Title:

Ecosystem Services Assessment at Steart Peninsula, Somerset, UK

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Abstract

A systemic valuation was undertaken of marginal changes in ecosystem services assessed as likely to result from the Steart Coastal Management project, some in monetary terms and others semi-quantified. The Steart Coastal Management project entails allowing seawater once again to inundate formerly defended farmland, including modifications to the landform of to assist the re-creation of a range of wetland habitats on the Steart Peninsula. Primary drivers for this project include habitat creation and management of coastal flooding, although implications for a range of other connected services need also to be taken into account. Ecosystem services for which a market exists (typically traded goods with associated use values) were valued using market prices. For non-traded services, this study relied substantially on the economic valuation technique of 'value transfer'. Despite having to rely on some wide but transparently stated assumptions and uncertainties, a conservative, yet considerable, net annual benefit range of £491,155 to £913,752 was deduced. Research gaps that limited our ability to quantify and/or value several ecosystem services were identified.

Highlights

- The Steart project provides a net annual benefit range of £491,155 to £913,752
- Coastal wetlands provide clear economic benefits in terms of ecosystem services
- Habitat management does not imply a trade-off between private and public benefits
- Ecosystem services may not be received by the same individuals or groups
- Ecosystem services assessment should be undertaken at project's design stage
- Many research and knowledge gaps remain in ecosystem services assessment of European coastal wetlands

Key words

Ecosystem services
Economic valuation
Value transfer
Wetlands
Coastal management
Managed realignment

1 Introduction

Ecosystems, comprising both abiotic elements and biodiversity, provide a wide range of services supporting human wellbeing, including economic activities. However, exploitation of the services provided to society by ecosystems has tended to focus on provisioning services for which market values have become established (food, fibre, water yield, etc.), disregarding most other services in conventional economic analyses and decision-making contributing to their progressive degradation (Millennium Ecosystem Assessment, 2005; UK National Ecosystem Assessment, 2011; Russi *et al*., 2013). Management regimes favouring a wider set of socially desirable services does take place, particularly on land in public ownership such as National Parks as well as at various types of nature reserve and floodwater attenuation sites and on private holdings where land use is shaped significantly by subsidies addressing wildlife and landscape considerations or where management favours a recreational, amenity or other uses. However, commercial drivers still tend to favour ecosystem exploitation focussed substantially upon marketable outputs as a generality, with wider beneficial services a net unintended casualty. Recognition of these currently externalised values in corporate and governance decision-making is essential to halt or reverse ecosystem degradation and the systematic undermining of human wellbeing, also helping identify opportunities where multiple benefits can be realised. It is certainly consistent with commitments to taking an Ecosystem Approach at international scale (Millennium Ecosystem Assessment, 2005) and in stated government intent in the UK (HM Government, 2011).

Recognising, and where possible quantifying in monetary or other terms, the value of all interconnected services promotes incorporation of the diverse values provided of ecosystems into the mainstream of planning and other decision-making processes. If services are omitted from consideration, there is a significant risk that they may be underrepresented or completely disregarded in decision-making processes (Everard and Waters, 2013). 'Mainstreaming' the value of the natural environment not only contributes to more robust decision-making, but may help diversify and integrate funding streams directed at nature conservation, flood risk managemnet and other purposes, contribute to job and wealth creation, and ensure a more equitable sharing of the benefits provided by nature (HM Government, 2011).

1.1 The Steart Costal Management Project

The Steart Coastal Management Project (SCMP) comprises re-profiling and allowing the controlled inundation of a formerly defended farming landscape in order to re-create a range of wetland habitats, including extensive intertidal habitat following the managed breaching of existing man-made defences on the Steart Peninsula. Initiated by the Environment Agency (EA), this project addresses predicted sea level rise and is driven primarily by the requirements of the EU Habitats Directive. Recreated wetland habitat augments designated habitat of particular wildlife interest and offsets losses of intertidal habitat across the wider Severn Estuary due to rising sea levels as well as planned development and coastal flood defence schemes which, without compensatory habitat, would not be permitted. The project also contributes to the sustainable management of flood risk to people, property and public infrastructure on the Steart Peninsula by realigning the sea defences further inland, a process known as managed realignment (MR) (Environment Agency, 2011).

1.1.1 The study site: Steart Peninsula

The Steart Peninsula is located on the north Somerset coast at the confluence of the River Parrett with the Severn Estuary (Figure 1-1).

Prior to managed realignment, land use on the Steart Peninsula predominantly comprised cultivated fields, improved grassland and permanent pasture, divided by a network of rhynes (freshwater ditches) which are either open or enclosed by species-poor hedgerows. The peninsula is adjacent to internationally and nationally designated nature conservation areas forming part of the Severn Estuary Ramsar Site, Special Area of Conservation (SAC) and Special Protection Area (SPA), as well as Bridgwater Bay National Nature Reserve (NNR) and Site of Special Scientific Interest (SSSI).

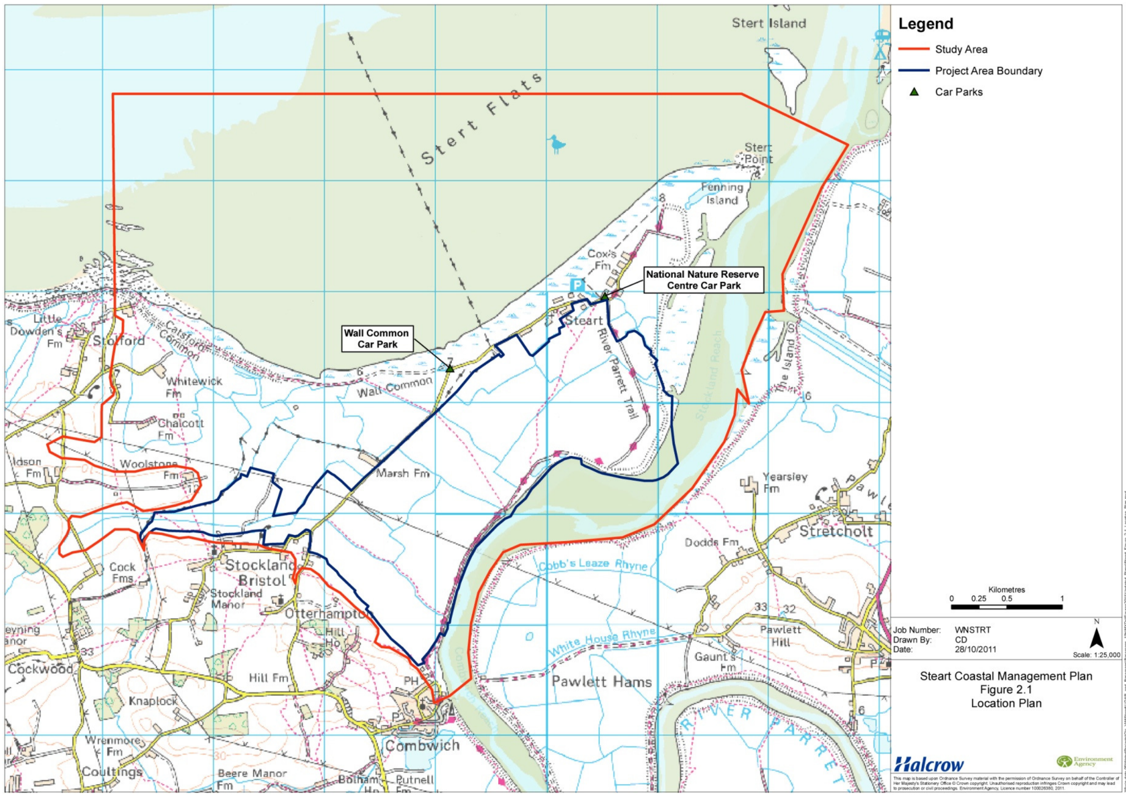


Figure 1-1 Steart location plan (©CH2M Hill & Environment Agency)

1.1.2 Description of the project

The SCMP involves recreating intertidal habitat by managed realignment of the existing coastal defences (Figure 1-2, Area D), the creation of additional saline-influenced habitat through regulated tidal exchange in Area E, and freshwater habitat in Area B. Figure 1- shows the Steart Peninsula prior to and following establishment of the planned new wetland features. This future management option has been assessed and adopted as the preferred one prior to this study. In this way, the present research only looks at this single project versus the present baseline.

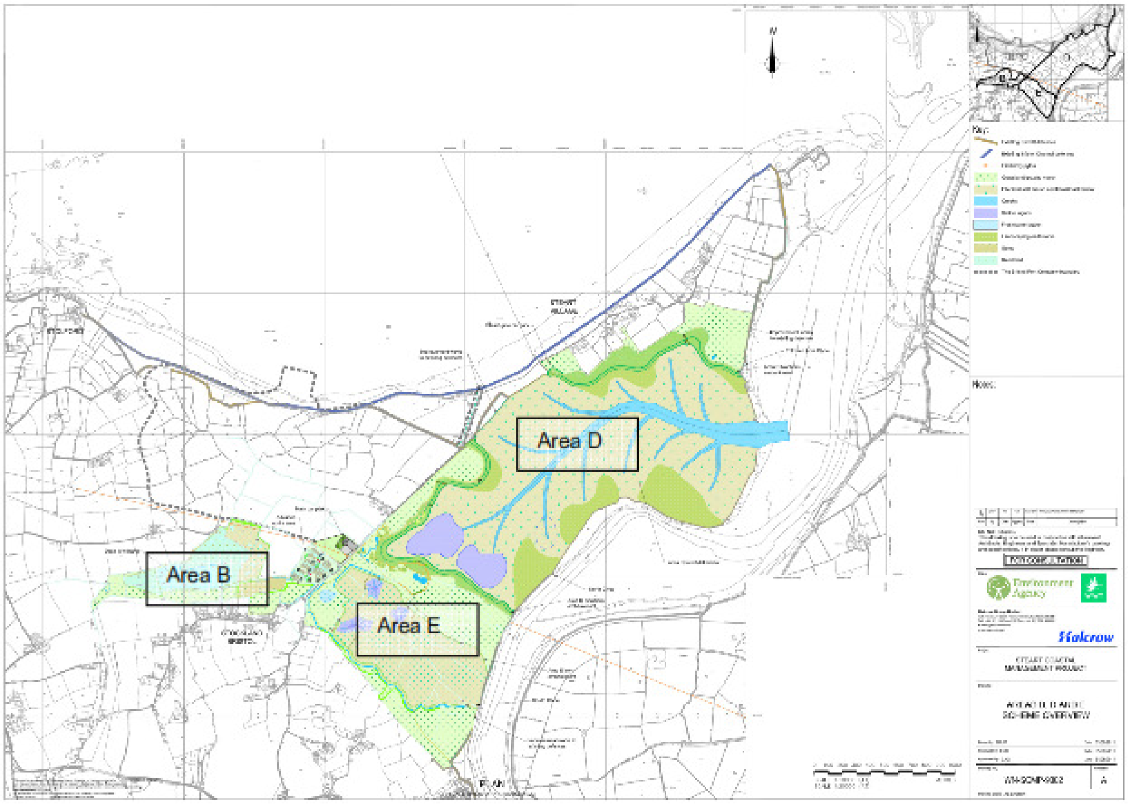


Figure 1-2 Steart coastal management project (©CH2M Hill & Environment Agency)

Figure 1-3 Steart peninsula land use change – current and future scenarios. ©WWT (Image ©2010 TerraMetrics Data SIO, U.S. Navy, NGA, GEBCO Image ©2010 Infoterra Ltd & Bluesky Image ©2010 FRLA Ltd Image ©2009 Google)

1.2 Study aims and objectives

The study comprised an assessment of marginal changes to ecosystem services likely to arise through managed realignment at the Steart peninsula. This was based on the Millennium Ecosystem Assessment (2005) classification of ecosystem services, seeking as far as possible to identify economic and non-monetary value of the SCMP. Study aims included:

1) Assessment of the environmental benefits/costs from habitat creation at Steart to provide evidence to guide optimal outcomes in related projects;
2) Learning for the future by identifying ecosystem service assessment best practices, identify knowledge gaps and further research needed and lessons learnt;
3) Contributing to a growing, though still limited, portfolio of ecosystem service assessment case studies of large-scale managed realignment sites in the UK.

1.3 Ecosystem services valuation techniques

This study makes use of the benefits transfer (or 'value transfer') technique, as shown in Figure 1-. Value transfer methods estimate the value of an ecosystem (or services and goods from an ecosystem) by applying conservative and stated assumptions values derived from relevant pre-existing valuation studies. Principal advantages of the benefits transfer approach is avoidance of resource-intensive primary valuation studies with their associated time delays, including rapid assessment of uncertainties about deduction of the value of potentially significant services. Principal disadvantages are that values have to be transferred with a high degree of caution, applying conservative assumptions to address the context sensitivity of both the study and source value site, and that only a limited subset of relevant primary values may be available.

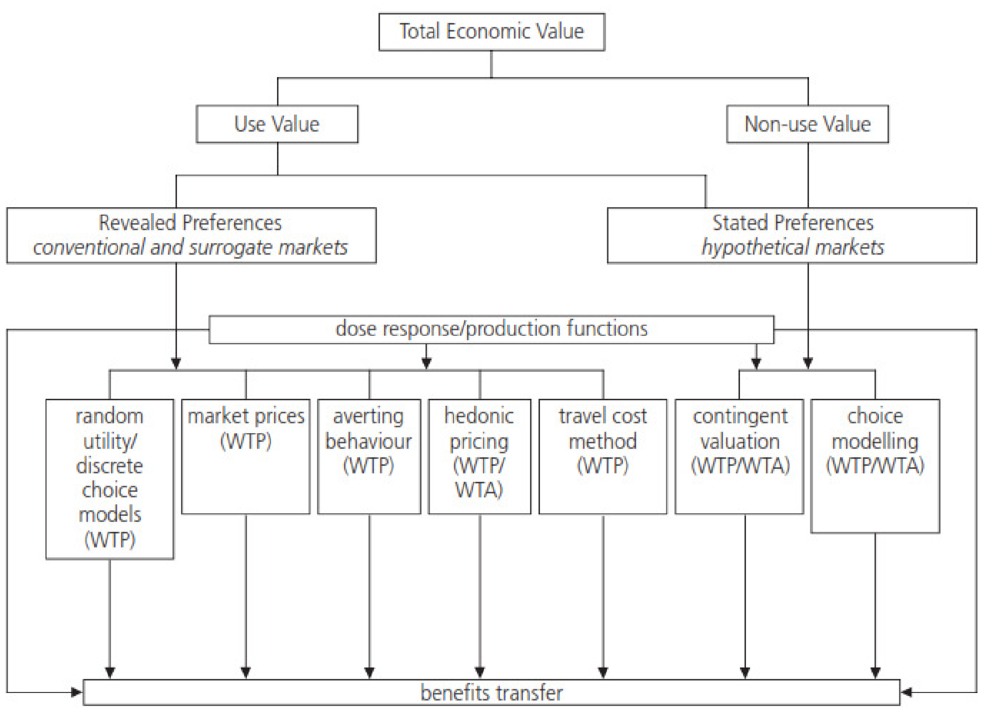


Figure 1-4 Techniques for monetary valuation (taken from Defra, 2007)

For services where monetary valuation is not possible, it is essential to ensure that the systemic focus is retained by undertaking non-monetary valuation based on a qualitative assessment of implications for the full spectrum of services, and by implication benefits or detriment to all service beneficiaries. Such non-monetary valuation needs to proportionate to the scale, risk and degree of contention of the scheme (Dunn, 2012) but not be onerous, for example using the 'likelihood of impact' scoring system promoted by Defra (2007). However, systemic context is essential to ensure that externalities are not unwittingly perpetuated in decision-making, supporting decisions that are equitable, resilient and optimal in terms of public value. Non-systemic valuation, in which only a predetermined service or subset of services are 'cherry picked', not only risks partial valuation but can lead to unintended negative consequences for non-focal services.

1.4 The use of value transfer

The robustness of value transfer depends on the availability of suitable pre-existing studies, success of the 'matching' of the policy site to an appropriate study site, appropriate and conservative assumptions used to adjust valuation between studies, and the quality of the original economic valuation study and its relevance to the present day. In this study, two different approaches to value transfer were used:

1) Unit value transfer: estimates the value of a good or service at the policy site by multiplying a mean unit value estimated at the study site (e.g. £/ha).

2) Meta-analytic function transfer: uses a value function estimated from a collection of studies. Specific parameter values for the policy site are introduced into the value function to calculate a transferred value which better characterizes the policy site.

Eftec (2010b) identifies and provides background information on studies which are potentially relevant to the valuation of environmental effects associated with FCERM (flood and coastal erosion risk management) capital schemes. **Error! Reference source not found.** highlights the studies that have investigated the economic value of wetlands and wetland ecosystem services and that have been used for the purpose of value transfer.

Table 1-1 Economic valuation evidence from wetlands studies

Ecosystem	**Meta-analyses study**	**Primary study***
Wetlands	Brander *et al.* (2008)	
Saltmarsh		Luisetti *et al.* (2011)

* Values estimated based on a combination of value transfer and Willingness-to-pay primary research

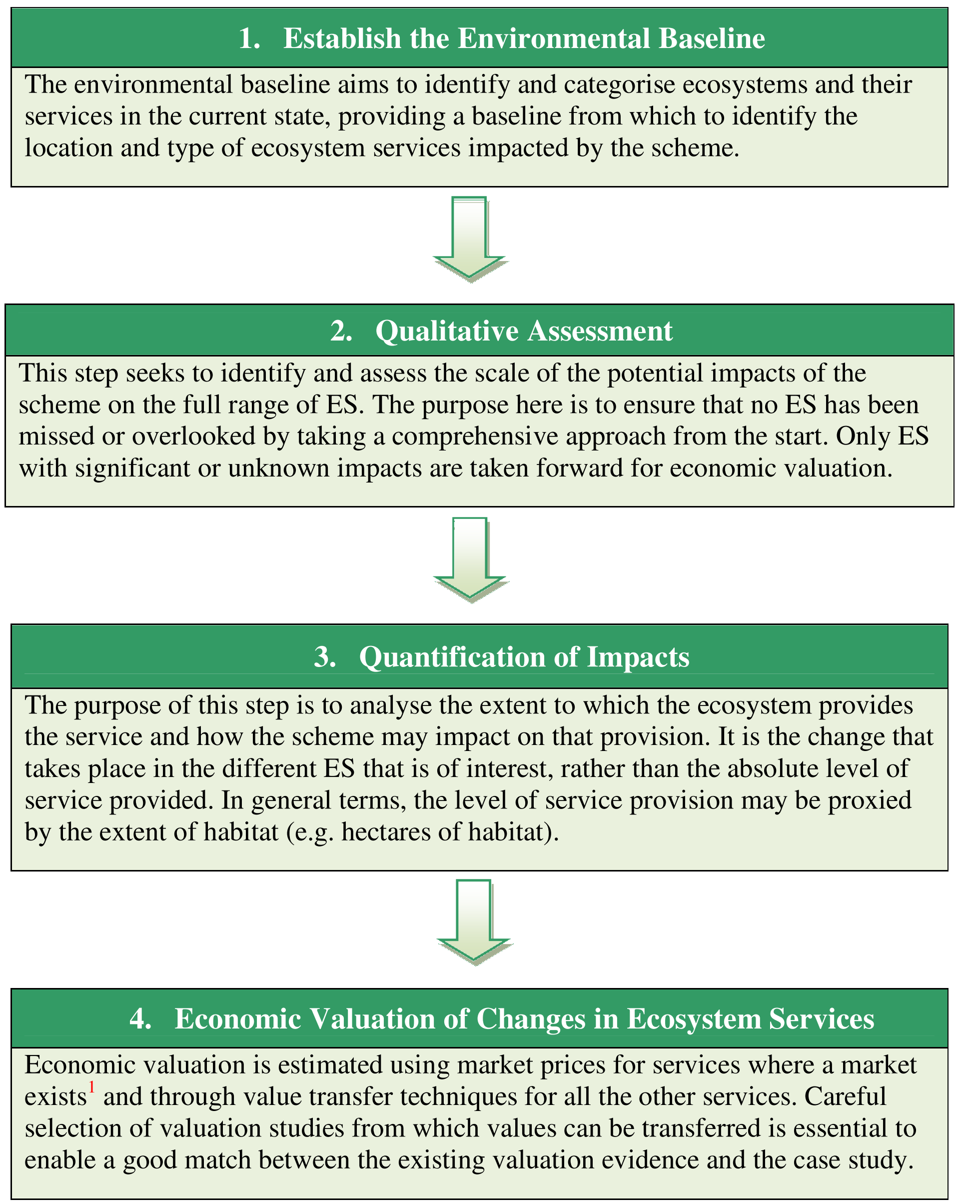
A limited set of economic valuation studies of ecosystem service outcomes at management realignment sites, based on value transfer methods, has been produced in the UK context. The ones used in this study which represent the most similar sites are Alkborough Flats (Everard, 2009) and the Blackwater Estuary Management Realignments (Luisetti *et al*., 2011).

2 Methods

2.1 Methodological framework

This study used market values where available (such as goods with established use values) and value transfer techniques to estimate the costs and benefits of other marginal changes stemming from the SCMP.

Figure 2-1 illustrates the methodological framework used in this study, identifying and briefly describing the main steps in the process.



[1] Market prices for 'food' as a provisioning service are distorted by subsidies. However, if we accept valuation techniques such as travel cost (itself substantially distorted by tax which is only a poor proxy for externalities), stated preference, willingness-to-pay and other means as appropriate for deducing how people value a spiritual or aesthetic place or a valued habitat or species, we acknowledge that we are not valuing the thing itself but how people relate to it. So the same argument applies in how we value other ecosystem services, including food (including public decisions about subsidies a significant proportion of which reaches farmers in a way that does not relate directly to food production, mainly having the perhaps perverse effect of pushing up land prices).

Figure 2-1 Methodological framework of Steart ecosystem services assessment study

2.2 Steart ecosystem services assessment in the context of previous research studies

Most of the research studies on valuation of ecosystem services, such as TEEB (2010a), UK NEA (2011), Luisetti *et al*. (2011), Eftec (2010) and Brander *et al.* (2008), make a clear distinction between ecosystem services and benefits derived by people. They then suggest that, due to the complexities and inter-relationships between supporting, provisioning, regulating and cultural services, placing a value on each individual service may not be appropriate. The approach taken in these studies is therefore to value end points of direct relevance to market values or non-use values, to avoid the problem of double-counting.

This study acknowledged and considered the complementarities as well as conflicts between services and the problem of double-counting as well as the complexities of being able to fully account for all changes to ecosystem services. However, this study followed the guidance of Everard and Waters (2013) by seeking firstly to value all services, and only then explicitly excluding values where double-counting would occur. The rationale for this is that it is unsafe to assume that societal values stemming from 'intermediate' ecosystem services are substantially internalised into their contribution to 'final services' and the production of goods. Our approach to averting the risk of continuing to externalise important services is to attempt to value all services, acknowledging that methods are currently imperfect and there is some reliance on prior meta-study values, then explicitly removing those where double counting is likely to occur.

3 Results

3.1 Environmental Baseline

3.1.1 Current main ecosystem types

Key habitats present on the Steart Peninsula (and at the project area) prior to MR are summarised in Table 3-1, with a brief outline of the main characteristics (adapted from Environment Agency, 2011).

Table 3-1 Ecosystem types at Steart Peninsula

Ecosystem type	Description
Intertidal	These include mudflat, saltmarsh, shingle and sand habitats and saline lagoons. These areas are predominantly within the Severn Estuary designated sites and all are UK BAP habitats.
Ditches and Pools	The extensive ditch networks are integral to the grazing marsh and support an important invertebrate assemblage as well as the nationally-threatened water vole.
Grazing Marsh (improved and semi improved permanent pasture)	There is approximately 500ha of grassland within the peninsula. Grazing marsh is a priority habitat under the UK BAP (Coastal Floodplain and Grazing Marsh) Most of the value of the grazing marsh is associated with wetland features (e.g. ditches and ephemeral standing water).
Cultivated Land (arable and grass leys)	Extensive areas of arable farmland, sown predominantly with cereal crops, may provide breeding habitat for ground-nesting birds such as skylark. Fallow land is also an important food source for insects such as bees, butterflies and moths.
Trees and hedgerows	Hedgerows are associated with many of the field boundaries but are largely absent from most seaward fields. An assessment of hedgerow ecological quality concluded that they are generally species poor. Very few mature trees are present, mainly associated with hedgerows on the higher ground on the perimeter of the site.

3.1.2 Current significant ecosystem services

The ES present at Steart Peninsula flow from these current habitat types and are summarized in Appendix A.

3.2 Qualitative assessment

The qualitative assessment of the potential impacts of the project on ecosystem services undertaken for this study is described and presented in Table 3-3 to Table 3-6 for provisioning, regulating, cultural and supporting services respectively.

This initial screening assessment was undertaken for each service using the semi-quantitative scoring system proposed in Defra (2007) (see Table 3-2), including specific additional services relevant for this scheme.

Table 3-2 Qualitative assessment scoring system (Defra, 2007)

Score	Assessment of likely impact
++	Potential significant positive effect
+	Potential positive effect
0	Negligible effect
-	Potential negative effect
--	Potential significant negative effect
?	Gaps in evidence / contention

The impacts scores for each ecosystem service were attributed based on a thorough review of all documents submitted for the project's planning application. In addition, expert and stakeholder consultation was undertaken to ensure that all significant impacts and evidence gaps were captured and that the scores were appropriate. A total of 20 people from 8 different organizations were consulted, including local and national experts from planning, wildlife, environmental regulator (Environment Agency), fisheries, hydrology, navigation, and academic organisations, seeking to represent a broad spectrum of stakeholder interests.

Table 3-3 Qualitative assessment of potential impacts on provisioning services

Services	Marginal benefit assessment	Anticipated change
Fresh water	The scheme will result in the concentration of freshwater flows to the peninsula in Area B, with overflows to habitat in Area E. Small loss of freshwater flows into the northern end of peninsula.	**-**
Food (e.g. crops, fruit, fish, etc.)	Loss of approximately 110 hectares of Grade 3b agricultural land. Potentially compensated for by fish/shellfish and *Salicornia* productivity as well as enhanced conditions in the River Parrett for elvers recruitment. A new market of saltmarsh lamb/beef may also be promoted.	?
Fibre and fuel (e.g. timber, wool, etc.)	Reeds and oil seed rape are not known to be harvested for thatch, fuel or compost. Sheep wool and cattle leather marginal change is considered negligible.	0
Genetic resources (used for crop/stock breeding and biotechnology)	No known genetic resources being used. Potential benefit if rare breeds grazing are brought to the site and native black poplar is planted.	+
Biochemicals, natural medicines, pharmaceuticals	No known species being utilized for the production of biochemicals, natural medicines or pharmaceuticals.	0
Ornamental resources (e.g. shells, flowers, etc.)	Cobbles and other beach aggregates are not actively collected, and such practices are likely to be discouraged due to the coastal defence benefits to which they contribute. No net change anticipated unless new markets are created.	0

Table 3-4 Qualitative assessment of potential impacts on regulating services

Services	Marginal benefit assessment	Anticipated change
Air quality regulation	Dust generation will not be increased once salt marsh vegetation becomes established, and any reduction in vehicle emissions due to the changes in management of the land will be minor.	0
Climate regulation (local temperature / precipitation, greenhouse gas sequestration, etc.)	Saltmarsh acts as a significant carbon sink (Laffoley & Grimsditch, 2009, estimate that the long-term carbon storage rate in saltmarsh sediments is 2.1 tonnes/ha/year) increasing sequestration of carbon dioxide and methane.	++
Water regulation (timing and scale of run-off, flooding, etc.)	Creation of freshwater and intertidal habitats will significantly improve regulation of water flows on site, and modelling demonstrates that it will reduce the tidal flood risk. There will be no adverse impact on the fluvial flood risk.	++
Natural hazard protection (e.g. storm, flood, landslides)	The removal of existing defences to create new habitat will require some replacement of defence further inland to protect Steart village and the access road. Although these will be constructed to the existing standard of protection, by doing so the EA will be able to continue the maintenance of the defences for the next 20 years (15 years longer than if there was no MR). It is also anticipated that there may be enhanced protection from storm surges on the River Parrett.	+
Pest regulation	*Azolla* has been discovered at the site, and therefore there is potential for expansion of population with the creation of new wetlands. Potential for seaweed (*Enteromorpha*) growth. Not seen as having a significant impact with proper management practices in place.	?
Disease regulation	Potential creation of favourable conditions for water-related diseases, particularly in the light of climate change. Intertidal habitats are however good in preventing microbial diseases. Not seen as having a significant impact with proper management practices in place.	?
Erosion regulation	HR Wallingford (2011) concluded that any changes in physical processes are confined mainly to the area surrounding the entrance to the realignment with negligible changes elsewhere. Over time the estuary morphology will reach a new equilibrium.	0

Water purification and waste treatment	Recreated wetlands will provide a potential significant improvement in natural water treatment (wetland purification processes). Specific treatment wetlands will also be created to treat flows from visitor facilities. In addition, there will be a reduction in current negative agricultural impacts to water quality as fertilizer spreading will cease, potentially leading to improved water quality on the river Parrett and therefore contributing to EA's obligations under the Water Framework Directive (WFD).	++
Pollination	There may be a change in species pollinating/pollinated. Not seen as having a significant impact.	0

Table 3-5 Qualitative assessment of potential impacts on cultural services

Services	Marginal benefit assessment	Anticipated change
Cultural heritage	Environment Agency (2011) indicates that, with an appropriate mitigation strategy in place, the residual effects on the archaeological receptors potentially affected by the scheme will have no significant effect. The scheme will bring additional cultural interpretation of the site providing education to visitors and celebrating the site's recent development and international importance. Overall considered that there is a potential net positive effect.	+
Recreation and tourism	The site is used by local residents and visitors for recreational activities, including dog walking, cycling, bird watching, and horse riding. The development, subject to sensitive management, will enhance these activities bringing more visitors into the site. Planning Solutions Consulting Limited & DT Transport Planning (2011) indicate a 3-fold increase in the number of visitors.	++
Aesthetic value	Environment Agency (2011) assessed the effects on landscape character and visual receptors during operation. The overall assessment of the development concluded that they would have a beneficial long-term impact on the area's landscape character and visual amenity, through the replacement of a managed, agricultural landscape with a more diverse, sustainable and natural one.	+
Spiritual and religious value	Potentially enhanced by the spiritual value of water and increased sense of wilderness.	+
Inspiration for art, folklore, architecture, etc.	Potentially enhanced by a more diverse and native landscape with new interpretation signs and viewing points attracting more artists, photographers, etc.	+
Social relations (e.g. fishing, grazing or cropping communities)	Potentially enhanced by new farming, angling and bird watching community groups.	+

ADDENDUM: Education & Research	Will create educational and learning resources for schools, colleges and the wider public. Education themes are likely to include land management for wildlife, agricultural use associated with coastal habitats, coastal evolution and climate change. Further research opportunities for valuing saltmarshes, coastal change, etc.	++
ADDENDUM: **Employment**	At present, employment opportunities on the Steart peninsula are principally linked to agriculture, employing 7-8 Full time Equivalent (FTE) positions. The effective loss of 2 FTE agricultural jobs is anticipated. However, the site will employ a higher number of staff to undertake site management, wardening and to engage with local communities, visitors and organised groups.	+

Table 3-6 Qualitative assessment of potential impacts on supporting services

Services	Marginal benefit assessment	Anticipated change
Soil formation and retention	The majority of the managed realignment site will accrete due to sediment deposition thus creating the environments sought for the habitat creation scheme. Accretion will continue until the intertidal area reaches the elevation of existing saltmarshes in the Parrett.	++
Primary production	The creation of a more complex/varied habitat may lead to enhanced assimilation and accumulation of energy and nutrients by organisms, potentially improving primary productivity.	?
Nutrient cycling	The creation of new intertidal habitat will enhance nutrient processing while significantly reducing the input of fertilizers formerly applied to converted agriculture land. Equally applied to seasonally inundated grassland in freshwater area.	++
Water cycling	Wetland habitats are efficient in recycling water at local scale and it is therefore anticipated a significant net change from current land use.	++
Photosynthesis (production of atmospheric oxygen)	Oxygen generation has not been quantified. There is possibly an increase from a more complex/varied habitat, however, some tree and hedgerows will be lost.	?
Provision of habitat	Intertidal habitat creation is the main driver for this project aiming at increasing local biodiversity. Mitigation strategies will be put in place to protect legally-protected species such as water voles, badgers, newts, etc. that may die or get injured during the saline inundation of Area D.	++

The above tables show that the project will yield significant benefits across all of the four ecosystem service categories. It should be noted that, for each ecosystem service, there may be some positive and negative impacts within them, but a judgement has been made by the authors in collaboration with a stakeholder group as to the overall semi-quantified impact.

The ES with significant or unknown impacts to take for further evaluation are:

- Provisioning services
    - Food
- Regulating services
    - Climate regulation
    - Water regulation
    - Water purification and waste treatment
- Cultural services
    - Recreation and tourism
    - Education
- All supporting services

The services of pest and disease regulation, although with unknown impacts, are not taken forward as their impacts were not deemed significant with appropriate management practices in place.

3.3 Quantification and economic valuation of changes in ES

3.3.1 Food

This service considers agriculture and fishery goods. Agriculture goods are quantified based on the changes in available area of arable and grassland fields and their consequent productivity in terms of arable and livestock output. Valuation is estimated based on annual farming income using market prices. Fishery goods quantification is associated with enhanced fish biological productivity and recruitment in intertidal habitats and consequent improved catch for commercial purposes. Quantification and valuation were based on the value transfer method.

3.3.1.1 Agriculture

Environment Agency (2011) quantification and valuation estimates have been used as shown in Table 3-7 . Detailed information on how these figures have been derived are provided in Annex B.

Table 3-8 Current and future agriculture income potential at the project area

Income potential	Gross Income from land use (arable + livestock)	Total costs	Subsidies	
			Single Payment Scheme (SPS)	Environmental Stewardship
Existing scenario (£/year)	645,000	630,000	110,500	27,000
Future scenario (£/year)	111,000	156,250[1]	0 – 110,500[2]	125,000[3]

[1] Assuming that stewardship schemes cover around 80% of the costs to manage the land
[2] SPS uncertainty due to CAP reform in 2013
[3] Revised estimate based on the final application for Higher Level Stewardship (HLS) scheme

Summary of impacts on farm income within the project area

At the current time, the project area has the ability to generate agricultural net income of the order of **£152,500** (gross income – costs + subsidies). Considering the future scenario with less agriculture output income but higher income from agri-environmental schemes the project area will generate income from **£79,750** to **£190,250** annually. This means that overall the project area may incur from an annual loss of **£37,750** to an annual benefit of **£72,750**. It should be noted that the consideration of impacts on farming incomes does not factor in the added value of future specialist/niche farming opportunities (e.g. saltmarsh lamb, salicornia harvesting, shellfisheries). These are growth markets in the UK and have the potential to make a significant contribution in the overall annual income.

3.3.1.2 Fisheries

A few studies have been conducted on intertidal fish communities in North West Europe, to which a likely contributory factor are inherent sampling difficulties in large tidal ranges.

Fonseca (2009) studied fish utilisation of newly-created habitats and adjacent mature saltmarshes in the Blackwater Estuary in East England. Quantitative sampling was undertaken at three locations and a total of 18 samples were collected. Bass was selected for further analysis, since this was the only significant commercial species present in the catches. Table 3-9 appears in Fonseca (2009) and is reproduced in Luisetti *et al.* (2011) as part of an overall economic analysis. The table shows the value of bass per hectare contributing to the inshore fishery after five years (the age at which bass will most likely have attained the minimum length eligible for harvesting) and for every year thereafter.

Table 3-10 Value of bass (£ per hectare) contributing to inshore fishery after five years

Survival parameter estimates:	Upper	Mean	Lower
Value per hectare at average wholesale price (£7/kg)	47.75	11.55	1.93
Value per hectare at lowest wholesale price (£4.50/kg)	30.50	7.43	1.24
Total weight (kg) of juvenile bass per hectare surviving to 36 cm after 5 (or 4) years	6.78	1.65	0.28

This work remains the only reported quantitative study of its kind in Europe and has therefore been used for value transfer to our policy site despite a high degree of uncertainty and assumptions. In this study only sea bass is considered for economic valuation (ignoring therefore recruitment of other important commercial fish species and shellfish). It was deemed therefore that this could provide at least a minimal figure to the potential of the policy site for commercial fishing.

In this way, for 232 ha of new saltmarsh area to be created at Steart and considering the upper and lower values per hectare at average wholesale price of sea bass estimated in Luisetti *et al.* (2011) the project area will be able to yield a benefit of around **£450** to **£11,100**.

3.3.2 Climate regulation

3.3.2.1 Greenhouse gas sequestration

The biggest net change in habitat conversion, with significance for changes in greenhouse gases emissions (GHG), is the creation of 232 ha of saltmarsh from both arable (50%) and improved grassland (50%). The greenhouse gases considered most significant at this site are: carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O).

Following Eftec (2010b) guidance, to determine the change in emissions associated with a change in habitat, an estimate of net (or equivalent) carbon sequestered per hectare (e.g. t CO_2e/ha) has been estimated. This is to allow for the interactions between the three greenhouse gases referred above.

According to Adams *et al*. (2011), Blackwater MR saltmarshes are currently sequestering C at a rate of 2.23 t CO2e/ha/yr (medium value).

According to Alonso *et al*. (2012), agricultural practices based around grasslands are predicted to be a net carbon sink while arable land is a net source. Freibauer *et al*. (2004) cite mean carbon flux measurements of 0.60 t C/ha/yr and -0.83 t C/ha/yr respectively in a review of European soils. These values however only refer to soil C stocks and have been converted into (CO_2e)[2] equivalence (grasslands: 2.20 t CO_2e/ha/yr; arable: -3.04 t CO_2e/ha/yr). A net C sequestration change of about 615 t CO_2e/yr is then estimated.

Emissions arising from FCERM schemes that map to the non-traded carbon sector, which is the case for emission from land use change (e.g. habitat gains and losses), should be valued using the 'non-traded price of carbon' (NTPC). The NTPC increases over time, so the values applied here were selected as relevant to the timescale of the study. DECC (2010) guidance specifies a lower-upper bound range of £25 - 75/t CO2e. In this way, the scheme will be able to yield a benefit of about **£15,375** to **£46,125** per year.

3.3.2.2 Microclimate

It is likely that when compared to arable fields, mudflat, saltmarsh and reedbed habitats will transpire different quantities of moisture and will form a more differentiated microclimate. However, there are no apparent methods at present to quantify this change unless local measurements in temperature are undertaken at the current site and in a saltmarsh with similar characteristics to Steart (e.g. proximity to the sea).

3.3.3 Water regulation

This service focuses on the environmental benefits/costs resulting from changes in the water regulation function of water systems when we create space for water by realigning the defences.

The creation of a more diverse habitat composed by saline and freshwater lagoons, reedbeds, saltmarshes, creeks, etc. is likely to provide a more natural hydrology which will benefit fish and other aquatic wildlife. The benefits of improved hydrology for fish and other estuarine wildlife are however going to be assessed under 'recreation and tourism' and 'provision of habitat' services respectively. In this way, and to avoid double-counting, this service is not assessed discretely.

3.3.4 Water purification and waste treatment

This ecosystem service considers two aspects:

1) The benefits resulting from costs saving of using wetland habitat for wastewater treatment in lieu of any existent conventional treatment; and
2) The environmental benefits stemming from improved water quality.

[2] Freibauer et al (2004) figures are converted to CO_2e considering that CO_2 weighs 44.01 g/mole and carbon weighs 12.01 g/mole. It does not consider however CH_4 and N_2O fluxes.

3.3.4.1 Wastewater treatment

Currently the run-off flows from agriculture fields and the manure collection of the chicken farm do not pass through any kind of conventional treatment, but are instead washed away and ultimately discharged into the River Parrett. Two treatment wetlands are planned as part of changes on the Steart site. Despite the improved water quality both by treatment wetlands and reduced chemicals used in agriculture, no costs savings are achieved since no conventional water treatment are being currently undertaken in the area. In this way, there are deemed to be no benefits to be assessed on wastewater treatment.

3.3.4.2 Environmental benefits from water quality improvement

The environmental benefits stemming from improved water quality, such as enhanced fish productivity and other aquatic wildlife, are captured by the estimation of their human welfare impact via amenity/recreational and habitat values, and therefore are not considered in this section to avoid double-counting.

3.3.5 Recreation and tourism

Existing recreational uses of the Steart Peninsula were investigated through a dedicated visitor assessment survey undertaken by Planning Solutions Consulting Limited & DT Transport Planning (2011). The findings indicate that there are up to 11,200 visitors to the Steart Peninsula every year mainly due to the Bridgwater Bay NNR.

The creation of new wetland habitat combined with the extensive development of the multi-use path network and a series of new observation points and hides offers significant opportunities for recreational uses. The visitor assessment survey estimate that visitors to the project site will increase to about 33,000 per annum once the site is fully established and that from these, 8% of the visitors will be holiday makers, 12% will be locals and the remaining 80% will be day visitors for which the Steart wetlands reserve is the main reason for the visit.

Values were transferred from 3 RSPB case studies provided by RSPB (2011) which assessed the main drivers of economic activity and their impacts on 10 of their reserves (Table 3-11). These reserves were chosen based on their similarity with Steart's particular characteristics in terms of remoteness/landscape, habitat and geography/socio economic conditions.

Table 3-12 Average visitor spend in RSPB study sites

	Average visitor spend (£/person/trip)	
RSPB Reserve	**Day visitors**	**Holiday makers**
South Stack	13.61	121.32
Frampton Marsh	6.40	108.5
Arne	9.73	133

It was assumed that local visitors bring additional economic activity through their visit. On this basis, the Steart visitor projection will yield a benefit in the order of **£300,840** to **£469,310** per annum. Whilst recognising that this figure reflects total expenditure, it is assumed that displaced expenditure (i.e. not additional but due to visitors coming to Steart rather than other local sites) will be balanced by value-add to other economic activities (shops, catering, etc.) occurring locally to the Steart site. It would have been possible to draw upon the extensive literature on the value of recreation, but at this point a detailed breakdown of likely recreational activities was not foreseeable (though angling and birdwatching are recognised as significant contributors).

In previous Sections, it has been considered that the improved hydrology and water quality leading to enhanced fish biological productivity would be estimated through their human welfare impact via recreational values (e.g. enhanced angling activities). Even though the visitor assessment study, as shown in Appendix I, does not explicitly refer to angling visits, it has been assumed that their increased numbers is expressed in the overall assessment. It has also been assumed that the average spend by anglers is similar to the average spend of other types of visitors.

3.3.6 Education

The Steart project will bring enhanced opportunities for public engagement and formal learning of the site, to include schools, colleges, research and other interested groups. Here we consider the benefits that enhanced primary, secondary and tertiary education from school trips and potential 'citizen science' projects bring to society.

According to the demographic profile data provided on the Steart visitor assessment survey, there are 112,275 school aged children (5 to 14 year olds) living with the 60 minute drivetime catchment. There are 180 state primary schools and 53 secondary schools in Somerset.

Mourato *et al.* (2010) considered case studies of both school trips to UK nature reserves and a national 'citizen science' project. These case studies provide just the 'cost of investment' involved in these visits and not the true economic valuations of educational benefits concerned. Nevertheless, assuming that these undertakings are good value for money, such costs should provide a lower bound minimum of the values concerned (UK NEA, 2011).

Transferring the values from Mourato *et al.* (2010):

- £850,000 to £1.3 million of expenditure value on 2,000 school trips per annum (i.e. £425 to £650 per school trip per annum)
- £188 expenditures per participating school on citizen science project

And adjusting these into the local number of schools and pupils involved and assuming that:

- Each trip involves 28 pupils;
- 5% of school children aged 5 to 14 years old will undertake school visits to Steart (i.e. 5,600 students and 200 schools trips); and

- 5% of schools (i.e. 10 schools) will participate in one annual citizen science project at Steart.

The project will be able to yield a benefit per annum of **£87,000** to **£132,000**. Such an assessment is likely to provide only a very lower bound investigation of such values. As for 'Recreation and tourism', costs are taken as a proxy for benefits as some of this value is not wholly additional (for example displacing values from other sites) yet the contribution of ecosystem services to the tertiary education sector is unaccounted for (though occurring already, this would require further analysis).

3.3.7 Soil Formation

Long-term rates of saltmarsh accretion across the wider Severn Estuary, which take account of compaction, range between 0.46mm/year and 10.5mm/year. No valuation case studies were found to be able to transfer a value into the policy site and therefore no value has been attributed to this service. Nevertheless, the site's potential to develop similar habitat to the saltmarshes elsewhere on the Parrett has been confirmed through accretion rate estimates. It should be noted that soil formation has a strong inter-relationship with carbon sequestration and other supporting services and its economic evaluation could potentially have lead to double-counting of benefits.

3.3.8 Primary Production

According to the UK NEA (2011) 'primary production is the fixation by photosynthesis of either atmospheric or aquatic carbon dioxide, or its assimilation as organic compounds by plants and algae'. As such, primary production both influences, and is influenced by, the supporting services of nutrient cycling, water cycling and soil formation.

Assessment of status and trends of primary production across UK habitats is limited (UK NEA, 2011). There are currently many knowledge gaps which limit full quantification of primary production in both terrestrial and marine habitats. For this reason, it has not been possible to quantify net changes in primary production due to habitat conversion. In addition, even if quantification was possible, there is a strong likelihood that at least a proportion of it might double-count with other ecosystem services as primary production underpins the delivery of all other ecosystem services (i.e. regulating, provisioning and cultural services).

3.3.9 Nutrient cycling

Wetlands are a major provider of water quality improvement benefits through their ability to recycle nutrients. Adams *et al.* (2011) estimated that potential MR areas within the Blackwater Estuary (29.5 km^2 saltmarsh and 23.7 km^2 intertidal mudflat) could bury 695.5 t N/yr , with a further 476 t N/yr denitrified. The MR saltmarsh was also able sequester 139.4 t P/yr. These figures show the potential of MR intertidal habitats to reduce estuarine nutrient loads which can be particularly relevant in achieving the WFD goals.

The net change in nutrient loads in Steart was not possible to quantify due to unknown current geochemical data. Nevertheless, this service will be captured under 'provision of habitat' through its impact on water quality improvement, avoiding therefore a potential element of double-counting.

3.3.10 Water cycling

According to the UK NEA (2011), the water cycle considers the major water fluxes (rainfall, evapotranspiration, river flow) and the major water storages (soil, groundwater, lakes) that combine to determine the availability of water in time and space.

Our ability to predict future variability in the water cycle in space and time relies on the hydrological models being coupled to climate models capable of producing rainfall fields at an appropriate scale and time resolution. Further research in terms of local hydrological modelling would be required in order to be able to quantify this service.

3.3.11 Photosynthesis

This service is tied closely to primary production and there are currently no pragmatic means for quantifying or valuating it.

3.3.12 Provision of habitat

Although there is substantial anecdotal evidence of non-use (existence and bequest) values associated with maintaining biodiversity, the estimation of such values is problematic (UK NEA, 2011). Most commentators argue that this can be better achieved by the application of estimates of individual preference, with the most common approach to assessing the non-use value of biodiversity being via Stated Preference (SP) studies. Others would argue that a lower boundary estimate of values could be depicted by the payments provided by policies designed to promote biodiversity (e.g. opportunity costs or biodiversity offsets). The later approach however needs to be treated with caution, with the potential circularity of the valuation process being recognised (UK NEA 2011). Given this, the SP approach is adopted and the valuation of habitat creation is estimated by using the meta-analytic function transfer method used in Eftec (2010b) previously described in section 1.4.

According to Eftec (2010b) and Morris & Camino (2010), the recent meta-analyses of wetland valuation provided by Brander *et al.* (2008) provide the most appropriate value transfer function for valuation of UK wetlands, also in the context of FCERM schemes. It permits control of factors such as habitat type, ecosystem service provision, wetland size, availability of substitutes and affected population that should be controlled for in value transfer analysis.

Table 3-13 presents economic value ranges derived from the Brander *et al.* (2008) meta-analysis to estimate the environmental benefits associated with FCERM schemes that create saltmarsh and intertidal mudflat.

Table 3-14 Economic value ranges for different habitats by area and abundance of substitute wetland (£/ha/yr, 2008 prices). (taken from Eftec, 2010b:p 44)

Area of substitute wetland (ha)	Area of habitat (ha)					
	1-10	11-30	31-50	51-100	-500	-1000
			Saltmarsh			
1-100	1280-200	930-1440	800-1240	650-1000	400-630	330-510
100+	1120-1890	880-1370	750-1170	610-960	380-610	310-480
			Intertidal mudflat			
1-100	1240-1930	900-1390	770-1200	630-980	390-600	320-490
100+	1180-1830	850-1320	730-1140	600-920	370-570	300-470

These figures only consider the provision of the following services: biodiversity, water quality improvement, non-consumptive recreation and aesthetic amenity (only for the lower bound estimates). The services 'omitted' from the specified meta-analysis function are: flood control and storm buffering, surface and groundwater supply, commercial fishing and hunting, recreational hunting, recreational fishing, harvesting of natural materials and fuel wood. This will avoid double-counting with services which have already been estimated separately or that are not relevant for this study. Note that there is potential for double-counting in terms of the non-consumptive recreation and aesthetic amenity elements, as some of this is addressed through assessment of 'Recreation and tourism' benefits. Although Brander *et al.* (2008) do not make it clear precisely how questions behind their stated preference surveys leading to meta-analysis figures were framed, there are also non-linearities of these services with respect to habitat size. Furthermore, service values are also non-additive. In the absence of more detail about the finer breakdown of likely non-consumptive recreation and aesthetic amenity uses and consequent benefits, the cumulate figure provided by Brander et al. (2008) covering the three elements of biodiversity, water quality improvement, and non-consumptive recreation/amenity is reduced by 1/3 to minimise the potential double-counting and to ensure that estimates are conservative. This approach may be somewhat arbitrary, but is considered indicative of the scale of benefit; to attempt to be more precise about a figure derived from a meta-study transferred to a different site would be to ignore the substantial uncertainties introduced by multiple assumptions in the initial studies, during aggregation and on transfer.

To account for the 'marginal' values of the services, the upper bound estimates of Table 3-14 are used. Considering that the project will create 232 ha of saltmarsh and 30 ha of intertidal mudflat and assuming that the area of substitute wetland available is less than 100 ha, a net annual benefit of **£125,240** to **£182,467** is estimated.

3.4 Summary results

Table 3-15 summarises the results of the economic valuation for the ES assessed.

Table 3-16 Summary results from ecosystem services assessment at Steart

Ecosystem Service	Annual benefit/cost assessed / Research gaps
Provisioning Services	
Food	Annual value = loss of £37,300 to benefit of £83,850 Research gaps: contribution of intertidal habitats to fish and shellfish biological productivity as well as salicornia productivity.
Regulating services	
Climate regulation	Annual benefit = £15,375 to £46,125 Research gap: Quantification of microclimate effects
Water regulation	Not assessed to avoid double-counting. Improved hydrology for fish and wildlife to be assessed under 'recreation' and 'habitat provision'
Water purification and waste treatment	Not assessed to avoid double-counting. Improved water quality for fish and wildlife to be assessed under 'recreation' and 'habitat provision'
Cultural Services	
Recreation and tourism	Annual benefit = £300,840 to £469,310 Research gap: Recreational fishing evidence base
Education	Annual benefit = £87,000 to £132,000 Research gaps: Contribution of ES to the tertiary education; Intrinsic value studies of education (rather than using the cost based approach)
Supporting Services	
Soil formation	Benefit quantified but not valued. Research gap: lack of valuation studies in the literature
Primary production	Benefit not quantified. Research gap: lack of quantification methods in the literature
Nutrient cycling	Benefit not quantified. Research gap: lack of geochemical data
Water cycling	Benefit not quantified. Research gap: lack of local hydrological modelling data
Photosynthesis	Benefit not quantified. Service linked to primary production. Research gap: lack of quantification methods in the literature

Provision of habitat	Annual benefit = £125,240 to £182,467 Research gap: lack of valuation studies on biodiversity in the UK
Total annual benefits	**£ 491,155** to **£913,752**

4 Discussion

4.1 Key outcomes

4.1.1 Efficacy of the Ecosystem Approach

This study highlights the significance of a broad range of values beyond the traditional costs and benefits of near-market goods and services (usually the provisioning services). Ecosystem services provide the analysis with a basis for expressing the broader societal benefits or costs consequent from ecosystem-based interventions, offsetting the often implicit political perception that biodiversity conservation and environmental protection measures are necessarily a net cost and constraint upon economic development (Everard, 2009). This in turn supports taking an Ecosystem Approach (as defined by the Convention on Biological Diversity: www.cbd.int/ecosystem) which takes account of wider impacts on ecosystems, their services, all affected stakeholders and their inclusion in decision-making and economic contexts.

Many of these benefits are assessed on the basis of some wide assumptions, and are subject to further uncertainties where surrogates have to be applied to derive values. However, despite all uncertainties, when those values are assessed, the scale of public benefits arising from improved ecosystem functioning can be significant. This provides a clear argument in favour of ecosystem-based interventions, as opposed to more narrowly-framed engineered solutions, and for assessments of likely scheme outcomes based on ecosystem services.

4.1.2 Economic benefits of the Steart Costal Management Project

This study clearly evidences the economic benefits from a range of ES that can be provided by coastal wetland habitats/MR schemes, which exceed estimated values stemming from bird conservation for which much more evidence has been collected.

The view of this project as favouring regulatory services (i.e. water regulation), supporting services (i.e. biodiversity) and cultural services (i.e. recreation) to the detriment of provisioning services (i.e. crops) is no longer supported. In fact, were we able to (i) properly quantify the contribution of intertidal habitat to fish and shellfish biological productivity (which has both significant food and recreational values), (ii) value all commercially important fish species present within the area, and (iii) estimate the contribution of added value agriculture outputs such as saltmarsh lamb and *Salicornia*, it is likely that significant additional benefits could be estimated. The management of habitat for wider public services does not necessarily imply a 'trade-off' with other private benefits, even if it may imply a trade-off between beneficiaries and a shift in the benefits provided. This may help inform how ecosystem services can be used as a framework for the beneficial redirection of agricultural subsidies to deliver wider public benefits.

We recognise that some of the values deduced are more robustly supported than others, reflecting their closeness to market. However, to fail to assign sometimes illustrative values to as many services as possible, emphasising only reductive analysis of services more robustly monetised, is to fall into the trap of failing to consider systemic outcomes: the key purpose of this paper. We also recognise three aspects of 'costs': (1) expenditure entailed in scheme implementation; (2) the negative consequences of failing to implement the scheme; and (3) any ecosystem service disbenefit outcomes from scheme implementation. The latter costs are addressed directly. The former two 'costs' are confounded by the primary driver for scheme approval being as a cheap option to address EU Habitats Directive obligations to mitigate habitat loss elsewhere in the wider Severn system, in addition to baselines costs associated with existing defences reaching end-of-life and so risking collapse. As cost savings elsewhere in the Severn and in terms of failing defences are omitted, we perceive assessment only of direct costs versus cumulative net present value of service benefits as a highly conservative approach to assessing cost-benefit.

4.1.3 'Winners and losers' and spatial scale of ES provision

Whilst the economic benefits provided by this scheme are recognized, one other important issue to consider in ES assessment is their distribution: the determination of the 'winners and losers' within the scheme based on change in the balance of ecosystem services and associated beneficiaries. Although the loss of some services will be (to varying degrees) compensated in economic terms by gains in other services, these services and the benefits that flow from them may not be received by the same individuals or groups. In this case, there is a shift from services largely benefiting local farmers across to those benefitting the wider public. Although the main beneficiaries of the scheme are the wider public, the implications for current farmers are not clear. Future grazing opportunities at the site are likely to benefit a different group of farmers. Failure to evaluate the overall impacts of the scheme on the different groups of winners and losers is a limitation of this present study, but is significant in supporting the acceptability of future development schemes.

In addition to the distributional factor, spatial scale is also an important aspect for the valuation of ES considered in this study. The spatial scale at which ES are supplied and demanded contribute to the complexity of ES valuation (Brander *et al*., 2008). From a supply point of view, the coastal wetlands provide, for example, recreation opportunities (on-site), flood protection at Steart village (local off-site), education (local and national off-site) and climate regulation (global off-site). From a demand perspective, beneficiaries of ES also vary in terms of their spatial distribution, and of course recognition of the value of the service through markets. For many services, as already observed, there are not effective markets to link the supply and enjoyment of these benefits across scales.

4.2 ES and economic benefits in the context of previous studies

Many research gaps and complexities found with ES valuation at Steart have already been reported by Everard (2009) and other UK studies. This demonstrates a clear need for further research and long-term monitoring at MR sites once they are established.

Temporal scales also add complexity to ES evaluation. Most ES assessment studies in the context of FCERM schemes, such as Luisetti *et al*. (2011) and the MR case studies provided at Eftec (2010b), estimate the Net Present Value (NPV) of ES benefits which are calculated for a certain time horizon (typically for 50 and 100 years) based on a specified discount process. This study did not attempt to estimate a NPV as the annual average contributions are a more useful means to assess benefits and disbenefits between services and their various beneficiaries. Were we to need to calculate a NPV, this should take account of the different time horizons associated with the many constituent ecosystem services (e.g. agriculture outputs were assessed for a 20 year time horizon whilst climate regulation estimates underlie a longer time horizon of about 100 years).

The complexities and inter-relationships between the supporting services and the provisioning and regulating services are evident throughout this study and explain why recent major studies such as UK NEA (2011) and TEEB (2010a) have moved away from the traditional MEA services categorization to explore ES economic valuation and rather focus on 'final services' or 'benefits' with direct impacts on human welfare.

4.3 Learning beyond the scheme

4.3.1 Recommendations for improved sustainability and public value

In order to maximize the benefits of such schemes, a full ES assessment should ideally be undertaken earlier in the design/development stage to enable the conclusions and interplay/trade-offs between potential services to be properly factored into decision making and design. One potential element of this scheme which could have lead to enhanced environmental benefits was a proper consideration at the design stage of improved conditions for eel recruitment at the site.

4.3.2 Stakeholder engagement

Engagement with people is essential in undertaking ES assessment. Key stakeholders should be identified and engaged early in the ES assessment appraisal. In this study, only a focussed group almost entirely supportive of or with a vested interest in the scheme was consulted. While all efforts have been made to avoid the introduction of bias as a result, future studies should engage a broader range of stakeholders with diverse interests.

5 Conclusions

This study clearly demonstrates the economic benefits from a range of ecosystem services that can be provided by coastal wetland habitats. Despite having to rely on some wide assumptions and uncertainties a conservative, yet considerable, net annual benefit range of £491,155 to £913,752 has been deduced. It became apparent throughout the study that many research and knowledge gaps exist with respect to several ecosystem services, particularly the supporting services for which market values are clearly elusive. This is of concern as it affects our current ability to quantify and/or value them, and hence to include these important aspects of ecosystem integrity, functioning and resilience into decision-making. These gaps therefore demonstrate a clear need for further research, both theoretical and through long-term monitoring of these schemes once established.

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Annex A - Current ecosystem services at Steart Peninsula

	Main Ecosystem Types				
Types of service	**Intertidal**	**Ditches and Pools**	**Grazing Marsh**	**Cultivated Land**	**Trees and hedgerows**
Provisioning services					
Food	Rich in food for farmland birds, waders and wildfowl. Fish/eels. Grassy banks provide grazing for livestock (sheep and beef cattle).	Watering places for livestock. Locally important for wildfowl.	Livestock grazing (beef cattle and sheep). Hay crop. Rich in food for farmland birds, waders and wildfowl.	Winter stubbles, oil seed rape, sown cereals (wheat/barley/maize). Rich in food for farmland birds.	Foraging for wild food
Fibre and Fuel	Sheep wool, cattle leather.		Sheep wool, cattle leather.	Straw.	
Fresh water*		Surface water used for local agriculture.	Two ponds supplied by shallow fresh groundwater.	Two ponds supplied by shallow fresh groundwater.	
Genetic resources					
Biochemicals, natural medicines, pharmaceuticals					Sea buckthorn.

	Main Ecosystem Types				
Types of service	**Intertidal**	**Ditches and Pools**	**Grazing Marsh**	**Cultivated Land**	**Trees and hedgerows**
Ornamental resources	Possible cobbles extraction. Flotsam and jetsam (e.g. driftwood, objects from other countries).				
Regulating services					
Air quality regulation	Fine particulates from sea-salt aerosol and beach sand.	Carbon sequestration.	Carbon sequestration.	Occasional dust pollution from arable farming.	Carbon sequestration.
Climate regulation (local temperature/ precipitation, greenhouse gas sequestration, etc.)		Carbon sequestration.	Carbon sequestration.	Greenhouse gas emissions due to agriculture activity.	Carbon sequestration.

	Main Ecosystem Types				
Types of service	**Intertidal**	**Ditches and Pools**	**Grazing Marsh**	**Cultivated Land**	**Trees and hedgerows**
Water regulation (timing and scale of run-off, flooding, etc.)	Flood attenuation.	Flood water storage potential.	Flood attenuation.	Flood water storage potential.	
Natural hazard regulation (i.e. storm protection)	Flood control.	Flood control.	Absorption of seasonal flood waters.		Creation of wind breaks.
Pest regulation		Azolla noted in the north of the peninsula.			
Disease regulation			'Black leg' reported to be an issue with cattle in the area where freshwater habitat will be created.		

	Main Ecosystem Types				
Types of service	**Intertidal**	**Ditches and Pools**	**Grazing Marsh**	**Cultivated Land**	**Trees and hedgerows**
Erosion regulation	Absorption of tidal Energy.		Soil fixing/stabilising.	Risk of enhanced erosion due to tillage.	Soil fixing/stabilising.
Water purification and waste treatment	Natural purification/filtration.	Natural purification/filtration.	Natural purification/filtration.		
Pollination			Habitat for pollinating species.	Food source for pollinating species.	Habitat for pollinating species.
Cultural services					
Cultural heritage (archaeology, historic structures, historic landscapes, maritime archaeology and palaeoenvironment)	Historic landscape with archaeological features and palaeochannels.	Historic landscape with archaeological features and palaeochannels.	Historic landscape with archaeological features and palaeochannels.	Historic landscape with archaeological features and palaeochannels.	Historic landscape (parish boundaries) with archaeological features.

	Main Ecosystem Types				
Types of service	**Intertidal**	**Ditches and Pools**	**Grazing Marsh**	**Cultivated Land**	**Trees and hedgerows**
Recreation and tourism	Bridgwater Bay NNR, bird watching, adjacent wildfowling, dog walking, regional and long distance walkers, seasonal visitors (blackberry pickers), horse riding, picnicking, cycling.	Walkers, dog walkers, horse riding, cycling. adjacent wildfowling.	Bridgwater Bay NNR, bird watching, adjacent wildfowling, dog walking, regional and long distance walkers, seasonal visitors (blackberry pickers), horse riding, picnicking, cycling.		
Aesthetic value	Rivers Parrett and Severn estuaries visual amenities. River Parrett trail and other public footpaths providing visual amenity.	Public footpaths providing visual amenity.	Traditional landscape. Public footpaths providing visual amenity.		
Spiritual and religious value	Contact with nature.	Contact with nature.	Contact with nature.		Contact with nature.

	Main Ecosystem Types				
Types of service	**Intertidal**	**Ditches and Pools**	**Grazing Marsh**	**Cultivated Land**	**Trees and hedgerows**
Inspiration of art, folklore, architecture, etc.	Local artists from Steart and Combwich.		Local artists from Steart and Combwich.		Local artists from Steart and Combwich.
Social relations (e.g. fishing, grazing or cropping communities)				Farming community relations	
ADDENDUM: Education & Research	Potential opportunities for public engagement and education, (formal and informal).	Potential opportunities for public engagement and education (formal and informal).	Potential opportunities for public engagement and education (formal and informal).	Potential opportunities for public engagement and education (formal and informal).	Potential opportunities for public engagement and education (formal and informal).
ADDENDUM: **Employment**	Tourism/recreation related, agricultural employment.		Agricultural employment.	Agricultural Employment.	

	Main Ecosystem Types				
Types of service	**Intertidal**	**Ditches and Pools**	**Grazing Marsh**	**Cultivated Land**	**Trees and hedgerows**
Supporting services					
Soil formation	Accretion/erosion.		Soil fixing/stabilising.		Soil fixing/stabilising.
Primary production	Saltmarsh plants.	Fresh/brackish water and vegetation cover.	Vegetation cover.	Crops.	Vegetation cover.
Nutrient cycling	High in nutrients – important for natural food chain.	Part of nutrient transfer to intertidal habitats.	Nitrogen fixing.		
Water cycling	Part of water cycling.	Part of water cycling.	Part of water cycling.	Flood storage.	Vegetation complexity can enhance recapture of evaporation.
Photosynthesis (production of atmospheric oxygen)	Production of oxygen.	Production of oxygen.	Production of oxygen.	Production of oxygen.	Production of oxygen.

	Main Ecosystem Types				
Types of service	**Intertidal**	**Ditches and Pools**	**Grazing Marsh**	**Cultivated Land**	**Trees and hedgerows**
Provision of habitat	Biodiversity rich: community of botanical species. Value to breeding, migrating and over-wintering birds. Feeding and breeding fish/eels.	Invertebrates, mammals (water vole) and amphibians (great crested newt).	Generally species-poor neutral grassland. Value to breeding, migrating and over-wintering birds and breeding / foraging habitat for mammals.	Value to breeding, migrating and over-wintering birds.	Generally species poor, consisting predominantly of hawthorn, blackthorn and dog-rose. Value as foraging corridor to bats. Value to breeding, migrating and over-wintering birds.

* There are no licensed surface or groundwater abstractions actually present within the study area itself

Annex B – Existing and future agriculture income potential at Steart (Environment Agency, 2011)

Existing Income Potential

The average income of the project area as per the land use for the 2009/10 cropping year has been calculated using data from the Farm Management Pocketbook 2010. With regards to the income from the livestock enterprises, this is based on the number of units that the grass leys and permanent grass land within the project area can support. The stocking numbers have been based on stocking rate data taken from the Farm Management Pocketbook 2010 and where land is extensively grazed on actual stocking rates provided by the farmers. Table B-1 sets out the overall income from land use. Due to the fact that the data are generalised, figures have been rounded to the nearest £5,000.

Table B-1 Income potential from land use (taken from EA, 2011:p85)

	Livestock Output (£/year)	Arable Output (£/year)	Total Arable and Livestock Output (£/year)
Area B	60,000	10,000	70,000
Area D	365,000	105,000	470,000
Area E	50,000	55,000	105,000
Total	475,000	170,000	**645,000**

Copies of the source data along with a breakdown of income per individual Area can be found in Appendix J of Environment Agency (2011).

Using the same approach, i.e. industry standard data, the total costs estimated are of about **£630,000** annually. These comprise of the order of £270,000 of variable costs (e.g. feed) and £360,000 of fixed costs (e.g. labour, power and machinery). Again based on standard data and with regards to subsidies, additional income of about **£110,500** is also being derived from the Single Payment Scheme (SPS). WWT advised that in 2010 the project area derived of the order of **£27,000** of stewardship income per annum.

In summary, currently the project area of approximately 470 ha is capable of generating about **£152,500** of net income from agriculture per year.

Future Income Potential

Following the proposed inundation the intertidal area of the project will no longer be suitable for cultivated / intensive grassland use and hence the agricultural income potential of the land will be substantially reduced. However, in the years following inundation large parts of the intertidal and non-intertidal areas will be still suitable for grazing, as set out in Table B-2. It is anticipated that during April, May and June, low grazing levels of approx 0.6 Grazing Livestock Units (LSU) / hectare will be required in order to meet the biodiversity aims of the project. By early July these stocking rates will increase to approximately 2.0 LSU/hectare. Some areas will also be used for the production of hay.

Table B-2 Approximate future land use across the site (taken from EA, 2011:p88)

Land use	Area (ha)		
Years	**1-5**	**6-10**	**11-20**
Pasture	100	100	100
Salt marsh	0	116	232
Hay meadows	26	26	26
Non- agricultural	344	228	112
		470	

WWT envisages that much of the grazing will be carried out by cattle (or sheep, depending on local availability). Based on the land availability and relative stocking rates, the potential direct agricultural income from the individual Areas over the next 20 years has been set out as shown in Table B-3. Copies of the source data, which are taken from the Agricultural Budgeting Book, along with a breakdown as to how the figures have been calculated, are available in Appendix K of Environment Agency (2011).

Table B-3 Predicted income from the future agricultural use of the site (EA, 2011:p88)

	Years 1-5		Years 6-10		Years 11-20	
	Livestock	Hay	Livestock	Hay	Livestock	Hay
Comp B Output (£/year)	8,000	700	8,000	700	8,000	700
Comp D Output (£/year)	0	0	37,000	0	75,000	0
Comp E Output (£/year)	25,000	2,300	25,000	2,300	25,000	2,300
Total Output (£/year)	33,000	3,000	70,000	3,000	**108,000**	**3,000**

WWT intends to enter the project area into the Higher Level Stewardship Scheme which will bring about **£125,000** annually over 20 years and SPS income is predicted to be about **£110,500** annually although with a high degree of uncertainty due to the CAP reform in 2013.

As a general rule, stewardship schemes cover around 50-80% of the costs to manage the land. It has been assumed here that the Higher Level Stewardship Scheme will cover 80% of the total costs, which will be then of about **£156,250** per year.