Coordinated plan for the application of monetary valuation in selected exemplars

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Contents

Introduction

In this milestone we present a brief coordinated plan of economic valuation in selected exemplars. The coordination of these research endeavours has been done through several routes. First, we presented the possibilities for collaboration at the third OPERAs meeting in Lisbon (presentation is available on Owncloud). Second, we followed up this presentation with a document in which we explained what we can offer as WP3, and sent this document to exemplar. Based on responses of exemplars we continued discussions about collaboration. Of course, some collaborations were initiated in other ways, generally during OPERAs meetings.

An extensive overview of available monetary valuation methods is provided in OPERAs Deliverable 3.2 (see Koetse et al., 2015). In this deliverable we also address several recent developments in monetary valuation, i.e., reference dependence, payment vehicle non-attendance, effects of adding a payment vehicle on trade-offs and choices in choice experiments, and regret minimisation as an alternative to utility maximisation as a decision making paradigm. In the valuation of ecosystem services in selected exemplars we will pay special attention to payment vehicle non-attendance and regret minimisation, although this will be done in the modelling stages.

In this milestone we address the application of monetary valuation in a selection of OPERAs exemplars. The range of valuation methods applied is wide, but two methods stand out. For exemplars at a local scale we generally apply contingent valuation or choice experiments (or both), while for exemplar at a national or regional scale we apply meta-analysis and value (function) transfer (see also OPERAs milestone 3.3, Koetse and Brouwer, 2014). Other methods applied are generally model-based. For example, we aim to apply an integrated ecosystem service assessment model (developed by UEA; see Bateman et al., 2014) and the DICE model (Dynamic Integrated Climate-Economy model). Also the non-economic methods used for the valuation studies are generally model-based. More specifically, various land-use models are applied to simulate changes in biophysical units at different geographical scales. The outputs of these models are generally combined with monetary value estimates to generate changes in welfare terms alongside the changes in biophysical units.

In two of the exemplars (Inner Forth in Scotland, and Montado in Portugal) we aim to explicitly combine and/or compare the outcomes of economic valuation methods with those of socio-cultural valuation methods, thereby making a link between WP3.2 and WP3.3. The aim here is to assess whether there actually is a difference between these two types of values, and to assess the complementarity of methods generally used to assess them. Exemplar studies that do not include a monetary valuation part do generally include a socio-cultural valuation part. For an overview of valuation activities in these exemplars we refer to MS 3.10, which provides a ‘Coordinated plan for the application of social valuation in selected exemplars’.

In this milestone we discuss the application economic/monetary valuation methods in the following exemplars:

- Scotland: National scale
- Scotland: Inner Forth
- Portugal: Montado
- Switzerland: Swiss Alps
- Europe
- Global

We furthermore discuss economic valuation exercises in two additional case studies that are relevant for the OPERAs project:

- Netherlands: Valuation of biodiversity and landscape development
- UK: Valuation of climate change impacts in the Yorkshire's River Aire basin

Scotland: National exemplar

Two research activities will take (or have taken) place for this exemplar. First, integrated assessment models are used to provide insights into welfare changes due to land use changes. Second, spatially specific meta-analysis value functions are linked to spatially specific land use change models in order to provide insights into welfare changes of selected land use change and policy scenarios. We discuss both activities below.

Integrated Ecosystem Services Assessment Models

The first activity is to explore the welfare effects of land use change in Scotland, an optimising integrated ecosystem service valuation model was developed and applied to a policy-relevant case study, namely an afforestation policy proposed by the Scottish Government for implementation over the next 50 years. Such a policy would require the conversion of land out of its current uses into forestry. Within the context of on-going climate change, The Integrated Model (TIM) brings a wide range of land use types and ecosystem services into a spatially explicit, formal optimisation routine that seeks to identify where new planting should take place. As part of the analysis, TIM considers ecosystem services, including: agricultural production, greenhouse gasses from agriculture, timber production, greenhouse gasses from forestry, water quality, outdoor recreation, and biodiversity. Specific research questions (RQ) include:

RQ 1: Under a business as usual (BAU) scenario (i.e. with no new planting) how will climate change affect land use?

RQ 2: Where would new planting take place if the objective were to maximise market values? (i.e. agricultural and timer production)

RQ 3: How does this analysis change when GHGs are taken into consideration?

RQ 4: How does the analysis change when recreation is taken into consideration?

RQ 5: Where would new planting take place if the objective were to maximise social values, including market values from agriculture and timber, as well as non-market values from GHGs and recreation?

To answer these questions, a series of individual, yet interlinking modules were developed that analyse land use at the 2km grid square resolution. The farm module develops an econometric model linking climate change to farm level decisions regarding crop and livestock production. This in turn drives changes in agricultural run-off (described by a water quality module); agricultural greenhouse gasses ($CO_{2,}$ $N_2 0$, CH_4; described in a farm GHG module); and farm bird species (described in the biodiversity module). The impact of climate change on timber production is considered within the timber module, which also incorporates forestry decisions (which species to grow, rotation periods and management practices) and the resulting GHG implications (sequestration in livewood, emissions from felling waste, emissions and sequestrations from various types of soils) are described in the forestry GHG module. An innovative recreation module developed a new Random Utility Model to analyse and value the impact of land use change on outdoor recreation and associated travel costs. Crucially, TIM makes it possible to explore how the availability of substitute recreation sites impacts values, how this changes over time as new substitutes become available. Finally, a biodiversity module links to the farm and timber models to identify the impact of land use change on wild bird species. Owing to the difficulty of directly valuing biodiversity, TIM instead explores the welfare impact of imposing various ‘biodiversity constraints’ such as requiring no net loss in biodiversity. We refer to Chapter 5 in Koetse et al. (2015) for more detailed discussion and some results of TIM in the Scottish case, and to Bateman et al. (2014) for formal treatment.

While the case study described here considers the implications of an afforestation policy, TIM was developed with a high degree of flexibility and is readily applicable to a range of other policy-relevant questions (e.g., impact of new agricultural subsidies, the costs of meeting various water quality or biodiversity regulations, etc.). Moreover, the modular approach makes it possible for each component to be developed and improved independently and for new modules to be included in future analyses.

Spatially specific meta-analysis value functions

The second separate research activity within the Scottish national exemplar is to apply the value functions obtained from the water and forest meta-analyses (see Koetse and Brouwer, 2014) to the Scottish national scale. First agreements on this have been made with the exemplar leads. The preliminary plan is to calculate welfare effects of various land use and policy scenarios with respect to the supply of forests and water areas in Scotland. Although specific research questions will be developed in the first half of 2015, general research questions addressed are:

RQ1: What are the welfare effects of changes in forest and water supply in Scotland?

RQ2: Which national and regional policies aimed at affecting forest and water supply are welfare enhancing?

As stated above we use the spatially specific meta-analyses value functions to derive monetary values for changes in water and forest supply. The model used for deriving changes in supply is the CLIMSAVE model (Harrison et al;. 2013; Holman et al., 2014). The CLIMSAVE IA Platform is an interactive, exploratory web-based modelling tool to enable stakeholders to improve their understanding of impacts, adaptation responses and vulnerability under uncertain futures. The numerical models and underlying physical and scenario data sets use server-based web technologies to maximise access speed, whilst the web-based interface uses a clientbased (i.e., the user’s PC) computing solution to allow (i) fast reply to the user actions; (ii) output data from (server-based) models to be sent synchronously and asynchronously to the interface and (iii) the opportunity to use map services to display spatial data. Two versions of the CLIMSAVE IA Platform are freely available (www.clim save.eu/iap): one for Europe and one for Scotland. In this case we will use the Scottish version, which is described in detail by Holman et al. (2013, 2014).

The preliminary aim is to employ a MSc student from April to June 2015, who will work on the land use and policy scenarios, and produces the biophysical output required for linking with the meta-analyses value functions. That is, spatially specific changes in supply of forest and water areas in Scotland at the National Scale. We also plan to use a MSc student to link the output of the CLIMSAVE model to the meta-analyses value functions. This depends largely on the availability of students and timing (i.e., suitability of the period in which students write their MSc theses).

The expected outputs are: (1) maps of biophysical changes in water and forest supply in Scotland in some year in the future, e.g., 2050; (2) maps of welfare changes due to changes in water and forest supply in Scotland in some year in the future; (3) insights at the Scottish national scale into welfare changes due to changes in water and forest supply and for various policy scenarios.

Scotland: Inner Forth exemplar

Introduction and research questions

The Inner Forth area stretches over 23 km between Bo’ness and Stirling along the Firth of Forth. The natural coastal systems and processes in the Inner Forth make the coastline adaptable to changes in climate and sea-levels, and the network of intertidal habitats support internationally important wintering and migratory wildfowl and wader populations. However, these functions have been affected by a number of intervening factors for centuries. Land claims, transport along its waters, coal mining, waste disposal and fishing have all influenced the functions, patterns and structures of ecological and cultural elements in the Inner Forth. Over half of the intertidal zone in the Inner Forth has been claimed from the sea over the past 200 years, through building flood defences along the coastal margin to convert the natural intertidal zone into farm land, oil refinery and docks at Grangemouth, and coal power station at Longannet. Moreover, the firth has been an important transportation route for both international trade and local traffic throughout the past centuries. Pollution arising from the various human activities has resulted in the environmental degradation and habitat degradation of the area. The environmental degradation in the Inner Forth has influenced the delivery of ecosystem services such as flood protection, climate regulation, nutrient recycling and amenity. This study aims to explore how coastal realignment in the Inner Forth would affect the delivery and value of services using ecological, sociocultural and economic valuation techniques. Research questions addressed are:

RQ1: At which locations is wetland restoration possible in the Inner Forth?

RQ2: How do residents in the beneficiary areas of the Inner Forth value potential future coastal ES changes in monetary and non-monetary terms?

RQ3: How do learning and group deliberation shape preferences and values for coastal ES changes?

To answer these questions we perform a valuation study among citizens in four ‘beneficiary areas’. These areas define the boundaries of a sample area in which demand for ecosystem services is identified and described, values are aggregated, and distances to supply areas (where feasible) are estimated. The four proposed beneficiary areas are the towns of Airth (population: 1,273), Grangemouth (population: 17,771), Alloa (population: 18,989), and Stirling (population: 32,673). They are distributed across the Inner Forth area on both sides of the river and represent a relatively wide range of population sizes. All four areas are located within 1 km distance from the river Forth on both sides of the river, and are roughly within a 5 km distance from potential wetland restoration sites.

Research design

First, opportunity areas for wetland restoration are currently being mapped using LiDAR topography data and interpolated tidal height data. I will receive interpolated Mean High Water Springs data for the entire area from SNH by the end of April. Tidal heights will then be mapped against the land heights to identify areas that lie low enough for wetlands to be restored if existing flood embankments were removed.

Second, monetary values and preferences for future coastal changes will be obtained by using a choice experiment in a workshop context (n=100) and a one-to-one survey (n=400). The payment vehicle will be varied itself in order to identify any stakeholder preferences for different modes of ES governance. The non-monetary choice attributes will include land use (coastal realignment versus artificial flood embankments), landscape characteristics that are of interest to stakeholders (potentially access to green space and water quality) and a policy instrument for implementing coastal realignment (land buy versus PES). The monetary choice attribute is a financial contribution per household that will be used to transform preferences into estimates of willingness to pay

Third, impact of learning and social deliberation on preferences and values for coastal ES change will be measured in a workshop where participants complete choice tasks three times: prior to learning, after learning, and after learning and deliberation.

The aim of the learning task is to elicit values that are better informed and reflect the broader values that are held in the landscape. The learning exercise will build on the findings of Kenter (2014) who asked participants to list the most important landscape benefits in the Inner Forth in a stakeholder workshop. The key aim of the learning task is to provide participants with a broad understanding of how the ‘most important landscape benefits’ have been influenced by environmental change in past and their potential change in future, and how realignment may intervene with the trajectories of change. The learning exercise covers environmental history in the area, consequent changes in coastal ES and wildlife, how coastal settings can be renaturalised, motivations and trade-offs for doing so, and future uncertainties in environmental change. Participants will repeat the choice task after the learning task, so that the ‘informed’ and ‘non-informed’ values can be compared.

Group deliberation is defined here as the process of considering and appreciating values or decisions with other people. Aim of the deliberative group task is to elicit better considered and reasoned choices that appreciate the views of others and their consequences on a community level. Group deliberation provides participants with an opportunity to discover and reconsider values through sharing views and learning from others, which is expected to increase the consideration of social and shared values (described in Kenter et al., 2014) and aggregate preferences and values towards a more collective view. Participants will be asked to list drivers that are likely to impact most important landscape benefits in the area in the future, rank their importance and consider solutions for addressing any identified risks. The facilitator will introduce top 10 landscape benefits that were identified in the Kenter (2014) study, followed by a 10 min group discussion. Each participant fills five empty post its with drivers that they think will influence landscape benefits now and/or in the future. The facilitator will introduce all drivers that were identified and build them into a conceptual model. The group will determine through 10 min discussion, which landscape benefits each driver is likely to influence. Each participant allocates three points towards drivers, to represent how much effort should be allocated to minimize the impact of that driver, followed by a group discussion on the results. Participants will repeat the choice task after the group task, so that the deliberated and non-deliberated values can be compared.

Choice experiment: Attributes and levels

We selected a preliminary set of attributes and attribute levels. These are described below.

Attribute 1: Different types of land use: flood defence, farming practices, and habitats for nature

- Maintenance of flood embankments and intensive agriculture regardless of flood risk. Land is protected using embankments and used for intensive farming regardless of flood risk.
- Wetland restoration in areas near the river margin. Coastal wetlands are restored in areas certain areas. Coastal habitats can be restored on the landward side of existing flood embankments by breaching existing embankments or by installing a sluice/pipe through the embankment.
- Combination intensive agriculture and wetland restoration. A portion of wetlands is restored. Embankments maintained in areas where salt marsh has been restored.

Attribute 2: Flood regulation by coastal wetlands

- Small proportion of the potential capacity for regulating flood risk through coastal wetlands is provisioned in the area. This is the status quo in the Inner Forth.
- About half of the potential capacity for regulating flood risk through coastal wetlands is utilised. This is the possible if a small proportion of wetlands are restored.
- Close to full capacity. This is possible if wetlands are restored on a landscape scale.

Attribute 3: Access to green spaces

- Limited access to the river, and limited maintenance of existing paths.
- Access to existing nature areas along the river is improved through better paths and roads.
- Access to existing and restored nature areas along the river is improved through better paths and roads.

Attribute 4: Water quality - Water quality is currently moderate.

- No change

- Improvement

Attribute 5: Payment vehicle

- Donation through a landscape initiative
- Council tax

Attribute 6: Policy instrument (descriptions of how land buys and PES work)

- Buying land
- PES

Attribute 7: Contribution per household

- £10
- £20
- £50
- £60

Activities envisaged

Focus group (June 2015)

The focus group will meet prior to the pilot study. The aim of the focus group is to identify the socio-cultural values that participants attach to natural coastal settings, and how they respond to changes in coastal ES. It also has to ensure we are including the most relevant environmental attributes and appropriate levels of choice attributes in the choice task, and should test participant responses to the services that were chosen for the cultural valuation. In order to obtain a representative sample of stakeholder views in the focus group, 64 community groups identified by Kenter (2014) will be invited to the workshop.

Pilot study (July 2015)

The aim of the pilot is to verify that the participants have a preference, perception, use and/or appreciation for the choice attributes and cultural values in the study. For this, 30-50 people are interviewed door-to-door in one of the beneficiary areas. The results of the pilot study will be used to make the final changes to the survey and the choice experiment. The results of the pilot study choice experiment will be used to generate an efficient statistical design for the choice experiment in the main study.

Workshops (August-November 2015)

The aim of the workshop is to perform a choice experiment (three times). In total 100 people will be invited to participate in the workshop. These people are sampled from within the boundaries of a single beneficiary area. Beneficiaries should be invited to participate in the workshop through channels that reach a variety of age and social groups: elderly homes, high schools, supermarkets, notice boards of local businesses and nurseries, booking through phone or email.

One-to-one surveys (August-November 2015)

The aim of the one-to-one surveys is to perform the choice experiment and assess cultural values for current and alternative states of the Inner Forth. In total 400 people are invited to participate. These people are sampled from within the boundaries of the four beneficiary areas. One of the beneficiary areas is the same beneficiary area where the workshops are held, and we ensure that sampling procedure is identical, implying we can sensibly compare the outcomes of both approaches. The survey participants will be recruited on site through door-to-door contact.

Portugal: Montado

With respect to research in Portugal, agreements between various partners (IVM, UCD, Lund, Lisbon) have been made to conduct a joint socio-cultural and economic valuation study. Similar to the Inner Forth, we also aim at integrating insights from governance perspective. For the economic part, the current plan is to make use of Portuguese Master's students for these purposes, beginning in September 2015. Discussions between Lisbon and IVM will take place on research design, coordination of the study and supervision of the students, during the course of 2015.

RQ1: What and how large are the use values of the Montado?

RQ2: What and how large are the non-use values of the Montado?

RQ3: How much are landowners willing to accept as compensation for changing their production practices?

To address these questions we design and conduct choice experiments (for details on the method see Koetse et al., 2015) for three independent samples, i.e.:

Sample 1: Visitors of the Montado in or near Lisbon (RQ1)

Sample 2: Portuguese citizens (RQ2)

Sample 3: Montado landowners in or near Lisbon (RQ3)

The design of the choice experiment will be done from June to October 2015, data collection will take place from November 2015 to February 2016, and data analysis and writing will be done from March 2016 to June 2016. For each of the three research questions we aim to use MSc students.

The data collection for RQ1 and RQ3 will be done through face-to-face interviews in Montado areas in or near Lisbon. For RQ2 a representative sample for the whole of Portugal is required, so we aim to do data collection through an online panel. This panel covers the whole of Portugal and allows for representative sampling.

Switzerland: Swiss Alps

Study design

In the Swiss Alps Exemplar a choice experiment is linked to an integrative land-use and ecosystem services model in a backcasting framework (Figure 1). The framework was developed to link ecosystem services supply and demand and to identify alternative socio-economic and political pathways resulting in a societally envisioned landscape. As both the stated choice experiment and the economic optimization model ALUAM-AB are anchored in economic theory, the framework is based on a common theoretical background.

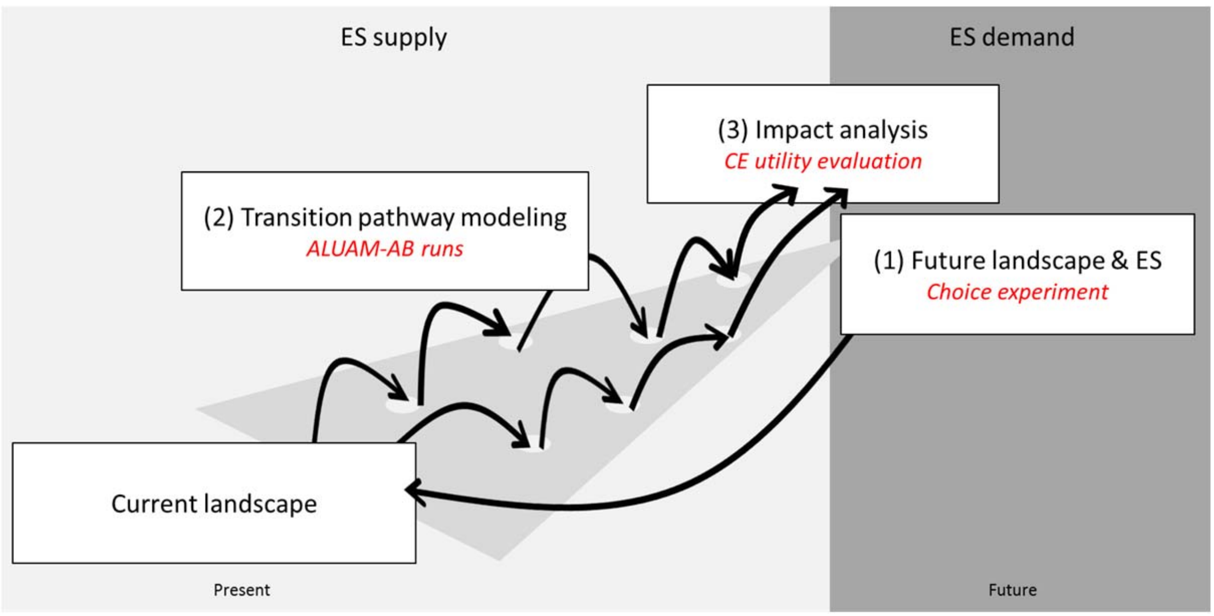

Figure 1. Backcasting approach for linking ecosystem services (ES) supply and demand and for inferring transition pathways resulting in an envisioned landscape.

In a first step, we conducted a discrete choice experiment for eliciting how local residents value and trade future changes in regionally relevant ecosystem services with a focus on cultural services. In the survey, participants had to choose between the current landscape and two alternative future landscapes, each landscape being described by a set of ecosystem services. The results of the survey were fed into a nested logit model and marginal utility coefficients for each ecosystem services indicator were estimated. The marginal utility coefficients show how future changes in ecosystem services compromise or improve the utility of the landscape for the participants.

In a second step, we modelled a multitude of transition pathways of the landscape driven by socio-economic and political interventions with the economic land-use optimization model ALUAM-AB. The model was set up to quantitatively assess changes in the target ecosystem services along these pathways.

Finally, we derived an additive utility function for landscape changes based on the marginal utility coefficients of each ecosystem services indicator. The function allowed for evaluating the change in the overall utility of the landscape under each modelled development pathway.

Exemplary results

The backcasting approach we apply in our Exemplar allows inferring how different pathways of socio-economic and political interventions change the landscape and its utility for local people (Figure 2). The change in the overall utility is an aggregated and weighted measure amalgamating changes in different ecosystem services according to stated preferences elicited in a choice experiment that indicates how well ecosystem services supply matches future ecosystem services demand. All modelled pathways result in undesirable landscape changes indicated by the negative trend of the utility. Figure 2 shows that the type and the timing of interventions determine how well ecosystem services demand can be satisfied.

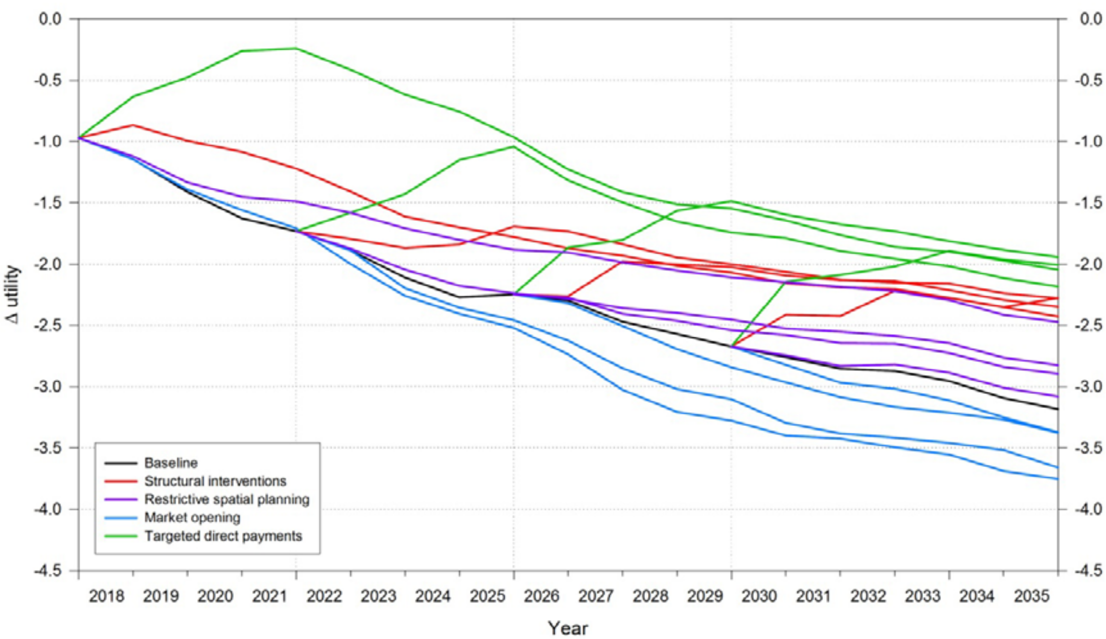

Figure 2. Change in the overall utility of the landscape as compared to 2013 following different pathways of socio-economic and political interventions. The negative utility indicates that ecosystem services supply cannot satisfy future ecosystem services demand.

European exemplar

The value functions obtained from the water and forest meta-analyses (see Koetse and Brouwer, 2014) will be applied to the European scale as well. First agreements on this have been made with the exemplar leads. Preliminary plans are similar to those in Scotland, i.e., to derive welfare effects of various land use and policy scenarios with respect to the supply of forests and water areas in Europe. Although specific research questions will be developed in the course of 2015, the general research questions addressed is:

RQ 1: What are the welfare effects of land use and policy changes in forest supply in Europe in the period 2010-2040?

For answering this research question we use the spatially specific meta-analyses value functions to derive monetary values for changes in water and forest supply. The model used for deriving changes in supply is the CLUE model, which is available at IVM-VU. The CLUE-scanner is a multi-scale, multi-model framework that combines sector models, a land use allocation model and indicator models, connecting global and European scale analysis to environmental impacts at the local level. In the CLUE-scanner framework, global economic developments simulated with the CAPRI economic model and the IMAGE integrated assessment model are used to project future land-use changes at national level. Land use is subsequently allocated to land cover types with a 1-year time step and 1 km^2 spatial resolution with the Dyna-CLUE model (Verburg and Overmars, 2009), which is the core of the CLUE-scanner. The CLUE family of models are the most frequently used land-use allocation models and very appropriate for scenario analysis.

The preliminary aim is to employ a student, who will work on linking the biophysical output from land use and policy scenarios with the meta-analyses value functions. That is, spatially specific changes in supply of forest areas in Europe. Research will be carried out mostly in 2015, and partly in 2016.

The expected outputs are: (1) maps of biophysical changes in forest supply in Europe from now until 2040; (2) maps of welfare changes due to changes in water and forest supply in Europe from now until 2040; (3) insights at the European level into welfare changes due to changes in water and forest supply and for various policy scenarios.

Global exemplar

Based on discussions with KIT, the preliminary plan is to combine modelling results on ecosystem services from the LPJ-GUESS model with space- and time-dependent economic value estimates. The global ecosystem model LPJ-GUESS simulates the development of land vegetation and ecosystem structure in response to driving factors in the environment. The model is applied in the Global Exemplar to predict ecosystem services on a global scale. Based on ecosystem state variables that are simulated for historical and future times (e.g., NPP, carbon stocks, runoff), a number of ES is quantified, namely carbon sequestration, surface water supply, food and fodder provision and transpiration. The quantification of additional ES, such as timber volume, soil fertility and bioenergy production, is investigated. Development of ES is mapped over time and in response to environmental drivers such as climate and land use. For future time periods, ES development will be available for different socio-economic scenarios that underlie the different scenarios of land-use derived from the CLUMondo model, which is developed within the Global Exemplar.

Economic value estimates may be obtained from two sources. First, the value functions obtained from the meta-analyses (see Koetse and Brouwer, 2014) can be used to derive space- and time-dependent value estimates for forests and water. By combining the changes in physical units from LPJ-GUESS with the value changes we aim to obtain welfare changes due to changes in ecosystem services that incorporate the increasing marginal value of ecosystem services due to a decreasing supply in these services.

Second, we aim to combine the LPJ-GUESS predictions on carbon sequestration with scarcity- and time-dependent carbon prices from the DICE 2013 model (Dynamic Integrated Climate-Economy model, see Nordhaus and Sztorc, 2013). The DICE model views the economics of climate change from the perspective of neoclassical economic growth theory. The DICE model extends the classical approach, in which investments in capital, education, and technologies decrease consumption today but increase consumption in the future, by including natural capital. More specifically, in the model concentrations of GHGs are interpreted as negative natural capital, and reductions in GHG emissions are seen as investments that increase natural capital. By investing in emissions reductions, economies decrease current consumption in order to prevent harmful climatic changes in the future. In the model the carbon price is obtained by assuming that it is equal to the marginal costs of emissions, which in turn is derived from an abatement cost function. The aim is to incorporate carbon sequestration data from LPJ-GUESS into the DICE model, and to derive time-dependent carbon prices and sequestration values. Subsequently, by multiplying sequestration values with carbon prices we obtain estimates of welfare change due to changes in carbon sequestration.

Additional case study: Netherlands

Introduction and research questions

In the Netherlands a study is taking place on valuation of biodiversity and landscape development. Next to the valuation itself, the aim of the study is to address hypothetical bias in economic valuation, and to analyse social network and threshold effects. Although the study addresses many issues, the most relevant research questions are:

RQ 1: What is the willingness of the Dutch population to compensate farmers for switching to biodiversity enhancing production practices?

RQ 2: What is the impact of including cheap talk and real payments on the willingness to compensate?

RQ 3: What is the impact of social network and threshold effects on the willingness to compensate?

RQ 4: What is the impact of contract characteristics on the willingness to compensate?

Contingent valuation study

For answering the first three questions we perform a contingent valuation (CV) study on the willingness to donate to a fund from which land is bought for a farmer to either (1) switch to an extensive and biodiversity enhancing production method (FFN), or (2) use part of his land for introducing landscape elements (FFL). Focus is on a specific farmer in a specific area, so we can also measure distance decay effects. The landscapes for the three types of farming as presented to respondents are below in Figure 1.

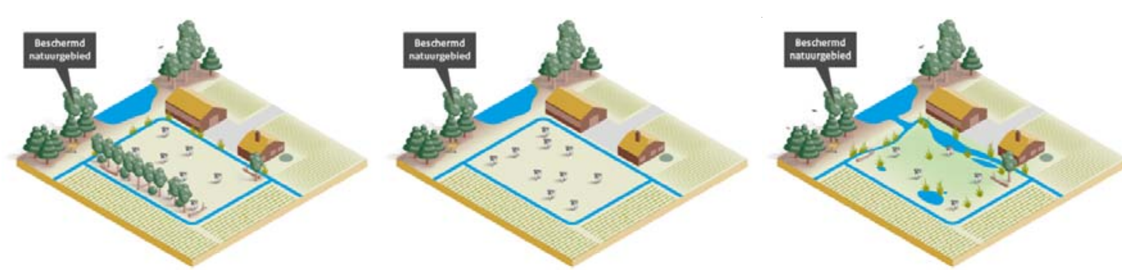

Figure 1. Presentation of landscapes in the survey for different farming practices: intensive farming (left), Farming for Landscape (middle), and Farming for Nature (right)

For answering the first three research questions the research design includes 10 independent samples for 10 different treatments. These treatments are all aimed at the contingent valuation study. Treatments are aimed at assessing the extent of hypothetical bias in stated preference research, and of identifying social network and threshold effects in environmental valuation. The 10 different treatment are presented in Table 1.

Table 1. Treatment matrix for the contingent valuation study

Treatment 1 T1: Hypothetical T2: FFN T3: No T4: No info	**Treatment 4** T1: Hypothetical T2: FFL T3: No T4: No info
Treatment 2 T1: Cheap talk T2: FFN T3: No T4: No info	**Treatment 5** T1: Cheap talk T2: FFL T3: No T4: No info
Treatment 3 T1: Real T2: FFN T3: No T4: No info	**Treatment 6** T1: Real T2: FFL T3: No T4: No info
Treatment 7 T1: Real T2: FFN T3: No T4: Info	**Treatment 9** T1: Hypothetical T2: FFN T3: No T4: Info
Treatment 8 T1: Real T2: FFN T3: Yes T4: Info	**Treatment 10** T1: Cheap talk T2: FFN T3: No T4: Info

T1: CV type	(Hypothetical; Cheap talk; Real)
T2: CV content	(Farmers for nature; Farmers for Landscape)
T3: Threshold in CV	(No; Yes)
T4: Information in CV	(No info; Info)

Treatments 1 to 6 aim to measure hypothetical bias in willingness to pay studies by comparing the outcomes of a hypothetical donation experiment (treatments 1 and 4) with those of real donation experiments (treatments 3 and 6). Moreover, we aim to assess the impact of including so-called cheap talk scripts (see Cummings and Taylor, 1996) as a means to mitigate this bias (treatments 2 and 5). We do this for both the Farming for Landscape and the Farming for Nature options.

The info treatments aims to measure social network effects, i.e., they aim to assess whether donations change when information on other people's donations is provided. For this we ask first from respondents to provide their assessment of how many households made donations, and what the average donation from a donating household is. After these questions we provide, in the info treatments, the real statistics on these two questions and the differences with a respondent's assessment. The threshold treatment is aimed at measuring whether providing a threshold increases or decreases donations. Both the information in the info treatment and the magnitude of the threshold (treatments 7-10) were based on results of treatments 1-6.

Choice experiment

For answering RQ4 we perform a choice experiment with the following attributes: (1) Label for type of farming (FFN, FFL), (2) Fund operator (Nature fund, Landscape fund, Farmers themselves), (3) Geographical level of investment (National or Province), (4) Size of the developed area (25, 40, 75 hectare), (5) one-time donation level (5, 10, 20, 35 Euro). The choice experiment includes a status quo choice, i.e., an option with no donation and intensive farming practices. The focus of the choice experiment is on implementation of FFN or FFL in the entire Netherlands, in contrast to the situation in the CV, which is location specific.

Timeline

Two pretests were done, one in December 2014 and one in March 2015. Results of both pretests led to changes in the design of both the CV and the CE study. Moreover, results were used to generate an efficient statistical design for the choice experiment. The main study was implemented in April-May 2015. For each treatment we collected minimally 400 complete responses, thereby having sufficient data per treatment for reliable hypothesis testing.

Additional case study: UK

Introduction and research questions

Environmental systems are inherently complex and intricately interconnected. A single direct change in any environmental system (e.g. climate) may initiate a ‘domino’ effect, generating indirect impacts across numerous environmental processes and welfare bearing ecosystem services. This is true whether the initial change occurs naturally, or is the result of economic activity and public decision making. Thus, human influences such as environmental policy and agricultural land use drive a range of direct and indirect effects. Evaluating secondary (and often non-market) impacts is especially important in environmental management as their welfare consequences can outweigh that of direct impacts, possibly by a large margin (Bateman et al., 2014). This poses a challenge for investment and policy decisions because without considering the full range of likely impacts, welfare maximizing decisions cannot be robustly identified. However, carefully designed studies using GIS and integrated biophysical and socioeconomic models can greatly improve the evidence base for decision makers. To illustrate this, we developed a case study in Yorkshire’s River Aire basin (86,000ha). Specific research questions include:

RQ1. How can various climate, economic and biophysical models be combined to improve the evidence base for environmental decision making?

RQ2. How do the values generated change when considering only the direct, rather than both direct and indirect effects of environmental change?

RQ3. What can spatially explicit modelling techniques tell us about the geographic distribution of economic and environmental impacts?

Research design

The western half of the River Aire catchment is sparsely populated, upland areas dominated by rough grazing and pastoral agriculture. However, the remainder includes mixed and arable farming but is progressively dominated by high density urban zones, including Bradford and Leeds. The case study demonstrates how integrated modelling and GIS methods can be used to examine a chain of related impacts arising from a simple climate change scenario (1^{o}C temperature rise) and, crucially, to value these impacts in terms of economic welfare so that trade-offs may be readily identified.

We employ a spatially explicit, climate sensitive econometric model of agricultural land use developed by Fezzi and Bateman (2011) to examine the direct effect of climate change on agricultural land use. The model predicts changes in on-farm decisions (e.g., crop selection and livestock intensities) resulting from changes in temperature and precipitation patterns. It incorporates six land use types (cereals, oilseed rape, root crops, temporary grassland, permanent grassland and rough grazing), which capture 88% of UK agricultural land use as well as three prominent livestock types (dairy cattle, beef cattle and sheep).

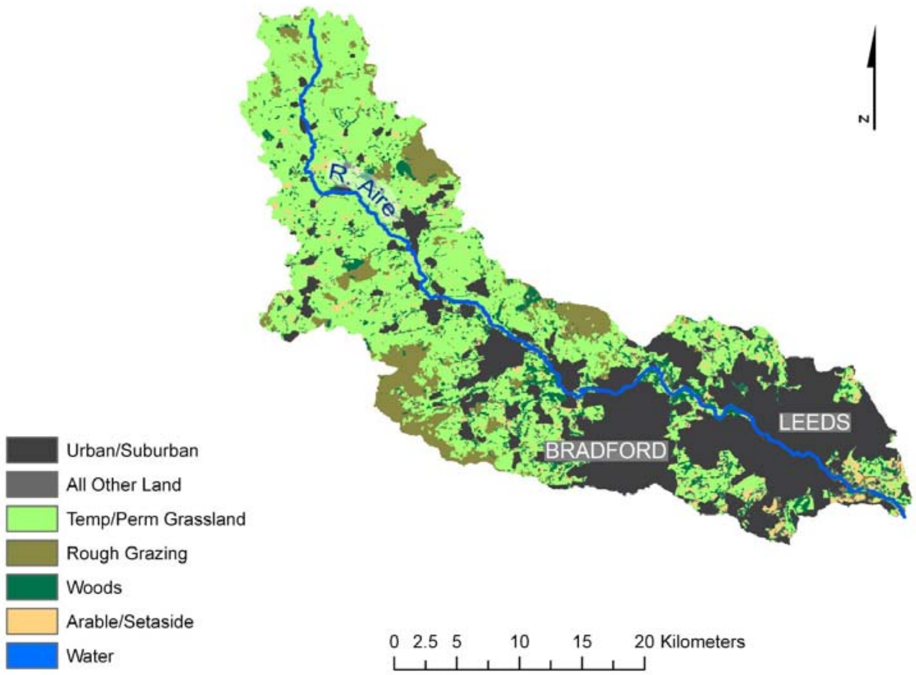

Figure 1: Land use in the River Aire catchment

As land use shares and livestock intensities shift in response to climate change, the level of agricultural diffuse pollution also changes, with run-off driving a second round impact on river water quality. To capture this, we used panel data observations of river water quality (specifically, chlorophyll-a concentrations) across England and Wales to estimate the relationship between land use change and ecological status of rivers. Chlorophyll-a is a measure of algal production, which is in turn an accepted indicator of water quality and the risk of eutrophication. Figure 2 shows water quality in the catchment area on a four-point colour coded scale with blue indicating the highest and red indicating lowest water quality.

High density urban zones mean that marginal water quality around Leeds may impact a large population, with important implications for outdoor recreation.

To model the impact of changing water quality on recreation values a survey was conducted in which 1782 face-to-face household interviews were collected to elicit preferences over recreation sites, with further information on each site's environmental characteristics being integrated via GIS. To capture the spatial sensitivity of values and likely substitution effects, a large survey area (35km diameter) was used and data was collected for visits to 531 recreational sites along rivers (spanning approximately 230km in length). Values for changing water quality were then identified using a travel cost random utility model (detailed in Bateman et al., 2015).

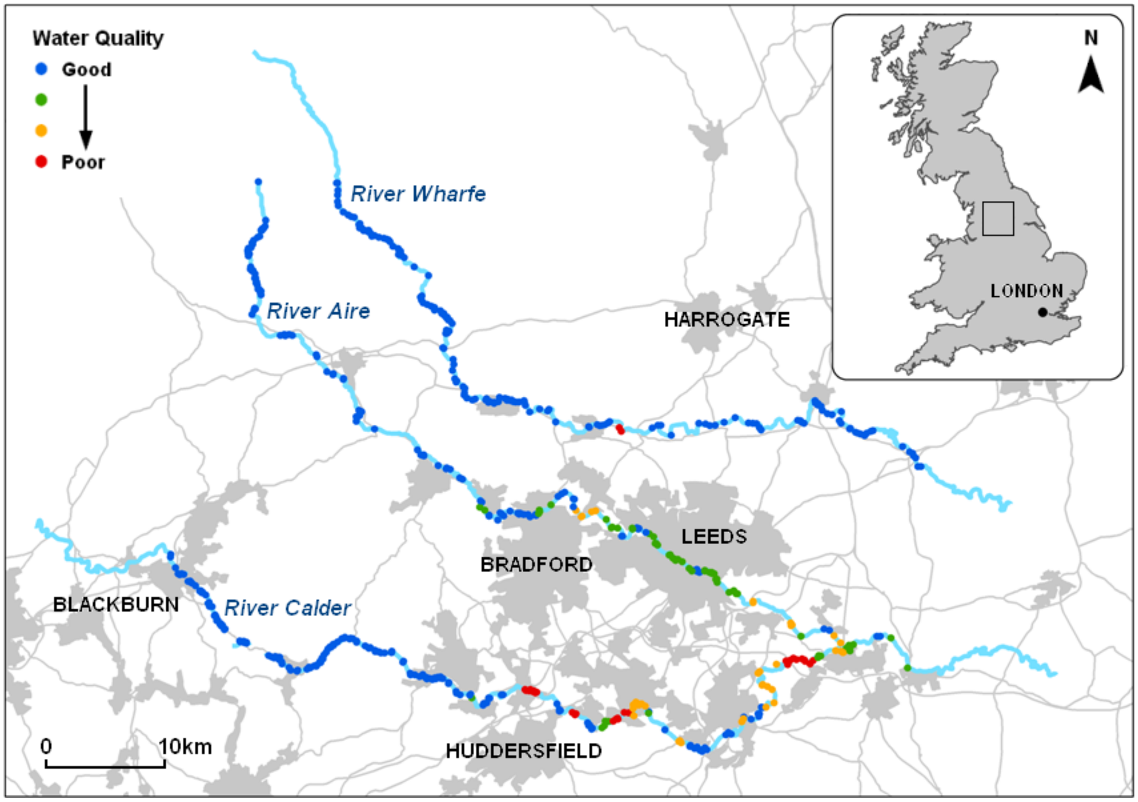

Figure 2: Sampling area and the quality of recreational access sites

This integrated analysis enabled us to elicit economic values along the full chain of impacts, reporting recreation values at both the individual and catchment level. In a final step, we link the chain of climate-agricultural-water-recreation models to a timely, policy relevant question: What would be the welfare gain (in economic terms) of meeting the EU Water Framework Directive's (WFD) classification of "good ecological status" in the catchment. We refer to Bateman et al., 2015 for a more formal treatment.

Results

Results indicated that without new policy intervention, on-farm responses to a 1^{o}C rise in temperature would increase agricultural diffuse pollution and decrease water quality throughout the case study area, with an average disutility expressed as compensation required (i.e. negative willingness to pay) of £10.44 per person, per year. In contrast, meeting WFD targets of having all rivers achieving good ecological status was estimated to generate benefits of £17.89 per person per year. Finally, GIS methods and the spatially explicit model design enabled us to aggregate impacts and value changes at the catchment level. Starting from the current baseline and introducing the climate change scenario (but no new policies) resulted in estimated, catchment wide losses of approximately £26 million per annum, with the greatest losses occurring in the western half of the catchment. In contrast, starting from the current baseline and imagining a scenario in which all sites attained good ecological status was estimated to generate annual benefits of £65 million.

Our analysis illustrates how biophysical data and GIS methods can be used in environmental economic analyses. While acknowledging that the direct market impacts of climate change on UK agriculture may be net positive, a central contribution is to demonstrate that focusing solely on these direct impacts paints a highly misleading picture. By incorporating indirect and non-market effects, the results our case study shifts from a net positive, to a net negative. In order to guide efficient policy making, research should incorporate as many rounds of (positive and negative) indirect impacts as possible. This entails high data, modelling and computing requirements, combined with both natural science and economic expertise. Thus, genuinely integrated modelling of this kind a substantial undertaking. But it is also an exciting area of research with great potential to improve environmental-economic decision making.

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