Valuing Environmental Impacts: Practical Guidelines for the Use of Value Transfer in Policy and Project Appraisal

Case Study 3 – Valuing Environmental Benefits of a Flood Risk Management Scheme

Submitted to

Department for Environment, Food and Rural Affairs

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CASE STUDY 3: VALUING ENVIRONMENTAL BENEFITS OF A FLOOD RISK MANAGEMENT SCHEME

- *Case Study 3 focuses on valuing environmental benefits associated with the creation and restoration of wetland areas and moorland as part of the Lower Derwent Flood Risk Management Strategy Project.*
- *It demonstrates the use of a meta-analysis function (Step 5) that accounts for: wetland type; wetland size; provision of ecosystem services; the size of the affected population; socio-economic characteristics of the affected population; and the availability of substitute wetland sites.*
- *The ecosystem services framework is used to define the policy good (Step 2).*
- *The case study highlights the types of data that need to be collected (Step 2) to undertake value transfer via a meta-analysis function and the iterative process involved between Steps 2 through to 5 in doing so (see Appendix to Case Study 3).*

STEP 1: ESTABLISH THE POLICY GOOD DECISION-CONTEXT

The River Derwent (Derbyshire) is a tributary of the River Trent. Much of the Derwent flows through the Peak District and joins the Trent south of Derby. Most existing flood defences on the Derwent are in the Derby area. These defences are reaching the end of their design life, which is leading to a lower standard of protection in some areas of the river catchment. In turn this implies an increasing flood risk in the absence of further intervention.

The Lower Derwent Flood Risk Management Strategy (LDFRMS) (Environment Agency, 2008a) establishes the ‘preferred option’ for managing future flood risk in the Derwent Catchment. This consists of a selection of interventions to increase water storage capacity in the catchment through the creation and restoration of different wetland and upland habitats along with more traditional hard defences (e.g. embankments). The habitat creation and restoration components also contribute to Biodiversity Action Plan (BAP) objectives.

The general guidance for appraising flood risk management schemes requires that environmental impacts be valued where possible (Defra, 2000; FHRC, 2005). Time and resources required for a primary valuation study are rarely available and value transfer is typically the ‘default option’. Specific guidance for valuing environmental effects of flood risk management schemes (eftec, 2007) recommends that the use of value transfer be based on the best available evidence, and that the level of effort and detail of analysis reflect the status of scheme planning. In particular initial optioneering and feasibility assessments can accommodate a lower degree of precision in the analysis than the appraisal of a preferred option. This provides the basis for demonstrating the use of results from a meta-analysis study (see **Box 1** below) in this example, where a relatively high degree of effort is involved in collating data and estimating the value of environmental benefits of the proposed scheme.

STEP 2: DEFINE THE POLICY GOOD AND AFFECTED POPULATION

What is the good to be valued?

The policy good is broadly defined as the environmental benefits associated with the creation and restoration of wetland and upland habitats for the purposes of increasing water storage in the River Derwent catchment. The specific management options for the LDFRMS are:

- Flood storage via habitat creation and restoration;
- Sustainable urban drainage systems (SUDS) including creation of wetlands and drainage channels; and
- Improvement of recreational facilities and access along the Derwent.

The two habitat types affected are:

- Inland marsh (wetland) (through the LDFRMS): this is typically inundated pasture, or meadow with ditches that maintain water levels, containing standing fresh water; and
- Upland moorland, including peat and blanket bogs (through the Moors for the Future Project, MFP, 2005): this is mostly open land with peaty soils covered with heather, bracken and moss. This change is valuable but not covered in this case study, given its focus on illustrating the use of meta-analysis.

Figure 1 shows the location of the Peak District and habitat creation aspects of the LDFRMS.

Figure 1: Case study location: Peak District and Lower Derwent Flood Risk Management Strategy

Map source: 'Large Map of England' (http://www.itraveluk.co.uk/maps/england.html)
Notes: The circle shows the boundaries within which it is expected that the affected population will have positive willingness to pay for the relevant improvements (based on the value function used in Step 5).

Ecosystem services framework

The policy good features a complex set of environmental attributes from which a range of market and non-market goods and services derive. To identify the final services to human populations and the use and non-use values these attract the ecosystem services framework (see Step 3 in the main guidelines document and Defra (2007)) is applied. The assessment for the wetland habitat alone is presented in **Table 1**. This basic table template links ecosystem services, final goods and services, the type of economic value generated and the relevant population (for the final service). Tracing from ecosystem services to final goods and services and the affected population reduces the potential for double-counting of the benefits.

From **Table 1**, wetland habitat is associated with a variety of market (e.g. agriculture) and non-market outcomes. The latter includes consumptive (e.g. fishing) and non-consumptive direct use values (general environmental amenity and recreation) as well indirect use values, such as flood protection (the primary objective of the LDFRMS), water quality improvements and potential carbon sequestration (though this will depend on the rate of carbon storage compared to emissions of methane). Non-use values are also potentially relevant, particularly in relation to biodiversity maintenance.

Who is the affected population?

In general the policy good relates to local and regional user populations in terms of the final benefits identified in Table 1. The primary indirect user population are households in the Derwent catchment that benefit from flood risk reductions arising from increased flood storage capacity. In addition, local residents may also benefit from general improved environmental and recreation amenity. This may consist of both users and non-users. Specialist user populations (anglers, birdwatchers, etc.) may also be relevant.

Overall there are several potential boundaries that can be applied for the affected population:

- The regional population; this is likely to exceed the scale of the user population benefiting from flood protection and other environmental and amenity values (except carbon sequestration); i.e. residents of Derby and populated areas along the Derwent;
- The area at risk of flooding; this would be indicated by detailed flood risk modelling of the catchment; and
- The boundary required by the meta-analysis function applied to estimate the value of environmental benefits (see **Box 3**, **Step 5**).

Supporting data

As detailed in Step 5, the meta-analysis function applied here requires data to be collated on the affected population, their socio-economic characteristics and the availability of substitute wetland sites. In practice these data are collated via an iterative process involving Steps 2-5; as summarised in the **Appendix to Case Study 3**, which sets out the data collection efforts and sources of information used.

Table 1: Final ecosystems services of wetland habitat to be created near Derby (Lower Derwent catchment)				
Ecosystem service	**Contributing ecosystem functions**	**Final goods and services**	**TEV**	**Population**
Food	Primary production, habitat provision, nutrient cycling, water quality	Livestock grazing	DU	Local
		Value of recreational fish catch	DU	Local
Water	Cycling processes, water quality	Water for cooling in commercial factories	DU	Local
		Water for agriculture	DU	Local
	Bioremediation of waste, nutrient cycling	Waste disposal, (inc. detoxification of water & sediment)	IU	Local
Climate and regulation	Cycling processes, soil formation and retention	C sequestration	IU/NU	Global
Water regulation	Soil formation and retention	Flood protection	IU	Local/Regional
Water purification	Cycling processes, Soil formation & retention	Drinking water quality & quantity	IU	Local/Regional
Cultural and heritage	Soil formation and retention	Heritage / archaeological value	DU/NU	Local/Regional/National
Recreational values	Primary production, habitat provision, nutrient cycling, water quality, landscape, biodiversity.	Freshwater angling (migratory)	DU	Local visitors and specialist
		Freshwater angling (coarse)	DU	Local visitors and specialist
		Other wildlife recreation	DU	Local visitors and specialist
Landscape	Primary production, habitat provision, landscape, biodiversity	Landscape (amenity to local residents)	DU	Local
Habitat provision	Primary production, habitat provision, landscape, biodiversity	Biodiversity	NU	Local/Regional/National

Notes: TEV = component of total economic value; DU = direct use value; IU = indirect use value; NU = non-use value.

STEP 3: DEFINE AND QUANTIFY THE CHANGE IN THE PROVISION OF THE POLICY GOOD

The change in the provision of the policy good (wetlands only) is set out in **Table 2**.

Table 3: Measures to be implemented as part of the Lower Derwent Flood Risk Management Strategy and the Moors for the Future Project

Measure	*Location*	*Habitat type*	*Quantity (ha)*
Flood storage - habitat creation	Duffield & Little Eaton, S. Derbyshire	Flood plain grazing marsh (BAP habitat)	29.2
	Derby	Creation of wildflower meadow (BAP habitat)	0.6
		Creation of wetland habitat (SUDs)	2.4
	Mercaston & Markeaton Brook	Creation of wetland habitat (BAP habitat)	2.8
Flood storage - restoration of habitat	Duffield & Little Eaton, Derby	Floodplain grazing marsh and woodland (BAP habitat)	7.49
Improve planting and landscaping of Bass recreation field	Derby	N/A: amenity land	6.6
Creation of a city wildlife corridor	Derby	Information not available	1.59
Enhancing river edge, fish passage	Duffield and across the areas listed above	N/A	2.8
Improve recreational facilities, existing footpaths/cycle paths etc.	Duffield and across the areas listed above	N/A	N/A

Source: Environment Agency (2008a)
Notes: LDFRMS = Lower Derwent Flood Risk Management Strategy; BAP = Biodiversity Action Plan; SUDs = Sustainable urban drainage scheme.

Table 2 indicates that LDMRS measures can be divided into two categories:

1. Habitat creation (inland marsh): consisting of flood grazing marsh (29.2 ha), non-classified wetland (5.2 ha) and wildflower meadow (0.6 ha).
2. Habitat restoration (inland marsh): floodplain grazing marsh and woodland (7.49 ha).

Following eftec (2007), the area of habitat is taken as a proxy for the ecosystem services derived from the habitat types (as detailed for wetlands in Table 1 and 2). Hence in basic terms, habitat creation implies an increase in the quantity (and quality) of ecosystem service provision in an area; habitat restoration implies an improvement in the quality of ecosystem services in an area.

Other measures – planting and landscaping, wildlife corridor, fish passage and recreation facilities – are additional to these changes but are not considered further in the analysis given the relatively small effects entailed. In addition no scientific evidence was available as to the carbon sequestration potential of (1) and (2) above.

STEP 4: IDENTIFY AND SELECT MONETARY VALUATION EVIDENCE

Potentially relevant studies

A number of studies have estimated economic values associated with the ecosystem services provided by wetlands and riverine floodplains including a series of meta-analysis (see **Box 1**)[1]. These studies are summarised in **Table 3**.

Box 1: Meta-analysis studies

Meta-analysis is defined as "the statistical evaluation of summary findings of empirical studies, helping to extract information from large masses of data in order to quantify a more comprehensive assessment" (Brouwer et al, 1999; p48). Essentially, meta-analyses collate information from multiple studies and provide a quantitative synthesis of existing literature. In the context of economic valuation, this enables the investigation of the range of economic value estimates from the same or similar good from different studies, producing summary statistics such as mean value, median value, confidence intervals etc., as well as identifying the key factors that influence estimated economic values via a meta-analysis function.

A **meta-analysis function** relates economic value estimates (the 'dependent variable') from various studies to explanatory variables, such as wetland type, size, provision of ecosystem services, socio-economic characteristics of the affected populations, availability of substitutes etc. as well as study characteristics and methodology.

A typical meta-analysis function can be expressed as (see Brander et al, 2008):

$$v_i = \alpha + \beta_S X_{Si} + \beta_W X_{Wi} + \beta_C X_{Ci} + u_i$$

Where:

- The index *i* relates to observations of economic value estimates in the sample (i.e. n = 1,…, *i*).
- The *β*s correspond to vectors of coefficients for the explanatory variables.
- A constant term *α* is estimated.
- A set of study characteristic variables are included in X_S: e.g. valuation method, year of publication, authors, etc.
- The characteristics of the good are included in X_W: e.g. wetland type (coastal, inland, etc.) size, ecosystem services provided, etc.
- Context variables are included in X_C; e.g. socio-economic characteristics of the affected population, availability of substitutes, etc.

A meta-analysis function that includes such a range of variables will enable the analyst to adjust economic value estimates to the policy good context. This gives direct control of the criteria for matching the study and policy good contexts as set out in Step 4 of main guidelines document.

[1] In fact Brander et al. (2006) report that the earliest wetlands valuation study was carried out in 1969. Since then almost 200 studies have been undertaken, considering a range of wetland sites, investigating methodological questions concerning the valuation of wetland ecosystem services, and comparing and reviewing findings between studies.

Selecting appropriate evidence

In general, the purpose of the meta-analysis studies reviewed in Table 3 has been to investigate various empirical questions pertaining to the valuation of wetland ecosystem services. These include the comparison of results derived by different valuation methods and for different wetland types, functions or locations. Overall the analyses have not sought to provide 'generally applicable' unit value estimates or meta-analyses functions that can be applied in practical value transfer applications. That said, these studies provide currently the best basis of available evidence and allow for control of a range of variables in estimating economic values.

The two most recent studies Brander et al. (2008) and Ghermandi et al. (2008) effectively update the WWF (2004) and Brander et al. (2006) studies, since they are based on the same dataset but the 2008 studies employ a larger set of observations. The key difference between Brander et al. (2008) and Ghermandi et al. (2008) is their coverage of the habitat types in the CORINE database[2]. The former (264 observations) estimates a meta-analysis function for a sub-sample of CORINE land cover classes only while the latter (383 observations) is based on all observations in the dataset, including wet forests, forested floodplains, estuaries and lagoons which are excluded from the CORINE dataset (and hence covering both temperate and tropical wetlands).

From the perspective of the policy good, Brander et al. (2008) provides the most appropriate match, being limited to temperate European wetlands. The meta-analysis function from that study is set out in Step 5.

Importantly, the meta-analysis function permits the estimation of the economic value of ecosystem services associated with an area of wetland (one hectare). This matches well with habitat creation (approximately 35 hectare of inland marsh) aspect of the policy good change identified in Step 3, where the assumption is that prior to the LDFRMS measures (the 'without' case) there is no provision of the wetland ecosystem services. Difficultly is encountered however with respect to the habitat restoration (approximately 7.5 hectares of inland marsh) change since no account is given for the baseline provision of ecosystem services prior to the LDFRMS measures, so it is not possible to identify the net change between the baseline and intervention case.

[2] CORINE land cover 2000 is part of the European Commission programme to COoRdinate INformation on the Environment (Corine). It provides consistent information on land cover changes during the past decade across Europe: http://dataservice.eea.europa.eu/dataservice/

Table 3: Summary of wetland meta-analysis studies

Reference	*Study good*	*Definition of the Good*	*Study good site*	*Substitutes*	*Mean WTP (currency and year of data)*	*Population*
Brouwer et al. (1999)	Fresh and salt water wetlands	Mean WTP for all wetland functions relating to freshwater wetlands	US and other developed countries	Not considered	Mean WTP for freshwater wetlands = $73.48 per hectare ($2008 – OECD) Broad meta-analysis that derives values for specific wetland functions and wetland types	n=30 studies
Woodward & Wui (2001)	Wetlands	Value of single wetland functions only	North American and European studies	Not considered	$ per hectare (2001) Mean val. Lower val. Upper val. Flood 971 220 4317 Quality 1030 311 3405 Quantity 314 12.36 6353 Rec.fish 882 235 3316 Com.fish 1922 267 13882 Birdhunt 173 61.78 487 Birdwatch 2995 1305 6874 Amenity 7.41 2.47 34.59 Habitat 756 235 2424 Storm 586 27.18 12706	n=39 studies
WWF (2004)	Fresh and salt water wetlands	Value per ha per year Freshwater marsh	Global studies	Not considered	Average value derived from studies $3.83 ($2001)	n=89 studies
Brander et al. (2006)	Fresh and salt water wetlands, mangroves Freshwater woodland Freshwater marsh	Per hectare value of wetland type	Global source of studies	Not considered	$ 2000 Freshwater woodland: Median $206 Freshwater marsh: Median $145	n=80 studies
Troy & Wilson (2006)	Fresh water wetland	Value per ha per year	US studies only	Not considered	$8474 ($2001) Lower-upper band $ 18,979 - $ 38,167	n=42 studies (USA based)
Brander et al. (2008)	Fresh and salt water wetlands, mangroves, peat bogs	Value per ha per year	Based on global studies	Considered	Mean values not reported but function is available	n = 166
Ghermaldi et al. (2008)	Fresh and salt water wetlands, mangroves, peat bogs	Value per ha per year	European wetlands	Considered	€4129 mean value per hectare. Function described by Ghermaldi can be used within a function transfer for the policy site and a per ha value derived	n=166 studies yielding 265 observations)

STEP 5: TRANSFER EVIDENCE AND ESTIMATE MONETARY VALUE

Meta-analysis function

Brander et al. (2008) provide a meta-analysis function for estimating the value of ecosystem services provided by different wetland habitats. This is estimated in 2003 US $, which needs to be converted to 2008 UK £ for value transfer here (see below).

The function permits control for spatial factors and substitutes on the basis of a 50 km boundary from the centre of the inland marsh site of interest. **Table 4** sets out the parameters of the function, providing descriptions of the explanatory variables and the estimated coefficients. In addition the table also reports estimated value of the explanatory variable in the LDFRMS policy good context (for habitat creation only) along with the data source.

Practically applying the model set out in Table 4 requires the following steps:

i). Determine which of the wetland types is applicable for the policy good (from **Step 2** above);
ii). Determine which ecosystem services are provided by the policy good (from **Step 3** above);
iii). Determine the GDP per capita for the policy good affected population (see **Box 2** below);
iv). Determine the population density within with a 50km radius, in the policy good context (see **Box 3** below); and
v). Determine the availability of substitute wetland sites within 50km from the policy good site (see **Box 4** below).

Assumptions

In applying the Brander et al. (2008) meta-analysis function, two assumptions are employed:

- Substitute wetland sites within the 50 km radius of the policy good site are limited to nature reserve and nature park sites only (see **Box 4** below); and
- The populations of the main towns and cites within 50 km of the policy good site is an appropriate proxy for the entire population in the area (see **Box 3** below).

Table 4: Economic value function for LDFRMS wetland creation (34.4Ha in the Derwent catchment)				
Variable	***Coefficient value***	***Value of explanatory variable LDFRMS policy good context***		***Data source***
	(a)	***(b)***		
Constant	-3.078	-3.078	N/A	N/A
Wetland Type A group of dummy variables relating to: Inland marshes Peatbogs Saltmarshes Intertidal mudflats	 0.114 -1.356 0.143 0.110	 1 0 0 0	Wetland created by LDFRMS is classified as inland marsh (mostly flood plain grazing marsh).	Environment Agency (2009)
A group of dummy variables relating to economic valuation method used: Contingent valuation Choice experiment Hedonic pricing Travel cost Net factor income Replacement cost Production function Opportunity cost Market prices	 0.065 0.452 -3.286 -0.974 -0.215 -0.766 -0.443 -1.889 -0.521	 0 0 0 0 0 0 0 0 0	All set to zero since the case study does not use the meta-analysis function to predict the value of an economic valuation study for the area.	N/A
Marginal or average value: Relates to the study characteristics; i.e. whether the study conducted was to find average (0) or marginal values (1) (dummy)	1.195	0	Set to zero since this provides a more conservative estimate and information of the baseline provision of ecosystem services in the policy context is limited.	N/A
ln Wetland size (in hectares): Size of wetland area created (natural log)	-0.297	*ln* 34.4	34.4 hectares of inland marsh created – see Step 3.	EA, 2008b
Flood control: Dummy variable for ecosystem service	1.102	0	Flood protection benefits are estimated separately in the LDFRMS appraisal, hence this value is set to zero to avoid double-counting in the overall decision-making context – see **Step 7**.	EA, 2008b
Surface and ground water supply: Dummy variable for ecosystem service	0.009	0	No assumption of this service provision in Table 1.	EA, 2008b

Table 4: Economic value function for LDFRMS wetland creation (continued) (34.4Ha in the Derwent catchment)				
Variable	***Coefficient value***	***Value of explanatory variable LDFRMS policy good context***		***Data source***
	(a)	***(b)***		
Water quality improvement: Dummy variable for ecosystem service	0.893	1	Water quality improvements are a likely outcome of creation of the inland marsh habitat.	EA, 2008b
Recreational fishing: Dummy variable for ecosystem service	-0.288	1	Recreational fishing opportunities are a likely outcome of creation of the inland marsh habitat.	EA, 2008b
Commercial fishing and hunting: Dummy variable for ecosystem service	-0.040	0	No assumption of this service provision in Table 1.	EA, 2008b
Recreational hunting: Dummy variable for ecosystem service	-1.289	0	No assumption of this service provision in Table 1.	EA, 2008b
Harvest of natural material: Dummy variable for ecosystem service	-0.554	0	No assumption of this service provision in Table 1.	EA, 2008b
Material for fuel: Dummy variable for ecosystem service	-1.409	0	No assumption of this service provision in Table 1.	EA, 2008b
Non-consumptive recreation: Dummy variable for ecosystem service	0.340	1	Improvements to non-consumptive recreational amenity are an explicit objective of the LDFRMS.	EA, 2008b
Amenity and aesthetic services: Dummy variable for ecosystem service	0.752	1	Improvements to amenity and aesthetics services are an explicit objective of the LDFRMS.	EA, 2008b
Biodiversity: Dummy variable for ecosystem service	0.917	1	Biodiversity is an explicit objective of the LDFRMS.	EA, 2008b
ln GDP per capita: Base currency and year = 2003 US $	0.468	*ln* 28,383	GDP per capita for the East Midlands is €24,800. This is then convert to 2003 US $ ($28,383) – see **Box 2**.	Eurostat database

Table 4: Economic value function for LDFRMS wetland creation (continued) (34.4Ha in the Derwent catchment)				
Variable	***Coefficient value***	***Value of explanatory variable LDFRMS policy good context***		***Data source***
ln Population within 50 km of the wetland site: Population density (population per km^2) An area of 50km radius from the a wetland site = 7,854km^2	0.579	*ln* 216	Population of Leicester, Derby, Nottingham, Chesterfield, Mansfield, Sheffield and Stoke-on-Trent is approximately 1.72 million. On the basis of 2,854km^2, this equates to 219 people per km^2. See **Box 3**.	ONS 2001 Census: Standard Area Statistics England and Wales
Ln Wetland area within 50 km radius of the policy site: Substitute availability (hectares of wetland)	-0.023	*ln* 264.2	Wetland sites identified within a 50km radius of policy good site total 264.2 ha: Attenborough gravel pits (146 ha) Alvecote pools (26.2 Ha) Brandon marsh (92 Ha) See **Box 4**.	Wildlife Trust See Box 4 on calculating substitute wetland areas
Summary statistics reported by Brander et al. 2008: n = 265, R^2 = 43%				

Estimating the value of ecosystem services provided by creation of inland marsh

Based on the function and data reported in Table 4, the value of **£425 per hectare per year** (2008 £) is calculated for the habitat creation (inland marsh) aspect of the policy good. This is calculated from the parameters set out Table 4, by multiplying the coefficients in column (a) with the policy good site data in column (b) and summing across all the relevant rows (only non-zero terms):

$$\$/ha/year = -3.078-(0.297 \times ln(34.4))+(0.114 \times 1)+(0.893 \times 1)-(0.288 \times 1)+(0.34 \times 1)+ (0.752 \times 1)+(0.917 \times 1)+(0.468 \times ln(28383))+(0.579 \times ln(216))-(0.023 \times ln(264.2)) = ln\ 6.383$$

The value of the dependent variable ($/ha/year) is in natural log terms. This is transformed by raising the exponential to the power of 6.383:

$$e^{6.383} = \$592 \text{ per hectare per year (2003 US \$)}$$

Using a purchasing power parity exchange rate and inflated to 2008 £ using the CPI (see Step 5 of the main guidelines document):

$592 x 0.64 = £379 converts the value 2003 £ (PPP exchange rate converision)
£379 x 1.12 = £425 converts the value to 2008 £

Comparison to average values per hectare

Based on all observations in meta-analysis, Brander et al. (2008) report a 'mean wetland value' for the UK of £3,109 per hectare per year[3]. Use of the meta-analysis function results in a per hectare value estimate that is approximately seven times less (£425/ha/yr) than the average UK value from the meta-analysis. This difference arises from explicitly controlling for the conditions of the policy good context; i.e. wetland type, size, ecosystem services provision, affected population and socio-economics characteristics.

[3] This is calculated from a reported value of $4,331 per hectare per year (2003 US $) by Brander et al. (2008). Conversion to 2008 £ follows the calculations above. The average UK value reported by Brander et al. corresponds to the summation of the total value of all UK sites divided by the number of UK sites.

Box 2: Calculating the GDP per capita (modified from Brander et al. 2008)

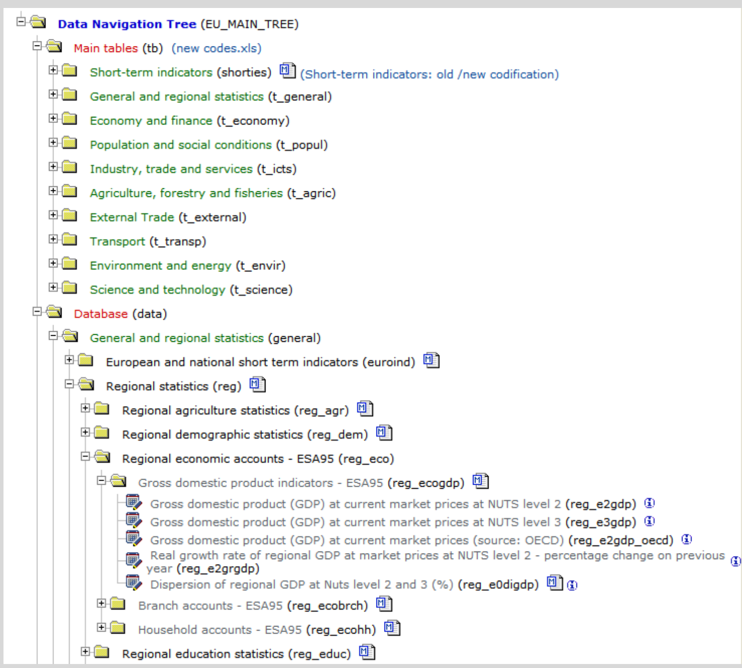
GDP per capita data used for the policy good site (Table 4) come from the NUTS data. NUTS are defined as Nomenclature of Territorial Units for Statistics (NUTS) and exist for all EU Member States, candidate countries, other EEA countries and Switzerland. They are divided into three levels, below which a further division into two local administrative units (e.g. counties, regional authorities) exists for some European Member States (EUROPA, accessed 2009).

Brander et al (2008) use data from EUROSTAT, which detail the GDP per capita in 2003 € at NUTS level 2. This income information can then be matched to lower level data e.g. administrative units available from alternative datasets; e.g. regional and local administrative areas. Within this case study, the NUTS output is used without matching it to lower administrative level as the area over which the policy good spans is relatively small and as such the EUROSTAT data can be used to provide an average measure of income for the area as a whole.

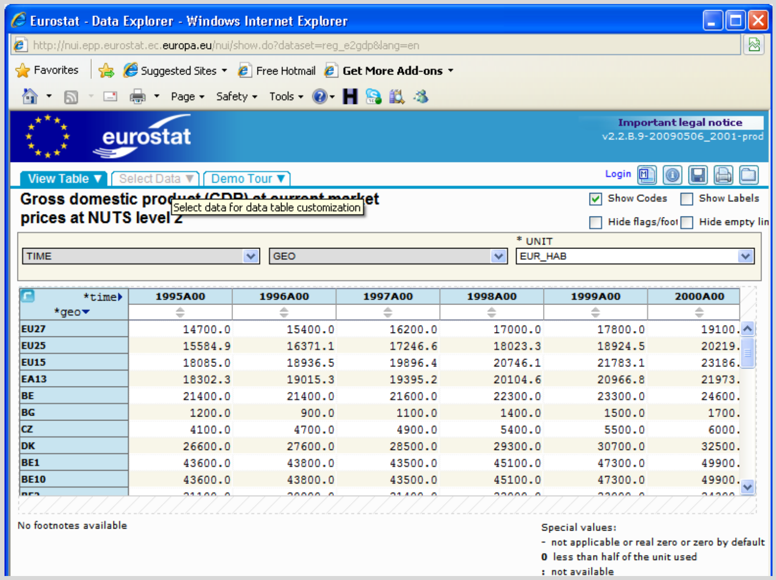
To obtain information from the EUROSTAT database

2. Go to the EUROSTAT website and search the database: (http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database)

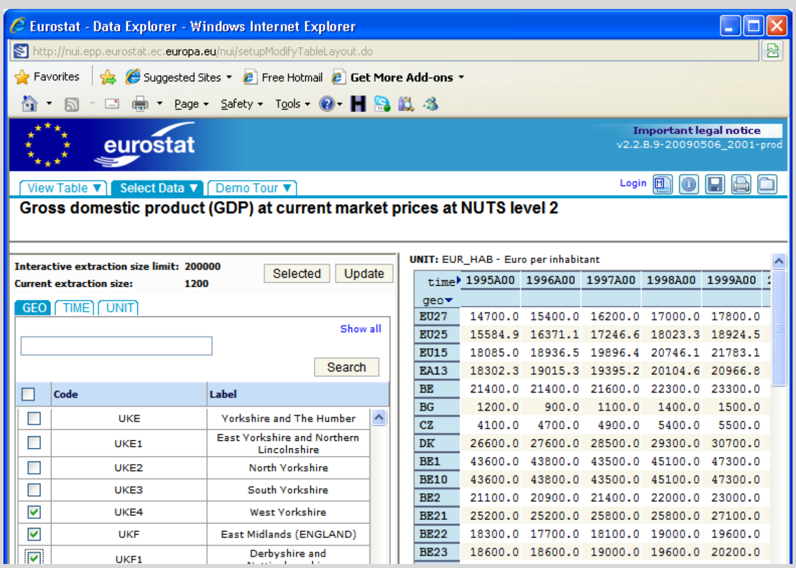
The appropriate file (reg_e2gdp.xls) is available in the following location; database – General and regional statistics – Regional statistics – Gross domestic product indicators – ESA95 (reg_ecogdp).



3. To edit the data and download the appropriate information within an .xls format click the square on the left and side of the file (labelled the data explorer), this opens a pop up window and allows you to select the data you wish to download by clicking on the select data tab.



1. The "select data" tab allows the user to specify which units they wish to download data. In this example information GEO tab shows selected data at various county levels (check boxes next to each code of interest are ticked). The save button is then clicked and the appropriate data format chosen (i.e. .xls).



The GDP per capita for the East Midlands is €24,800. Using OECD purchasing power parity exchange rate tables the conversion from € to 2003 US $ gives:

GDP for East Midlands 2003 US $ = £24,800/0.87 = **$28,383**

Source for OECD tables:
http://www.oecd.org/document/47/0,3343,en_2649_34347_36202863_1_1_1_1,00.html

Box 3: Calculating the population within a 50 km radius of the policy good site

The population within 50 km of the policy good site is calculated by using the ONS census data:

- Population estimates for each of the main towns and cites within the 50 km area (see **Figure 1**) provide a quick method to obtain an approximate population estimate for the area surrounding the policy site. Population data for each relevant town can be obtained from the ONS 2001 Census: Standard Area Statistics England and Wales:

  ⇒ The population of the following towns and cities was used to determine the total population for the policy good affected population area: Leicester, Derby, Nottingham, Chesterfield, Mansfield, and Stoke-on-Trent. This population estimate is 1.72 million.

  ⇒ This population estimate is converted into an average population density over the policy good area. Brander et al. (2008) set the radius (r) of this area to 50km from the policy good site: i.e. $r = 50km$, $r^2 = 2500km^2$, hence the policy good population area is equal to $\pi \times r^2$: i.e. $3.14 \times 2500 = 7{,}854km^2$.

  ⇒ The average population density over this area is calculated as 1.72m/7,854 = 219 per km^2.

- Alternatively population data from the ONS Census 2001 can be included into a GIS system and average values for each grid square (size as appropriate) can be derived. This can be a more time consuming process but is more accurate.

The method employed in this case study implies that the calculation of population density is a key parameter for testing in sensitivity analysis in Step 7.

STEP 6: AGGREGATION

The annual aggregate benefit of creation of wetland habitat (inland marsh) as part of the LDFRMS is calculated by multiplying the estimated unit value from the meta-analysis function in Step 5 by the area of wetland created by the LDFRMS:

Annual benefit (£/yr) = 34.4 hectares x £425 per hectare per year = £14,620 per year

This equates to approximately £374,000 in present value terms over 50 years (using a discount rate of 3.5% for years 1 – 30 and 3% for years 31 – 50 based on Green Book guidance (HM Treasury, 2003).

Note that this sum is a lower bound estimate of the environmental benefits associated with the Derwent catchment flood risk management measures since it excludes the following likely benefits from:

- Habitat restoration (inland marsh) under the LDFRMS - due to lack of information;
- Other measures in the LDFRMS such as planting and landscaping, wildlife corridor, fish passage and recreation facilities; and
- Restoration of upland moorland resulting from the MFP.

Box 4: Identifying substitute wetland sites

Substitutes for the policy good site are accounted for within the Brander et al. (2008) meta-analysis function by identifying the amount of wetland habitat within a 50 km radius of the policy good.

- A simple approach to estimating the total area of wetlands within the 50 km radius of the policy good site is to identify wetland reserve sites from the Wildlife Trust website (http://www.wildlifetrusts.org) and sum the reported hectares for sites. In this example the following reserve sites where identified:

  ⇒ Attenborough gravel pits (146 ha)
  ⇒ Alvecote pools (26.2 Ha)
  ⇒ Brandon marsh (92 Ha)
  ⇒ Rutland Ramsar site (202 Ha) – although this is just outside the 50 km radius the value can be included within a sensitivity analysis as the site has achieved Ramsar designation and is quite large (See Step 7).

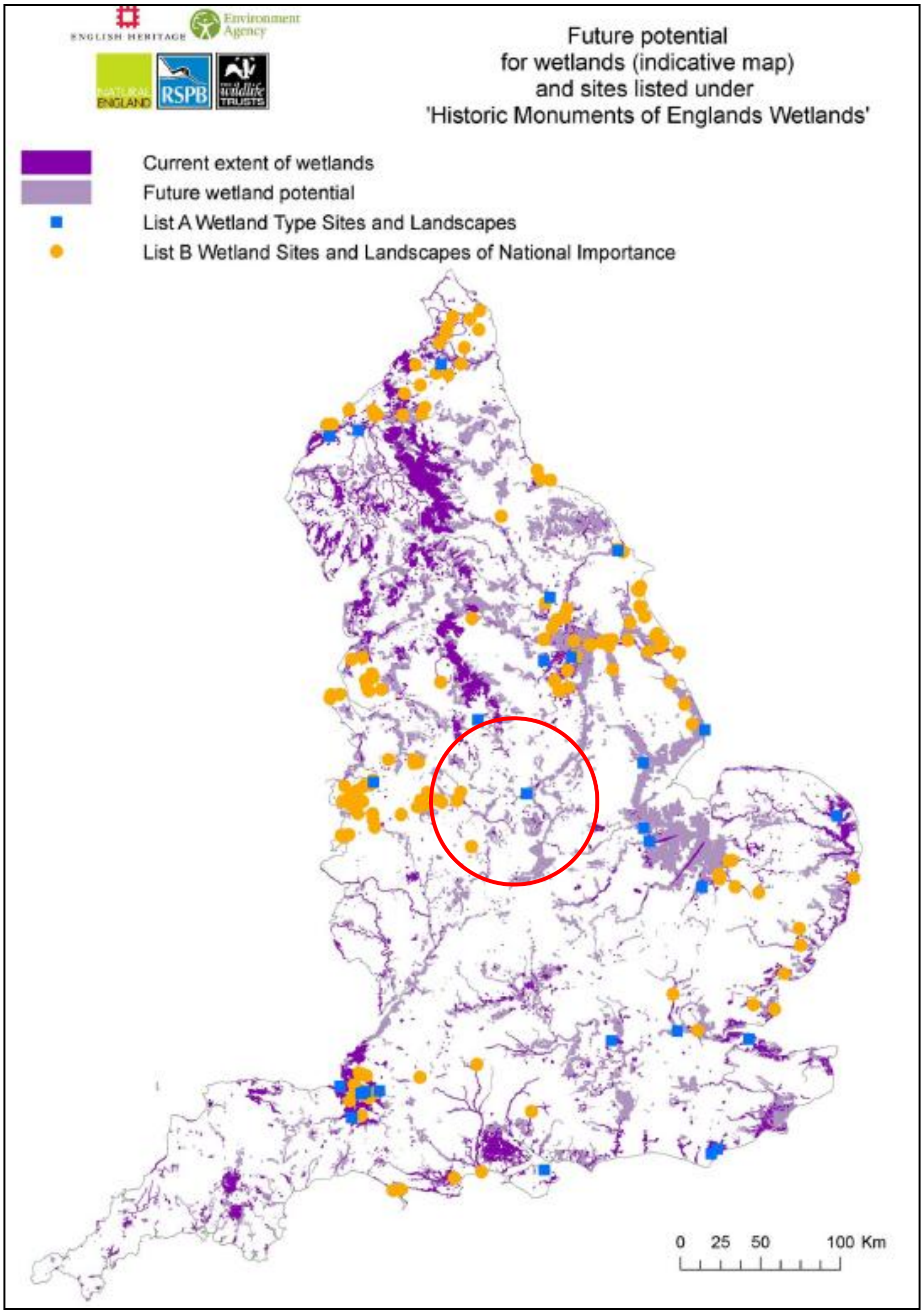
- Alternatively Natural England's Wetland Visions website (http://www.wetlandvision.org.uk) can be used to show an approximate area of wetlands within the 50 km radius of the policy site (see **Figure 2** below). The interactive map also provides information on the SSSIs within the area along with information relating to their character and size.

- Finally, www.magic.gov.uk can be used to download GIS information. However access to datasets is limited and permission needs to be obtained for the use of some aspects of the data. Others are limited to use in non-commercial and/or public projects only. GIS information relating to the following site categories is included within www.magic.gov.uk:

  ⇒ Areas of Outstanding Natural Beauty (England)
  ⇒ Moorland Line (England)
  ⇒ National Character Areas (England)
  ⇒ Country Parks - Provisional (England)
  ⇒ Doorstep Greens (England)
  ⇒ Local Nature Reserves (England)
  ⇒ Lowland Grazing Marsh (England)
  ⇒ Sites of Special Scientific Interest (England)
  ⇒ Sites of Special Scientific Interest (Scotland)
  ⇒ Sites of Special Scientific Interest (Wales)
  ⇒ Sites of Special Scientific Interest Units (England)
  ⇒ Special Areas of Conservation (England)
  ⇒ Special Areas of Conservation (Scotland)
  ⇒ Special Areas of Conservation (Wales)
  ⇒ Special Protection Areas (England)
  ⇒ Special Protection Areas (Scotland)
  ⇒ Special Protection Areas (Wales)

The method employed in this case study implies that the calculation of area of substitute wetland site is a key parameter for testing in sensitivity analysis in Step 7.

Figure 2: Extent of current and potential wetlands across England



Source: Natural England Wetland Visions: http://www.wetlandvision.org.uk
Note: the red circle represents the approximate policy/case study area

STEP 7: SENSITIVITY ANALYSIS

Key sensitivities in the analysis include:

i). The omission or inclusion of the flood protection parameter in the meta-analysis function: guidance for flood risk management schemes provides detailed instruction for estimating the benefits of protecting people and property from flooding (see FHRC, 2005), based on expected damages. On the assumption that these will be calculated separately and hence to avoid double-counting here, the flood protection parameter in the meta-analysis (Table 4) is set to zero.

ii). The estimate of GDP per capita value: the analysis applies the value for the East Midlands but this can be compared to for Derbyshire and Nottinghamshire ($27,467 in 2003 US $ as opposed to 28,383 in East Midlands as in **Box 2**).

iii). Size of affected population: this is used to estimate population density for the policy good population area.

iv). The amount of substitute wetland area within 50 km of the policy site: this is identified via a method that is expected to be less accurate than would be the case if GIS was used.

The following illustrates the use of sensitivity analysis with respect to (i) and (ii).

Including flood protection in the application of the meta-analysis function

As noted in Step 5 (see **Table 4**), use of the meta-analysis function does not attribute any flood protection benefits to avoid double counting in the scheme appraisal with avoided flood damages. Including the flood protection parameter in the meta-analysis function gives the following calculation:

$$-3.078-(0.297 \times \mathit{ln}(34.4))+(\underline{\mathbf{1.102 \times 1}})+(0.114 \times 1)+(0.893 \times 1)-(0.288 \times 1)+(0.34 \times 1)$$
$$+(0.752 \times 1)+(0.917 \times 1)+(0.468 \times \mathit{ln}(28383))+(0.579 \times \mathit{ln}(216))-(0.023 \times \mathit{ln}(264.2))$$
$$= \mathit{ln}\ 7.485$$

This yields a value of £1,278 per hectare per year (2008 £) for the habitat creation (inland marsh) aspect of the policy good. This is around three-times greater than £425 per hectare per year estimated without the flood protection benefits.

Aggregated over the 34.4 hectares this gives an annual benefit estimate of £43,962 per year. This equates to approximately £1.1 million in present value terms over 50 years (using the same discount rates as above). This is a substantial uplift in the aggregate benefit estimate compared to the case where the flood protection is omitted from the analysis.

Sensitivity to estimate of GDP per capita

The influence of the estimate of GDP per capita in the meta-analysis function is illustrated by assuming a lower value than applied in Step 5 (see Table 5). In particular taking reported GDP per capita for Derbyshire and Nottinghamshire, which is $27,467 in 2003 US $ and 3% lower than the value applied in Step 5 ($28,383). This gives the following calculation:

$$-3.078-(0.297 \times ln(34.4))+ (0.114 \times 1) (0.893 \times 1)-(0.288 \times 1)+(0.34 \times 1)+(0.752 \times 1)+ (0.917 \times 1)+(0.468 \times ln(\underline{\mathbf{27467}}))+(0.579 \times ln(216))-(0.023 \times ln(264.2)) = ln\ 6.368$$

and results in a value of £418 per hectare per year. Hence a 3% reduction in GDP per capita gives only a 1 % reduction in the value per hectare (£7 less than £425 per hectare per year). This suggests that the modest uncertainty that surrounds the GDP per capita estimates is unlikely to influence aggregate benefit estimates significantly.

STEP 8: REPORTING

Comparison to scheme costs

The LDFRMS (EA, 2008b) reports the overall scheme costs as £25 million over 50 yrs. The cost of wetland creation (measures set out in Table 3) is estimated to be around £1.2 million (2008 prices). Estimated environmental benefits from the creation of wetland habitat is approximately £0.4 million in present value terms (over 50 years) increasing to £1.1 million if flood protection benefits are explicitly included[4]. However, overall the estimate of aggregate environmental benefits is likely to be an under-estimate since a number of aspects remain non-monetised, including habitat restoration (inland marsh), measures such as planting and landscaping, wildlife corridor, fish passage and recreation facilities and restoration of upland moorland resulting from the MFP.

Application of the meta-analysis function

This case study illustrates the application of the meta-analysis function from Brander et al. (2008) for estimating the value of ecosystem services provided by different wetland habitats. Use of the function is a fairly involved process as shown in Steps 4-7 and also the **Appendix to Case Study 3** which sets out the data collection efforts and sources of information used in more detail.

The approach used here illustrates how the meta-analysis function can be applied in the absence of GIS (see particularly **Boxes 2-4**).The analysis could be improved by use of GIS to give a more accurate account of availability of substitutes and the affected population.

Importantly the meta-analysis function allows for control of factors such as wetland type; wetland size; provision of ecosystem services; the size of the affected population; socio-economic characteristics of the affected population; and substitute wetland sites. This gives a stark contrast between the unit value estimated from the function (£425/ha/yr) in comparison to the average UK wetland value from the meta-analysis (£3,109/ha/yr).

[4] In practice flood protection benefits are estimated separately in terms of damages to properties and avoided loss of lives (following guidance in FHRC, 2005). The appraisal undertaken for the LDFRMS indicates that these benefits substantially outweigh the scheme costs (EA, 2008b). Here the correct approach is to exclude flood protection benefits from the estimate of environmental benefits to explicitly avoid double-counting.

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APPENDIX TO CASE STUDY 3

This flow chart illustrates the data collection efforts in Case Study 3, based on the use of the Brander et al. (2008) meta-analysis function. It shows the progression through Steps 1-8 and the re-iteration in Steps 2-3 once evidence needs from the meta-analysis function are identified.