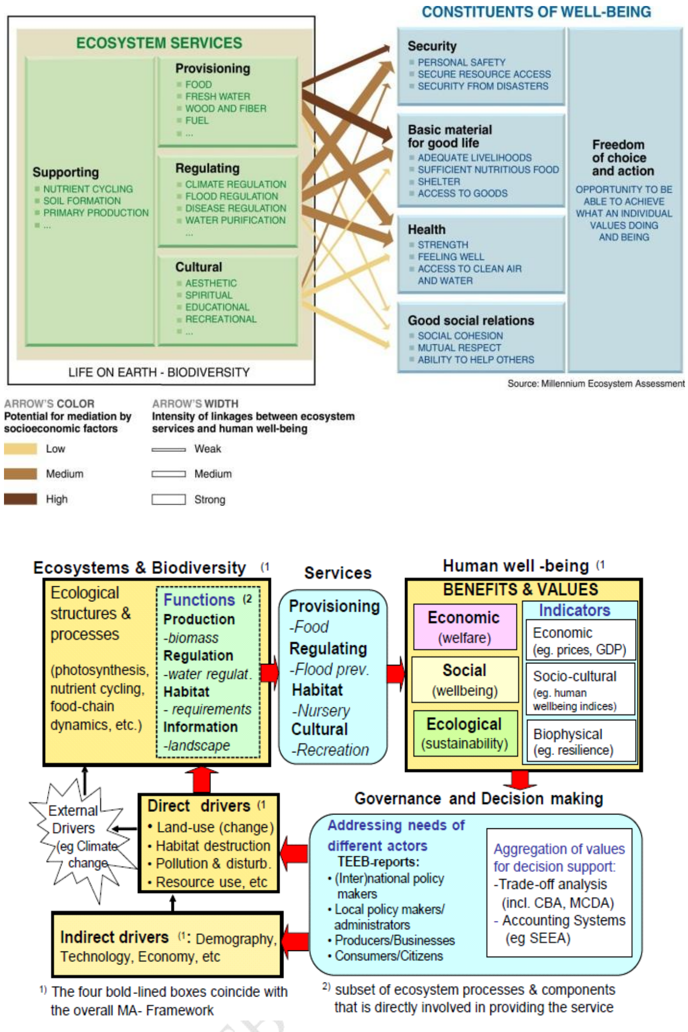

Figure 1. Comparison of the analytical frameworks of the MEA (2005, Top) and TEEB (De Groot et al. 2010, Bottom).

We propose here to adopt the simple framework of the MEA (2005), rather than a more complicated version forwarded by the TEEB initiative (De Groot et al., 2010), which includes drivers, adds habitat provision as a separate service category, and separates governance from human well-being. This proposal is made because the former is more directly suitable for the application of the final services perspective (cf Figure 1), and because it is emerging as a common standard (the Common International Classification of Ecosystem Services, CICES; Weber, 2011).

Our analytical approach could start from one of two opposing perspectives: 'the ecosystem', or 'the beneficiary' that makes us of the final service. REFORM focuses on the reach and the services provided by that particular ecosystem, i.e. the river channel and its accompanying floodplain. In wp4, restored reaches are compared with thier non-restored counterparts. Also, both in land planning and management as well as integrated river basin management, the plea is for considering 'the whole'rather than a sectoral part (e.g. Brils et al., 2013). We therefore chose to start from the real-world ecosystem as a 'whole' in the form that can be perceived by riparian inhabitants and other stakeholders. This is an empirical approach we consider best suited to a methodology that is to be applied for comparing restored and non-restored reaches.

3. What services would a river corridor deliver?

Before this report moves to the description of a method, it appears worthwhile to take a step back and imagine how rivers and their valleys have been useful to humanity in the past and how useful they currently are.

From the earliest stages in the development of human society, rivers have shaped these societies in multiple ways. They provided water, food and construction material, but were also avenues for long distance transport. Large rivers formed formidable natural boundaries directing and halting migration of people as well as defensive and offensive military movements. Since the Roman occupation of large tracts of central and southern Europe, most towns of importance have been erected at cross-roads of overland trading routes (Roman Roads) and rivers at fordable places. Equally, rivers regularly have paid society a disservice, for example when a spring flood wreaked havoc to humans and property. Modern society still depends on rivers although the perspective and the importance of different usages may have changed. Across much of Europe, waves of modernization have optimized river networks for drainage, irrigation and transport since the industrial revolution spawned powerful mechanization.

The functional breakdown of ecosystem services by the MEA (2005) distinguishes provisioning, regulating and cultural services. Weber (2011) classified different categories within these three main types of services for an economic accounting system (Table 1). Provisioning services are generally easily coined as final services and hence valued: beneficiary parties are distinct and the service is used directly hence can be valued well with economic tools. The economic value of regulating and cultural services may be less straightfoward to estimate (see section 6 below).

Table 1. The CICES classification of ecosystem services based on the broad MEA types (adopted from Weber, 2011)

MEA type	Class	Generic examples
Provisioning	Nutrition	Plant and animal food stuffs, potable water
	Materials	Biotic and abiotic materials
	Energy	Renewable bio-fuels, renewable abiotic energy sources (hydropower, wind, tidal)
Regulation (and maintenance)	Regulation of wastes	Bioremediation, dilution, sequestering
	Flow regulation	Flow of air, water or mass
	Regulation of the physical environment	Atmospheric, water quality, soil quality
	Regulation of the biotic environment	Life cycle maintenance and habitat protection, pest and disease control, gene pool protection
Cultural	Symbolic	Aesthetic, heritage, religious and spiritual
	Intellectual and experiential	Recreation and community activities, information and knowledge

Current European rivers and their floodplains provide a range of straightforward provisioning services that are generally exploited in an economically explicit, market-driven way. Floodplains are parceled out for cattle grazing land and hay-making, fishing rights for the main channel and backwaters are generally well established for entrepreneurs as well as recreative fishermen. Gravel, sand and clay deposits are excavated from floodplains by market-oriented companies and hydropower is generated almost wherever the gradient would allow it (e.g. Nilsson et al., 2005). Also, wherever gradient and flow allow, most European rivers have been highly modified to allow for navigation, resulting in a well-developed international transport and trade system along the regulated branches of Rhine, Danube and other rivers in central and western Europe.

Floodplain and channel together provide a regulating service by affecting the downstream flowing water both quantitatively and qualitatively. During flood periods, wide floodplains level off the flood peak, reduce flow velocity and retain sediment and nutrients (Haycock et al., 1993; Olde-Venterink et al. 2003, 2006; De Klein and Koelmans, 2011). Downstream communities are obvious potential beneficiaries of this regulating service, although the benefits greatly depend on upstream interventions. Equally, upstream communities can benefit from the export of pollutants to downstream, although the capacity of the river system may not be sufficient to sequester and dilute pollutants, leading to downstream water quality problems. Historically, rivers that drained major urban industrial centres in Europe and had turned into anoxic, lifeless sewers were a prime impetus for the development of sewage treatment techniques. The economic significance of this often unequal upstream-downstream dependence is most powerfully illustrated in larger, trans-boundary rivers, such as the Ganges and the Brahmaputra, or the Euphrates and Tigris, where upstream and downstream riparian states are engaged in a complicated political process on water rights (e.g. Yoffe et al., 2004). Benefits foregone (=losses) can be quantified here in terms of volumes of water not received per unit time and these can be monetized. Equally, upstream mitigation of downstream flood risk can be assessed. Literature on monetary compensation of or trade in such (possibly altruistic) measures is developing (e.g. Chang and Leentvaar, 2008; Brouwer et al., 2011). The development of a shadow market for carbon-credits as a means to mitigate climate change effects (Bonnie et al., 2002) has led to the recognition of carbon sequestration as a regulating service. Hajdu (2011) has estimated that carbon sequestration was a major process in the Brazilian floodplain of the Parana, where cattle grazing had been terminated and natural re-afforestation occurred rapidly. Here sequestration was on average 3 Mg C ha^{-1} y^{-1} (range 1-10), which would crudely correspond to ~24 US\$ ha^{-1} y^{-1} (at a rate of 8.2 2008US$ / Mg C, Derwisch et al. 2009)[1].

Tourism and recreation make use of the river, but generally do not deplete (non-consumptive use) the river and its surrounding landscape. This is a cultural service that has received substantial interest and methodologies exist to estimate both use value and non-use value in the literature (e.g. DEFRA, 2007; Bateman et al. 2010; see also section 6). An important issue here is that tourists appreciate the river as a feature comprised in its landscape setting and it is the full scenery that is valued rather than a single landscape element, type of vegetation, or the presence of a particular species of plant or animal (Hein et al., 2006). Other aspects of cultural services, such as spiritual recognition, are more difficult to value economically.

[1] Currently, carbon taxes vary between 1 and 7 €/Mg (1.3-8.8$) across Europe, and Nordhaus (2008) estimated that the social cost of carbon dioxide should be taxed at 30 US$/Mg C.

Table 2. Qualitative listing of major ecosystem services potentially provided by river types proposed in REFORM D2.1. Type numbering and typical slope are conform D2.1, table 6.2. Based on Petts and Foster, 1992, Brouwer et al., 2009, Watson and Albon, 2011, and our own expert judgment). This tabulation is an aggregate conversion of Annexe 1.

River type (number)	Longitudinal slope	Service		
		Provisioning	Regulating	Cultural
single thread, confined in bedrock or colluvial deposits (90%) (1-3)	often steep (>5%)	hydropower, forestry products, drinking and irrigation water	carbon sequestration in forests; reduction of organic and inorganic pollutant load (in-stream 'self-purification')	trout and salmon* fly fishing, hunting, rafting, kayaking, hiking, scenic beauty of the landscape
single thread, on alluvial, coarse beds (boulders to gravel) (4-6)	fairly steep, (up to > 3%)	construction gravel, water for drinking and irrigation, forestry products, hydropower	carbon sequestration in forests; flood retention, notably when channel path >> talweg; self purification	trout and salmon* fishing, hunting, rafting, kayaking, hiking, scenic beauty of the landscape
single thread on alluvial gravel beds (sinuous, meandering) (7-10)	> 0.5%	construction sand and gravel; water for drinking and irrigation; agricultural dairy and fruit trees, crops on terraces, hydropower (reservoirs), commercial fisheries, poplar plantations	carbon sequestration in riparian woodland; flood retention in floodplain (water, sediment, nutrients); self-purification	trout and salmon* fishing, sunbathing, hiking, canoeing, swimming, scenic beauty of the landscape
multiple thread on alluvial gravel (braided, anastomosing) (11-13)	>0.5%	as above for single thread; probably more extractable gravel	as above for single thread	as above; good chance for wildlife and biodiversity in complex mosaic landscapes of islands, bars, channels and pools
single thread on alluvial sand (14, 15)	<0.5%	construction sand and gravel; water for drinking and irrigation; agricultural dairy and fruit trees, crops on terraces; hydropower (reservoirs), commercial fisheries, poplar plantations	as above for single thread gravel	angling, waterfowl hunting, sunbathing, canoeing, hiking and swimming, scenic beauty
multiple thread on alluvial sand (17, 18)	<0.2%	as above for single thread; probably more extractable sand	as above for single thread gravel	as single thread but better chance for biodiversity in complex landscapes
single thread on alluvial silts and clays (19, 20)	~0%	agriculture: dairy, meat; clay for construction, bricks and pottery; commercial fisheries; in artisanal communities reed and stems and branches are used for thatching, tools, baskets, seats and floor mats; poplar plantations	as above	angling, waterfowl hunting, sunbathing and swimming, yachting, sailing, scenic beauty
multiple thread on alluvial silts and clays (21)	~0%	as above	as above	as single thread but better chance for biodiversity in complex landscapes

*Trout and salmon fishing mainly in Northern, and Central Europe, not in Mediterranean countries, where steep upland lower order streams and their gallery forests are often wildlife refuge corridors .

Based on our knowledge of river we have compiled a long list of ecosystem services that can be provided potentially by European rivers in their corridors. We link these to the 21 river types identified in D2.1, identify the abiotic and biotic conditions necessary for their provision and postulate the minimal scale (grain) required before such a provision is viable. Certainly, not all services are provided by all rivers to a similar extent. As trivial examples just imagine that one rarely sails a dinghy up a first order stream or digs for sand in hard bedrock. At the same time the sheer length of the list illustrates how human society has become dependent on its rivers. All this is brought together in Annexe 1. We have selected the most important ones for te major river types identified in D2.1 (Table 2). We can draw three conclusions from these two listings: (1) many regulating services appear not final since they serve other usage, hence may not be directly evaluated; (2) many services are provided by a wide range of geomorphological river types and the relevance of their degree of naturalness is hard to pinpoint in a general assessment; and (3) the importance of a river as provider of services depends greatly on the local context: geomorphology, landscape, past and current land use and types of potential beneficiaries present can make a great difference, particularly when the aim is to go deeper than a few generic qualitative statements, hence to go beyond the level of table 2. Again, this justifies an empirical assessment and calls for a compilation of case studies.

4. Spatial scale of the ecosystem and habitat typology

Spatial delimitation is an important practical issue in the assessment of ecosystem services. By definition, an ecosystem has no distinct boundaries, quite unlike an administrative unit on the map. Even an apparently clear boundary like the one between land and sea is blurred and variable upon close inspection, and rather an interface across which intensive exchange occurs. Ecosystems are nested, hierarchical time-variant open systems of interacting components that can be living creatures or their dead, a-biotic surroundings. This is not necessarily problematic, as long as we acknowledge the compromise.

The MEA (2005) used very large-scale global units to delimit different ecosystems (the ocean, coastal waters, inland waters, forests, dry lands, islands, mountains, polar, cultivated and urban), and argued to remain pragmatic whilst defining: 'A well-defined ecosystem has strong interactions among its components and weak interactions across its boundaries. A useful ecosystem boundary is the place where a number of discontinuities coincide, for instance in the distribution of organisms, soil types, drainage basins, or depth in a water body.' For the UK-NEA, Watson and Albon (2011) used rather 'broad habitats': mountains, moorlands and heaths, semi-natural grasslands, enclosed farmland, woodland, freshwaters, wetlands and floodplains, urban, coastal margins and marine.

Table 3. Delineation of river segment and reach in REFORM (adopted from wp2 D2.1)

Entity	Extent (area or length)	Description
Catchment	10^2 km^2 - 10^5 km^2	Watershed, drainage basin, stream system; A clearly defined topographic and hydrological entity and represents the fundamental spatial unit of the landscape
Landscape unit	10^2 km^2 - 10^5 km^2	A landscape unit is a portion of a catchment with similar characteristics in terms of relief variability, i.e. landscape morphology, assessed in terms of elevation, slope, geology, valley confinement, and position (e.g., upland versus lowland settings).
Segment	10^1 km^2 - 10^2 km^2	Valley: Identifiable large riverine landscape area with similar valley morphology and type of confinement or slope-channel connectivity. Valley corresponding to a specific river segment. River channel: Section of river subject to similar valley-scale influences and energy conditions. Portion of a stream system flowing through a single bedrock type and bounded by tributary junctions or major waterfalls. The portion of the river that crosses the valley sector. Lengths of channels tens of km long separated from each other by major boundaries (i.e. dams, major tributaries, geologic structures, major changes in geologic substrate) that impose significant changes in river process or forms.
Reach	Length 10-20 channel widths to tens of km	Section of river along which boundary conditions are sufficiently uniform that the river maintains a near consistent internal set of process-form interaction. A river segment can contain one to several reaches.

Since our study object is rivers in their floodplain corridors, our spatial scale will be much smaller than that of the MEA (2005) or Watson and Albon (2011). The case studies selected in REFORM range in restored length from ~1-20 km (pers. comm. Daniel Hering). Our spatial scale should have the size of a forest patch, meander or sand bar as grain (~100 m) and the wider landscape of the reach as minimal extent (~10 km). Only in this way will we be able to grasp spatial heterogeneity (different grains) within the landscape mosaic formed by a river reach that is viewed by human users as a homogeneous entity (Holling, 1992; Skøien et al. 2003). A system with a high resolution (~ 100 m) can also offer us the possibly necessary higher resolution to analyse linkages between ecosystem services and biodiversity (e.g. Balvanera et al. 2006; Duffy et al. 2009), but that is not the prime focus of this report. Based on river geomorphology, REFORM has adopted a typology of floodplain and channel land forms (D2.1, in prep; table 3 is an excerpt). Our requirements for spatial extent thus correspond with those of a reach for both floodplain and channel (Table 3). This will not prevent us from scaling up to segment scale or even larger when needed, since some services are provided only at a larger scale.

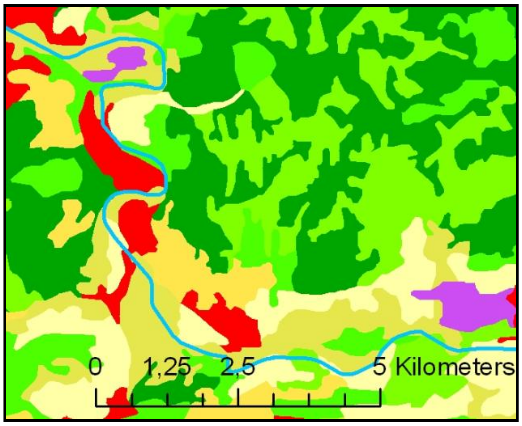

Figure 2. CORINE 2006 image of the river Ruhr and its vicinity upstream of Arnsberg (Germany). A larger section and legend is provided in Annexe 2.

The CORINE land cover system exists as a consolidated land cover (~habitat) classification for the whole of the EU. The EEA proposed an aggregated CORINE land cover typology in its framework for ecosystem capital accounting (Weber, 2011). It is available at a 1 km grid and provides more ecological detail than the 'broad habitats' (agricultural land, uplands and bogs, rivers) of e.g. the UK-NEA. At the same time, CORINE offers considerably less ecological detail than ecological and nature conservation assessments may find necessary. For this purpose, Davies et al. (2004) provided the detailed habitat EUNIS classification (over 6000 categories in 6 hierarchical levels). We have extracted the second order level EUNIS habitat types relevant for central European floodplains and cross/linked these to the CORINE CLC units (Annexe 3). As an illustration we display the CORINE imagery for the Ruhr river upstream of Arnsberg, one of the case study sites in REFORM (Figure 2).

It is difficult to distinguish the river corridor from the surrounding uplands. The extent of a restored reach is illustrated in Figure 3, here 4.5 km along the river Ruhr in Arnsberg (Germany). Clearly, CORINE offers little spatial heterogeneity and it will be necessary to implement this ourselves. Our approach will be to (1) delineate the study reach on a topographic map or aerial photograph of higher resolution (1:10,000), and then (2) attach CORINE or preferably EUNIS typology labels to the land elements identified in the map for the emergent, aerial part of the reach. This will ensure consistency and exchangeability across study sites and beyond the project. For the submerged part of the reach, a compromise will have to be found between ecological detail and applicability for the valuation of non-market ecosystem services. The general public may not understand and appreciate the degree of ecological detail used by experts. The system of morphological elements of the spreadsheet 'REFORM_Framework.xlsx' of D2.1 as well as the substrate typology applied in the surveys of WP4 are considered to be too complicated to be used for such valuation exercises. [2]

Figure 3. Site of a restored reach along the river Ruhr in Arnsberg (broken red line) on a topographic map (left) and downstream view of the same site (right, topographic map and photo courtesy Daniel Hering), Google Earth screen shot (bottom) offers a wider view of the landscape setting of the restored reach.

- [2] This is a critical issue. We assume that CORINE-EUNIS is sufficient as a typology in the floodplain, we will see during application of the method whether we should use a strict geomorphological series of channel features (riffles, glides, point bars etc), or a more flexible microhabitat distribution, like patches of vegetation, trees, gravel, logs, rocks, pools.

5. Building the analytical framework

Our analytical framework starts from the mapped habitat units, or landscape elements, and lists the potentially delivered services by each habitat. Thus we treat these landscape elements as the smallest spatial unit (grain) of our analysis. This can be considered equivalent to the service providing unit (SPU) of the ecosystem services literature (e.g. Kremen, 2005; Nelson et al., 2009; Raudsepp-Hearne et al., 2010). Subsequently, the exercise is re-iterated to assess whether a service is only provided at a larger scale by a combination of landscape elements, at the larger scale of the mapped unit and finally at the scale of the restored reach. Thus, the landscape element is the lowest level unit, or the grain, of our approach, and for each type of landscape element a list of potentially provided services is drawn up (Annexe 1 and table 4). Together this should provide a cumulative estimate of the value of the services delivered by a stretch of river and adjacent valley floor, which can be broken down to service or habitat type if required. The contribution of different services to Total Economic Value will probably differ greatly among restored and not-restored reaches, but also among regions within Europe (e.g. Thorp et al., 2010; Maes et al., 2012; Martin-Lopez et al., 2012).

We structure the framework as a series of subsequent questions:

1. Delineate the study and reference (or restored and not restored) reach as a series of CORINE-type land surfaces and list the lowest level landscape elements present in each CORINE shape identified on a detailed map of each reach.
2. For each landscape element, list the potentially provided services, their quantity, rate or flux in biogeochemical or physical units (e.g. kg ha^{-1} y^{-1}, m^3 y^{-1}, or similar); Follow the guidance provided below in table 3.
3. Subsequently define the beneficiary, which sector, stratum, enterprise, public body or individual benefits from this service? Also identify the location of the beneficiaries and evaluate the importance of distance: is distance decay relevant? Several potential services may not be used hence have no beneficiary.
4. Then for each service decide at which scale it is provided: landscape element, CORINE shape, or full reach. Define in which terms the benefit accrues to the beneficiary. Aggregate to the appropriate scale, and quantify the final service in biophysical units per unit area of the study reach.
5. Define the economic valuation method, and estimate the potential range from a benefit transfer function available in the literature (see section 6 below). This will be used as reference value to be tested against the outcome of a primary valuation study in the field for selected ecosystem services.
6. Design and pre-test the primary valuation study. Maintain focus on the contrast of restored and not restored reaches
7. Carry out the valuation study using an internet panel or face-to-face interviews, ensuring that different beneficiary categories are well represented.
8. Estimate the value assigned to each final service from the valuation study and aggregate these per landscape element and reach.
9. Carry out a comparative analysis across surveyed rivers.

Landscape elements have been defined using the coarse CORINE CLC typology for both the river channel and the valley floor keeping in mind that respondents in economic surveys will have to be able to identify these elements rather than experts (Table 4). Together, the landscape elements form the landscape of the reach or segment under study. Prevalence of landscape elements may differ greatly between reaches within a type (proportion of woodland, ponds and backwaters) and also among the river types identified in REFORM.

Table 4. List of ecosystem services provided potentially by each distinguished landscape element. Where possible a quantitative range is provided with the supporting literature. Note that monetary values are to be interpreted with caution. Corine CLC codes and corresponding more detailed EUNIS habitat types are given in Annexe 1.

landscape element (CLC code)	provisioning services	regulating services	cultural services
standing water (512)	fish yield (food; marketed yield and price, generated income; generally minor in Europe; a)	water for aquifer infiltration for crops, drinking water and cattle ($m^3\ ha^{-1}\ yr^{-1}$; bank infiltration in Germany: 16% of 5x10^9 $m^3\ y^{-1}$ drinking water, corresponds to 78833 $m^3\ km^{-1}\ y^{-1}$, or 134000 euro $km^{-1}\ y^{-1}$ at 2003 tap sale price; but percentage water derived from bank infiltration varies from 0 to 60%; b)	recreative fishing (permits issued per stretch of river per year). Revenue in UK was 12x10^6 GBP y^{-1} for 42123 km of river in 1995, this corresponds to 285 GBP km^{-1}. (c, d)
		sedimentation during flooding (124-190 ton dry sediment $ha^{-1}\ y^{-1}$; e); improves downstream water quality, enhances floodplain fertility	recreative hunting: ducks, geese, other water fowl (permits)
		nutrient retention: P generally attached to particulate matter, N dissolved as nitrate, this affects mechanisms dominating retention (e); ~260 kg P and 600 kg N $ha^{-1}\ yr^{-1}$	
running water (511)	water for crop irrigation and cattle watering; as for standing water	water for aquifer infiltration ; as for standing water	recreative fishing; as for standing water, but salmon and trout fishing in fast flowing water is possibly valued higher; that angling in standing ponds
		water quality improvement (self purification capacity, BOD: Streeter-Phelps; instream nutrient retention: 10.4 kg N ± 1.6 and 0.6 ± 0.1 kg P ha (streambed) $^{-1}\ y^{-1}$; f)	recreative kayaking, yachting (permits, number of trips, generated income)
			recreation: scenery and rich biodiversity
bare sediment (331), mud,sand banks, gravel bars	construction material: gravel, sand and clay mining; (g)	sources of downstream sediment load, temporary storage of sediment,	sun-bathing on sand banks; also habitat for specific lotic fauna: spawning grounds for trout and salmon
littoral zone, marshes, reed beds (411)	natural fibers for thatching, baskets, fish traps	sedimentation during flooding: ~55 ton dry sediment $ha^{-1}\ y^{-1}$ (e)	recreation: scenery and rich biodiversity, the latter if together with open water
	biofuel, possibly	nutrient retention during flooding: 210-240 kg N and 90-100 kg P $ha^{-1}\ y^{-1}$; during base flow these zones can retain N and P entering with groundwater from adjacent higher grounds (e)	
wet, mesic and dry grasslands (231); including tall forb stands on flood marks	forage for cattle	sedimentation during flooding: 10-30 (up to 160) ton dry sediment $ha^{-1}\ y^{-1}$ (e)	recreation: scenery and rich biodiversity
		nutrient retention during flooding: 40-120 kg N and 20-40 kg P $ha^{-1}\ y^{-1}$; during base flow these zones can retain N and P entering with groundwater from adjacent higher grounds (e)	recreative hunting: hare, geese
willow scrub and carr (324)	stems and branches for baskets, brooms, tools and shore defense biofuel, possibly	sedimentation during flooding; possibly similar to reed beds (e)	recreation: scenery and rich biodiveristy, in combination with other landscape elements
		nutrient retention, unknown, possibly similar to reed beds (e) carbon sequestration (via NPP and carbon credits, h)	
woodland (311), soft and hardwood riparian forests	timber and fuelwood	sedimentation during flooding: 20-120 ton dry sediment $ha^{-1}\ y^{-1}$ (e)	recreation: scenery and rich biodiversity, in combination with other landscape elements
	forage for cattle	nutrient retention during flooding: 40-110 kg N and 15-50 kg P $ha^{-1}\ y^{-1}$; during base flow these zones can retain N and P entering with groundwater from adjacent higher grounds (e)	cultural heritage, often the landscape at large
		net carbon sequestration: 1-3 ton C $ha^{-1}\ y^{-1}$, this is NPP which can be monetised using carbon credits; carbon buried belowground in soil and sediment is ignored so far (h)	

references: (a) Gorski et al., (2011) and EIFAC (2010); (b) Schmidt et al., (2003) and Wackerbauer (2009); (c) EIFAC 1996; (d) Brown et al., 2012); (e) He and Walling, (1996); Craft and Casey, (2000); Owens and Walling (2006), Olde Venterink et al., (2006); Hoffmann and Baatrup-Pedersen, (2007); Piegay et al., (2008); Vermaat et al., (2009) (f) Cox, 2003; De Klein and Koelmans, 2011; (g) e.g. Marchetti, (2002); (h) Nabuurs and Schelhaas, (2002); Derwisch et al., 2009)

6. Economic methodology

The analytical framework for valuing the ecosystem services provided by river corridors presented in section 3 relies on an economic valuation methodology to put a monetary value on these services. The key to this valuation is to determine which services are final services, i.e. contributing to welfare. Subsequently, changes in welfare are related to changes in the underlying final services which creates a link between the physical flow of ecosystem services and the level of welfare enjoyed by society. As we adopt an economic methodology to assess changes in welfare, the only relevant criterion for determining welfare is given by individual's preferences. That is, changes in welfare are measured by the perceived (changes in) value of final services to human beings.

Value is a multi-facetted concept because final services can affect welfare in many ways. The standard taxonomy of value is given by the concept of Total Economic Value (TEV) which consists of two main categories: use value and non-use value (e.g. Pearce and Turner, 1990; Hanley and Spash, 1993; Figure 5).

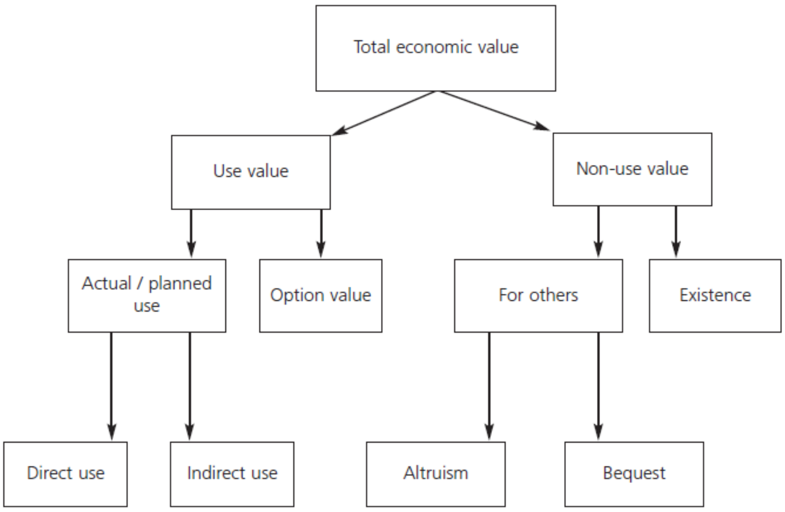

Figure 5. Taxonomy of total economic value (TEV, from DEFRA, 2007).

Use value is the value attached to the current, future, or potential use of the function or service. It comprises direct and indirect use value and a category of values called option (and quasi-option) value. Direct use value refers to the value of current and expected future use of final services, such as the value of recreational fishing. Indirect use value refers to the indirect use of ecosystems, which occurs mainly through the positive externalities that ecosystems provide (Munasinghe and Schwab, 1993), such as flood protection by aquatic ecosystems. Option value (and quasi-option) value relates to uncertainty. Given that individuals are uncertain about their future use of ecosystem services, they attach value to having the option to use those services in the future. Non-use value is the value that society assigns to the pure existence of an ecosystem, independent of the use of its services. Non-use value comprises existence, bequest, and altruistic value. Existence value is based purely on knowing that the ecosystem exists or mere existence itself, regardless of use by others. Bequest value refers to the value of knowing that the ecosystem may provide value to future generations. Altruistic value refers to the value of knowing that the ecosystem may provide value to others within the current generation.

It is important to realise that, in using the concept of TEV, a value is attached to the ecosystem as a bundle of final services provided by the ecosystem, and not to the ecosystem itself. The aggregation of all values of a river corridor, following the composition of TEV in Figure 5, provides the TEV of that corridor.

Table 5. matching the MEA ecosystem service typology to categories of TEV.

MEA service	Direct use	Indirect use	Option value	Non-use value
provisioning	x		x	
regulating		x	x	
cultural	x		x	x
supporting	No final service, hence valued through the other categories			

The next step is to link specific final services provided by the river corridor to the various components of the TEV. This is done at the level of service categories in Table 5. All categories of final services provide option values because each service may be used at a later moment in time, although this is uncertain right now. Direct use values can be assigned to the category of provisioning services such as the supply of freshwater and fish. Indirect use values are typically assigned to the category of regulating services because these are not enjoyed directly but do affect individuals' welfare. Non-use values are typically assigned to the category of cultural services.

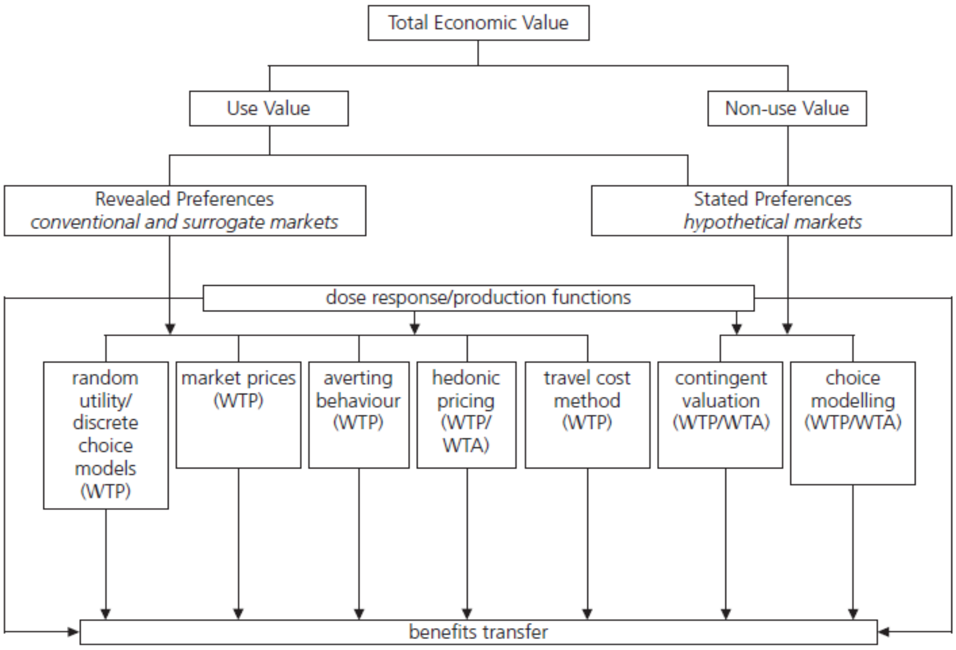

Figure 6. Valuation methodologies linked to TEV categories (from DEFRA, 2007).

Several caveats apply (see e.g. Brouwer et al., 2009), of which only a few are listed here. First, valuation of ecosystem services according to categories of services and various value components is prone to errors. The classification of TEV in various value components may easily lead to double counting of values. Similarly, the classification of final services may also lead to double counting, especially when two final services jointly affect one value component. Second, not all services can be easily valued. The ability to put a value on river corridors is constrained by the complexity of the aquatic ecosystem and its complex relation to welfare enjoyed by society. Third, valuation is usually done `at the margin', which implies that larger changes in the provisioning level of services are very difficult to value. To elaborate on this last point, note that economic valuation exercises cannot, generally, measure the TEV itself, because most ecosystem services can only be reasonably valued at the margin. That is, only the value of small changes in the flow of ecosystem services can be valued. This marginal value gives little to no information on the total value of the ecosystem service, since marginal values may, e.g. decrease, potentially in a non-linear way, when the flow of the service increases.

The various techniques presented here include the estimation of demand curves and the area beneath them, analysis of market-like transactions, use of production approaches that consider the contribution of water resources to the production process, estimation of the costs of providing alternative sources of water, as well other techniques used to estimate environmental resources more generally. The methods and techniques reflect the extent to which the goods and services provided by aquatic ecosystems touch on the welfare of society either as direct determinants of individuals‟ well-being (e.g. as consumer goods) or via production processes (e.g. as intermediate goods).

A range of methods to value specific ecosystem services, or monetary valuation methods, exists (Figure 6). Depending on the exact final service, these methods make use of revealed (or observed) preferences or stated preferences, where the preferences refer to the value that individuals attach to the service. Ideally, services are valued through revealed preferences since revealed behaviour gives an objective estimate of individual’s valuation. Nevertheless, observation of revealed preferences requires that there exists a market for the service that is to be valued (in case of direct use values) or a surrogate market for other goods or services that it affects (in case of indirect use values). Very often, such markets do not exist, so that one has to rely on methods that elicit stated preferences.

Table 6. Valuation methods that can be used for different ecosystem services (from DEFRA, 2007 and Brouwer et al, 2009).

Valuation method	Element of TEV captured	Service valued	Benefits of approach	Limitations of approach
Market prices	Direct and indirect use	Provisionary (wood, food, materials)	Data available and robust	Limited to existing markets
Cost-based	Direct and indirect use	Regulating; Depends on the presence of a market, man-made defences can be used as proxy for wetland storm protection and something similar holds for water quality	Market data are fairly robust when available	Overestimation possible
Production function	Indirect use	Regulating; Through input to market products, e.g. effect of clean water on agricultural or forestry production	Market data are fairly robust when available	Data on the link between change in service and reduced production often hard to estimate
Hedonic pricing	Direct and indirect use	All services that contribute to amenity of a landscape setting that is appreciated by real estate buyers	Market data are fairly robust and sufficiently available	Data intensive, only services that can be related to real estate property
Travel cost (TCM)	Direct and indirect use	Cultural and other linked to recreational services	Based on empirical data of human behaviour	Generally limited to recreation; multiple destinations may create complications
Random utility	Direct and indirect use	recreation	Observed behaviour	Use values
Contingent valuation (CV)	Use and non-use	All services	Use and non-use	Market is hypothetical, questionnaire responses may be biased, labour intensive
Choice modelling	Use and non-use	All services	Use and non use	Like CV

Three examples show the variety of valuation methods (see Figure 6 and Table 6). First, to value the provisioning of swimming opportunities at a river beach, the surrogate market is that people incur travelling costs and spend time to visit the beach and go swimming. The travel cost method can be used to estimate the value of this final service. Second, to value the provisioning of water supply for the production process of an industrial facility, the value of water in the production function can be estimated by simulating changes in production with lower water input in order to estimate the plant's demand function for water. Third, to value the provisioning of aesthetic values of a river corridor (e.g. a natural meandering river), a choice experiment can be implemented which elicits individual's value of this service by comparing their willingness to pay higher or lower water taxes in with changes in various aesthetic attributes of the river corridor. An example of a choice experiment design is provided in Annexe 4.

A number of criteria is important in choosing between valuation methods, including the type of services that is to be valued, the type of value that is to be estimated, the purpose of valuation, data availability, and required accuracy of the estimated value in relation to resource and time requirements. One possibility is to use existing value estimates from previous studies using so-called benefits transfer. This method applies earlier results to the new setting so that a new original valuation exercise can be skipped. For some services and relatively similar settings, such benefit transfer can be done with relatively small errors, while for other services this is more difficult.

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8. Annexes

Annexe 1. Long list of ecosystem services potentially provided by river corridors

	service, following the CICES classification (Table 2)	abiotic and biotic conditions necessary	possible in river type? Out of 21 types in tables 6.2 of D2.1 *	delivered in near natural or modified river corridor?	provided at what scale? Reach-segment-landscape (R-S-L; 1-10 km, 10-100 km2, > 100 km2; table 1)	beneficiary in society
	provisioning					
1	drinking water	minimum flow, alluvial floodplain	4-21	neutral	R	drinking water company
2	irrigation water	minimum flow, alluvial floodplain, fine sediments (gravel and finer)	7-21	modified	R	farmer
3	crops, vegetables, fruits, honey	minimum flow, alluvial floodplain, fine sediments (gravel and finer)	7-21	modified	R	farmer
4	dairy, meat	minimum flow, alluvial floodplain, fine sediments (gravel and finer)	7-21	modified	R	farmer
5	hay, fodder	minimum flow, alluvial floodplain, fine sediments (gravel and finer)	7-21	modified	R	farmer
6	fish	minimum flow, connected river network that allows fish movement, sufficient water quality	4-21	see conditions, can be modified	RSL	owner fishing rights, commercial fishermen
7	game	rural landscape, low settlement density, sufficient cover	1-21	see conditions, can be modified	R	land-owner, hunting association
8	construction wood	woodland of sufficient age and extent, trees of construction quality	4-21	modified	R	land-owner, forester

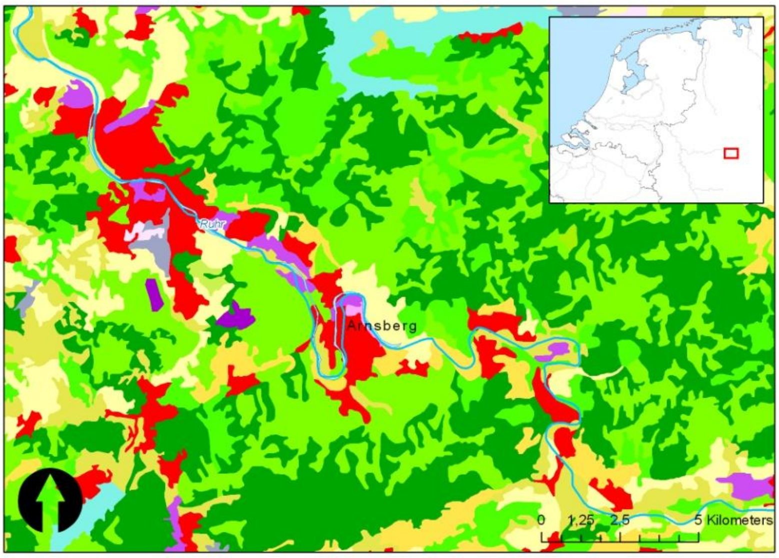
	service, following the CICES classification (Table 2)	abiotic and biotic conditions necessary	possible in river type? Out of 21 types in tables 6.2 of D2.1 *	delivered in near natural or modified river corridor?	provided at what scale? Reach-segment-landscape (R-S-L; 1-10 km, 10-100 km2, > 100 km2; table 1)	beneficiary in society
9	biofuel, fuelwood	woodland of sufficient extent, fast-growing trees	4-21	modified	RS	landowner, energy company, global society (carbon-sequestration)
10	construction clay, sand and gravel	alluvial floodplain with deposits of sufficient extent and depth	4-21	modified, will greatly modify the remaining floodplain	RS	land-owner, mining company
11	hydropower	sufficient gradient (> Xdegrees), hydromorphological constructions	1-13	heavily modified	SL	energy company, global society (C sequestration)
12	boatable navigation network for transport of raw material and manufactured products	sufficient width and depth of river channel	0, 14-21	heavily modified	L	transport company delivering the goods, economic sectors requiring these goods
	regulating					
13	flow regulation to prevent downstream flooding	floodplain requires sufficient extent of safely floodable area	7-21		SL	downstream settlements and infrastructure
14	flow regulation to ensure navigation, or downstream transport of floating logs from forestry	probably to be seen as supporting service, hydromorphological adjustments can be major	0, 14-21		L	see provisioning service
15	flow regulation to ensure minimal upstream flow	supporting, e.g. Fish, navigation, agriculture, drinking water	4-21		RSL	see provisioning service
16	flow regulation to enable bank infiltration for drinking water	supporting	4-21		RSL	see provisioning service

	service, following the CICES classification (Table 2)	abiotic and biotic conditions necessary	possible in river type? Out of 21 types in tables 6.2 of D2.1 *	delivered in near natural or modified river corridor?	provided at what scale? Reach-segment-landscape (R-S-L; 1-10 km, 10-100 km2, > 100 km2; table 1)	beneficiary in society
17	flow regulation to enable agricultural irrigation	supporting	4-21		RSL	see provisioning service
18	flow regulation to generate hydropower	supporting	1-13		SL	see provisioning service
19	sediment retention	sufficient area of floodplain available for flooding, sufficient duration of flooding	4-21	neutral, probably higher in near natural reaches	R	prevents downstream silting up and offers natural fertility for floodplain; downstream: navigation sector, in reach: agriculture
20	nutrient retention	sufficient area of floodplain available for flooding, sufficient duration of flooding; P generally particulate, hence will settle, N generally dissolved hence needs assimilation by plants and bacteria (denitrification)	4-21	neutral	R	reduces downstream eutrophication risk and offers natural fertility to floodplain; downstream: water quality management authority and drinking water, in reach: agriculture; upstream: sector responsible for the load
21	reduction organic loading from sewage (BOD); industrial or domestic	sufficient flow for dilution and reaeration to ensure bacterial degradation	4-21	neutral	RSL	polluter as well as managing auhtority of downstream receiving waters
22	reduction pollutant load (heavy metals, organic pollutants, pesticides)	sufficient flow for dilution, fine particulates for binding and settlement in floodplain and subsequent bioremediation	4-21	neutral, possibly wide floodplains are positive for extensive dilution in sedimenting matter	RSL	polluter as well as managing authority of downstream receiving waters
23	carbon sequestration	wood growth or peat accumulation	7-21	neutral	RSL	global society, notably those that suffer from global warming

	service, following the CICES classification (Table 2)	abiotic and biotic conditions necessary	possible in river type? Out of 21 types in tables 6.2 of D2.1 *	delivered in near natural or modified river corridor?	provided at what scale? Reach-segment-landscape (R-S-L; 1-10 km, 10-100 km2, > 100 km2; table 1)	beneficiary in society
24	pest and disease control	sufficient habitat area set aside for natural pest control agents in agriculture-dominated floodplains, such as hedges, patches of woodland	7-21	modified	RSL	farmers, benefitting from natural pest control; tourists enjoying a richer insect and birdlife
	cultural					
25	recreation: fishing and hunting	landscape setting and scenery should be amenable: accessibility and availability of target wildlife is critical; different type of fishingin different type of river	1-21	modified but sufficiently scenic	RS	fishing and hunting tourists, local residents, entrepreneurs, permit issueing agencies
26	recreation: rafting and kayaking	landscape scenic, sufficient slope and coarse bed material and rapids	1-13	modified but sufficiently scenic	RS	tourists, local entrepreneurs
27	recreation: sailing, jet-skiing, rowing, motorboating	landscape scenic, sufficient width and depth to allow manoevring, higher order segments or reservoirs	14-20	modified but sufficiently scenic	RS	tourists, local entrepreneurs
28	recreation: hiking, cycling, bird watching	landscape scenic, sufficently diverse floodplain	1-21	modified but sufficiently scenic	RS	tourists, local residents and entrepreneurs
29	recreation: swimming and sunbathing, camping	floodplain, bank and stream with pools and beaches or sandbanks	1-21	modified but sufficiently scenic	RS	tourists, local entrepreneurs
30	conservation for aesthetic, heritage or biodiversity protection	scenic or characteristic landscape, legal status	any	near natural or modified	RS	public at large, future generations

* river types 1-3 are on bedrock and colluvial channels; 4-6 are alluvial single thread on coarse bed material, 7-13 are gravel bed rivers from sinuous via meandering and braided to anabranching, 14-18 are sand bed rivers similarly varying in morphology , and 19-21 are fine sediment cohesive alluvial sediments; 0 = entirely artificial.

Annexe 2 CORINE 2006 image of the river Ruhr and its vicinity upstream of Arnsberg (Germany)



Annexe 3. Correspondence of EUNIS habitat classification with the CORINE Land Cover 2006 typology (source: EEA)

EUNIS-coding of habitat types present in central European floodplains (based on Davies et al. 2004) with corresponding CORINE CLC code. Where needed different levels in the hierarchy are presented. Note that in-channel habitat is incorporated as a mosaic of sub-habitats in either turbulent or smooth flowing river types. see also: http://bd.eionet.europa.eu/

EUNIS CODE	name	sub-units	description	CORINE CLC class
C1	Surface standing waters		Lakes, ponds and pools of natural origin containing fresh (i.e. nonsaline), brackish or salt water. Manmade freshwater bodies, including artificially created lakes, reservoirs and canals, provided that they contain seminatural aquatic communities.	512
		C1.3	Permanent eutrophic lakes, ponds and pools, rich in nutrients, often pH>7	512
		C1.6	Temporary lakes, ponds and pools	512
C2	surface running waters	C2.2	Permanent water courses with fast-flowing turbulent water and their associated animal and microscopic algal pelagic and benthic communities. Rivers, streams, brooks, rivulets, rills, torrents, waterfalls, cascades and rapids are included. The bed is typically composed of rocks, stones or gravel with only occasional sandy and silty patches. Features of the river bed, uncovered by low water or permanently emerging, such as gravel or rock islands and bars are treated as the littoral zone (C3). Includes high, mid and low-altitude, usually small to medium-sized streams as defined by the Water Framework Directive.	511
		C2.3	Permanent water courses with non-turbulent water and their associated animal and microscopic algal pelagic and benthic communities. Slow-flowing rivers, streams, brooks, rivulets and rills; also fast-flowing rivers with laminar flow. The bed is typically composed of sand or mud. Features of the river bed, uncovered by low water or permanently emerging, such as sand or mud islands and bars are treated as the littoral zone (C3). Includes mid and low-altitude streams as defined by the Water Framework Directive.	511
C3	littoral zone		shallow water with fringing, emergent vegetation that is periodically inundated	411
		C3.1	Species-rich helophyte beds	411
		C3.2	Water-fringing reedbeds and tall helophytes other than canes	411

EUNIS CODE	name	sub-units	description	CORINE CLC class
		C3.4	Species-poor beds of low-growing water-fringing or amphibious vegetation	411
D2	valley and transition mires, poor fens (peat formation below water table, acid)		Weakly to strongly acid peatlands, flushes and vegetated rafts formed in situations where they receive water from the surrounding landscape or are intermediate between land and water. Included are quaking bogs and vegetated non-calcareous springs. Excluded are calcareous fens (D4), and reedbeds (C3, D5).	411
D4	base-rich fens and calcareous spring mires		At the contact zone with higher grounds at the edge of the floodplain; 'Peatlands, flushes and vegetated springs with calcareous or eutrophic ground water, within river valleys, alluvial plains, or on hillsides. As in poor fens, the water level is at or near the surface of the substratum and peat formation depends on a permanently high watertable. Excluded are reedbeds (C3, D5).	411
D5	sedge and reed beds without standing water		transition to C3; 'Sedge and reedbeds forming terrestrial mire habitats, not closely associated with open water. Excluded are reedbeds and sedges where they form emergent or fringing vegetation beside water bodies (C3.2).	411
E1	dry grasslands		Well-drained or dry lands dominated by grass or herbs, mostly not fertilized and with low productivity. Included are [Artemisia] steppes. Excluded are dry mediterranean lands with shrubs of other genera where the shrub cover exceeds 10%; these are listed as garrigue (F6).	231
E2	mesic grasslands		Lowland and montane mesotrophic and eutrophic pastures and hay meadows of the boreal, nemoral, warm-temperate humid and mediterranean zones. They are generally more fertile than dry grasslands (E1), and include sports fields and agriculturally improved and reseeded pastures.	231
E3	seasonally wet and wet grasslands		Unimproved or lightly improved wet meadows and tall herb communities of the boreal, nemoral, warm-temperate humid, steppic and mediterranean zones.	231
E5	woodland fringes and tall forb stands		Stands of tall herbs or ferns, occuring on disused urban or agricultural land, by watercourses, at the edge of woods, or invading pastures. Stands of shorter herbs forming a distinct zone (seam) at the edge of woods.	231
F9	riverine and fen scrubs, carr		Riversides, lakesides, fens and marshy floodplains dominated by woody vegetation less than 5 m high.	324
		F9.1	Scrub of broad-leaved willows, e.g. [Salix aurita], [Salix cinerea], [Salix pentandra], beside rivers. Scrub of [Alnus] spp. and narrow-leaved willows, e.g. [Salix elaeagnos], where these are less than 5 m tall. Riverside scrub of [Hippophae rhamnoides] and [Myricaria germanica]. Excludes riversides dominated by taller narrow-leaved willows [Salix alba], [Salix purpurea], [Salix viminalis] (G1.1).	324

EUNIS CODE	name	sub-units	description	CORINE CLC class
		F9.2	Low woods and scrubs colonizing fens, marshy floodplains and fringes of lakes and ponds, dominated by large or medium sized shrubby willows, generally [Salix aurita], [Salix cinerea], [Salix atrocinerea], [Salix pentandra], alone or in association with [Frangula alnus], [Rhamnus catharticus], [Alnus glutinosa] or [Betula pubescens], any of which may dominate the upper canopy. In boreal regions and on cold subboreal plateaux, small shrubs may dominate, e.g. dwarf [Salix] spp. associated with [Betula humilis] or [Betula nana]. Excludes boreal and subalpine lakeside scrub on well drained soils (F2).	324
G1	woodland (10% crown cover)		Woodland, forest and plantations dominated by summer-green non-coniferous trees that lose their leaves in winter. Includes woodland with mixed evergreen and deciduous broadleaved trees, provided that the deciduous cover exceeds that of evergreens. Excludes mixed forests (G4) where the proportion of conifers exceeds 25%.	311
		G1.1	Riparian and gallery woodland, with dominant [Alnus], [Betula], [Populus] or [Salix] Includes woods dominated by narrow-leaved willows [Salix alba], [Salix elaeagnos], [Salix purpurea], [Salix viminalis] in all zones including the mediterranean. Excludes riverine scrub of broad-leaved willows, e.g. [Salix aurita], [Salix cinerea], [Salix pentandra] (F9.1).	311
		G1.2	Mixed riparian forests, sometimes structurally complex and species-rich, of floodplains and of galleries beside slow- and fast-flowing rivers of the nemoral, boreo-nemoral, steppe and submediterranean zones. Gallery woods with [Acer], [Fraxinus], [Prunus] or [Ulmus], together with species listed for G1.1. Floodplain woodland characterized by mixtures of [Alnus], [Fraxinus], [Populus], [Quercus], [Ulmus], [Salix].	311

Annexe 4. Generic Design Economic Survey (Roy Brouwer)

- Two visitor models will be estimated, with and without monetary entrance fees.
- Choice behaviour will be modelled as a function of site characteristics (see figure below: length of river restored, water quality, recreational activities, invloed op downstream flood probability), distance between site of residence and river stretch, and respondent characteristics. Respondents should have the option to prefer a non-restored reac, this allow assessing the utility value of restoration, next to marginal utility linked to specific characteristics.
- Underlying is a RUM (random utility model)
- Statistical approach is a Universal Multinomial Logit model allowing for an explicit assessment of substitution-elasticities