York, North Yorkshire & West Yorkshire Natural Capital Study

Final Report

York & North Yorkshire LEP &
West Yorkshire Combined Authority

May 2020

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Acknowledgements

The study team would like to thank Katie Thomas, Matthew Millington and Noel Collings for their input to this work.

Disclaimer

Document evolution

Interim Report	08/11/2019	Reviewed by Ian Dickie
Draft Report	03/12/2019	Reviewed by Ian Dickie
Final Draft Report	02/02/2020	Reviewed by Ian Dickie
Final Report	05/03/2020	Reviewed by Ian Dickie

This report is based on eftec's Version 1 - May 2019 report template

Executive Summary

- *This study identifies the current and future importance of natural capital to the economy of, York and North Yorkshire, West Yorkshire and East Yorkshire.*
- *Regional Gross Value Added (GVA) (£89 billion) is dominated by the service sector (76%), but natural capital plays an important role, directly supporting **7.6% of regional GVA**.*
- *Natural capital supports skills retention, inward investment, and the physical health of around 26% of the workforce (labour worth approx. **£20 billion**).*
- *Defining plausible 'Business as Usual' (BAU) and 'Enhance' scenarios suggests the latter could support an **additional £2.3 billion of GVA** (2.6%), plus additional **benefits of £2.2 billion** through avoided risks and new opportunities across all sectors of the economy.*
- *The enhance scenario will **avoid major risks to economic growth** by reducing damage and disruption costs by **£2 billion** in a 'perfect storm' year of extreme one-off events (2% of annual GVA) and mitigating potential negative impacts on investment.*

The aim of the study is to understand the importance of natural capital to the economy of York, North Yorkshire & West Yorkshire. The analysis applied the natural capital approach, considering the relationships between natural capital assets, ecosystem services, socio-economic benefits and beneficiaries, and economic impacts (e.g. on GVA). It is started by estimating the current value of natural capital assets to the region, and then developing natural capital forecasts for three scenarios, before using these to evaluate the risks, opportunities and challenges for the region:

- **'Business as Usual' (BAU)**: ongoing natural capital deterioration arising from current patterns of consumption and use, including impacts of climate change and biodiversity loss. The economy will be reactive to those changes, and current benefit levels will decline
- **'Maintain'**: investment is made to preserve condition of, and outputs from, existing natural capital in so far as that is possible within the constraints of expected climate change – but not all benefit levels can be maintained at current levels
- '**Enhance**': assumes proactive and transformational investment in natural capital that is integrated with Local Industrial Strategies. This increases the condition of, and outputs from, natural capital assets, which play a vital role in supporting a zero-carbon economy and moving towards a circular economy, increasing economic impact and benefit.

These scenarios benefited from inputs of regional stakeholders, gathered through consultations and meetings, both in relation to environmental outcomes and their economic consequences for key sectors. The timeframe used for modelling changes in natural capital use and investment is to 2050, with analysis of benefits flows and impacts up to 2100 to allow long-term benefits to be captured (for example the long-term benefits of woodland creation)[1].

[1] *This ties in with local targets to achieve carbon neutrality by 2030 (North Yorkshire) and 2038 (Leeds City Region), and national objectives of achieving carbon neutrality by 2050 and includes the span of the 25-year environment plan (Defra 2018) which runs to 2042: its objective to 'leave the environment in a better state for future generations' requires the capacity of the environment in 2042 to provide benefits into the future; post 2050)*

The outputs aim to inform management of the economic activity, including policy direction and Local Industrial Strategies (LIS) for the LEPs for York and North Yorkshire, and West Yorkshire. These two areas have close ties to East Yorkshire and so the scope of the analysis covers, and results are subdivided for, the following areas, giving the boundary shown in Figure S1:

York & North Yorkshire – comprising North Yorkshire County Council plus the City of York;
West Yorkshire – defined by the metropolitan county (5 metropolitan boroughs);
East Yorkshire – comprising the East Riding and the City of Hull;

Figures for these areas and the Leeds City Region are provided in the main report and appendices.

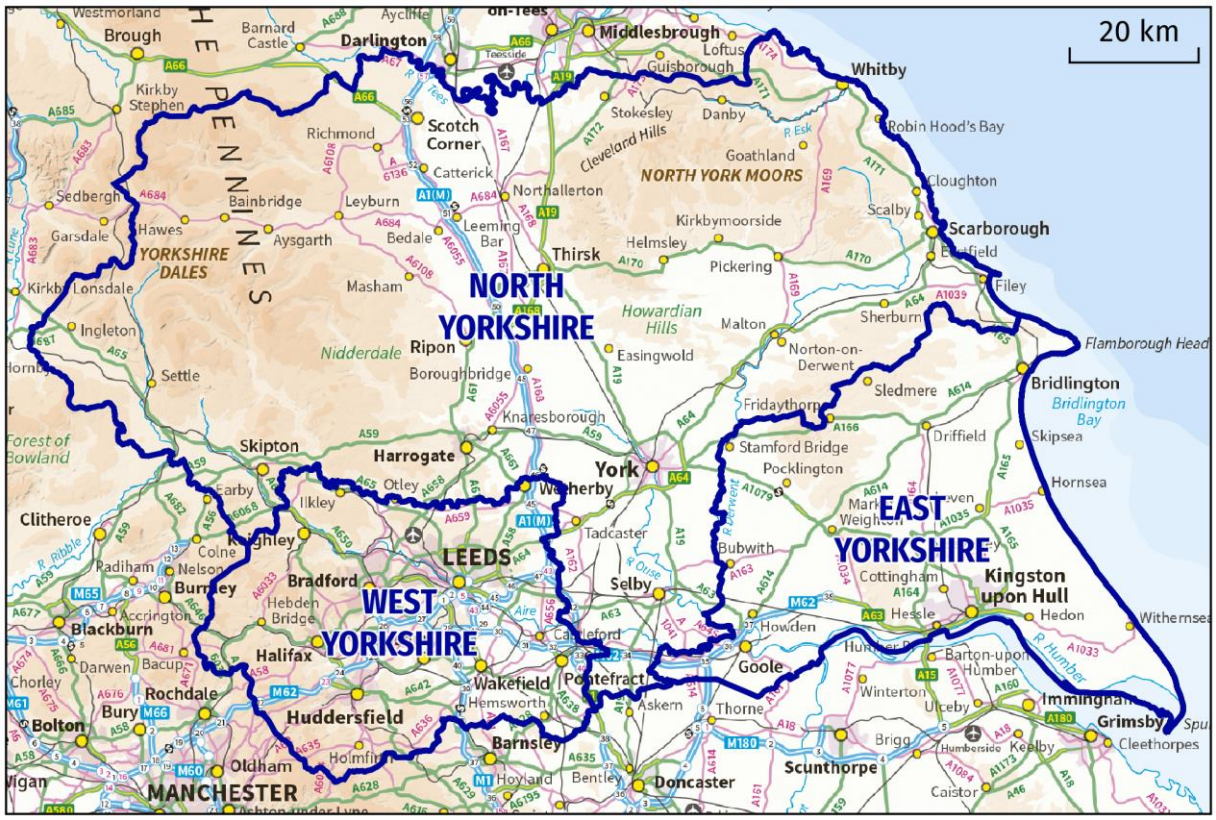

Figure S1. Map of study area boundary and human settlement

The modelling and calculations undertaken inevitably have gaps and uncertainties (see below), but have been sense-checked with expert stakeholders, so are plausible. For example, the 'enhancement' scenario would bring widespread changes to agriculture but are feasible based on expansion of existing best-practice in farming. Regional GVA by sector, and the extent to which it is estimated to be dependent on natural capital is in Table S.1. It shows some major interactions between natural capital and the regional economy, both direct (e.g. turnover supported in industries like agriculture) and indirect (e.g. through food manufacturing and bio-tech). **This summary shows that 7.6% of the local economy strongly depends on natural capital, and most of this dependency (5%) is upon natural capital within Yorkshire**.

In addition, there are wider dependencies on natural assets that are not reported under standard GVA measures. For example, savings in workforce absence and medical costs, as well as welfare enjoyed from recreation in greenspaces in the region provides benefits of over £700m/yr. In addition,

it is estimated that 26% of Yorkshire's workforce regularly use greenspace to support active lifestyles – so depend on nature to sustain their physical health. As an indication of economic significance, 26% of the local labour costs is around £20 billion annually.

Table S.1: Summary of Current GVA supported by Natural Capital

Sector	Baseline GVA (2018) £'m	Assumed Dependency on local Natural Capital	
		%	Value (£'m)
Direct Dependency Sectors			
Agriculture	681	100%	681
Forestry	40	100%	40
Water	340	100%	340
Minerals	202	100%	202
Tourism	2,719	66%	1,806
Indirect Dependent Sectors			
Food Manufacturing	1,771	52%	921
Manufacturing (Timber)	644	13%	84
Bio-tech/bio-energy	417	100%	417
Total Natural Capital Related	6,813	66%	4,489
All other sectors	82,292		82,292
Total GVA	89,105		89,105
Percentage that is NC related	7.6%		5.0%
Wider dependencies			
Recreation and physical health benefits			£728m
Proportion of working population visiting greenspace			51%
Proportion of working population using greenspace to sustain physical health			26%

Note that these values represent economic contributions measured as: net natural capital benefits (income less costs of production), an estimate of Gross Value Added (for tourism and minerals), avoided costs (in case of physical health) and welfare values (e.g. recreation). As a mixture of units is used, this limits comparability of some data.

Table S.2 shows potential changes to values in specific sectors under the three scenarios in 2050 (when changes assumed will have had time to take effect). Changes are estimated as changes in GVA and the percentage change from the baseline (i.e. current) position. The final column shows the change in value between the 'Business as Usual' scenario and the 'Enhance' scenario.

For NC related sectors, GVA falls by 4.7% in the BAU scenario and by 1.2% in the maintain scenario but rises by nearly 29% in the enhance scenario, providing an improvement of £2.3 billion between the BAU and enhance scenarios. Furthermore, there are significant differences in wider risks and opportunities on all sectors of the local economy across the three scenarios. The BAU and maintain scenarios modelled a 0.8% and 0.7% cost penalty respectively for; flood impacts, Greenhouse Gas (GHG) emission risks and reductions in health benefits. The enhance scenario shows a reduction in flood risks, improvement in property values and improvement in GHG sequestration (which is expected to realise a future market value). **Overall the enhance scenario has benefits of around £4.5 billion above the BAU case, which represents a value equivalent to over 5% of baseline**

GVA. In addition, the enhance scenario offers a greater level of protection to a major flood event and may reduce one-off impacts of such an event on GVA by 0.8%.

Table S.2: Changes in Benefits and Risks, annual values at 2050, by Scenario, 2018 prices.

Sector GVA at 2050	Business as Usual		Maintain		Enhance		Change Enhance Vs BAU £'m	% of 2018 GVA
	GVA £'m	% Change v baseline	GVA £'m	% Change v baseline	GVA £'m	% Change v baseline		
Direct Dependency Sectors								
Agriculture	656	-3.7%	664	-2.5%	746	9.5%	90	
Forestry	40	0.0%	40	0.0%	80	101.7%	40	
Water	312	-8.2%	326	-4.1%	501	47.3%	188	
Minerals	202	0.0%	202	0.0%	202	0.0%	0	
Tourism	2,532	-6.9%	2,719	0.0%	3,638	33.8%	1,106	
Indirect Dependent Sectors								
Food Manufacturing	1,705	-3.7%	1,727	-2.5%	1,906	7.6%	200	
Manufacturing	644	0.0%	644	0.0%	725	12.5%	80	
Bio-tech/energy	403	-3.4%	408	-2.1%	989	137.1%	586	
Total NC Related	**6,493**	**-4.7%**	**6,730**	**-1.2%**	**8,785**	**28.9%**	**2,292**	**2.6%**
All other sectors	82,292	0.0%	82,292	0.0%	82,292	0.0%	0	
Total GVA	**88,785**	**-0.4%**	**89,022**	**-0.1%**	**91,076**	**2.2%**	**2,292**	**2.6%**
Wider risks and opportunities across all sectors (costs)[1]:								
Flood costs (average)	-167		-167		-104		64	
Property uplift	-		-		75		75	
GHG impacts	-472		-472		1,468		1,940	
Health impacts	-28		-		113		143	
Total wider impacts	**-669**	**-0.8%**	**-639**	**-0.7%**	**1,552**	**1.7%**	**2,221**	**2.5%**
Total Value Change		**-1.1%**		**-0.8%**		**4.0%**	**4,513**	**5.1%**
Major Flood event	-1,792	-2.0%	-1,773	-2.0%	-1,099	-1.1%	693	0.8%
Total value change							**5,206**	**5.8%**

Notes 1: wider risks and opportunities do not show up in GVA measures but have impacts across the whole economy.

Costs of investing in Natural Capital

All the scenarios involve expenditures to manage natural capital. Under BAU, ongoing expenditures continue, and some major impacts are through increases in costs to mitigate environmental degradation (e.g. in the water sector). In the maintain and enhance scenarios, resources would be devoted to preventative actions. The one-off costs of the enhance scenario are estimated at around £1 billion (e.g. for woodland creation and peatland restoration). Ongoing costs are more difficult to estimate - a wide range of possible measures could be adopted (e.g. catchment management and regenerative farming practices). However, a significant proportion of the one-off costs, and a significant proportion of the ongoing costs can be funded from existing budgets. Revision of agricultural payments post-Brexit creates an opportunity to redirect funds to maintenance and enhancement of natural capital under the new Environmental Land Management Scheme (ELMS).

Risks to Regional Growth

The estimated economic effects of risks and opportunities have an average annual value of around 2.5% of baseline GVA. However, this does not fully reflect the risks to the regional economy for two reasons.

Firstly, the average annual economic effects will have implications for regional economic growth: UK targets are for growth to reach 2.5%. Growth is cumulative: as the economy grows there are more resources that can be invested in goods and services, supporting further growth. The impact of natural capital management on GVA will have consequences for regional investment and therefore growth. This can occur as spending is diverted to deal with costs (such as from flooding), rather than more productive investments, and as GVA is reduced, resulting in lower profits from which to finance investments. The potential loss of annual directly dependent GVA is estimated at 1.1% of regional GVA. If all this loss of returns within the regional economy translates into lower investment, it could approximately halve regional growth. Even a small reduction in growth in any one year can have major cumulative impacts: an economy that grows at 1.4% rather than 2.5% per year will be 30% smaller in 2050 as a result.

Secondly, the effects are likely to be concentrated:

- Geographically: such as in rural areas - the impacts of the enhance scenario over BAU are over 10% of GVA in York and North Yorkshire, but only 3% in West Yorkshire
- In particular years: if all negative impacts from natural capital on the economy occurred simultaneously (i.e. a 'perfect storm' with an extreme flood event and other major impacts) the enhance scenario could reduce damage and disruption costs by around £2 billion - over 2% of regional GVA, which illustrates the scale of risks involved. If only a proportion of these impacts occurred in a 'bad' year, the effects could have a major impact on regional economic activity, and a legacy effect on subsequent years – stalling economic growth.

Uncertainty

In interpreting these results it should also be borne in mind that the data represent the scale of some of the economic risks and opportunities, rather than specific predictions of performance. Nevertheless, the results give a useful insight into the potential effects of natural capital on the future economic performance of the region. The region is better placed to achieve its economic objectives if it makes use of these data than if it overlooks the risks and opportunities they reflect. While the analysis has significant uncertainties, overall it is more likely to underestimate the value of natural capital than overestimate it.

The results illustrate the role of natural capital in the regional economy. However, it has limitations due to the data available, which is designed to support the traditional forms of economic decision-making that omit consideration of many interactions between natural capital and the economy. Including these interactions has required novel analysis and modelling approaches within this study, which inevitably have gaps and uncertainties. Within the analysis there are also tradeoffs between benefits from potential future land uses, and significant unquantified effects, such as the role of natural capital in attracting inward investment. Further work is justified into the issues examined

around major areas of regional economic value, including:

- As better climate risk and adaptation science emerges, e.g. on extreme drought and floods,
- The economic consequences and responses to impacts, particularly in a diverse SME-dominated sector such as agriculture which is hard to model, and in relation to the implications for workforce skills.

Contents

Abbreviations & Acronyms

AoNB	Area of Outstanding Natural Beauty
BAU	Business as Usual
BEIS	Department for Business, Energy and Industrial Strategy
BRES	Business Register and Employment Survey
CCC	Climate Change Committee
CCRA	Climate Change Risk Assessment
DEFRA	Department for Environment, Food and Rural Affairs
ELMS	Environmental Land Management scheme
GI	Green Infrastructure
GVA	Gross Value Added
LCR	Leeds City Region
LEP	Local Enterprise Partnership
LIS	Local Industrial Strategy
LNP	Local Nature Partnership
NC	Natural Capital
NCC	Natural Capital Committee
NEVO	Natural Environment Valuation Online tool
NP	National Park
ONS	Office for National Statistics
SIC	Standard Industrial Classification
SOM	Soil Organic Matter
SPF	Shared Prosperity Fund
SUDS	Sustainable Drainage Systems
WFD	Water Framework Directive
WYCA	West Yorkshire Combined Authority
YNY	York and North Yorkshire
YNYERH	York, North Yorkshire, East Riding & Hull
YPP	Yorkshire Peat Partnership.

1.Introduction

The aim of the study was to understand the importance of natural capital to the economy of North and West Yorkshire, in order to identify how natural capital assets can be used sustainably to support economic performance and improve productivity. It addresses the growing need to connect local environmental management to local economic decisions. This stems from a series of drivers, including:

- Growing awareness of pressures on the natural environment, including climate change, the need for innovative adaptation measures, and recognition of the high rate of biodiversity loss;
- A trend of devolving responsibilities from Central Government to the regional level for economic development (e.g. to Local Enterprise Partnerships, LEPs) and greater engagement with local partnerships on environmental management (e.g. Local Nature Partnerships, LNPs);
- Pressure on public resources, which has reduced spending in traditional environmental management and protection activities, requiring them to seek new justifications for resources in competition with other needs of society, businesses and the economy, including public health and workforce productivity; and
- New objectives to enhance the natural environment, as reflected in the 25 Year Environment Plan, and policy opportunities, such as the Environmental Land Management Scheme (ELMS) being designed to replace the Common Agricultural Policy.

The LEPs for York, North Yorkshire and East Riding (YNYER) and Leeds City Region are currently developing Local Industrial Strategies (LIS), which need to respond to the clean growth challenge and opportunities. The work of this study helps to shape the policy direction of the two LEPs based on how natural capital can enhance local economic growth and productivity.

An understanding of the value of natural capital assets to a LIS can input to business and public sector decisions in several ways. These include providing evidence to the land-use planning system, highlighting new commercial opportunities to business, and supporting the case for spending on the natural environment. Spending can be through public sector grants (such as the Shared Prosperity Fund, SPF) or investment opportunities.

Box 1: The Natural Capital Approach

The concept of natural capital has been in use for decades but has received increasing attention in recent years. This stems from, amongst other things: a greater focus on ecosystem services and hence attention on the environment's capacity to provide them; and the need to use business and economics compatible language and frameworks in order to influence decision-makers in the public and private sector (i.e. the idea of stocks of capital assets that provide flows of benefits). Major developments include:

- the UK's ground-breaking Natural Capital Committee, including UK risk assessments, organisational accounting methods, and investment cases that supported the development of the 25 Year Environment Plan;
- UK natural capital and ecosystem accounts being developed by ONS[i], including accounts on woodland, peatland, urban, and air pollutant removal by vegetation.
- the Natural Capital Protocol which has become the primary business-sector reference on natural capital.

The Natural Capital Coalition aims to communicate the 'Natural Capital Approach'[ii] to a wider business audience, describing how it goes beyond other environmental analysis because it:

- Focuses on the quality and quantity of the **stocks** of natural capital assets, as well as **flows** of benefits;
- Incorporates both **biotic** (living: e.g. forests) **and abiotic** (non-living: e.g. minerals) natural resources
- Assesses how both stocks and flows are likely to change in the **future**
- Considers both **dependencies** of an economic activity on natural capital and its **impacts** on natural capital
- Uses **valuation** of impacts and dependencies to measure the relative importance, worth, or usefulness of natural capital to people (or to a business), in a particular context. Valuation may involve qualitative, quantitative, and/or monetary approaches.

These features, in particular the stock/flow distinction, collectively define the 'natural capital approach' and in combination support more integrated systems-based thinking that can give greater insight into environmental management challenges.

[i] *ONS: https://www.ons.gov.uk/economy/nationalaccounts/uksectoraccounts/methodologies/naturalcapital*
[ii] *NC Approach: https://naturalcapitalcoalition.org/wp-content/uploads/2019/06/NCC-WhatIs-NaturalCapitalApproach-FINAL.pdf*

1.1 Scope of Study

Spatial

As the intention of the study was to inform the development of York, North Yorkshire and Leeds City Region Local Industrial Strategies, the scope of the study area covered this region as a minimum. In addition, it was

agreed that there are significant natural capital interactions between this area and the East Riding and Hull. Consequently, it was decided that the area of East Yorkshire be included in the scope too.

Where feasible, data was collected at local authority level, although it was recognised that some data items would not be capable of disaggregation to this level. For output reporting, it was decided that all results should be reported by the three main sub-regions as follows:

York & North Yorkshire – comprising North Yorkshire County Council area plus the City of York
West Yorkshire – defined by the metropolitan county (5 metropolitan boroughs)
East Yorkshire – comprising the East Riding and the City of Hull.

Throughout the report, results are given by these three sub-regions as defined above. In addition, figures have also been provided for the Leeds City Region where feasible.

Timeframe

The time frame for considering decisions around natural capital was set in the Invitation to Bid to 2050. This ties in with local objectives to achieve carbon neutrality (by 2030, and 2038 for York, North Yorkshire and Leeds City Region respectively) plus this ties in with national objectives of achieving net zero carbon by 2050 and includes the span of the 25-year environment plan[2] (Defra 2018). Whilst the timescales for modelling changes in natural capital use and investment may be to 2050, the analysis of benefits flows and impacts will be to 2100, to allow for long term benefits to be captured (for example the long-term benefits of woodland creation).

[2] *While the 25 year environment plan runs to 2042, its objective to 'leave the environment in a better state for future generations' requires the capacity of the environment in 2042 to provide benefits into the future (i.e. to 2050 and beyond). DEFRA (2018) 'A Green Future: Our 25 Year Plan to Improve the Environment', At: https://www.gov.uk/government/publications/25-year-environment-plan*

2. Methodology and Baseline

2.1 Overview of Methodology

The overall approach for the study is illustrated in Figure 2.1. It is framed around the relationships (risks, impacts and dependencies) between natural capital assets, ecosystem services, benefits and beneficiaries, and economic impacts. This study uses these terms in the following way:

- Assets are stocks of natural capital. In this case approximated as land use types (e.g. arable farmland, woodland, or urban land types);
- Ecosystem services are the processes occurring within the asset(s) resulting in ecosystem services that these assets provide (e.g. food provision or carbon sequestration);
- Benefits are the ways that people derive utility from these ecosystem services (in combination with other capital inputs), such as food, flood risk reduction, and physical health and well-being;
- Beneficiaries are the groups that derive benefits from natural capital, and
- Economic impacts are assessments of the changes in value to the local economy or value chain arising from changes in natural capital extent, quality or use. They are made at a high level in this study.

The assessment is at a strategic level as its main purpose is to inform the Local Industrial Strategies (LIS).

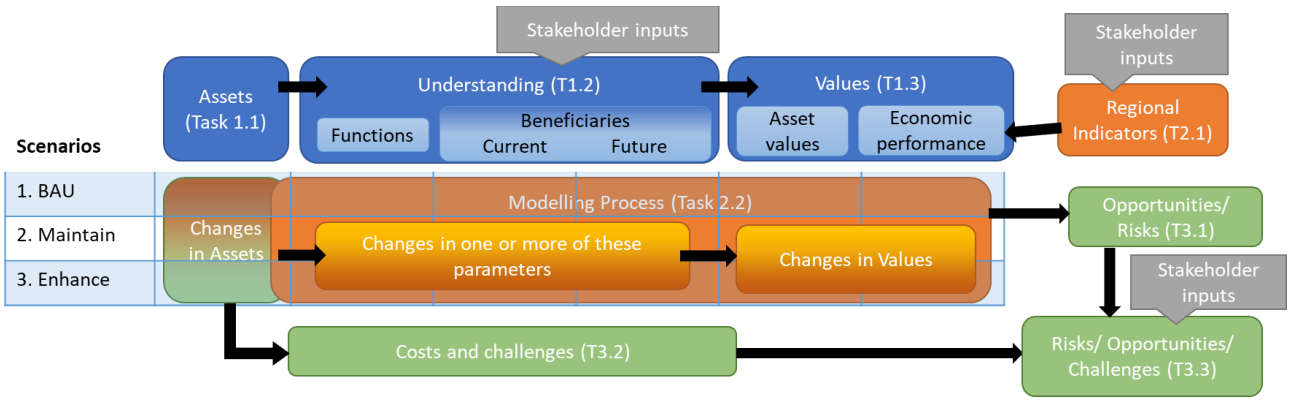

Figure 2.1. Modelling process

The approach comprised three phases:

- Task 1 – Understanding the value of natural capital assets (producing a baseline model)
- Task 2 – Developing three natural capital scenarios
- Task 3 – Evaluating risks, opportunities and challenges

Task 1 analysed the direct relationships between natural capital assets and impacts in the local economy (including GVA and productivity), and where relevant social value (e.g. enhanced wellbeing or quality of life). Task 2 developed three scenarios and forecast changes in metrics that reflect the quality of natural capital assets and their economic value:

- **'Business as Usual' (BAU)**: ongoing natural capital deterioration arising from current patterns of consumption and use, including impacts of climate change and biodiversity loss. The economy will

be reactive to those changes, and current benefit levels will not be maintained

- **'Maintain'**: investment is made to preserve condition of, and outputs from, existing natural capital in so far as that is possible within the constraints of expected climate change – but not all benefit levels can be maintained at current levels
- '**Enhance**': assumes proactive and transformational investment in natural capital that is integrated with Local Industrial Strategies. This increases the condition of, and outputs from, natural capital assets, which play a vital role in supporting a zero-carbon economy and moving towards a circular economy, increasing economic impact and benefit.

These scenarios were developed in consultation with selected stakeholders, including a stakeholder workshop which involved the participation of selected local experts. The detail of the scenarios was used to assess changes in asset and economic performance values which in turn formed the basis of the analysis of risks, opportunities and challenges (see section 5). The process of identifying the value of natural capital to the North and West Yorkshire economy links to the development of a LIS.

The analytical framework used in the development of the model is shown in Figure 2.2. Note for simplicity of presentation, connections between individual elements are not illustrated.

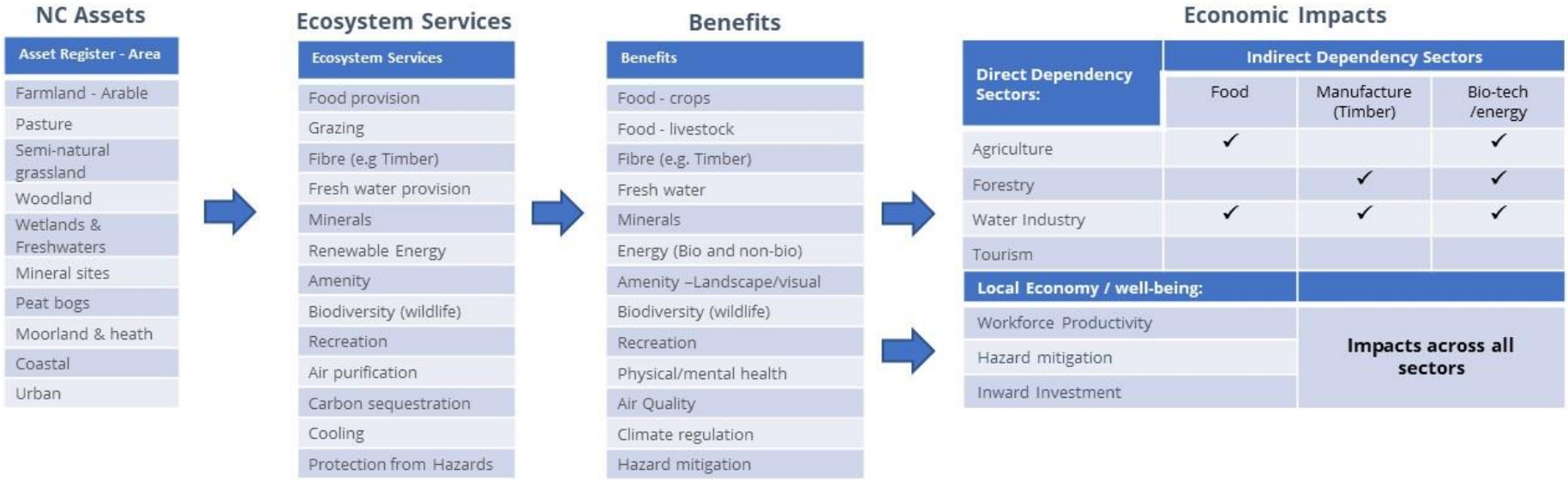

Figure 2.2: Analytical Framework

The purpose of the framework is to make explicit the linkages between natural capital assets and the economic impacts that these assets influence. This framework used four distinct elements:

- **Natural Capital Assets**. This captures the extent and condition of natural capital within the region. This categorisation was closely aligned to the ONS approach to natural capital land cover types but has been modified to highlight certain land types that are of significance for the local economy. (See Table 2.3 for the rationale for selection and the relationship to ONS category)
- **Ecosystem Services**. The services that these assets provide (e.g. food provision or carbon sequestration). For simplicity the main ecosystem services are listed in the figure, but refer to Table 2.1 for the full list of ecosystem services.
- **Benefits.** The utility that people derive from these ecosystem services (in combination with other capital inputs), such as food, physical health and well-being.
- **Economic impacts**. Measures of economic activity that are influenced by natural capital.

Table 2.1: Ecosystem Services

Provisioning Services	Regulating Services	Cultural Services
• energy (renewable and fossil fuels) • minerals • timber • agricultural production • water • wild animals and plants • navigation [use of waterways for navigation]	• carbon sequestration • air pollution removed by vegetation • mediation of smell, noise and pollution removed by water • flood, erosion and landslide protection • temperature regulation • water flow control and water condition regulation	• setting for outdoor recreation • scientific and educational interactions • heritage and aesthetic interactions • value placed on nature simply existing • settings for outdoor physical activity (health benefits)

The important relationships between these elements and economic benefits was assessed using logic chains. These logic chains can be complex, however Figure 2.3 illustrates the chain of causality for woodland. These relationships were used to identify the most significant economic impacts, where the benefits affect people, the workforce and businesses, for evaluation.

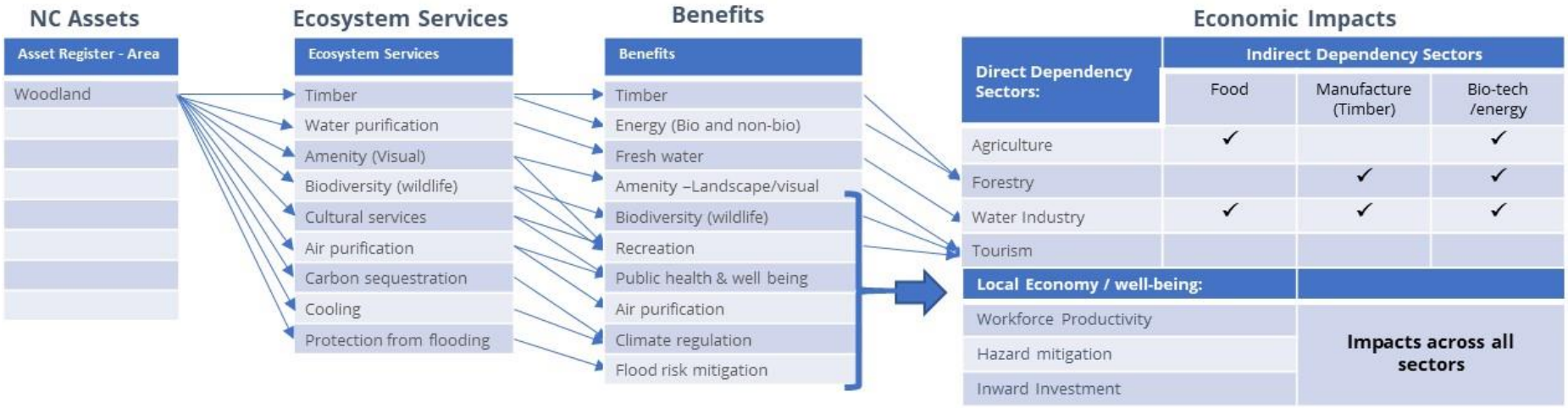

Figure 2.3: Logic Chain of Impacts: Woodland example

For example, woodland can provide the services of timber provision, water purification, visual amenity, biodiversity, cultural services, air purification, carbon sequestration, cooling and protection from flooding. In turn, these services provide benefits to people (e.g. timber provision can provide biomass energy as well as timber, and visual amenity can support recreation as well as general appreciation of landscape benefits). Many of these benefits have very direct impacts on first tier industries (e.g. timber on forestry and freshwater benefits on the water industry), however some impacts can influence the local economy through indirect effects across all sectors. For example, recreation and physical health can influence productivity levels within the workforce and reduce workplace absence through ill-health, and flood risk mitigation can maintain productivity through the avoidance of flood damage and disruption. Finally impacts to primary industries can also influence secondary and tertiary industries (e.g. forestry impacts on the bio-tech and bio-energy sectors).

2.2 Baseline

The development of each element of the framework for the baseline, that is the current state of natural capital, is described in the remaining sections.

2.2.1 Natural Capital Assets

This section details the extent and condition of natural capital assets in the region.

Asset Type and Extent

The Natural Capital Committee (NCC 2014) defines natural capital assets as; ecological communities, minerals, soils, water, air, etc. Whilst this is a comprehensive framework for assessing the different elements of natural capital assets, they are not readily related to economic activity. Categories of land use are more readily related to patterns of economic activity and benefits, consequently this study used the practical approach of major land use types to characterise natural capital assets and related these to ecosystem services and benefits. The CORINE land map was used to classify the major land use types within the region, and this was supplemented with woodland cover information from the National Forest Inventory. Table 2.2 shows the land cover types by each major sub-area of the region.

Table 2.2: Land Cover in the Study Area

	York & North Yorkshire		East Yorkshire		West Yorkshire		Total Region	
Land Cover	ha	%	Ha	%	Ha	%	Ha	%
Arable	305,556	37%	202,850	79%	37,757	19%	546,163	42%
Pasture/Grassland	265,758	32%	14,712	6%	58,999	29%	339,468	26%
Woodland	71,104	9%	5,323	2%	19,470	10%	95,897	7%
Mineral Sites	2,268	<1%	571	<1%	654	<1%	3,493	<1%
Moorland & Heath	55,185	7%	145	<1%	4,890	2%	60,219	5%
Peat Bogs	95,859	12%	391	<1%	18,846	9%	115,096	9%
Freshwaters	1,312	<1%	1,004	<1%	1,799	<1%	4,115	<1%
Coastal	988	<1%	9,865	4%	-	-	988	<1%
Sparse/rock/other	4,034	<1%	-	-	-	-	4,034	<1%
Urban (including GI)	30,360	4%	22,802	9%	60,511	30%	113,672	9%
Total	**832,424**	**100**	**257,661**	**100**	**202,925**	**100**	**1,293,010**	**100**

The rationale for selecting these categories was as follows:

Table 2.3: Rationale for selection of land cover types

Land cover type	ONS Land cover type	Rationale and notes
Arable	Farmland	Farmland is a major land use and important to distinguish between crops and land used for grazing livestock.
Pasture & Grassland	Farmland & Semi Natural Grassland	Farmland is a major land use and important to distinguish between crops and livestock. Difficulties in separating semi-natural grassland from grazed land led to the inclusion of the former in this category
Woodland	Woodland	Woodland is a distinctive resource and may be a significant element of land use change. Includes coniferous, broadleaved and mixed woodland as defined by the National Forest Inventory[3]. Within the timescales of this project it was not considered possible to model benefits at a lower level of categorisation.
Mineral Sites	None	Minerals are a non-renewable natural capital asset and as such warrant a separate category for the purposes of valuation.
Moorland & Heath	Moorland & Heath	Moorland is a major land cover type in the region and with a distinctive pattern of benefit types.
Peat Bogs	Wetlands	Peat bogs are a major opportunity for improving carbon sequestration and water flow benefits, and a substantial proportion of UK peat bog is contained within Yorkshire.
Wetlands/ Freshwater	Freshwaters (wetlands)	Wetlands can have important and distinctive water quality, flood risk and wildlife benefits. Note the area of this habitat is small (less than 1%) in the mapping data.
Coastal	Coastal margins	Coastal features can have a significant influence on coastal tourism.
Bare/other	None	Catch-all category and not used any further in this analysis.
Urban (Built and GI)	Urban	Urban area consists of both continuous built fabric (with little natural capital) and urban green infrastructure (parks, gardens, allotments, etc.) providing significant natural capital benefits

Table 2.2 highlights the predominantly agricultural land cover, but also significantly different characteristics of the three sub-regions, notably:

- York & North Yorkshire contains a mix of arable and grazing land (69% combined), with significant areas of peat bog (12%), moor (7%) and woodland (9%).
- West Yorkshire has the most urban area (30% total), with significant areas of farmland/grassland (48%) and substantial peat bog habitat (9%).
- East Yorkshire is overwhelmingly arable (79%) and grassland/pasture (6%).

Figure 2.4 shows the distribution of these land cover types across the region.

[3] *The area of woodland was defined as that reported by the National Forest Inventory. This provided a higher area of woodland than CORINE (by about 3% more land cover) and higher woodland area was offset by assuming equal and proportionate decreases (3% total land cover) in areas for arable, pasture, moorland and urban areas.*

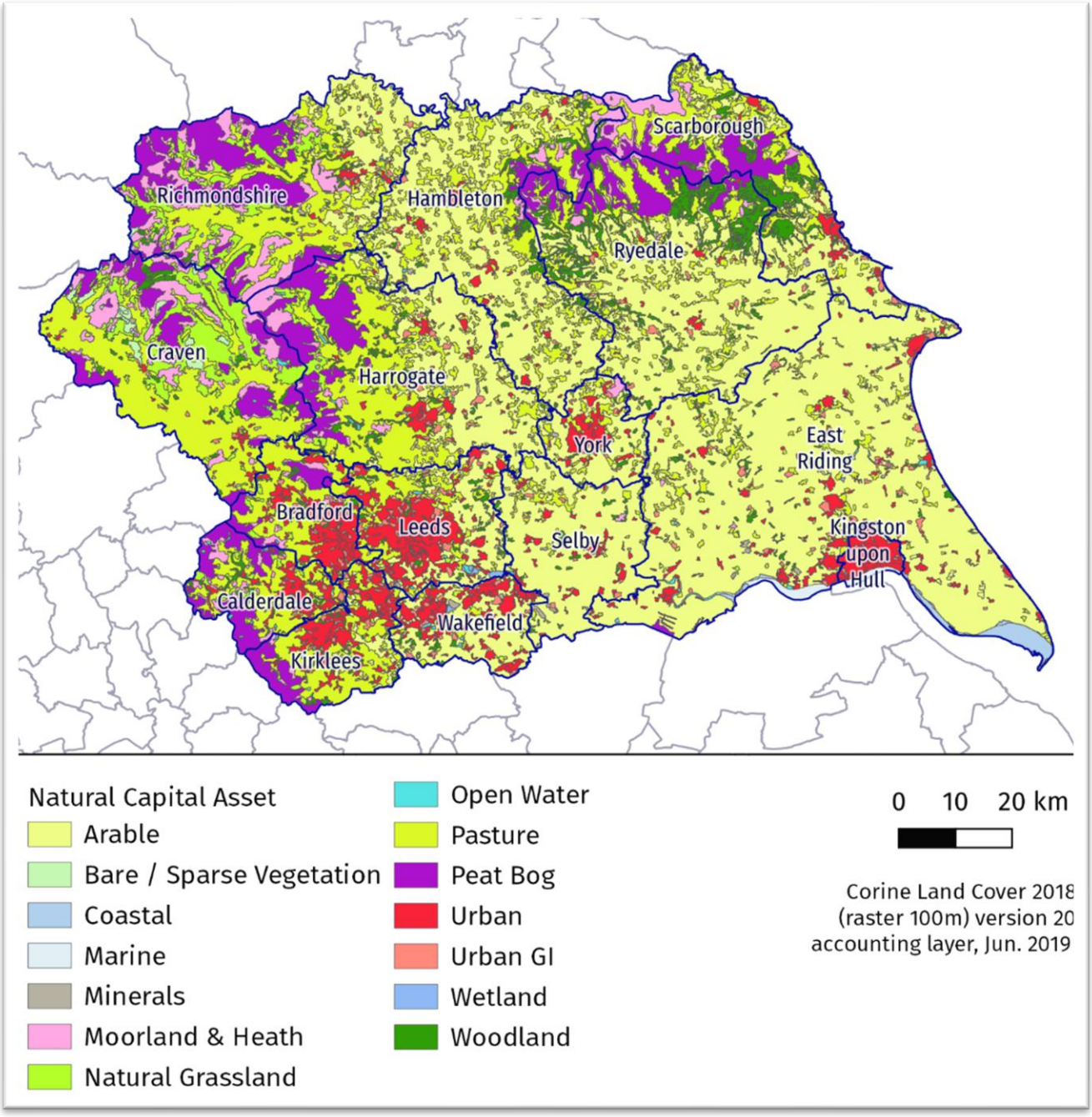

Figure 2.4: CORINE land cover types across the study region

Asset Condition

High level indicators of asset condition provide insight into the health and capacity of the natural capital in the region to sustain levels of benefit and support to the local economy. The high-level indicators of condition included in this study were:

- The condition of Sites of Special Scientific Interest (SSSIs),
- Water Framework Directive (WFD) Status,
- Bathing water status, and
- Level of recreational use,

Condition of designated sites is an important measure of the state of priority biodiversity assets and a summary of the condition of SSSI sites is given in Table 2.4. These important sites (328 in all) are a sub-set of the total land area shown in Table 2.2, representing nearly 12% of the total land area. This shows that only 16% of these sites are in favourable condition, and 81% are in unfavourable but recovering condition. These sites are mapped by condition in Figure 2.5.

Table 2.4 : Summary of SSSI status by sub-area

Region	Favourable	Unfavourable Recovering	Unfavourable (no change or declining)	Destroyed or Part Destroyed	Total
West Yorkshire (ha)	426	18,150	1,103	13	19,691
York, North Yorkshire (ha)	22,715	92,381	2,849	35	117,980
East Yorkshire (ha)	906	11,026	529	-	12,461
Total area	**24,048**	**121,557**	**4,481**	**47**	**150,132**
West Yorkshire (%)	2%	92%	6%	0%	100%
York, North Yorkshire (%)	19%	78%	2%	0%	100%
East Yorkshire (%)	7%	88%	4%	0%	100%
Total (%)	**16%**	**81%**	**3%**	**0%**	**100%**

This profile is worse than the all England SSSI condition profile which is; 39% favourable, 54% unfavourable recovering, and 6% unfavourable (either no change or declining). Figure 2.5 shows that most of the unfavourable recovering areas are in the uplands, which should be an important area of focus for improvement.

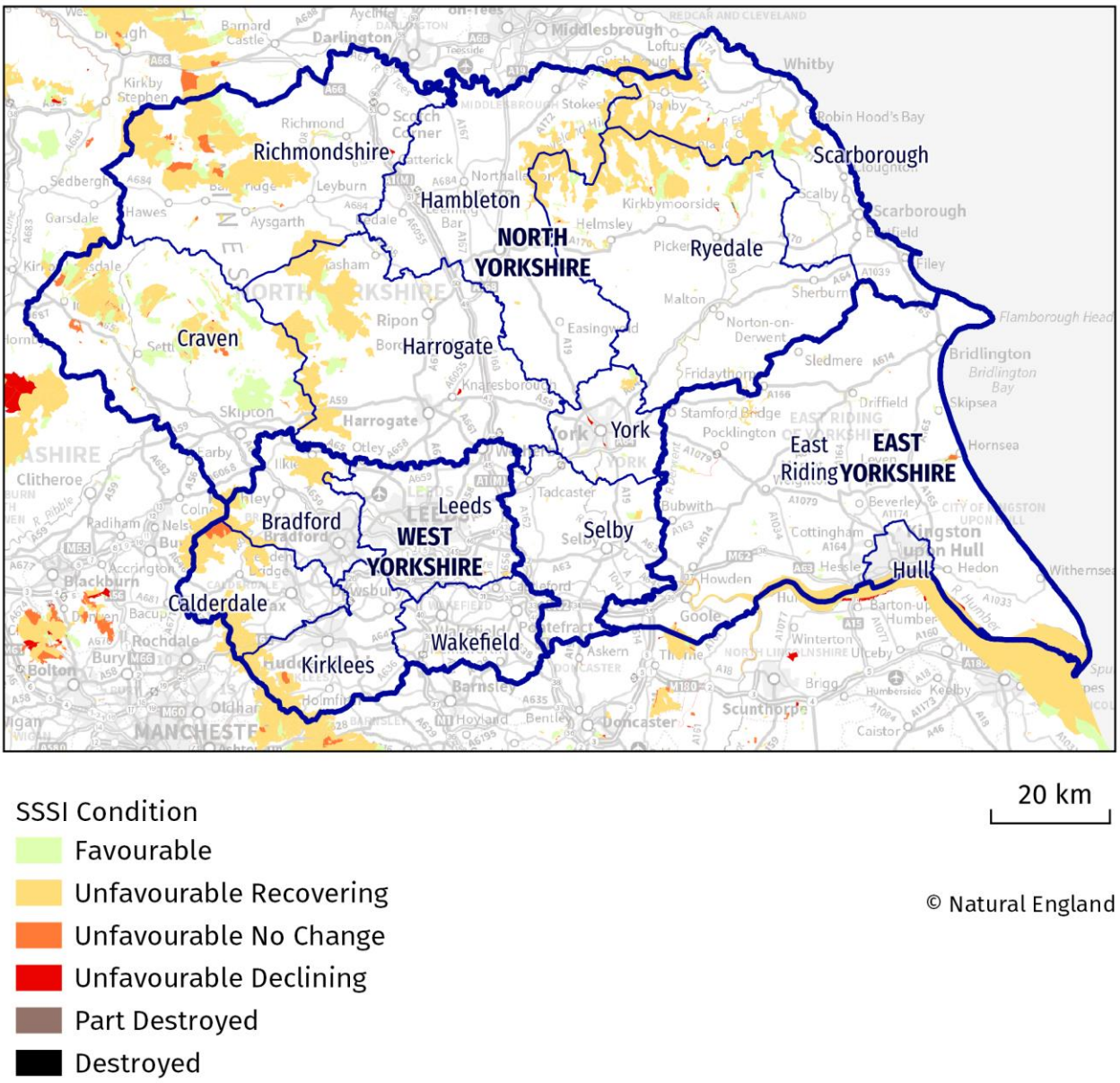

Figure 2.5 : Map of SSSI by condition

Water Framework Directive (WFD) status is an important indicator of the quality of water in the region and this is mapped by catchment in Figure 2.6. Table 2.5 shows that in the study area, 70% of the catchments (by sub-area) are in moderate condition, with 15% being either poor or bad.

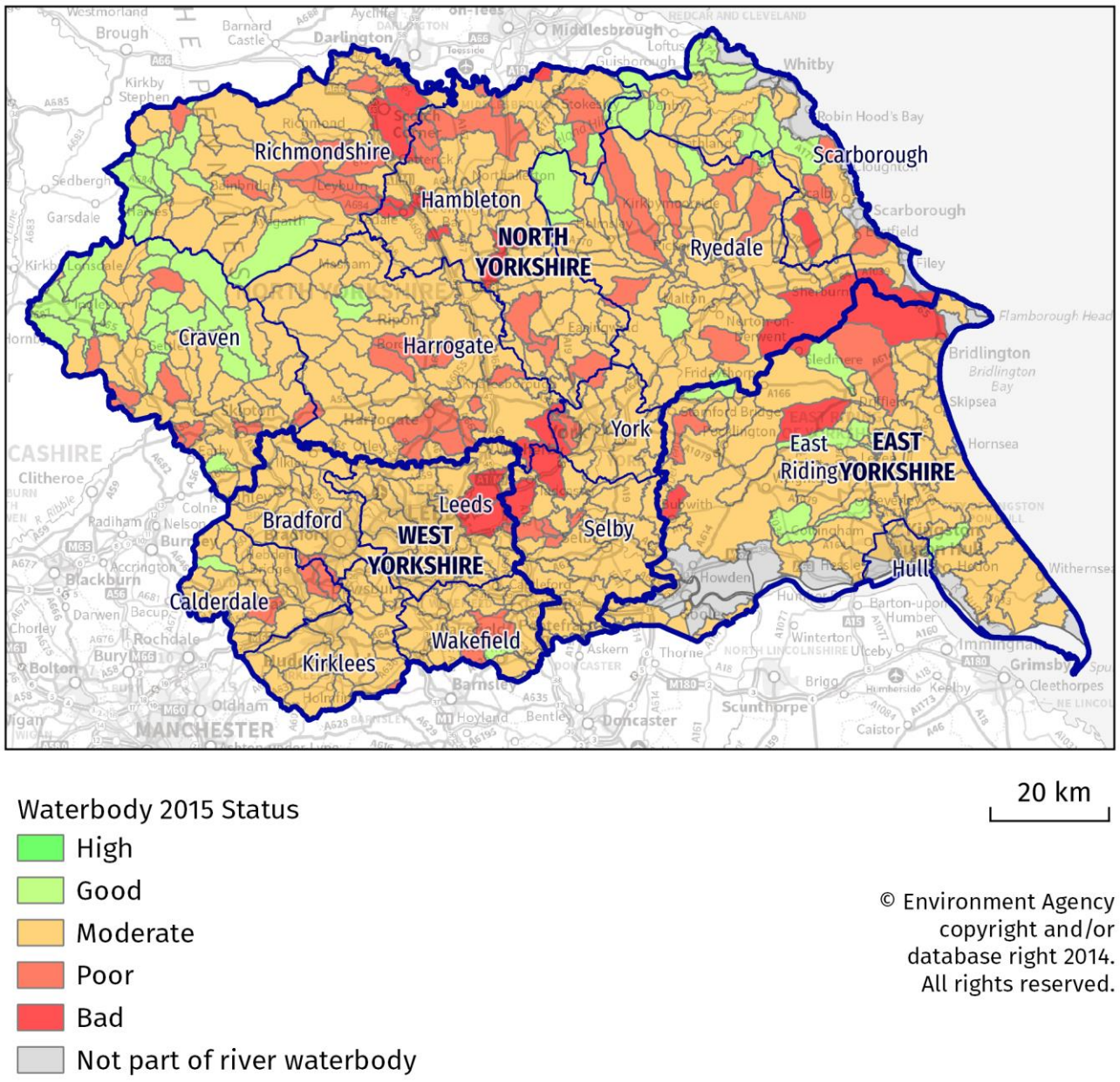

Figure 2.6 : WFD Status by catchment

Table 2.5 : WFD Status by catchment

Region	High or good	Moderate	Poor or bad	Total
York, North Yorkshire (ha)	167,828	561,029	148,606	877,462
East Yorkshire (ha)	17,244	168,752	30,345	216,341
West Yorkshire (ha)	2,515	181,562	18,849	202,926
Total area	**187,587**	**911,342**	**197,800**	**1,296,729**
York, North Yorkshire (%)	19%	64%	17%	100%
East Yorkshire (%)	8%	78%	14%	100%
West Yorkshire (%)	1%	89%	9%	100%
Total (%)	**14%**	**70%**	**15%**	**100%**

Bathing water status is important for coastal tourism, and for 2019 was rated as follows (out of 19 sites):

- 8 excellent,
- 8 good,
- 1 sufficient, 1 poor, and 1 closed.

Access to green space for recreation is important for the well-being and physical and mental health of the local population. The Outdoor Recreation Valuation (ORVal)[4] tool gives data on recreational areas, visits and welfare values (see Figure 2.7 and Table 2.6:). This shows a range of public open spaces including parks, woodlands, commons, and cemeteries. The values and visits data also include visits to public rights of way. The map shows the higher concentration of parks close to urban areas in West Yorkshire, whilst the larger areas of park around the North Yorkshire moors are mainly Forestry Commission parks.

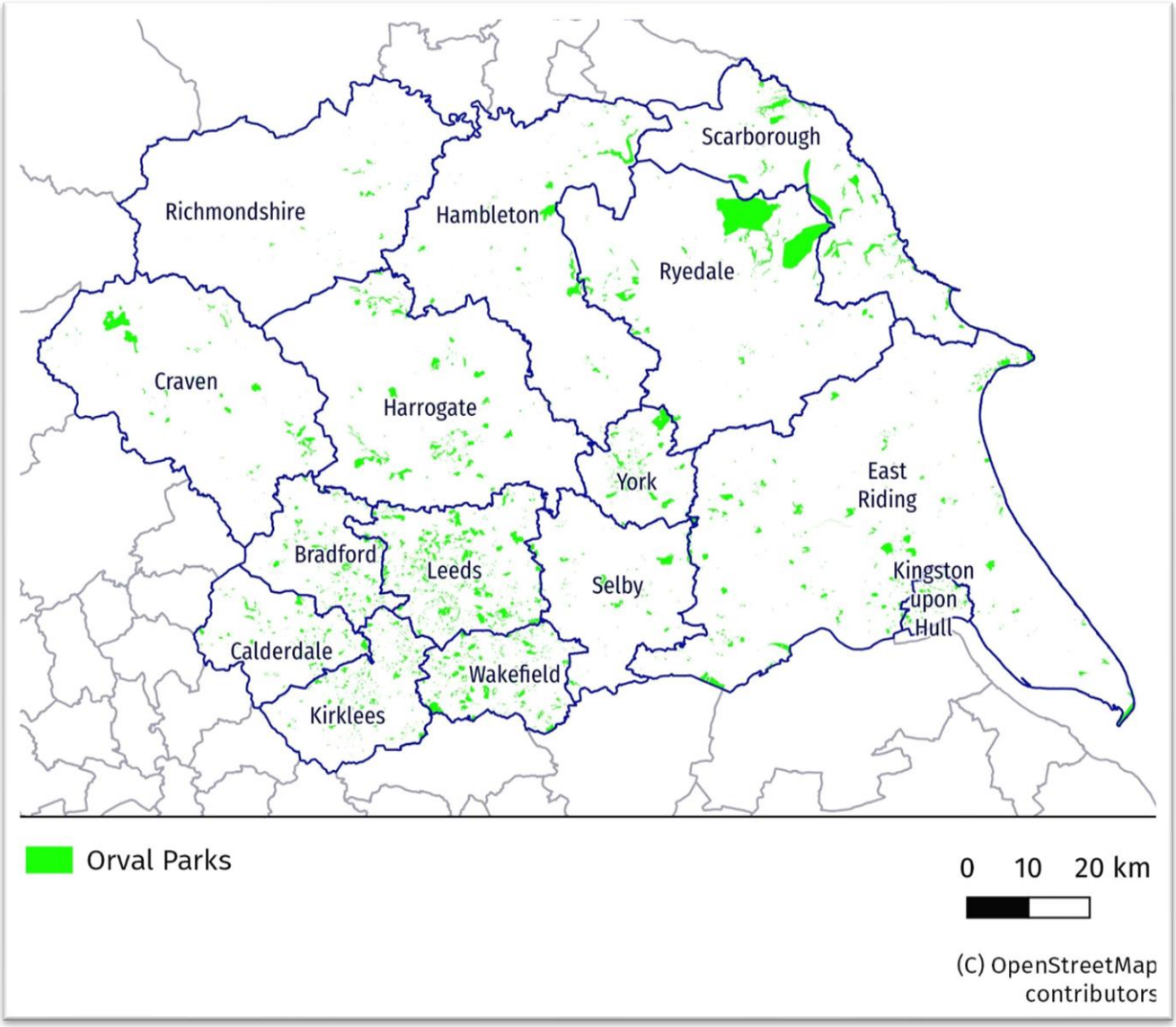

Figure 2.7: Distribution of ORVal recreational areas

[4] *Developed by the University of Exeter, see Day et al (2018) and available at: https://www.leep.exeter.ac.uk/orval/*

Table 2.6: ORVal Recreational Data

Region	Area of Parks (ha)	% of Region	Annual Visits (millions)	Welfare Value (£'m)	Annual visits /population
West Yorkshire	23,412	11.5%	98.4	£306 m	42.3
York, North Yorkshire	5,474	1.5%	47.0	£161 m	57.1
East Yorkshire	12,501	2.1%	26.2	£89 m	43.5
Total	**41,387**	**3.2%**	**171.6**	**£556 m**	**45.7**
LCR	21,219	3.9%	126.4	£340 m	44.4

Although West Yorkshire shows the the highest number of visits and welfare value, plus the greatest area of provision, the annual visits per head of population is slightly below regional average and well below the average for North Yorkshire. One possible reason may the the number of visitors from outside the region to the national parks and AoNBs.

2.2.2 Ecosystem Services

Ecosystem Services are functions from nature that can be turned into benefits with varying degrees of human input. In line with the broader definition of natural capital to include all natural resources, provision of minerals and renewable energy are also included in the list of functions below. The high-level nature of this study did not allow for an exhaustive analysis of all ecosystem services, consequently the analysis was restricted to those services that were considered significant at a regional scale for economic or social welfare benefits.

Ecosystem Service	Description
Food provision - arable	Food provision for human consumption & animal feed
Grazing	Grazing for livestock
Timber provision	Timber for all uses (e.g. building) For bio-energy see renewable energy below.
Fresh water provision (quantity)	For public water supply, irrigation and natural flows
Fresh water provision (quality)	For public water supply, irrigation and natural flows
Minerals provision	All minerals available for extraction
Renewable Energy	Renewable energy supply (Solar, wind, hydro, bio energy)
Amenity	Landscape benefit (visual amenity)
Biodiversity (wildlife)	Diversity and abundance of species
Recreation	Natural space for human activity
Air purification	Air pollution removal by vegetation
Carbon sequestration	Natural processes of sequestration
Cooling	Urban cooling effects of green and blue space
Protection from flooding	Natural processes for reducing flood events including fluvial and coastal

2.2.3 Benefits

Benefits are goods and services that people derive from ecosystem services, in combination with various forms of other capital (e.g. farm machinery and human labour to harvest crops). Furthermore, several ecosystem services can combine to provide a particular benefit (for example, visual amenity and biodiversity can both contribute to the value of recreational benefit experienced by a walker).

The following benefits classification was developed from the NCC (2017) categorisation of benefits[5], and adapted to meet the needs of this study, by focusing on the more economically significant types. Table 2.7 shows the benefit categorisation used and the rationale for their selection.

Table 2.7: Definition of Benefit Categories used.

Benefit Type	Definition	Rationale & notes
Food – crops	Plant and fungi consumed by people	Changes in crops/livestock mix may be important in the scenario analysis so justify separate categories.
Food – livestock	Animals and animal products consumed by people	
Fibre (e.g. Timber)	Timber used for building and fibre. Other materials used in production (e.g. bio-based plastics)	Note, timber for biomass is covered under energy.
Clean water	Water for human use – a combination of quality and quantity	High value, for example, drinking, bathing, industrial processes.
Minerals	Minerals extracted for human use	High value and finite resource. Provides opportunities for new land use on completion.
Energy	All sources of energy (fossil fuels, wind, tidal, wave, hydro, biomass, solar)	The major focus for this study will be biomass. Note solar, hydro and wind are included to capture the potential for land use change.
Amenity	Passive enjoyment of the natural environment, e.g. landscape appreciation and views	Important benefit in support of place making and inward investment. Important benefit for tourism. Contributor to property value uplift.
Biodiversity (wildlife)	Wild species diversity and abundance which has aesthetic and recreational value, and has cultural and spiritual significance	Distinct part of natural assets, in that these represent species that are significant to England and people care about. Also supports tourism.
Recreation	Active enjoyment of the natural environment e.g. walking, fishing, canoeing	An important benefit for tourism and local well-being.
Public health and wellbeing	Preservation of physical health and well-being from contact with natural spaces.	Important for workforce productivity and avoiding healthcare costs.
Clean air	Removal of pollutants by vegetation that has beneficial impact upon human health.	Contributes to both health and place making.
Carbon sequestration	A stable climate that has no increased adverse impact upon human health or wellbeing.	Covers global scale (e.g. carbon sequestration)
Local climate regulation	Urban cooling by green and blue space that mitigates heat events.	Covers local scale effects in conurbations, benefit to workforce productivity
Flood risk mitigation	Natural regulation of flooding events	Significant opportunities to reduce flood risk in the plains of Yorkshire.

[5] *NCC (2017) defines benefits as changes in human welfare (or wellbeing) that result from the use or consumption of goods, or from the knowledge that something exists (for example, from knowing that a rare or charismatic species exists even though an individual may never see it). Note that benefits can be both positive and negative (dis-benefits),),).*

2.2.4 *Economic Impacts*

The framework for assessing economic impacts is shown in Figure 2.8. Key impacts are measured primarily through sector employment and associated gross value added (GVA).

The framework has been designed to facilitate the separation of direct and indirect impacts on economic activity.

Direct dependency impacts are on those industries or elements of the local economy that depend upon one or more natural capital benefit as a major factor of production.

Indirect dependency impacts are secondary effects on other tiers of economic activity that would be influenced by a change in any level of natural capital benefit provided to a primary sector (e.g. a reduction in local farm output may lead to food producers switching food production elsewhere).

The definitions of direct impacts are given in Table 2.8. Note that the outputs of one sector can be inputs to another (e.g. crops from the farming sector may be used in biomass or anaerobic digestion to create energy for the energy sector).

Figure 2.8: Framework for Economic Impacts Impacts

Direct Dependency Sectors:	Indirect Dependency Sectors		
	Food	Manufacture (Timber)	Bio-tech /energy
Agriculture	✓		✓
Forestry		✓	✓
Water Industry	✓	✓	✓
Tourism			
Local Economy / well-being:			
Workforce Productivity	**Impacts across all sectors**		
Hazard mitigation			
Inward Investment			

Table 2.8: Definition of Tier Impacts on Industry Sectors Industry Sectors

Impact	Definition	Notes/rationale
Direct		
Agriculture	All agriculture sector – broken down in data by crops and livestock production	Major area of growth in industrial strategies – links to tackling climate change and the circular economy.
Forestry	All forestry sector	Important for timber and fire and potential to support biomass sector – an important opportunity for natural capital in the region to sequester carbon.
Water industry	Water collection, treatment and supply	Opportunities to reduce cost and improve resilience to climate change.
Mineral extraction	All mining and mineral extraction sector	An abiotic and non-renewable element of natural capital. Mineral activities may have a negative impact on natural capital.
Tourism	Activity relating to accommodation, food and drink consumption and passenger transport.	Nature-based tourism expected to be a significant driver of regional tourism.
Indirect		
Food manufacturing	Linked to agriculture – food and drink production in the region.	Major area of growth in local industrial strategies.
Manufacturing (Timber/fibre)	Use of timber and fibre in manufacturing, construction, and packaging	Products such as hemp can be used in construction.
Biotech- bioenergy	Novel biotech sector, plus energy crops and agricultural waste to generate energy through biomass and anaerobic digestion	Businesses starting up and moving to the region to capitalise on local bioresources (e.g. seaweed, potato peelings, peas) and intellectual capital. Bio energy a significant growth opportunity, linked to local energy aspirations links to energy and circular economy

The description of local economic impacts is presented in Table 2.9.

Table 2.9: Local Economic Impacts

Impact	Definition
Workforce Productivity	Provision of, green space for exercise, and urban trees for air pollution removal, which jointly improve physical and mental health which in turn provide Improvements to local productivity through: • Reductions in absence levels as a result of better health. Evidence shows access to high quality green spaces plays an important role in enabling individuals to exercise more and stay healthy, which can reduce work absence levels and enhance productivity. • Lower health service costs in terms of avoided treatment Available data (see section 4.5) suggests that 26% of the workforce derives health benefits from physical activity in green space as part of a healthy lifestyle. The output from these employees is thus partly dependent on the role of those employees in keeping them healthy. If they are assumed to be evenly distributed across the economy, their collective output would be around £20 billion/year.
Productivity – Hazard mitigation	Potential improvements in productivity through: • Avoided damage costs and loss of output from flood events – natural capital assets can play a key role in reducing flood risk, the prevention of which has productivity benefits for all residents and businesses in areas of high flood risk. • Resilience to heatwaves through urban cooling – natural capital assets can play a role in urban cooling which can improve workplace environments, helping to avoid losses of productivity

Impact	Definition
	• Avoided loss of output from drought events – natural capital assets can play a key role in reducing drought risk, the prevention of which has productivity benefits for businesses that are dependent on significant volumes of water (e.g. some manufacturing, food production).
Inward Investment Attract workforce	Improvements to the quality of living and working space which enable: • Inward investment in the region • New business growth • Retaining and attracting skilled workforce in the region, including through ability to live healthy lifestyles (see above). • Uplifts in property values

There are, however, significant limitations with this data, particularly that it does not capture jobs within businesses operating below the VAT threshold and does not capture job numbers relating to casual workers, which can be significant for example in the agricultural sector. As such, these figures are included as a useful guide Table 2.10, and to provide a sense of the breakdown of jobs in different parts of the study area, however for several sectors, more sector specific data is drawn on in the subsequent table to provide a more accurate baseline (discussed by sector below). The table also includes an estimate of the dependency of that sector upon local natural capital. For the primary sectors (agriculture, forestry, water and minerals) this was assumed to be 100%. For the other sectors the assumptions are explained in the discussion by sector below.

Table 2.10: GVA Baseline for Sectors Affected by Natural Capital Assets

Sector	Baseline GVA (2018) £'m	Assumed Dependency on local Natural Capital	
		%	Value (£'m)
Direct Dependency Sectors			
Agriculture	681	100%	681
Forestry	40	100%	40
Water	340	100%	340
Minerals	202	100%	202
Tourism	2,719	66%	1,806
Indirect Dependent Sectors			
Food Manufacturing	1,771	52%	921
Manufacturing (Timber)	644	13%	84
Bio-tech/bio-energy	417	100%	417
Total Natural Capital Related	**6,813**	**66%**	**4,489**
All other sectors	82,292		82,292
Total GVA	**89,105**		**89,105**
Percentage that is NC related	7.6%		5.0%
Wider dependencies			
Recreation and physical health benefits			£728m
Proportion of working population visiting greenspace			51%
Proportion of working population using greenspace to sustain physical health			26%

The split of GVA by each geographical area is shown in Table 2.11.

Table 2.11: GVA Analysis by Sector and Area

Sector	Total GVA (2018) £'m	YNY GVA (2018) £'m	EY GVA (2018) £'m	WYCA GVA (2018) £'m
Direct Dependency Sectors				
Agriculture	681	402	143	136
Forestry	40	25	3	11
Water	340	14	10	317
Minerals	202	63	64	76
Tourism	2,719	919	372	1,428
Indirect Dependent Sectors				
Food Manufacturing	1,771	619	322	830
Manufacturing (Timber)	644	84	203	357
Bio-tech/bio-energy	417	137	82	198
Total Natural Capital Related	**6,813**	**2,262**	**1,199**	**3,353**
All other sectors	82,292	18,454	11,837	52,000
Total GVA	**89,105**	**20,716**	**13,036**	**55,353**
Percentage that is NC related	7.6%	10.9%	9.2%	6.1%

As the table shows, there is significant variation in GVA dependency upon natural capital across the region, ranging from 6% (in West Yorkshire) to 11% (in York and North Yorkshire).

Agriculture and Food Manufacturing

North Yorkshire has by far the largest agricultural sector of the three sub-regions and is home to two major research organisations driving sector innovation: The Crop Health and Protection Centre, and the Centre for Excellence in Livestock. Food and drink employment in this LEP area is most concentrated in meat production, dairy, and bakery products.

The York, North Yorkshire and East Riding Local Industrial Strategy Consultation Document (2020) highlights the important role of agriculture in powering local identity and delivering a strong economic distinction in food and drink manufacturing. This LEP area has three times the concentration of agriculture and food manufacturing businesses of the national average, that over 40% of Innovate UK's agri-tech investment has gone into the area over recent years and that 80% of inward investment value to the area in 2017-18 was in Food and Drink.

In West Yorkshire, employment numbers are lower in agriculture but higher in food manufacturing, with this employment being strongly concentrated in bakery products and meat production. The 2016 Strategic Economic Plan for Leeds City Region highlighted food and drink as a priority focus sector, recognising the significant growth in the sector over previous years. The strong food and drink base in this sub-region also extends to the presence of headquarters for major supermarket chains Asda and Morrisons.

In East Yorkshire, the agriculture and food manufacturing employment numbers are similarly highly significant to the local economy, with food manufacturing similarly concentrated in bakery and meat

production activity.

Local natural capital is highly important to the local food and drink industry, with many high profile manufacturers basing production in the area. Detailed data on local sourcing are not readily available, but based on UK information on production, around 52% of the supply chain[6] was estimated as depending upon local natural capital inputs. In discussion with local stakeholders there are many important factors that food manufacturers consider when making decisions on locating production and sourcing (see Box 2).

Box. 2: Agri-food sector

Factors that were mentioned as important for food manufacturers in choosing to site their operations and/or source their supply chains in the local area included:

- Cost and quality of produce, with many manufacturers have very high specifications for the inputs required (e.g. wheat, milk).
- Farmland resilience to climate impacts and other supply chain shocks. Some stakeholders reported that this will become a more important consideration as climate impacts become more acute.
- Carbon impacts. This will become more important as brands commit to zero carbon targets. In achieving these targets manufacturers have the option work with farmers to minimise impacts and then invest in local sequestration to mitigate and emissions that cannot be eliminated (in-setting rather than offsetting). The key issue for the success of these arrangements will be the farmer's cost of achieving these savings and the extent to which the manufacturer will pay for these carbon benefits, either directly or as part of agreed supply chain terms.
- Proximity of supply - to reduce transport costs, carbon footprint and reduce delivery risks.
- Flood risk mitigation. As floods become more frequent and severe, the capacity of the local area to maintain transport and logistics links will be vital.
- Staff recruitment and retention. Some suppliers highlighted the quality of place as an important factor in attracting and retaining a skilled and healthy workforce in the local area.

Forestry and Timber Manufacturing

York and North Yorkshire has the highest number of jobs in forestry of the three sub-regions, but the lowest number in timber manufacturing. West Yorkshire has the largest number of people employed in the timber manufacturing sector of the three sub-regions, with this mainly concentrated in manufacture of articles of paper and paperboard and manufacture of products of wood, cork, straw and plaiting materials. In East Yorkshire, there are very few jobs in primary forestry activity, but significant numbers in timber manufacturing, particularly in manufacture of products of wood, cork, straw and plaiting materials.

Based on national average data, 13% of the supply chain[7] of wood and paper industry was assumed to be sourced from local natural capital.

Water Management

[6] *In the UK 52% of food produced is sourced from the UK. See Grant Thornton (2017)*
[7] *Forest Research (2019) Forestry Statistics 2019.*

The water management sector in the region is primarily comprised of Yorkshire Water activity, which is headquartered in Bradford, meaning that a large proportion of sector activity is listed under West Yorkshire.

Mineral Extraction

There are similar numbers of jobs in mineral extraction in each of the three sub-regions, but in each case the numbers are modest. In North Yorkshire, a major new Polyhalite mine is under development which could create 1,000 new jobs in production activity and support a further 1,500 jobs in the supply chain. This would significantly increase jobs and GVA generation from mineral extraction.

As minerals are an abiotic and non-renewable resource, this sector has not been considered further in this study. However, its strategic importance in the regional economy (e.g. for infrastructure) should not be overlooked.

Tourism

Estimating the extent to which tourism depends upon local natural capital is challenging. The figure used in this study is based on a wide perspective of natural capital which assumes in rural areas 100% of tourist visits depend in some part on the quality of local natural capital, and that in urban areas this is 50%. This gives an overall GVA dependency of 66% in the region. Another method, (eftec et al (2019)) estimated that of the overall tourist spend in the area (£4.1 billion per year), 45% was attributable to nature-based activities such as walking, playing golf and outdoor swimming

Going forward, tourism is seen as an important growth sector, with local strategies highlighting the need to enhance global brand recognition and increase higher value tourism (see section 4.6). For example, in West Yorkshire, the 2016 Strategic Economic Plan for Leeds City Region highlights the range of visitor economy assets across the sub-region and the successes the area has had in attracting major events in recent years that have boosted tourism. It also highlights the importance of investment in natural capital assets to support growth of the tourism sector.

Bio-tech /Bio-energy sector

This sector includes bio-chemicals/plastics/pharmaceuticals, agri-chemicals and energy (Capital Economics 2016). Within the region there is a strong focus on the bioeconomy. With organisations such as the Biorenewables Development Centre, BioVale innovation cluster and BioYork, there are potential linkages between agriculture and forestry activity into emerging biotechnology and energy sector. This sector has considerable potential for growth, to capitalise on the natural resources of Yorkshire to supply feed stocks (such as food waste for bio-plastics, feed stocks for anaerobic digestion and novel uses of fibre such as hemp for concrete), coupled with the bio-technology expertise in the area.

This sector is not defined in the Standard Industrial Classification, so has been estimated based on the UK average for this sector (13% Source: Capital Economics 2016) as a proportion of the other elements of the bio-economy (Agriculture, forestry, water, and food manufacturing). It is not known what proportion of feedstocks into this sector is supplied locally but given the need for proximity of supply it has been assumed to be 100%.

3.Scenarios

The framework enables an understanding of plausible future economic outcomes related to the extent, location and condition of natural capital assets in North and West Yorkshire. Three scenarios are analysed within the framework to illustrate pressures, trends and investments on natural capital assets. The three scenarios are:

- **'Business as Usual' (BAU)**: ongoing natural capital deterioration arising from current patterns of consumption and use, including impacts of climate change and biodiversity loss. The economy will be reactive to those changes, and current benefit levels will not be maintained
- **'Maintain'**: investment is made to preserve condition of, and outputs from, existing natural capital in so far as that is possible within the constraints of expected climate change – but not all benefit levels can be maintained at current levels
- '**Enhance**': assumes proactive and transformational investment in natural capital that is integrated with Local Industrial Strategies. This increases the condition of, and outputs from, natural capital assets, which play a vital role in supporting a zero-carbon economy and moving towards a circular economy, increasing economic impact and benefit.

'

3.1 Business as Usual Scenario

For the business-as-usual (BAU) scenario, existing rates of natural capital deterioration were assumed and were supplemented with changes expected from climate change (which may accelerate degradation of some assets – e.g. peatlands through greater risk of drought and fires). In addition, forecast population growth is factored into the assessment of natural capital benefits (which can change future demand for benefits from natural capital).

Overall, the changes and risks to benefits and economic impacts for this scenario were modelled as follows:

- The profile of overall benefits was forecast over the timeframe to 2100. This is to make visible the long-term differences arising from management changes (up to 2050) and the longer-range impacts of climate change such as rising flood risks.
- The effects of risks to benefits were estimated. Some benefits may be prone to risk impacts (such as droughts affecting food output in a given year, or flood events which can cause disruption to the local economy). Whilst it may be difficult to factor these impacts into long-term benefit projections, the impacts of some of these risks can be quantified and potentially evaluated in monetary terms.
- Impacts on the economy. These were assessed by considering the benefit trends and risks detailed above.

The detailed assumptions for the BAU scenario are detailed in Table 3.1. Overall, the major impacts to benefits of the BAU scenario involves:

- Risk to food production through both drought risk and lack of resilience (due mainly to current farming practice, in particular soil management).
- Ongoing deterioration in water quality, through several sources but mainly diffuse pollution.
- Significant increase in flood risk arising from climate change impacts, coupled with lack of

mitigation measures (e.g. through peatland degradation and soil compaction).
- Deteriorating GHG emissions from multiple sources; including soil organic matter loss, higher use of mineral fertilisers, peatland degradation and risks from wildfires.
- Ongoing decline in biodiversity.

In terms of the economic impacts produced by these benefit trends and risks, these will cause direct adverse impacts to the agri-food, water and tourism industries. In addition, indirect impacts of floods will cause disruption to the whole regional economy.

Table 3.1: Definition of BAU Scenario

Natural Capital (Land type)	Land use and management assumptions	Impacts
Farming – Arable and Pasture/ semi-natural grassland	• Existing farming practice continues • Output types and markets remain as is • Climate Change scenario assumes hotter drier summers and wetter winters.	• Fall in some crop yields - with 5-10% fall in crop yield per event[8] • Climate impacts on livestock costs - assume summer drought risk rises to 1 in 50, with 20% increase in bought in feed and water costs for livestock farmers • Reduction in soil organic matter (SOM) – drives increased manure use and GHG emissions • Soil erosion run-off – loss of nutrients, burden on water treatment costs and sediment removal costs • Deterioration in water quality (diffuse pollution), with ongoing costs to water industry • Reduction in biodiversity due to existing nitrate levels • Higher flood risk linked to sedimentation from soil runoff, soil compaction, and low level of hedgerows and trees in the lowland landscape
Woodland	Current woodland use and management practice	Assume no significant change in yields as forecasts are difficult to establish with confidence (Moffat et al 2012). Higher temperatures may increase yields, but may be offset by droughts, more disease/pathogens (e.g. Ash-dieback, Ramorum) and fire risks. [Factor in increase fire risk 30-40%]
Moorland and Heath	Current use mix of grazing and management for shooting Ongoing practice of burning moors for game	• Further drying and risk of fires • Damage costs and impacts on tourism
Peat Bogs	Bogs with ongoing management plans assumed to remain stable (c. 30% re-wetted to date) Planned restoration of peat bogs assumed successful Peat bogs without a management plan assumed to deteriorate and dry out	Further deterioration in non-managed peat bogs: • Some healthy bogs degrade due to drought/ lack of management • GHG emissions increase (4tCO_2e/ha/yr for drained peatland[9]) • Increase flood risk, and water quality treatment costs

[8] *NFU - Learning Lessons from the 2018 Agricultural Drought. At https://www.nfuonline.com/nfu-online/science-and-environment/climate-change/221-1118-leasons-learnt-drought-2018-final/*
[9] *See Evans et al (2017)*

Natural Capital (Land type)	Land use and management assumptions	Impacts
Wetlands and Freshwaters	Ongoing catchment management activities avoid deterioration (or small improvement) (One third in good ecological condition). Remainder of wetlands and freshwaters assume little or no management for maintenance or improvement	For deteriorating rivers and wetlands: • GHG emissions increase • Increase flood risk due to loss of flood water storage capacity, and development in floodplains
Urban Green Infrastructure (GI)	Existing GI has existing or falling levels of funding Further loss of GI due to poor planning Loss of urban trees to disease and to poor planning Increase in area under continuous urban fabric No increased investment in SUDS or in green roofs/walls	• Decline in quality of recreational green space due to long-running underfunding, and further decline of relative provision where population increases • Small reductions in activity rate - health and productivity • Lower rates of economic growth and inward investment in low-GI communities • Reductions in air quality • Loss of urban cooling effect • Loss of noise mitigation • Increased impacts of flooding events
Cross cutting themes		
Biodiversity	Loss of biodiversity across the area due to farming and fishery practices, increased development, climate change, invasive species, air and water pollution	• Adverse impacts on tourism – loss of off-peak market to more biodiversity-rich locations • Reduced pollination of crops and increased pest species populations • Increased abundance of invasive species detrimental to human health and economic activities

3.2 Maintain Natural Capital Scenario

For the maintain scenario, existing stocks and condition of natural capital are sustained (in so far as this is possible) and this will require increased spending against baseline outlined in section 3.1. The the detailed assumptions are given in Table 3.2.

Firstly it is important to acknowledge that not all natural capital stocks can be maintained at existing levels and condition, (for example, given the climate change impacts that have not and may not be avoided it may be that certain species may not be maintained at existing levels and that some level of adaptation/change will have to be accepted). Furthermore, even if the function of natural capital is maintained, some risks (such as flood risk) will increase with climate changes that are unavoidable given the most likely scenario for global emissions mitigation. Therefore, this scenario should be considered as a best attempt to maintain natural capital condition, which does not necessarily mean that current benefits are maintained.

The key residual risks are likely to be:

- Water supply costs will increase as the climate becomes drier and more drought prone.
- Some deterioration or risk to local biodiversity and wildlife will be unavoidable.
- Flood risks will remain (and will be only marginally lower than the BAU scenario).
- Some level of urban warming is unavoidable, with moderate risk to the local economy.

The maintain scenario requires investment in a range of natural capital assets, including the following:

- Soil management (mainly farming) to maintain organic matter, and avoid further erosion, run-off, mineral leaching and compaction.

- Investment to retain the extent and condition of urban GI.
- Programmes to maintain key habitats and biodiversity, not only in designated sites but in key land types such as farmland.

Table 3.2: Definition of Maintain Scenario

Land type	Land use and management assumptions	Impacts
Farmland - Arable Pasture and semi-natural grassland	Agricultural natural capital sustained through: • Less mineral fertiliser use, more manure and digestate • Soil management to avoid run-off and regulate water flow resulting in reduced impact from flood events	• Output falls with drought risk and drier climate • Water quality maintained at current levels
Woodland	Same woodland coverage but invest in restocking for disease and any climate impacts. Active management of woodland for biodiversity, generating some local fuel supplies and offsetting climate impacts	• Timber output maintained • Woodland biodiversity maintained • Carbon sequestration maintained
Moorland and Heath	Peatland under existing schemes is protected from further drying / degradation. Remaining peatland continues to degrade.	• Reduce flood risk • Avoid GHG emissions from further degradation
Peat Bogs	• Maintain peat bogs in existing condition • Maintain water flow regulation and quality services	• GHG emissions increase (4tCO_2e/ha/yr for drained peatland) • water quality reduces through discoloration
Wetlands and Freshwaters	Maintain rivers and wetlands in existing condition	• Improve water flow regulation, contributing to flood risk management • Improve catchments and groundwater for flow resilience to drought
Urban Green Infrastructure (GI)	Maintain Urban GI Maintain urban trees	• Maintain benefits of recreation and physical health to current population • Reduce flooding impacts • Maintain carbon sequestration • Maintain air quality • Maintain urban cooling effect
Cross cutting themes		
Biodiversity	Reduce decline in current levels of biodiversity via agricultural stewardship, planning policies and management of key sites e.g. SSSIs, nature reserves, local wildlife sites.	• Difficult to maintain with climate change, and might mean to maintain extent of wildlife-rich habitat, but accept changes to species makeup

3.3 Enhance Natural Capital Scenario

The enhance scenario has been constructed to support both local and national natural capital related strategies, targets and timescales, specifically:

- York and North Yorkshire vision for a carbon neutral circular economy by 2030;
- Leeds City Region's net zero carbon target by 2038; and carbon budget of 118 $MtCO_2$.
- The CCC (2018) report on future land use change to meet the UK carbon neutral target by 2050.

Key changes include:

- Improved farming practices such as regenerative farming, better soil and livestock management to improve productivity, reduce greenhouse gas emissions and increase sequestration;
- Changes in farming practices and consumer behaviours to drive the release of land for other uses;
- Afforestation (increasing forest cover from 7% of the region today to up to 17% by 2050) coupled with increasing forestry and biomass production;
- Restoring remaining peatlands so avoiding irreversible damage, such as the loss of peat due to warmer, drier conditions;
- Catchment-sensitive farming and agricultural diversification.
- Investment in urban green infrastructure, to match population growth and improve provisions to improve health, well-being and support workforce recruitment and inward investment

Note that the enhance scenario is not selected to simply maximise climate mitigation benefits but is a balanced approach to realising multiple natural capital benefits and managing environmental risks in the long term. Furthermore, the precise application of land use change must be adapted to suit the needs and natural capital characteristics of the local area.

Within the Yorkshire context, the major land use changes have been proposed as follows:

- The creation of between 65,000ha and 130,000ha of woodland (an additional 5 to 10% of land cover in line with the CCC (2018) suggested maximum target and local plans). The majority of this will be through the conversion of low value farmland land, but some will be determined by the appropriate location of woodland to meet the objectives of the White Rose Forest (which incorporates the delivery of the Northern Forest within the study area), often around the urban fringe. Some will be by planting trees along margins;
- Restore up to 60,000ha of peatland which involves re-wetting and low or minimal grazing;
- To meet population growth (c 5% by 2040), additional accessible urban green space will be needed to meet demand.

The detail of the land management practices is presented in Table 3.3

Summary of Enhance Scenario

Overall, the major impacts to benefits of the enhance scenario are:

- Increased food production (for both crops and livestock) through better soil management, and by employing regenerative and best practice farming techniques, whilst improving soil carbon sequestration, water quality and farmland biodiversity. This is in line with the changes envisaged in the NFU (2019) zero carbon target, namely:
    - Boosting productivity and reducing emissions
    - Increasing farmland carbon storage
    - Coupling bioenergy to carbon capture and storage
- New markets for farming wastes and by-products;
- Large increase in forestry output for both timber and biomass for energy. The 10% increase in woodland cover being selected to optimise benefits and minimise reductions on food output;
- Major improvement to water quality, through better farming, woodland creation and peatland restoration;

- Increases in biodiversity and quality of habitat;
- Significant GHG sequestration from multiple sources; including woodland and wetland creation, peatland restoration, and better soil management;
- Mitigation of flood risk arising through increased woodland cover, restored peatlands and better soil management. In urban settings this may be through better use of GI (e.g. SUDS);
- Improvements in number of recreational and active visits to greenspaces.

In terms of economic impacts this can be expected to:

- Increase GVA in farming (direct) and agri-food (indirect) sectors;
- Increase GVA in forestry and related industries;
- Reduce costs for the water industry;
- Support major growth in the bio-tech/and bio-energy industry;
- Provide a boost to the local tourist industry;
- Improve local productivity through enhanced physical and mental health
- Mitigate disruption to the local economy through hazards such as wildfires and floods;
- Improvements to the natural environment to stimulate inward investment and the attraction and retention of a skilled workforce.

Table 3.3: Definition of Enhance Scenario

Land type	Land use and management assumptions	Impacts
Farmland – Arable and Pasture and semi-natural grassland	Agriculture changes: • Increase in productivity to match upper quartile • Better management of field margins for regulation of runoff and pollinators / other wildlife • Switch of 65,000ha to 130,000ha from grazing to woodland (see above) • Investment in hedgerows and trees • Enhanced SOM and carbon sequestration in soils through best practice (e.g. regenerative farming) • Lower intensity higher value production for local processing. Reduced stock density and fertiliser input, and use of more diverse seed mix, can change improved low-input grassland to legume and herb rich swards • Sustainable grazing management can increase carbon absorbed • Greater use of wastes (e.g. long grass sward cuttings) for bio-energy • Slowing the flow where possible through changes in grassland management and appropriate tree / hedge planting	• Increased food and fibre yields linked to increased SOM • Slowing the flow and better regulation of water runoff • Greater production of bio-energy • Fibre for other uses (packaging, energy crops) - some pasture switches to fibre • Improved water quality • Benefits to biodiversity including pollinators • Better regulation of soil erosion, pest control in arable crops • Improved landscape through more diverse field margins • Increased carbon sequestration without reduced forage production • Increase in wildflowers in the sward leading to increased biodiversity and pollination services • (See woodland for increase in woodland output)
Woodland	Increase in woodland area (65,000ha to 130,000ha) • Manage for carbon sequestration – develop with carbon credit scheme • Develop local markets, timber, biomass and fibre for packaging • Manage for flood risk mitigation • Manage for biodiversity and public access	In line with area change: • Increased carbon sequestration • Improved water quality • Slowing the flow and better regulation of water runoff • Benefits to biodiversity including pollinators • Higher timber output and use • Increase in bio-energy • Increase in recreation and active visits to

Land type	Land use and management assumptions	Impacts
		woodland
Moorland and Heath	Restore biodiversity on moors and heaths, through lower intensity grazing, and appropriate tree planting	• Slowing the flow and better regulation of water runoff • Improved water quality (lower grazing intensity) • Benefits to biodiversity including pollinators • Better regulation of soil erosion • Improved landscape through more diverse habitats
Peat Bogs	Enhance Peat bogs: • Re-wet at scale (up to 60,000ha or c 50% of peat in the area)	• GHG benefits – Avoid emissions and move to small net carbon sequestration • Flood risk mitigation benefits • Improve water flow regulation and quality
Urban Green Infrastructure (GI)	Extend Urban GI • Improved quantity and quality of recreation and green space • Improved access/coverage to communities • Plant more urban trees, green roofs green walls etc. • Increase in SUDs as part of developments	• Enhanced health benefits and associated workforce productivity benefit • Better levels / distribution of inward investment • Urban cooling and air pollutant removal • Reduced noise exposure to residents • Habitat creation and connectivity • Reduce flood impact • Increased green travel through increased footpaths and cycle paths
Wetlands and Freshwaters	Maintain rivers and wetlands in existing condition	• Improve water flow regulation, contributing to flood risk management • Improve catchments and groundwater for flow resilience to drought
		•
Cross cutting themes		
Biodiversity	Enhance biodiversity in: • Peatland • Woodlands • Grasslands • Improve nearly all SSSIs to Favourable condition	• Tourism benefits (e.g. designated landscapes and coasts) • Maximise biodiversity via flood alleviation schemes carbon offsetting, green infrastructure

4. Outputs by Sector

This section describes the major changes in benefits and risks that may be expected with the three scenarios detailed in the previous section. The changes are expressed as either increases or decreases in benefits or risks relative to the existing benefit level (section 2.2.3). In addition, some changes are described in non-monetary or qualitative terms. Typically, (but not necessarily) the changes relative to existing benefits are:

- BAU changes are reductions in benefits or increased risks
- Maintain scenario changes involve both reductions and increases in benefits and risks
- Enhance scenario produces increases in benefits and reductions in risks.

Assessments do not model the impact of other factors that are likely to vary significantly over the next 80 years. These factors include:

- Projections of economic growth
- Policy changes (although policy change will be essential to achieve some of the potential benefits)
- Impacts of future technology
- Future investment decisions (e.g. the Sirius mineral project in North Yorkshire, Drax along Humber estuary)

For example, there are likely to be many future technological developments which will improve the productivity of agriculture and these have not been included in this assessment. This study has included those improvements that are natural capital related and can be reasonably foreseen as being feasible for adoption with existing technological knowledge (e.g. precision application of fertilisers).

Figures are given for the whole of the study region, Breakdown of the impacts by LEP area are given in Annex 1: .

4.1 Farming and Agri-food Sector

As farmland covers over 70% of the study area, it has a crucial role to play in maintaining and enhancing the multiple benefits of natural capital in the region. Clearly farmers are best placed to manage farmland natural capital and realise these benefits which include:

- Food production, coupled with the opportunity to grow the local agri-food sector through shorter supply chains, and strengthening links between food producers and manufacturers, so supporting a major element of the emerging Local Industrial Strategies.
- Increasing resilience to climate change impacts (especially droughts). Resilience is a consideration of increasing importance for the siting of food manufacturing businesses (see Box. 2: Agri-food sector).
- Water quality benefits through effective management of fertiliser inputs and soils.
- Greenhouse gas benefits through mitigating emissions and improving sequestration.
- Biodiversity benefits through the provision of diverse habitat.
- Provision of wood, fibre, energy crops, bio-wastes and other products for the bio-tech, manufacturing, construction, packaging and energy sectors.
- Provision of public rights of way and landscape that supports recreation, and the tourism sector.

In addition, there are many other benefits and roles that agriculture plays in the regional economy, which are clearly important but beyond the scope of this study, namely:

- Providing social cohesion within rural communities
- Supporting UK food security
- Maintaining unique culture and heritage (especially within the National Parks and other designated areas).

Whilst these are important aspects of farming that deserve serious consideration in policy and support to human and social capital, these benefits are beyond the scope of this study and not considered further.

Furthermore, there are many factors and future changes that will profoundly influence farming in the next 30 years, including:

- Reform to the agricultural subsidy system (i.e. the end of direct payments and a transition to a new ELMS payments system based on delivery of public goods);
- Market changes, including changing consumer preferences, and changing patterns of market access and global trade, especially post Brexit;
- Government policy, including the 25-year environment plan, national and local policies for mitigating and adapting to climate change;
- Technological change, (e.g. precision farming techniques, bio-economy innovations for new products, productivity improvements through selective breeding).

This study cannot anticipate developments in these areas, consequently the approach taken has been to identify the potential for natural capital improvements without making any particular assumptions about these important areas of change. The exceptions have been to make the following assumptions which are assumed in the scenarios as set out in section 3:

- Under the enhance scenario, to meet the requirements of the local zero carbon targets (both YNY and LCR), plus the targets recommended by the CCC on land use change a range of 5% to 10% extra land cover as a target for woodland creation.
- The enhance scenario assumes farming practice will move in line with the NFU (2019) zero carbon goal of 2040.
- The local industrial strategies support the growth of local agri-food and bio tech sectors, encouraging closer links between farming and these secondary sectors.

Whilst making no assumptions about other elements of government policy, we have highlighted areas where government policy should change to assist the realisation of natural capital benefits (see conclusions).

It is likely that there will be a diverse range of responses to these future changes and challenges by 2050. The farming sector is predominantly composed of SMEs, with different skills, investment capabilities (both cultural and financial) and assets. There is potential for significant diversification, with some farm businesses continuing with current models, and others changing production systems to new methods of food production, or to supply new markets (e.g. biotech, biofuels, carbon sequestration etc.).

Given the strategic nature of this study, only the most significant potential changes can be modelled. Furthermore, quantifiable changes are focused on those for which reasonable estimates and assumptions can be made with readily available information. Consequently, the most significant farming benefits and impacts which were quantified under this scenario include:

- Increasing productivity of the land through regenerative practices and exploiting new technologies. Raising productivity generally (and on lower performing farms in particular), through adoption of best practice (currently, the productivity of the top 25% of farms is double that of the lowest 25%[10]). Discussion with local experts suggest that productivity improvements of 10% to 25% are feasible by 2050.
- Land use change, converting the least productive land to woodland and greater adoption of agro-forestry. The benefits of woodland creation are described in section 4.2. The impact obviously entails the loss of some space for farm outputs.
- Resilience to climate impacts of drought (which reduce output and increase costs of production).
- Soil and catchment management measures aimed at maintaining and enhancing soil organic matter, avoiding compaction, erosion, run-off, nutrient leaching and regulating water flow.

In addition to the benefits above, the following benefits are addressed in other sections as highlighted below:

- GHG risks and benefits from soil management are considered in section 4.7.
- Water quality and flood risk benefits from catchment management measures are considered in section 4.4.
- Contribution to supporting tourism is considered in section 4.6.

There are numerous measures that can be adopted to achieve these benefits and selection of the most effective and appropriate practices will vary from farm to farm, but some examples can be drawn from the NFU (2019b) Achieving Net Zero document:

- Preventing soil compaction in cropland and pasture, reducing the need for cultivation and minimising N_2O emissions.
- Precision farming for crops to deliver nutrients and crop protection more efficiently.
- Use of controlled release fertilisers and inhibitors to increase efficient use of nitrogen and reduce emissions.
- Improving animal health and use of feed additives to reduce methane emissions from ruminant livestock.
- Selective breeding and gene editing for disease resistance to improve health and productivity of crops and livestock and reduce emissions.
- Inclusion of woodland, shelter belt and hedgerow planting to improve biodiversity, carbon sequestration and water regulation.

[10] *See CCC (2018) Land use: Reducing emissions and preparing for climate change*

Table 4.1: Summary of Changes in Farming Benefits and Risks by Scenario

Item	Business as Usual	Maintain	Enhance
Risks: Drought risk & resilience.	Cost of drought (based on 2018[11]) is typically in the range of 5-20% of cost of sales, or £95-190m locally (13-27% of agricultural GVA). To become twice as frequent and more severe by 2050. Assume 50% increase in drought impacts due to deterioration in soil condition (3.7% average reduction in annual GVA).	Maintenance of existing soil condition would do little to improve resilience. Assume drought risks are in line with projections (2.5% average reduction in annual GVA).	90% of drought risk can be mitigated through regenerative practices and planning for resilience, avoiding £85 to £170m of risk. Residual risk represents annual GVA reduction of 0.2%.
GVA: Agricultural productivity & land use change. The enhanced scenario assumes two cases: • Low productivity increase (10%) and low woodland creation (5% land cover) • High productivity (25%) and high woodland creation (10% land cover)	Productivity loss through loss of soil carbon (not quantified)	Assume no change	Productivity gains in the region of 10-25% more than offset the loss in output through conversion of lower productivity land to woodland. • Low case increases food production GVA by 4% (£27m). • High case increases food production GVA by 11% (£77m).
GVA: Soil Management. Avoiding compaction	Existing cost included in baseline GVA	Existing cost included in baseline GVA	£13m/year cost saving[12] to GVA (2% increase)
GVA: Second Tier impact on food production.	Risk of losing businesses to other parts of UK due to lack of resilience and loss of competitiveness. (not quantified)	Assume no change	Enhanced productivity increases the attractiveness of the region to food manufactures. Assume additional agricultural output attracts second tier business at existing ratio (2.6:1), low case £70m GVA, High case £200m GVA.
GVA: Second Tier impact on Bio-tech sector.	Assume any sector is not dependent on local natural capital	Assume any sector is not dependent on local natural capital	Investment in local natural capital supports BEIS (2018) strategy to double the size of sector over the next 10-15 years.
Total	Drought risk to Agriculture (13-27% of Agricultural GVA per event, or 2% annual reduction).	Drought risk to Agriculture (13-27% of Agricultural GVA per event, or 1.8% annual reduction in GVA).	**GVA**: low case £113m increase, High case £290m increase. **Risks:** Drought risks reduced to £10-19m per event

Costs

Estimating the costs of agricultural improvements and catchment improvements is challenging because there are many and varied measures that are suitable in different locations and for different catchments. Furthermore, some measures are self-financing (e.g. cost savings from better breeds or avoiding compaction costs), whilst others can be financed by smarter allocation of government payments (e.g.

[11] *NFU (2019a) Learning Lessons From the 2018 Agricultural Drought.*
[12] *From Graves et al (2015), the average farm costs of compaction in England & Wales are £14.65/ha. Assume this cost applies to Yorkshire.*

payments for planting hedgerows). Also, the costs of woodland creation and peatland restoration are covered elsewhere (see sections, 4.2 and 4.3). For this study, it is assumed that the costs of specific measures can be funded either by cost savings or by changes to the existing system of agri-environment payments.

However, these improvements must be correctly targeted in catchments, so there is an additional cost of coordinating actions (eftec 2015)[13]. This report estimated that the average cost of delivery of each of the integrated land management and farm business plans was £1,338 per farm, (or £1,720 in 2018 prices). Assuming 9,500 farms in the study area[14] this gives a total estimate of £16 million as a one-off cost.

Challenges

Investment in productivity improvements (precision farming, etc) requires long term markets to provide a level of confidence in the decision to invest. This faces challenges that:

- Productivity requires continuous improvement and a commitment from numerous stakeholders (not just farmers). to enable investment in new technology and refurbishment of existing capital. This can be supported by the local and national industrial and Clean Growth Strategies.
- ELMS reform will be key to incentivising the most beneficial improvements.
- To encourage woodland planting, it will be important to develop a strong local bioenergy base in the short term, and for bioenergy in general through a variety of pathways as well as through the wider bioeconomy
- Realising many environmental benefits will require collaborative working with local environmental NGOs and the water sector.

4.2 Woodland

Tree planting and woodland creation presents a major opportunity to sequester carbon and realise other multiple benefits (e.g. timber products, biomass, recreation, urban cooling, air quality improvement, water quality and flow regulation and enhancement to woodland biodiversity). In an urban context this would form part of the local green infrastructure strategies which would target planting to maximise recreation, health & wellbeing, inward investment, air quality improvements, urban cooling effects and support urban drainage schemes. In a rural context, location of planting would be determined by the scale of benefit, such as flood regulation benefits, timber production, biodiversity gain, enhancement to landscape and tourism, and set against the opportunity costs of the next most beneficial use.

Carbon sequestration benefits of woodland are less spatially sensitive than the benefits listed above, hence woodland creation decisions should be determined by careful consideration of the spatially specific benefits and costs to maximise the benefits of woodland creation. Investment and funding decisions will need to include these as part of the overall land use change process.

The climate emergency has raised the importance of carbon sequestration and the role that woodland creation can play in mitigating climate change. This is reflected in the local zero carbon targets and national

[13] *See appendix on Land use: Catchment management measures, p173.*
[14] *Based on 886,000 ha of farmland in the study area and an average farm size of 93 ha for Yorkshire- source: Defra Statistics (2018) at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/866811/regionalstatistics_yorkshumber_20feb20.pdf*

level plans to tackle climate change. The CCC suggested a target of an additional 5-10% land cover change to woodland and tree cover. Priority should be given to planting in areas of greatest benefit and where the value of current use is marginal. This would include planting on:

- Low value land on non-peaty soils;
- Sites that offer strong flood mitigation and water quality benefits (which is often a function of steeper slopes, soil type, proximity to water courses);
- In and around the urban fringe to improve urban amenity, recreation, health and well-being;
- As corridors of connectivity between existing woodland habitats.

Applied to Yorkshire this target would represent between 65,000 and 130,000 ha which is an ambitious target, as the upper range represents about 14% of the farmland in the region. There are some important enablers that will be needed to achieve this level of ambition:

- Development of markets for carbon and biodiversity credits;
- Development of local markets for water quality improvements, wood products, packaging, bio-tech and biomass;
- Sufficient funding to provide incentives to support the public goods derived from woodland creation and management;
- The planning system should have a strong policy of encouraging tree planting and woodland creation.

Given the long timescales for the maturation of woodland and tree planting, coupled with the timescales required to plant at this scale (up to 20 years), many of the benefits will not be realised at steady state levels until the 2050s to 2070s. However, some benefits can be realised relatively quickly, such as visual amenity and space for recreation and well-being.

Table 4.2: Summary of Changes in Woodland Benefits and Risks by Scenario

Item	Business as Usual - Degrade	Maintain	Enhance
GVA: Forestry output change. The enhanced scenario assumes two cases: • 65,000ha woodland creation (5% land cover) • High (130,000ha) woodland creation (10% land cover)	Assume none, but small reduction possible with increase in pests, wildfires and pathogens.	Assume no change	Increase in output and GVA is at least proportional to the increase in woodland cover: • Low case GVA increase £27m by 2070 • High case GVA increase £54m by 2070
GVA: Second Tier impact on timber related production and energy.	Assume no change	Assume no change	Forestry output can be used for timber processing, paper, packaging or energy production. Assume existing second tier multiplier of 2:1 • Low case GVA increase £54m by 2070 • High case GVA increase £107m by 2070

Additional benefits include:

- Carbon sequestration which is considered in section 4.7.
- Flood risk mitigation which is considered in section 4.4.
- Recreational benefits and enhancement to tourism which is considered in section 4.6.
- Contribution to urban air quality, cooling and amenity which is considered in section 4.5.

Costs

The cost of planting at this scale may be in the region of £450 million to £900 million, with ongoing maintenance costs in the region of £13 million to £22 million per year[15].

Challenges:

- The challenge of woodland creation at the scale of 5 to 10% of regional land cover should not be underestimated. The key will be offering the right incentives and funding streams to make this option attractive. Some income streams are well established but could be extended (e.g. timber, biomass), others are emerging (e.g. woodlands for water grants and catchment management payments), whilst others need significant development (e.g. carbon and biodiversity offset markets).
- Conversion of land to woodland is a permanent land use change and hence requires a high degree of long-term viability before landowners will agree to such a change. Offering long-term income streams with a high degree of robustness will be an important of securing land use change at scale.
- It is crucial that the right tress are planted in the right place. The system of advice will be important.
- The role of land managers and agents as trusted advisors is likely to be very important in helping landowners understand the benefits and risks of woodland creation.
- It will be important to involve local communities in helping to shape land use change, as in some areas this will be at a scale which will alter landscape character. In designated areas with widely differing views for and against

4.3 Peat bogs

Within the study area there is around 115,000ha of peat bog of which 93,000ha is upland peat. To date 33,000ha (c35%) of this peatland has already been either restored, or restoration is close to completion (source - Yorkshire Peat Partnership (YPP)). YPP is in partnership with other organisations (The Great North Bog initiative which includes The North Pennies AONB and the Moors for the Future Partnership) to raise finance to fund restoration of a further 60,000 ha in Yorkshire. The total cost of this restoration is estimated at £95 million, and whilst funding is yet to be secured, the benefits would include:

- Avoiding GHG emissions of around 240,000 to 400,000 tCO_2e per year. This benefit could be valued at up to £130m by 2050.
- Storing water and providing flood risk mitigation benefits to high risk areas of Yorkshire.
- Improving water quality and reducing water treatment costs (for discolouration and dissolved organic carbon).
- Improving habitat for wildlife and supporting the tourist industry in the national parks and AONBs.

[15] *Based on current FC grants of £6.8k/ha, plus planning costs and ongoing maintenance based on maintenance grant of £200/ha.*

The BAU and maintain scenario cases assume that this peatland will continue to erode, releasing carbon at a rate between 4 and 6.6tCO_2e/ha/year, giving an annual emissions figure of 240,000 to 400,000 tCO_2e/year. The enhance case assumes that full restoration is achieved over the next 20 years (in line with The Great North Bog plan).

Table 4.3: Summary of Changes in Peatland Benefits and Risks by Scenario

Item	Business as Usual - Degrade	Maintain	Enhance
Savings to UK GHG mitigation: GHG emissions	Ongoing degradation - GHG emissions 240 to 400 ktCO2e/year)	Ongoing degradation - GHG emissions 240 to 400 ktCO2e/year)	Peatland becomes GHG neutral by 2040 (worth up to £130m by 2050)
Qualitative benefits			
Ongoing water treatment cost	No Change (cost as is)	No Change (cost as is)	Cost reduction considered under Water Supply section 4.4.
Flood risk mitigation	No Change (cost as is)	No Change (cost as is)	Risk reduction considered under Flood risk section 4.4.
Biodiversity	Further deterioration	Unlikely that wildlife can be maintained without full restoration	All SSSI's in favourable condition by 2050. Rewetting also reduces the risk of upland wildfires.

Costs

The Yorkshire Peat Partnership estimate a cost of £95 million to restore 60,000ha of upland peat. The GHG savings alone can make a significant return on the investment in peatland restoration.

Challenges

The challenge is for adequate funding sources to be made available to realise these peatland benefits.

4.4 Water Supply and Flood Risks

Water supply is crucial for the local economy and healthy natural capital is vital for the quantity and quality of water supply. Natural capital also plays a key role in regulating water flow and hence mitigating flood risks. Yorkshire has seen several significant floods in recent years and the disruption to the local economy has been substantial. The impacts of climate change will create challenges to both water supply and to the mitigation of flood risk.

The most significant water issues (see Box 3) that will impact on the local economy are:

- **Water quantity** and the infrastructure required to cope with drier climate and the greater likelihood of drought. Resilience should improve with investment in natural capital and so lower investment and operating costs.
- **Water supply treatment costs** – driven by levels of diffuse pollution, which would reduce with investment in catchment management solutions, peatland restoration and appropriate woodland creation.
- **The impact of flooding on the local economy**, which will become more frequent and severe with increasing climate change. Natural capital can have a significant impact on mitigating flooding, with investment in sustainable urban drainage, catchment management solutions, peatland restoration

and appropriate woodland creation.

The impacts of the three scenarios on the water industry and on flood risk to the whole region over the timeframe to 2100 are assumed as follows.

Business as usual – Assumes ongoing loss of soil carbon/structure and peatland deterioration which entails;

- lack of re-charge in groundwater and therefore lower resilience to future future climate change,
- ongoing water treatment costs from diffuse pollution, plus
- no improvement to the mitigation of flood events.

Maintain – whilst this scenario includes some activity to maintain agricultural soils the improvement is small, hence the scenario assumes the same outcomes as the BAU scenario

Enhance – significant investment in; catchment sensitive farming, restoring degrading peatlands, targeted woodland creation to regulate flow and improve water quality, and sustainable urban drainage solutions, resulting in;

- mitigation of future climate risks to water supply.
- significant reduction in water treatment costs to remove nitrate and phosphate leaching.
- major reduction in peak flows, providing significant flood risk mitigation.

Supply shortfall in Yorkshire is expected to reach 100Ml/day by the 2040s[16]. This shortfall could be much larger in future decades and will be much higher with more severe climate outcomes. There is a range of options for addressing this problem including, reducing demand, addressing leakage, and building more capacity. Whilst it is difficult to outline a definitive mix of solutions to this problem, it is possible to estimate the value of extra water required and use this as a proxy for the value of water supply mitigated by improvements in natural capital water flow.

One approach is the use the resource rent method utilised by ONS in the natural capital accounts (2019), which calculates the value of water on the basis of sales value less the cost of all other capital costs (including labour). This provides a UK 5 year average unit value for water by dividing total resource rent value by the total volume of water abstracted, giving a value of £380/Ml supplied. This is the method used here and has been applied to a low case of providing an extra 100Ml/day and a higher value of 200Ml/day. This has been assumed to be an extra cost burden in the BAU and maintain scenarios. In the enhance scenario this cost has assumed to be mitigated on the basis that restored habitats and farming adaptations reduce pressure on water resources. It must be stressed that these are indications of additional cost and not detailed estimates.

[16] *YW Water Resources Management Plan 2019.*

Box. 3: Yorkshire Water

Yorkshire Water has a long standing focus on management of natural capital and climate change for the resilience of the region's public water and wastewater services. Below we explore three major climate risks and the priority actions related to management of natural capital:

Ensuring the supply of clean, safe water: Every five years Yorkshire Water produces a 25 year Water Resources Management Plan to help it ensure the balance of water supply and demand. The Plan is based on a detailed review and modelling of the latest evidence and projections on the availability of, and demand for, water. The latest evidence shows that Yorkshire Water needs to plan for more dry spells and less availability of water, at the same time as the population is expected to grow. The plan assesses the most cost effective and sustainable options to ensure resilient public water supplies. While Yorkshire is naturally blessed with a mix of water sources if needed in the longer term, this risks environmental harm and can be expensive. The plan therefore found that the optimal action is to work together to become much more water efficient in the region. Resilience should improve with each NC scenario and mitigate the need for investment and operating costs. Water availability could become a limitation on economic growth.

Cost pressures on water treatment: The quality of some sources of water are deteriorating with poor land management practices causing soil erosion and chemical run off. Yorkshire Water invests at its treatment works to ensure customers only receive safe, clean drinking water at their taps, but this is costly and uses more energy and chemicals. In addition, Yorkshire Water has been working on partnership catchment management solutions with land managers to slow and reverse the problems at their source, but the land takes a long time to recover. The pollution pressures should reduce with greater use of catchment management solutions in the maintain scenario and be improved by the enhance scenario.

The risk and impact of flooding: The risk of flooding is increasing with the impact of climate change bringing more storms and growing urbanisation causing water run-off. While many agencies have a role in managing flood risk, Yorkshire Water's role is to maintain the public drainage network to prevent sewer flooding. Traditionally this has involved building more sewer storage in concrete tanks and pipes, but increasingly there is also collaboration with land managers to 'slow the flow' upstream, and there is also an effort to keep surface water out of sewers. Along with water availability, sewer capacity is a potential limitation to economic growth.

The priority natural capital related actions needed over the next 30 years (to 2050) are:

- **Water efficiency** – Minimising the need to take water from the environment by becoming much more water efficient in homes and businesses, and by reducing leakage from water pipes. Yorkshire Water seeks to work collaboratively to meet the needs of the growing population without having to take any more water from the environment.
- **Land management to** protect and restore the peat uplands and to plant new woods to both protect water quality and to store and slow water upstream out of harm's way. Yorkshire Water has many activities in this regard, for example, planting 1m trees by 2028, a Beyond Nature sustainable farm tenancy programme, and long standing collaborative peatland restoration programmes.
- **Sustainable Drainage Solutions (SuDS)** deployment on a large scale can store and slow water as part of effective flood management plans. For example, Yorkshire Water is working with partner agencies in Hull and the surrounding area through the Living With Water partnership.

Find out more about Yorkshire Water's assessments and plans at www.yorkshirewater.com/resilience and www.yorkshirewater.com/climatechange

Savings in water treatment costs can be estimated by making assumptions about; the existing level of nutrient leaching (mainly nitrate and phosphate) to water sources, the savings in leaching that can be achieved and finally applying typical costs for removing these chemicals from water. Defra produce annual estimates of nitrogen (N) and phosphorus (P) balances (Defra (2019) and average rates for England have been assumed to apply in the study area. Indicative costs for nutrient removal were sourced from the Farmscoper tool as quoted in the Defra (2020) guide: Enabling a Natural Capital Approach. In the BAU and maintain scenarios it was assumed that existing leaching and treatment costs would continue. In the enhanced case it was assumed that 75% of these costs would be avoided.

For the local economy, flood risk means more disruption and damage to residential property, businesses and infrastructure. For example, the damage costs of the winter floods of 2015/16 where estimated by EA to be in the region of £1,600 million, and the Yorkshire share of this was around £700 million[17]. Furthermore, flood damage is becoming more frequent as over the past 12 years, Yorkshire Water (YW) have suffered flood related damage costs of more than £170m with damage occurring in 7 out of those 12 years[18]. These costs are under-estimates as they include only the direct damage to assets, and do not include overtime, lost opportunity costs, pumping costs and other indirect costs which are significant but not separately recorded. For an example of the impacts of flood disruption to industry see Box 4.

Flood costs have been assessed based on the estimated damage costs of the 2015/16 winter floods and extrapolated based on the Climate Change Risk Assessment (2017) projections of expected damages (Sayers et al (2015) for Yorkshire over the course of this century (giving projections for the 2020s, 2050s and 2080s). The BAU and maintain scenarios assume that these costs will occur, whilst the enhance scenario assumes that 38% of these costs can be mitigated by natural flood risk solutions and SuDs[19].

Box. 4 Flood Disruption to Industry

CEMEX's cement plant on the Humber South Bank was disrupted by severe coastal flooding from a storm surge in December 2013. This resulted in £millions of damage, including to electrics at the site, and the kilns. The local village and other local industries were also devasted, and CEMEX's initial steps were to assist with the community response.

In addition to damage costs, site production was lost for 1 year, and full production did not resume for 18 months. The site rebuild was 2 metres higher to ensure substations were not impacted by any similar future flood. 6 years after the event, there are still some ongoing implications for the site.

Initially no flood defence support was offered from Government, so the company had to fund extending improved defences for the village to also protect the works. CEMEX plant director Piotr Klepak said, *'It was estimated that more than £50 million worth of damage was caused. But more than the damage itself, the local community, of which we are part, live in fear of a similar event happening again. With the new flood defences, we will all have peace of mind*'.

Recently a £12m EA flood defence scheme has commenced work and should be completed by

[17] *Based on Yorkshire residential and non-residential properties accounting for 44% of all properties damaged*
[18] *Private communications with Yorkshire Water*
[19] *Based on peak flow reductions Sayers et al (2015), Table 4.1*

A summary of the changes in impacts and risks is shown in Table 4.4.

Table 4.4: Summary of Changes in Water Related Benefits and Risks by Scenario

Item	Business as Usual - Degrade	Maintain	Enhance
GVA: Impact of climate change on water supply.	Loss of GVA (8%) - Annual costs rise by £28m to provide infrastructure needed to supply extra 100-200 Ml/day.	Loss of GVA (4%) - Annual costs rise by £14m to provide infrastructure needed to supply extra 100-200 Ml/day.	This cost is mitigated through greater water retention and resilience through, soil management, peatland restoration and planting woodlands for water.
GVA: Catchment management benefits on water treatment costs.	Existing treatment costs are included in baseline GVA.	Existing treatment costs are included in baseline GVA	GVA increase: 75% of nutrient leaching avoided saving £130-190m per year in water treatment costs.
Risk: Flood damages and disruption.	Damage cost of floods could be in the region of £700m to £1,400 per flood by 2050. Expected damages rise by up to 70% by 2050. In addition, disruption costs to economic activity could be in around £350m per event.	Damage cost of floods could be in the region of £700m to £1,400 per flood by 2050. Expected damages rise by up to 70% by 2050. In addition, disruption costs to economic activity could be in around £350m per event.	38% of damage and disruption costs assumed mitigated by natural flood risk mitigation measures and sustainable urban drainage solutions.

Costs

The costs of realising the enhanced benefits of water quality and flood risk mitigation are covered by a combination of investments in:

- catchment sensitive farming (see section 4.1 – £16 million as a one-off cost for creating and coordinating pans by farm.
- restoring degrading peatlands (estimated cost £95 million – see section 4.3).
- targeted woodland creation. Although the total cost of woodland creation is the range £450 million to £900 million, only a targeted proportion of this would be needed to realise the water quality and flood risk benefits.
- sustainable urban drainage solutions. Whilst these are an important element of realising flood risk mitigation benefits, it is impossible to estimate the scale and cost of investment required without extensive modelling which is beyond the scope of this study.

Challenges

- The trade-off between investment in natural capital to increase water resilience (in the face of a drier climate) and the use of other measures (demand reduction, leakage, etc.) is still to be understood in greater depth.
- Providing the appropriate incentives for farmers to adopt spatially suitable measure will be key to achieving uptake.
- The extent to which natural capital investment can mitigate flood risk is needs to be better understood.

4.5 Local Economy Impacts

Natural capital has an impact on the local economy in several ways, for example:

- Providing recreational space for exercise which promotes physical health and reduces health costs and lost days of workforce absence. Existing green spaces and public rights of way provide 171 million visits annually[20] across the whole study region. According to White et al (2016), 51.5% of these visits may be reasonably estimated as active visits (that is 88 million active visits involving more than 30 minutes exercise) which can contribute to a healthy lifestyle. According to Butland et al (2007) the health treatment costs of obesity alone cost around £1 billion per year, and from McCormick et al (2007) the cost of working days lost through sickness and premature mortality are around £2.25 to £2.60 billion per year. Factored to the active visits of the workforce of the region this equates to £74 million in avoided health treatment costs and £170 million to £190 million in lost working days avoided.
- Trees (especially in an urban setting) provide important air pollution removal benefits and provide urban cooling, which avoids health costs and lost working days. From the eftec and CEH (2019) air quality tool, the tree cover in the region saves £44 million in health costs associated with respiratory diseases.
- Landscape improvements can provide uplifts to property prices and can attract more investment in the local area. The Northern Forest (2018) estimates that a typical property uplift of £5,000 per property is feasible.

Another way to account for the significance of active visits to the local economy is to estimate the proportion of the workforce that use green space as part of an active lifestyle. From ONS statistics 78% of the local adult population are of working age and of those 76.5% are in employment. Using these proportions, it is estimated that 52 million out of the 88 million active visits in the area are by people in the workforce. From the Monitor of Engagement in the Natural Environment survey[21] the average number of visits per visitor per year is 89, meaning that 52 million visits translates to 592,000 workers or 26% of the local workforce. If the local workforce labour is valued at £77 billion, then this proportion of the workforce is valued at £20 billion.

Other benefits can include habitat creation and connectivity, and an increase in green travel through increased footpaths and cycle paths

In the urban context the main improvement assumption is the planting of urban trees and creation of new green / blue infrastructure and recreational space to keep pace with the expected growth in population (5% to 2040). These enhancements provide the following benefits (which are quantified in Table 4.5:

- Avoided health costs through the physical activity facilitated by additional recreational infrastructure.
- Additional workforce productivity benefits through the provision of incremental green space;
- Further urban cooling cooling benefits from urban tree planting, manifest as avoided productivity losses during heatwaves.

[20] *From ORVal for the whole study area. See Day et al (2018).*
[21] *MENE at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/828552/Monitor_Engagement_Natural_Environment_2018_2019_v2.pdf*

In addition to these quantified benefits, these enhancements can support inward investment through improving quality of place and provide wildlife and connectivity benefits.

Table 4.5: Summary of Changes in Local Economy Benefits and Risks by Scenario

Item	Business as Usual - Degrade	Maintain	Enhance
Productivity - Health Benefits: Impact of greenspace on physical health.	Activity rate drops 10% with declining quality and quantity of greenspace. Cost £24m in costs of ill-health.	As current	Provision of greenspace not only keeps pace with population growth (5% by 2040) but urban visits grow to match rural rates (30% growth). Physical ill-health costs avoided: £77m
Productivity – urban tree planting: Cost savings from improvement to air quality & urban cooling.	Assuming 10% loss of tree cover, health and productivity impacts increase costs by £5m	As current	Assume doubling urban tree cover – health and productivity impacts £36m saving
Property uplift: Enhancement to properties from Northern Forest.		As current	Property uplift from Tree Planting[22] c £1,500 million
Total	**£29m increase in costs to local economy**	**As is**	**£113m saving in costs to local economy Property uplift £1,150 million**

4.6 Tourism

The regional tourist sector is worth around £2.7 billon in GVA terms, and the natural capital of Yorkshire plays a pivotal role in attracting visitors to the area. The national parks are major natural attractions, the Yorkshire Dales NP and the North York Moors NP bringing direct expenditure of £240 million and £524 million respectively[23]. Although rural tourism is important to the area, it is useful to be aware that around two-thirds of tourist jobs and GVA are based in the more urban local authorities of WYCA and York. This serves as a reminder that tourist motivations can be driven a mix of natural and cultural heritage and other factors.

Whilst attributing tourist income to any particular capital factor should be treated with caution, work done by eftec et al (2019) indicated that around 26% of the tourist spend in Yorkshire and Humber is wholly dependent upon natural capital. However, a wider perspective suggests that 66% is dependent in part upon natural capital (see section 2.2.4).

Consultations with local stakeholders revealed some useful insights into opportunities for natural capital to influence the tourist economy:

- Local distinctiveness is an important feature that attracts visitors to the area. This distinctiveness varies across the region, for example with the North Yorkshire Moors, the Yorkshire Dales and the

[22] *Based on Northern Forest (2018) which assumes 650,000 new homes in the Northern forest area at £5,000 uplift per property. Pro-rating on area gives 300,000 homes in the study area with an uplift of £1,500 million.*

[23] *Recent STEAM reports for both national parks at:*
https://www.yorkshiredales.org.uk/for-local-businesses/tourism-facts-and-figures/
https://www.northyorkmoors.org.uk/looking-after/advice-and-grants/tourism

Heritage Coast having very different characters.

- Preserving this distinctiveness requires ongoing attention in the light of future threats and changes such as climate change, changing visitor expectations/values and competition from other destinations.
- Whilst there is some capacity to increase rural visits (e.g. through more farm-based accommodation) there are limits on the number of additional visitors that can be accommodated without impairing visitor experience and landscape character. The implications for rural tourism are to prioritise increased value added rather than visitor numbers.
- Some businesses are exploring innovative ways of capitalising on nature, for example with immersive experiences (such as involvement in lambing, or guided walks) as a means to increase the value added of tourist visits.
- Climate change policy in particular will have an influence. For example, the North York Moors NP no longer supports marketing that encourages flying to the area but encourages travel by train or other low carbon transport. This may become a significant feature of the tourist sector.

It is difficult to predict the influence of natural capital on future growth rates of GVA[24]. However, the following is a reasonable set of assumptions by scenario and the GVA impacts of these assumptions are shown in Table 4.6.

- Business as Usual assumes ongoing decline in biodiversity with a knock on effect to the landscape character. Assuming a 1% year on year decline in the natural capital based tourism sector, this reduces GVA by £190 million by 2050, or 7% overall.
- The maintain scenario assumes that the character of the local area is maintained and that tourist sector GVA remains at existing levels.
- The enhance scenario assumes that investment in increasing biodiversity and sensitive woodland creation enhances the landscape and drives higher value added per visitor by 1% year on year, assuming capture of a proportion of global tourism growth[25]. This increases GVA by £1 billion by 2050 (33%).

Table 4.6: Summary of Changes in Tourism Benefits by Scenario

Item	Business as Usual - Degrade	Maintain	Enhance
GVA growth	GVA drops by £190 m (7%) overall by 2050 due to ongoing decline in local natural capital and landscape character	Assume GVA maintained at existing levels	GVA grows by £1 billion (33%) overall by 2050 due to enhancement of local natural capital and landscape character

Challenges

- Increasing value added from tourism without overwhelming the area with visitors and potentially harmful impacts to natural capital requires innovative ideas and local consultation.
- Getting visitors to pay for the unique features that nature provides will be a challenge.
- Climate impacts may alter the distinctiveness of some parts of the region.

[24] *From 2013-2025, tourism GVA is expected to grow by 3.8% CAGR with potential for 630,000 more tourism jobs. These forecasts are largely driven by international demand growth (Visit Britain, 2013, 'Tourism Jobs and Growth: The Economic Contribution of the Tourism.*

[25] *Globally, tourism is growing by 3.9% annually (compared to 3.2% for global GDP) World Travel & Tourism Council, 2019,* https://www.wttc.org/about/media-centre/press-releases/press-releases/2019/travel-tourism-continues-strong-growth-above-global-gdp/ Assuming this rate for Yorkshire, and that 25% of this tourism depends on local natural capital to grow, gives 1% growth dependent upon natural capital.

4.7 Greenhouse Gas Impacts

A range of natural capital investments have the potential to address climate change through positive greenhouse gas impacts. This is a clear local priority, supporting both the local carbon targets and national policy on climate change. The most significant local opportunities are:

- Investment in increasing soil carbon in farmland, through regenerative practices and greater focus on soil organic matter.
- Woodland creation and tree planting, in a diverse range of places (rural and urban) and for various purposes but all would have a positive impact on carbon sequestration.
- Restoring peatland to prevent the ongoing emissions associated with drained and eroding peat.

Whilst these benefits do not currently impact on GVA, they do make a valuable contribution to local, national and global targets for GHG reduction and they can be valued in monetary terms. The key challenge locally and nationally is to develop mechanisms for funding these benefits at the necessary scale, which will become an increasingly urgent task in the next few years.

It is important to appreciate that the value of GHG benefit changes significantly over time. For example, the current (2020) central non-traded value of carbon is £69 per tCO_2e, rising to £231 per tCO_2e by 2050, (BEIS guidance (2019). This is because the method of valuation is based on actions to abate carbon emissions which will become more costly as more expensive methods are required to reduce remaining carbon emissions. Secondly the BEIS guidance is subject to a wide value range, with the central and high price of carbon being £231 and £346 per tCO_2e respectively in 2050. This range reflects the high level of uncertainty in the costs of abating future carbon emissions. Finally, the existing guidance is based on estimates and reductions targets prevalent in 2010. Since then the Government has committed to more stringent carbon targets and there are more up to date estimates of carbon abatement measures. The government is in the process of revising its carbon price estimates and these should be published later this year. The general expectation is that prices will be higher but that the range of uncertainty will be lower. For this study we adopt the current BEIS guidance, which is to value carbon emissions and reductions at the central and high prices and to use that range in expressing the value of possible benefits.

A summary of the scale of these benefits is shown in Table 4.7.

Table 4.7: Summary of Changes in GHG Benefits and Risks by Scenario

Item	Business as Usual - Degrade	Maintain	Enhance
Farmland soil.	Risk of loss of soil carbon. Risk of a loss of 1.2 $MtCO_2e$ per year[26] at a value of £290m to £430m by 2050.	Risk of loss of soil carbon. Risk of a loss of 1.2 $MtCO_2e$ per year[27] at a value of £290m to £430m by 2050.	Assume arable soils organic carbon increase by 1% every 5 years. This sequesters around 4.5 $MtCO_2e$ per year at a value of between £1,040m and £1,560m per year by 2050. Cumulatively, every 1% increase in SoM[28] in arable soils sequesters 22.6 million tCO_2e in the region.
Woodland creation	No Change.	No Change.	65,000 ha of woodland creation sequesters on average 350,000tCO_2e/year, with value between £80m – £120m /year by 2050. 130,000 ha of woodland creation sequesters on average 700,000tCO_2e/year, with value between £160m – £240m /year by 2050.
Peatland restoration.	Ongoing degradation - GHG emissions 400 $ktCO_2e$/year, valued at £90m - £140m per year by 2050.	Ongoing degradation - GHG emissions 400 $ktCO_2e$/year, valued at £90m - £140m per year by 2050.	Peatland becomes GHG neutral by 2040 (saving up to £140m by 2050).
Total	Losses of £380m to £570m per year by 2050.	Losses of £380m to £570m per year by 2050.	At low woodland creation Gain = £1,120m to £1,680m At high woodland creation Gain = £1,200m to £1,800m.

Overall, the improvement between the enhance and the BAU scenario is worth between £1.6 billion and £2.4 billion, which is an indication of the large potential value of this market.

Costs

The costs of realising these climate benefits are covered by a combination of investments in:

- Regenerative farming (see section 4.1 – costs are covered by re-allocation of existing agri-environment payments.].
- restoring degrading peatlands (estimated cost £95 million – see section 4.3).
- targeted woodland creation costing between £450 million to £900 million (depending upon the scale of planting).

Challenges

- Developing mechanisms and markets to fund GHG sequestration and emissions reduction at scale is a key challenge. Local opportunities to address this include working with businesses that aim to become carbon neutral and work with local supply chains to reduce emissions and/or inset/offset unmitigable impacts.
- Providing the appropriate incentives for farmers to adopt spatially suitable measures will be key to achieving uptake

[26] Average loss of soil organic carbon in England and Wales is c 5.1Mt of carbon per year (or 18.7$MtCO_2e$/year) – source Graves et al (2015) for 13.9 million ha. Assuming the same average per unit area, this would mean a loss of 1.2 million tCO_2e/year in this study area
[27] Average loss of soil organic carbon in England and Wales is c 5.1Mt of carbon per year (or 18.7$MtCO_2e$/year) – source Graves et al (2015) for 13.9 million ha. Assuming the same average per unit area, this would mean a loss of 1.2 million tCO_2e/year in this study area
[28] 1% SoM stores approximately 41.4tCO2e/ha.

4.8 Summary of Impacts

Benefits and risks

Table 4.8 summarises the changes in benefits and risks for the whole region, with the three scenarios. These figures represent estimates of outcomes in 2050, for each scenario based on mid-point estimates (where figures have been calculated on a low-high range). The figures are expressed in 2018 terms to allow comparison with the baseline value. Figures for each sub-area are given in Annex 1: Detail by Sub-area.

Table 4.8: Summary of Changes in Benefits and Risks, annual values at 2050, by Scenario, 2018 prices.

Sector GVA at 2050	Business as Usual		Maintain		Enhance		Change Enhance Vs BAU £'m	% of 2018 GVA
	GVA £'m	% Change v baseline	GVA £'m	% Change v baseline	GVA £'m	% Change v baseline		
Direct Dependency Sectors								
Agriculture	656	-3.7%	664	-2.5%	746	9.5%	90	
Forestry	40	0.0%	40	0.0%	80	101.7%	40	
Water	312	-8.2%	326	-4.1%	501	47.3%	188	
Minerals	202	0.0%	202	0.0%	202	0.0%	0	
Tourism	2,532	-6.9%	2,719	0.0%	3,638	33.8%	1,106	
Indirect Dependent Sectors								
Food Manufacturing	1,705	-3.7%	1,727	-2.5%	1,906	7.6%	200	
Manufacturing	644	0.0%	644	0.0%	725	12.5%	80	
Bio-tech/energy	403	-3.4%	408	-2.1%	989	137.1%	586	
Total NC Related	**6,493**	**-4.7%**	**6,730**	**-1.2%**	**8,785**	**28.9%**	**2,292**	**2.6%**
All other sectors	82,292	0.0%	82,292	0.0%	82,292	0.0%	0	
Total GVA	**88,785**	**-0.4%**	**89,022**	**-0.1%**	**91,076**	**2.2%**	**2,292**	**2.6%**
Wider risks and opportunities across all sectors (costs)[1]:								
Flood costs (average)	-167		-167		-104		64	
Property uplift	-		-		75		75	
GHG impacts	-472		-472		1,468		1,940	
Health impacts	-28		-		113		143	
Total wider impacts	**-669**	**-0.8%**	**-639**	**-0.7%**	**1,552**	**1.7%**	**2,221**	**2.5%**
Total Value Change		**-1.1%**		**-0.8%**		**4.0%**	**4,513**	**5.1%**
Major Flood event	-1,792	-2.0%	-1,773	-2.0%	-1,099	-1.1%	693	0.8%
Total value change							**5,206**	**5.8%**

For the natural capital related sectors, GVA falls by 4.7% in the BAU scenario and by 1.2% in the maintain scenario but rises by nearly 30% in the enhance scenario, providing an improvement of £2.3 billion between the BAU and enhance scenarios.

The wider economic costs, benefits and risks (costs of flooding, and impacts on property values, GHG impacts and health) under BAU are on 'average' around £670 million per year, but in a flood event year these costs could be £1.8 billion higher. The maintain scenario gives almost the same level of costs at around £640 million per year. The enhance scenario mitigates some of the annual average flood costs and

provides significant benefits in terms of property uplift (from investment in urban tree planting) and in GHG sequestration (through increases in farm soil carbon and woodland creation). These wider benefits represent a £2,221 million improvement relative to the BAU scenario.

Considering the impacts in an extreme flood year event, the BAU and maintain scenarios have estimated costs of around £1.8 billion by 2050 under the 4°C climate scenario[29]. However, the enhance scenario mitigates costs by £693 million, which is equivalent to a saving of 0.8% of regional GVA.

The worst case scenario assumes the lower range of benefit values and assumes a bad flood event. This gives GVA impacts in 2050 as shown in Table 4.9. This shows that even in a major flood year and with lower estimated values for benefits, the enhance case still provides additional value equivalent 5.5% of total GVA (£4,938m) relative to the BAU scenario.

Table 4.9: Summary of Changes in Benefits and Risks, Worst Case values at 2050, by Scenario, 2018 prices.

Sector GVA at 2050	Business as Usual		Maintain		Enhance		Change Enhance Vs BAU £'m	% of 2018 GVA
	GVA £'m	% Change v baseline	GVA £'m	% Change v baseline	GVA £'m	% Change v baseline		
Direct Dependency Sectors								
Agriculture	375	-44.9%	477	-29.9%	702	3.1%	327	
Forestry	40	0.0%	40	0.0%	66	67.8%	27	
Water	312	-8.2%	326	-4.1%	472	38.7%	159	
Minerals	202	0.0%	202	0.0%	202	0.0%	0	
Tourism	2,532	-6.9%	2,719	0.0%	3,638	33.8%	1,106	
Indirect Dependent Sectors								
Food Manufacturing	1,705	-3.7%	1,727	-2.5%	1,841	4.0%	136	
Manufacturing	644	0.0%	644	0.0%	698	8.3%	54	
Bio-tech/energy	403	-3.4%	408	-2.1%	949	127.6%	547	
Total NC Related	**6,213**	**-8.8%**	**6,543**	**-4.0%**	**8,568**	**25.7%**	**2,355**	**2.6%**
All other sectors	82,292	0.0%	82,292	0.0%	82,292	0.0%	0	
Total GVA	**88,505**	**-0.7%**	**88,835**	**-0.3%**	**90,859**	**2.0%**	**2,355**	**2.6%**
Wider risks and opportunities across all sectors (costs):								
Flood costs (average)	-1,772		-1,772		-1,099		673	
Property uplift	-		-		75		75	
GHG impacts	-567		-567		1,125		1,503	
Health impacts	-29		-		113		143	
Total wider impacts	**-2,368**	**-2.7%**	**-2,339**	**-2.6%**	**215**	**0.2%**	**2,583**	**2.9%**
Total value change							**4,938**	**5.5%**

[29] *Based on Climate Change Risk Assessment, Sayers et al (2017) Projections of future flood risk in the UK. Values for Yorkshire and Humber.*

Investment

It is difficult to estimate investment costs accurately, as there are many different ways of achieving the above benefits (especially within the farming sector). However, the initial estimates described in previous sections and given in Table 4.10 give a rough indication of the level of investment needed to achieve the enhanced scenario benefits.

Table 4.10: Summary of Estimated Investment Costs

Investment type	One-off Investment Cost (£'m)	On-going costs (£'m/year)
Farm catchment planning	£16m	
Woodland Creation (range 5 to 10% land cover)	£450-900 m	£13-22m
Peatland restoration	£95m	Assume low
SuDs	Not evaluated	Assume low
Total	**At least £560 - £1,000m**	**At least £13-22m/year**

5. Risks, Opportunities & Challenges

The Local Industrial Strategies (LIS) need to be aware of natural capital-related economic impacts, the priority assets for investment and challenges investments face. The impacts relate to both avoiding potential costs associated with climate and other risks, as well as new opportunities for growth.

5.1 Risks

This work quantifies regional economic risks from environmental degradation and climate change. Some impacts from climate change on the region are inevitable and will bring risks to regional economic performance (e.g. from more extreme drought, flood and heat). In the long term a wide range of outcomes is possible, depending upon the effectiveness of global GHG mitigation actions. Planning for such a wide range of possibilities requires a focus on resilience and the ability to adapt.

There are uncertainties, but as a result also opportunities, in responding to climate change, for example in changing patterns of economic behaviour (e.g. in food consumption). Shifts to pro-environmental patterns of demand (e.g. buying local) may help the region which has a broad agricultural production base. However, this may require adaptation of current livestock-orientated production systems (both grazing and production of animal feed) and supply chains. Loss of biodiversity is also a major environmental concern with uncertain consequences, and therefore also brings risks and opportunities.

Despite these uncertainties, the analysis in this report demonstrates that the potential scale of these risks are material to the regional economy of North, East and West Yorkshire. The estimated benefits under the 'enhance' scenario, of £4 billion per year, are worth 4% of regional economic output (GVA of £90 billion/year).

Climate Change

Climate change will bring risks to regional economic performance from more extreme drought / heatwaves, flooding and fire risks, as well as changes to agricultural productivity and regional biodiversity. The most significant risks these pose to the regional economy are:

- Flood risk damage and disruption costs will increase and could be considerable (in the region of £1 to 1.8 billion per major flood event by 2050) and entail major disruption to economic infrastructure (homes, businesses, water, energy and transport infrastructure). Regulation of water flow is an effective strategy for mitigating damages and investing in natural capital has an important role to play in regulating peak flows.
- Water supply pressures will become more severe in the later part of this century, although in the immediate term drought risks can cause significant disruption to agriculture and industry (costing agriculture up to £200m in a drought year). Building resilience and regulating flows through better soil management and appropriate habitat creation and restoration can help to alleviate pressures.
- Heatwaves can cause disruption to productivity (especially in the construction, utilities and farming sectors), Investment in suitable green / blue infrastructure can provide a degree of cooling in urban areas.
- Fire risks may become more significant, especially on the upland moors. Impacts will include

increased air pollution (which may be severe for major fires) and potential loss of tourism income.
- Some biodiversity losses may be irreversible.
- These risks will increase if there is further loss of tree cover, peatland continues to drain and erode, and farmland soils are lost to run-off and erosion.

Other Risks

There are other risks to natural capital which also have impacts upon the local economy:

- Patterns of economic behaviour (mainly consumption) could both help and threaten local natural capital. Shifts to pro-environmental patterns of demand (e.g. conserving water and buying local) may help the regional economy. However, attachment to established production patterns may hinder the growth of some markets / sectors (e.g. circular economy, shifts to renewable energy) and exert further pressure on natural capital (e.g. high water use);
- Inappropriate development could further degrade biodiversity, damage or put extra pressure on recreational space, or exacerbate flood risks.

5.2 Opportunities

There are investments in natural capital that can maintain and enhance both the direct and indirect ways that natural capital supports economic activity in the region. Priorities identified in this study include:

- Improved productivity of farmland, whilst reducing GHG emissions and improving soil condition, biodiversity, water quality and flow (flood mitigation). This is in line with NFU target of achieving zero carbon (NFU 2019) and supports the local targets for a zero carbon circular economy.
- Good quality urban green infrastructure helps to attract inward investment and talent, and to improve the health and wellbeing of the workforce by enabling recreation and inclusivity. Currently green infrastructure provides opportunities for physical exercise which saves over £170m per year by avoiding loss of working time due to sickness and premature mortality.
- Peatland restoration can abate significant GHG emissions (saving over £3 billion of emissions over 80 years), mitigate fire risk, increase biodiversity, and improve water quality and flow (the latter reducing flood risk).
- Woodland creation can support increased timber output, while also sequestering GHGs (saving over £1.7 billion over 80 years). Well-planned planting can also provide biodiversity, recreation and water regulation benefits.

Opportunities (and enablers):

The economic opportunities supported by these investments will arise in both urban and rural areas:

Rural

- These investments can create more resilient rural sectors: enabling agricultural adaption to climate change, and maintaining the unique natural capital assets (dales, moors, and coast) that attract tourism and leisure activities to Yorkshire;
- New renewable energy sources can be developed from biomass and agricultural wastes, in line

with zero-carbon targets;
- Managing for water through greater cooperation and catchment planning with land managers to improve water quality and manage flows;
- Developing the agri-food and bio-tech/energy sectors connectivity to local supply chains, and a focus on higher margin lower-embodied carbon outputs.

Urban

Several of the rural opportunities clearly link into the urban economy:

- There are important employment opportunities in sectors linked to the rural activities described above, such as for the agri-food sector (including the cluster in the Leeds City Region), and for tourism;
- Natural capital is important to the resilience of society's water supplies to drought, and of logistics to disruption from flooding;
- The physical health benefits than urban green and blue spaces support help to maintain a healthy, and therefore productive workforce. The extent and quality of urban green infrastructure is also a factor in attracting inward investment.

5.3 Challenges

The data developed in this report point to several enabling factors that can help to achieve the potential economic benefits from maintaining and enhancing natural capital. It is crucial that economic activities and strategies recognise that risks to GVA from climate change and environmental degradation. Natural capital is important to the regional economy as an input to current activity, for resilience against future changes, and as a source of new areas of growth. However, in each of these areas there is a challenge to ensure there is the right knowledge and advice available to support management actions, including through:

- Support for wider understanding of, and implementation of, climate adaptation advice. For example, the extent to which natural capital investment can play a role in addressing climate change risks (e.g. mitigating flood risk) still needs to be better understood at a local scale;
- The role of land managers and agents as trusted advisors is likely to be very important in helping landowners understand the benefits and risks of woodland creation;
- Involving local communities in helping to shape land use change, as in some areas this will be at a scale which will alter landscape character. Changes will affect designated areas, and communities with widely differing views for and against different measures;
- Important areas of advice like ensuring the right trees are planted in the right place, and the ability to coordinate catchment management activities;
- Raising awareness and skills to support and deliver clean growth opportunities, including innovation to achieve zero carbon, and circular economy objectives.

Aspects of the challenges faced in managing natural capital as part of the regional economy in specific sectors include:

In agriculture:

- Despite ambitious land use change (see woodland creation below), agriculture will remain the dominant land use;
- Making the best use of agricultural subsidy reforms (i.e. new ELMS payments) in Yorkshire, by shaping the public goods it supports to benefit the regional economy. It needs to provide appropriate incentives for farmers to adopt spatially suitable measures, and build understanding and collaboration to engage in efficient delivery of the priorities the scheme will fund;
- Agricultural productivity requires continuous improvement, much of which can be achieved by widespread adoption of good practice already present in the sector. Enabling investment in productivity improvements (precision farming, etc) requires better long- term confidence in markets to support the decision to invest.

Woodland creation:

- The challenge of woodland creation at the scale of 5 to 10% of regional land cover should not be underestimated. The key will be offering the right incentives and funding streams to make this option attractive. Some income streams are well established but could be extended (e.g. timber, biomass), others are emerging (e.g. woodlands for water grants and catchment management payments), whilst others need significant development (e.g. carbon and biodiversity offset markets);
- Conversion of land to woodland is a permanent land use change and hence requires a high degree of long-term viability before landowners will agree to such a change. Offering long term income streams with a high degree of security will be an important element of enabling land use change at scale;
- The Northern Forest provides a vision for a step-change increase in the proportion of land used for woodland and agro-forestry. This can be linked to markets for carbon credits generated through enhancing natural capital (e.g. by avoiding peatland emissions or woodland planting), and local credits for Biodiversity Net Gain. Both markets will benefit from robust and transparent regulation that supports market confidence.

Tourism and recreation:

- Increasing value added from tourism without overwhelming the area with visitors and potentially harmful impacts to natural capital requires innovative ideas and local consultation;
- There is a lack of mechanisms for visitors to pay directly for the unique features that nature provides, but indirect linkages to natural capital (e.g. through local branding) are possible;
- Climate impacts may alter the distinctiveness of some parts of the region and require adaptation measures.

Across all sectors, investments and financial incentives will shape the links between natural capital and the regional economy, creating challenges which include:

- Developing funding from a variety of sources. This includes adapting some traditionally distinct market-economy or natural environment focussed funding streams to co-deliver in the areas where this study indicates they have shared priorities. There are also opportunities for developing new markets and finance for services not currently traded (e.g. public goods such as carbon credits,

habitat banking etc.);

- Developing mechanisms and markets to fund GHG sequestration and emissions reduction at scale is a key challenge. Local opportunities to address this include working with businesses that aim to become carbon neutral; work with local supply chains to reduce emissions and/or inset/offset unmitigable impacts; and making adequate funding available to restore peatland;
- Alignment between national and regional policy. In particular, agricultural subsidy reform, but also climate policy, regional infrastructure development, and biodiversity net gain in the planning system.

6. Conclusions & Recommendations

This study identifies the current importance of local natural capital to the regional economy of North, West and East Yorkshire, where it supports £4.5 billion of GVA of benefits per year (5% of the regional total). In addition, it is estimated that 26% of Yorkshire's workforce regularly use greenspace to support active lifestyles – so depend on nature to sustain their physical health. As an indication of economic significance, 26% of the local labour costs is around £20 billion annually.

The scenarios analysed identify both risks to this economic activity from ongoing climate change and environmental degradation, and opportunities relating to maintaining and enhancing the environment. The estimated benefits of managing natural capital cover both avoided costs and risks as well as new economic opportunities. Modelling of these scenarios estimates the scale of potential risks under a business as usual scenario could reduce natural capital related sector GVA by over £300 million and carry exposure to climate risks of nearly 3% of GVA. The enhance scenario increases GVA by £2.3 billion (2.6% of GVA) relative to the BAU scenario and provides wider benefits and risks reductions in the order of a £2.2 billion by 2050.

Therefore, investment in natural capital not only brings benefits in terms of enhanced outputs in certain aspects of the economy, such as over £1 billion per year of tourism GVA that is dependent on ecosystems, or through workforce productivity. It also reduces the risks from economically damaging factors, such as more severe and frequent droughts and floods.

It should be noted that while natural capital can support economic activity, it does not do so in isolation, and can work most effectively when enhanced in combination with investment in other capitals. However, the role of natural capital is often omitted from traditional economic statistics, and therefore the analysis developed in this report should be used to stimulate a wider discussion on the role of natural capital assets in the regional economy.

Uncertainties:

In interpreting these results it should be borne in mind that there are:

- Significant uncertainties in many of the scenarios and data sources, and the way they are combined, using innovative analysis, in this study. As a result, the results have a moderate confidence level: the data should be taken to represent the scale of the economic risks and opportunities associated with management of natural capital, rather than specific predictions of performance.
- Understanding and data are not sufficient to quantify all economic risks and opportunities relating to natural capital, therefore the results developed are an underestimate of natural capital's overall role in the economy and the impacts of its management.
- Significant areas of impact that are not quantified in the analysis, such as the connection between maintaining and enhancing natural capital and increased future inward investment to the region.
- Trade-offs involved within the economic activities examined, in particular that widespread woodland creation will inevitably utilise land that is currently devoted to agricultural production. However, whether this translates into lower farm output depends on which land is utilised for woodland and the types of remaining agricultural production in the future.

- Several suggestions are made for further work to examine the range of issues covered in this report, and several areas will benefit from the developing evidence base on the expected impacts of, and recommendations for adapting to, climate change (e.g. new CCRA on climate change impacts). For example:
    - More specific flood risk scenarios could be used in detailed modelling of risks to businesses at risk of flooding and of disruption effects to the economy;
    - The risks and opportunities identified have significant consequences for workforce skills within the region. These have not been analysed in detail, but stakeholders have noted some significant skills gaps (e.g. in managing agro-forestry systems) - further understanding can inform training strategies and enable better adaptation to climate change.
- The costs of investing in natural capital require further analysis, both in terms of overall funding and the timing and other specific needs of investment opportunities. However, it should be borne in mind that there are opportunities within current spending (in particular re-shaping agricultural subsidies), so not all investment requirements need additional funds.

Many of the major links between natural capital assets and the economy analysed in this report have significant uncertainties. Areas where more investigation and research are needed include:

- Current soil condition, and the role of improved soil management in outcomes for carbon, agricultural production, biodiversity and water management;
- Links between the extent and quality of natural capital assets and:
    - Inward investment into the region;
    - Workforce health and therefore productivity;
    - Ecosystem-dependent spending in the tourism and leisure industries;
- Specific modelling of flood risks within catchments, which can then be translated into risks to infrastructure and logistics, and consequences for the workforce and economy.
- As the bio-tech/energy sector is highly innovative and subject to rapid change, ongoing monitoring of developments in this emerging sector would be beneficial to understand specific local opportunities to capitalize on local feedstocks.

Recommendations:

As understanding of climate risks improve in the UK, so the accuracy of the type of economic analysis undertaken in this study will improve. At present the data produced have a moderate level of confidence and give a guide to the scale of economic risks and opportunities, rather than a specific prediction of future performance. It is recommended that the analysis in this report is updated as new climate risk evidence becomes available.

Building on current and future climate risk and adaptation evidence, it is recommended that:

- The challenge of integrating natural capital maintenance and climate adaptation into regional economic strategy is explicitly recognised as a material issue for the region, and
- Adapting current natural capital management towards enhancement of assets and benefits should be seen as a key response to climate change and a wider economic opportunity.

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Annex 1: Detail by Sub-area

York & North Yorkshire

A. 1: York and North Yorkshire Average Case

Impacts on Local Economy - 2050 Average Case
York and North Yorkshire (YNY)

GVA (at 2050) At current prices	Baseline (2018)	BAU £'m	%	Maintain £'m	%	Enhance £'m	%	Difference Enhance Vs BAU	% of 2018 GVA
Direct Dependency Sectors									
Agriculture	402	387	-3.7%	392	-2.5%	440	9.5%	53	
Forestry	25	25	0.0%	25	0.0%	51	101.7%	26	
Water	219	201	-8.2%	210	-4.1%	322	47.3%	121	
Minerals	63	63	0.0%	63	0.0%	63	0.0%	0	
Tourism	919	855	-6.9%	919	0.0%	1,229	33.8%	374	
Indirect Dependent Sectors									
Food Manufacturing	619	596	-3.7%	603	-2.5%	666	7.6%	70	
Manufacturing (Timber)	84	84	0.0%	84	0.0%	94	12.5%	10	
Bio-tech/bio-energy	162	155	-4.1%	158	-2.5%	393	143.1%	238	
Total NC related	**2,492**	**2,366**	-5.0%	**2,453**	-1.5%	**3,258**	30.8%	892	
All other sectors	18,224	18,224	0.0%	18,224	0.0%	18,224	0.0%	0	
Total GVA	**20,716**	**20,590**	-0.6%	**20,678**	-0.2%	**21,483**	3.7%	892	4.3%
Other impacts (all sectors) for average Year									
Flood damages		-27		-27		-17		10	
Flood disruption to economy		-9		-9		-6		3	
Health - avoided sick days & Health costs		-7		0		3		9	
Productivity - urban trees		-1		0		5		6	
GHG Impacts - Peat bogs		-95		-95		0		95	
GHG Impacts - Soil carbon		-231		-231		842		1,073	
GHG Impacts - Woodland creation						104		104	
Property Uplift (Tree planting & GI)						16		16	
Total Impacts/Risks		-370	-1.8%	-362	-1.7%	948	4.6%	1,317	6.4%
Total Value Change		**20,221**	**-2.4%**	**20,316**	**-1.9%**	**22,430**	**8.3%**	2,210	10.7%

A. 2: York and North Yorkshire Best Case

Impacts on Local Economy - 2050 Best Case
York and North Yorkshire (YNY)

GVA (at 2050) At current prices	Baseline (2018)	BAU £'m	%	Maintain £'m	%	Enhance £'m	%	Difference Enhance Vs BAU	% of 2018 GVA
Direct Dependency Sectors									
Agriculture	402	387	-3.7%	392	-2.5%	455	13.2%	68	
Forestry	25	25	0.0%	25	0.0%	59	135.6%	34	
Water	219	201	-8.2%	210	-4.1%	341	55.8%	140	
Minerals	63	63	0.0%	63	0.0%	63	0.0%	0	
Tourism	919	855	-6.9%	919	0.0%	1,229	33.8%	374	
Indirect Dependent Sectors									
Food Manufacturing	619	596	-3.7%	603	-2.5%	688	11.3%	93	
Manufacturing (Timber)	84	84	0.0%	84	0.0%	98	16.6%	14	
Bio-tech/bio-energy	162	155	-4.1%	158	-2.5%	410	153.6%	255	
Total NC related	**2,492**	**2,366**	-5.0%	**2,453**	-1.5%	**3,343**	34.2%	977	
All other sectors	18,224	18,224	0.0%	18,224	0.0%	18,224	0.0%	0	
Total GVA	**20,716**	**20,590**	-0.6%	**20,678**	-0.2%	**21,568**	4.1%	977	4.7%
Other impacts (all sectors) for average Year									
Flood damages		-23		-23		-14		9	
Flood disruption to economy		-9		-9		-6		3	
Health - avoided sick days & Health costs		-7		0		3		9	
Productivity - urban trees		-1		0		5		6	
GHG Impacts - Peat bogs		-76		-76		0		76	
GHG Impacts - Soil carbon		-185		-185		1,011		1,195	
GHG Impacts - Woodland creation						157		157	
Property Uplift (Tree planting & GI)						16		16	
Total Impacts/Risks		-300	-1.4%	-293	-1.4%	1,171	5.7%	1,471	7.1%
Total Value Change		**20,290**	**-2.1%**	**20,385**	**-1.6%**	**22,739**	**9.8%**	2,449	11.8%

A. 3: York and North Yorkshire Worst Case (including major flood event)

Impacts on Local Economy - 2050 Worst Case
York and North Yorkshire (YNY)

GVA (at 2050) At current prices	Baseline (2018)	BAU £'m	BAU %	Maintain £'m	Maintain %	Enhance £'m	Enhance %	Difference Enhance Vs BAU	% of 2018 GVA
Direct Dependency Sectors									
Agriculture	402	190	-52.7%	261	-35.1%	412	2.6%	222	
Forestry	25	25	0.0%	25	0.0%	42	67.8%	17	
Water	219	201	-8.2%	210	-4.1%	304	38.7%	103	
Minerals	63	63	0.0%	63	0.0%	63	0.0%	0	
Tourism	919	855	-6.9%	919	0.0%	1,229	33.8%	374	
Indirect Dependent Sectors									
Food Manufacturing	619	596	-3.7%	603	-2.5%	643	4.0%	47	
Manufacturing (Timber)	84	84	0.0%	84	0.0%	91	8.3%	7	
Bio-tech/bio-energy	162	155	-4.1%	158	-2.5%	376	132.6%	221	
Total NC related	**2,492**	**2,169**	-12.9%	**2,322**	-6.8%	**3,160**	26.8%	991	
All other sectors	18,224	18,224	0.0%	18,224	0.0%	18,224	0.0%	0	
Total GVA	**20,716**	**20,393**	-1.6%	**20,547**	-0.8%	**21,385**	3.2%	991	4.8%
Other impacts (all sectors) for average Year									
Flood damages		-309		-309		-192		117	
Flood disruption to economy		-74		-74		-46		28	
Health - avoided sick days & Health costs		-7		0		3		9	
Productivity - urban trees		-1		0		5		6	
GHG Impacts - Peat bogs		-114		-114		0		114	
GHG Impacts - Soil carbon		-429		-429		674		1,103	
GHG Impacts - Woodland creation						52		52	
Property Uplift (Tree planting & GI)						16		16	
Total Impacts/Risks		-934	-4.5%	-927	-4.5%	512	2.5%	1,446	7.0%
Total Value Change		**19,459**	**-6.1%**	**19,620**	**-5.3%**	**21,897**	**5.7%**	2,437	11.8%

West Yorkshire

A. 4: West Yorkshire Average Case

Impacts on Local Economy - 2050 Average Case
West Yorkshire (WYCA)

GVA (at 2050) At current prices	Baseline (2018)	BAU £'m	%	Maintain £'m	%	Enhance £'m	%	Difference Enhance Vs BAU	% of 2018 GVA
Direct Dependency Sectors									
Agriculture	136	131	-3.7%	133	-2.5%	149	9.5%	18	
Forestry	11	11	0.0%	11	0.0%	80	597.3%	68	
Water	53	49	-8.2%	51	-4.1%	79	47.3%	30	
Minerals	76	76	0.0%	76	0.0%	76	0.0%	0	
Tourism	1,428	1,329	-6.9%	1,428	0.0%	1,910	33.8%	581	
Indirect Dependent Sectors									
Food Manufacturing	830	799	-3.7%	810	-2.5%	893	7.6%	94	
Manufacturing (Timber)	357	357	0.0%	357	0.0%	402	12.5%	45	
Bio-tech/bio-energy	167	162	-2.9%	163	-1.9%	386	132.0%	225	
Total NC related	**3,058**	**2,914**	-4.7%	**3,029**	-1.0%	**3,974**	30.0%	1,060	
All other sectors	52,295	52,295	0.0%	52,295	0.0%	52,295	0.0%	0	
Total GVA	**55,353**	**55,210**	-0.3%	**55,324**	-0.1%	**56,269**	1.7%	1,060	1.9%
Other impacts (all sectors) for average Year									
Flood damages		-79		-79		-49		30	
Flood disruption to economy		-26		-26		-16		10	
Health - avoided sick days & Health costs		-14		0		62		76	
Productivity - urban trees		-4		0		29		32	
GHG Impacts - Peat bogs		-19		-19		0		19	
GHG Impacts - Soil carbon		-39		-39		143		182	
GHG Impacts - Woodland creation						25		25	
Property Uplift (Tree planting & GI)						47		47	
Total Impacts/Risks		-181	-0.3%	-163	-0.3%	241	0.4%	421	0.8%
Total Value Change		**55,029**	**-0.6%**	**55,161**	**-0.3%**	**56,510**	**2.1%**	1,481	2.7%

A. 5: West Yorkshire Best Case

Impacts on Local Economy - 2050 Best Case
West Yorkshire (WYCA)

GVA (at 2050) At current prices	Baseline (2018)	BAU £'m	BAU %	Maintain £'m	Maintain %	Enhance £'m	Enhance %	Difference Enhance Vs BAU	% of 2018 GVA
Direct Dependency Sectors									
Agriculture	136	131	-3.7%	133	-2.5%	154	13.2%	23	
Forestry	11	40	245.8%	40	245.8%	93	714.5%	54	
Water	53	49	-8.2%	51	-4.1%	83	55.8%	34	
Minerals	76	76	0.0%	76	0.0%	76	0.0%	0	
Tourism	1,428	1,329	-6.9%	1,428	0.0%	1,910	33.8%	581	
Indirect Dependent Sectors									
Food Manufacturing	830	799	-3.7%	810	-2.5%	924	11.3%	124	
Manufacturing (Timber)	357	357	0.0%	357	0.0%	416	16.6%	59	
Bio-tech/bio-energy	167	162	-2.9%	163	-1.9%	401	140.8%	239	
Total NC related	**3,058**	**2,943**	-3.8%	**3,057**	0.0%	**4,057**	32.7%	1,114	
All other sectors	52,295	52,295	0.0%	52,295	0.0%	52,295	0.0%	0	
Total GVA	**55,353**	**55,238**	-0.2%	**55,352**	0.0%	**56,352**	1.8%	1,114	2.0%
Other impacts (all sectors) for average Year									
Flood damages		-67		-67		-41		25	
Flood disruption to economy		-26		-26		-16		10	
Health - avoided sick days & Health costs		-14		0		62		76	
Productivity - urban trees		-4		0		29		32	
GHG Impacts - Peat bogs		-15		-15		0		15	
GHG Impacts - Soil carbon		-31		-31		171		202	
GHG Impacts - Woodland creation						38		38	
Property Uplift (Tree planting & GI)						47		47	
Total Impacts/Risks		-157	-0.3%	-139	-0.3%	289	0.5%	446	0.8%
Total Value Change		**55,081**	**-0.5%**	**55,213**	**-0.3%**	**56,642**	**2.3%**	1,560	2.8%

A. 6: West Yorkshire Worst Case (including major flood event)

Impacts on Local Economy - 2050 Worst Case
West Yorkshire (WYCA)

GVA (at 2050) At current prices	Baseline (2018)	BAU £'m	%	Maintain £'m	%	Enhance £'m	%	Difference Enhance Vs BAU	% of 2018 GVA
Direct Dependency Sectors									
Agriculture	136	100	-26.4%	112	-17.6%	142	4.3%	42	
Forestry	11	40	245.8%	40	245.8%	66	480.1%	27	
Water	53	49	-8.2%	51	-4.1%	74	38.7%	25	
Minerals	76	76	0.0%	76	0.0%	76	0.0%	0	
Tourism	1,428	1,329	-6.9%	1,428	0.0%	1,910	33.8%	581	
Indirect Dependent Sectors									
Food Manufacturing	830	799	-3.7%	810	-2.5%	863	4.0%	64	
Manufacturing (Timber)	357	357	0.0%	357	0.0%	387	8.3%	30	
Bio-tech/bio-energy	167	162	-2.9%	163	-1.9%	372	123.2%	210	
Total NC related	**3,058**	**2,912**	-4.8%	**3,036**	-0.7%	**3,889**	27.2%	978	
All other sectors	52,295	52,295	0.0%	52,295	0.0%	52,295	0.0%	0	
Total GVA	**55,353**	**55,207**	-0.3%	**55,331**	0.0%	**56,185**	1.5%	978	1.8%
Other impacts (all sectors) for average Year									
Flood damages		-898		-898		-557		341	
Flood disruption to economy		-215		-215		-134		82	
Health - avoided sick days & Health costs		-14		0		62		76	
Productivity - urban trees		-4		0		29		32	
GHG Impacts - Peat bogs		-22		-22		0		22	
GHG Impacts - Soil carbon		-47		-47		114		161	
GHG Impacts - Woodland creation						13		13	
Property Uplift (Tree planting & GI)						47		47	
Total Impacts/Risks		-1,201	-2.2%	-1,183	-2.1%	-426	-0.8%	775	1.4%
Total Value Change		**54,006**	**-2.4%**	**54,148**	**-2.2%**	**55,759**	**0.7%**	1,752	3.2%

East Yorkshire & Hull

A. 7: East Yorkshire Average Case

Impacts on Local Economy - 2050 Average Case
East Yorkshire (ER & Hull)

GVA (at 2050) At current prices	Baseline (2018)	BAU £'m	%	Maintain £'m	%	Enhance £'m	%	Difference Enhance Vs BAU	% of 2018 GVA
Direct Dependency Sectors									
Agriculture	143	138	-3.7%	139	-2.5%	157	9.5%	19	
Forestry	3	3	0.0%	3	0.0%	6	101.7%	3	
Water	68	62	-8.2%	65	-4.1%	100	47.3%	38	
Minerals	64	64	0.0%	64	0.0%	64	0.0%	0	
Tourism	372	347	-6.9%	372	0.0%	498	33.8%	152	
Indirect Dependent Sectors									
Food Manufacturing	322	310	-3.7%	314	-2.5%	347	7.6%	36	
Manufacturing (Timber)	203	203	0.0%	203	0.0%	229	12.5%	25	
Bio-tech/bio-energy	89	86	-3.1%	87	-1.9%	209	136.1%	123	
Total NC related	**1,264**	**1,213**	-4.0%	**1,248**	-1.3%	**1,609**	27.3%	396	
All other sectors	11,772	11,772	0.0%	11,772	0.0%	11,772	0.0%	0	
Total GVA	**13,036**	**12,985**	-0.4%	**13,020**	-0.1%	**13,381**	2.6%	396	3.0%
Other impacts (all sectors) for average Year									
Flood damages		-20		-20		-12		7	
Flood disruption to economy		-6		-6		-4		2	
Health - avoided sick days & Health costs		-4		0		13		17	
Productivity - urban trees		-0		0		3		3	
GHG Impacts - Peat bogs		-0		-0		0		0	
GHG Impacts - Soil carbon		-88		-88		321		409	
GHG Impacts - Woodland creation						32		32	
Property Uplift (Tree planting & GI)						12		12	
Total Impacts/Risks		-118	-0.9%	-114	-0.9%	364	2.8%	482	3.7%
Total Value Change		**12,866**	**-1.3%**	**12,906**	**-1.0%**	**13,745**	**5.4%**	879	6.7%

A. 8: East Yorkshire Best Case

Impacts on Local Economy - 2050 Best Case
East Yorkshire (ER & Hull)

GVA (at 2050) At current prices	Baseline (2018)	BAU £'m	%	Maintain £'m	%	Enhance £'m	%	Difference Enhance Vs BAU	% of 2018 GVA
Direct Dependency Sectors									
Agriculture	143	138	-3.7%	139	-2.5%	162	13.2%	24	
Forestry	3	3	0.0%	3	0.0%	7	135.6%	4	
Water	68	62	-8.2%	65	-4.1%	106	55.8%	43	
Minerals	64	64	0.0%	64	0.0%	64	0.0%	0	
Tourism	372	347	-6.9%	372	0.0%	498	33.8%	152	
Indirect Dependent Sectors									
Food Manufacturing	322	310	-3.7%	314	-2.5%	358	11.3%	48	
Manufacturing (Timber)	203	203	0.0%	203	0.0%	237	16.6%	34	
Bio-tech/bio-energy	89	86	-3.1%	87	-1.9%	217	145.2%	131	
Total NC related	**1,264**	**1,213**	-4.0%	**1,248**	-1.3%	**1,649**	30.5%	436	
All other sectors	11,772	11,772	0.0%	11,772	0.0%	11,772	0.0%	0	
Total GVA	**13,036**	**12,985**	-0.4%	**13,020**	-0.1%	**13,421**	3.0%	436	3.3%
Other impacts (all sectors) for average Year									
Flood damages		-17		-17		-10		6	
Flood disruption to economy		-6		-6		-4		2	
Health - avoided sick days & Health costs		-4		0		13		17	
Productivity - urban trees		-0		0		3		3	
GHG Impacts - Peat bogs		-0		-0		0		0	
GHG Impacts - Soil carbon		-70		-70		385		455	
GHG Impacts - Woodland creation						48		48	
Property Uplift (Tree planting & GI)						12		12	
Total Impacts/Risks		-98	-0.8%	-94	-0.7%	446	3.4%	544	4.2%
Total Value Change		**12,887**	**-1.1%**	**12,926**	**-0.8%**	**13,867**	**6.4%**	980	7.5%

A. 9: East Yorkshire Worst Case (including major flood event)

Impacts on Local Economy - 2050 Worst Case
East Yorkshire (ER & Hull)

GVA (at 2050) At current prices	Baseline (2018)	BAU £'m	%	Maintain £'m	%	Enhance £'m	%	Difference Enhance Vs BAU	% of 2018 GVA
Direct Dependency Sectors									
Agriculture	143	85	-40.5%	104	-27.0%	148	3.4%	63	
Forestry	3	3	0.0%	3	0.0%	5	67.8%	2	
Water	68	62	-8.2%	65	-4.1%	94	38.7%	32	
Minerals	64	64	0.0%	64	0.0%	64	0.0%	0	
Tourism	372	347	-6.9%	372	0.0%	498	33.8%	152	
Indirect Dependent Sectors									
Food Manufacturing	322	310	-3.7%	314	-2.5%	335	4.0%	25	
Manufacturing (Timber)	203	203	0.0%	203	0.0%	220	8.3%	17	
Bio-tech/bio-energy	89	86	-3.1%	87	-1.9%	201	127.0%	115	
Total NC related	**1,264**	**1,160**	-8.2%	**1,213**	-4.0%	**1,565**	23.8%	405	
All other sectors	11,772	11,772	0.0%	11,772	0.0%	11,772	0.0%	0	
Total GVA	**13,036**	**12,932**	-0.8%	**12,985**	-0.4%	**13,337**	2.3%	405	3.1%
Other impacts (all sectors) for average Year									
Flood damages		-222		-222		-138		85	
Flood disruption to economy		-53		-53		-33		20	
Health - avoided sick days & Health costs		-4		0		13		17	
Productivity - urban trees		-0		0		3		3	
GHG Impacts - Peat bogs		-0		-0		0		0	
GHG Impacts - Soil carbon		-106		-106		257		362	
GHG Impacts - Woodland creation						16		16	
Property Uplift (Tree planting & GI)						12		12	
Total Impacts/Risks		-386	-3.0%	-382	-2.9%	129	1.0%	515	3.9%
Total Value Change		**12,546**	**-3.8%**	**12,603**	**-3.3%**	**13,466**	**3.3%**	920	7.1%

Leeds City Region

A. 10: Leeds City Region Average Case

Impacts on Local Economy - 2050 Average Case
LCR

GVA (at 2050) At current prices	Baseline (2018)	BAU £'m	%	Maintain £'m	%	Enhance £'m	%	Difference Enhance Vs BAU	% of 2018 GVA
Direct Dependency Sectors									
Agriculture	308	297	-3.7%	301	-2.5%	338	9.5%	41	
Forestry	19	19	0.0%	19	0.0%	38	101.7%	19	
Water	328	301	-8.2%	314	-4.1%	482	47.3%	182	
Minerals	109	109	0.0%	109	0.0%	109	0.0%	0	
Tourism	1,976	1,840	-6.9%	1,976	0.0%	2,644	33.8%	804	
Indirect Dependent Sectors									
Food Manufacturing	1,126	1,084	-3.7%	1,098	-2.5%	1,211	7.6%	127	
Manufacturing (Timber)	408	408	0.0%	408	0.0%	459	12.5%	51	
Bio-tech/bio-energy	236	228	-3.3%	231	-2.1%	555	135.2%	327	
Total NC related	**4,510**	**4,286**	-5.0%	**4,456**	-1.2%	**5,836**	29.4%	1,550	
All other sectors	65,141	65,141	0.0%	65,141	0.0%	65,141	0.0%	0	
Total GVA	**69,651**	**69,427**	-0.3%	**69,597**	-0.1%	**70,977**	1.9%	1,550	2.2%
Other impacts (all sectors) for average Year									
Flood damages		-96		-96		-60		37	
Flood disruption to economy		-32		-32		-20		12	
Health - avoided sick days & Health costs		-18		0		66		84	
Productivity - urban trees		-4		0		22		26	
GHG Impacts - Peat bogs		-55		-55		0		55	
GHG Impacts - Soil carbon		-136		-136		496		632	
GHG Impacts - Woodland creation						68		68	
Property Uplift (Tree planting & GI)						57		57	
Total Impacts/Risks		-340	-0.5%	-319	-0.5%	630	0.9%	970	1.4%
Total Value Change		**69,087**	**-0.8%**	**69,279**	**-0.5%**	**71,608**	**2.8%**	2,521	3.6%

A. 11: Leeds City Region Best Case

Impacts on Local Economy - 2050 Best Case
LCR

GVA (at 2050) At current prices	Baseline (2018)	BAU £'m	%	Maintain £'m	%	Enhance £'m	%	Difference Enhance Vs BAU	% of 2018 GVA
Direct Dependency Sectors									
Agriculture	308	297	-3.7%	301	-2.5%	349	13.2%	52	
Forestry	19	19	0.0%	19	0.0%	44	135.6%	25	
Water	328	301	-8.2%	314	-4.1%	510	55.8%	210	
Minerals	109	109	0.0%	109	0.0%	109	0.0%	0	
Tourism	1,976	1,840	-6.9%	1,976	0.0%	2,644	33.8%	804	
Indirect Dependent Sectors									
Food Manufacturing	1,126	1,084	-3.7%	1,098	-2.5%	1,252	11.3%	168	
Manufacturing (Timber)	408	408	0.0%	408	0.0%	476	16.6%	68	
Bio-tech/bio-energy	236	228	-3.3%	231	-2.1%	577	144.5%	349	
Total NC related	**4,510**	**4,286**	-5.0%	**4,456**	-1.2%	**5,962**	32.2%	1,676	
All other sectors	65,141	65,141	0.0%	65,141	0.0%	65,141	0.0%	0	
Total GVA	**69,651**	**69,427**	-0.3%	**69,597**	-0.1%	**71,103**	2.1%	1,676	2.4%
Other impacts (all sectors) for average Year									
Flood damages		-81		-81		-50		31	
Flood disruption to economy		-32		-32		-20		12	
Health - avoided sick days & Health costs		-18		0		66		84	
Productivity - urban trees		-4		0		22		26	
GHG Impacts - Peat bogs		-44		-44		0		44	
GHG Impacts - Soil carbon		-109		-109		595		704	
GHG Impacts - Woodland creation						101		101	
Property Uplift (Tree planting & GI)						57		57	
Total Impacts/Risks		-287	-0.4%	-266	-0.4%	772	1.1%	1,060	1.5%
Total Value Change		**69,140**	**-0.7%**	**69,332**	**-0.5%**	**71,875**	**3.2%**	2,735	3.9%

A. 12: Leeds City Region Worst Case (including major flood event)

Impacts on Local Economy - 2050 Worst Case
LCR

GVA (at 2050) At current prices	Baseline (2018)	BAU £'m	%	Maintain £'m	%	Enhance £'m	%	Difference Enhance Vs BAU	% of 2018 GVA
Direct Dependency Sectors									
Agriculture	308	182	-40.8%	224	-27.2%	319	3.4%	136	
Forestry	19	19	0.0%	19	0.0%	31	67.8%	13	
Water	328	301	-8.2%	314	-4.1%	454	38.7%	154	
Minerals	109	109	0.0%	109	0.0%	109	0.0%	0	
Tourism	1,976	1,840	-6.9%	1,976	0.0%	2,644	33.8%	804	
Indirect Dependent Sectors									
Food Manufacturing	1,126	1,084	-3.7%	1,098	-2.5%	1,170	4.0%	86	
Manufacturing (Timber)	408	408	0.0%	408	0.0%	442	8.3%	34	
Bio-tech/bio-energy	236	228	-3.3%	231	-2.1%	533	125.9%	305	
Total NC related	**4,510**	**4,172**	-7.5%	**4,380**	-2.9%	**5,703**	26.5%	1,531	
All other sectors	65,141	65,141	0.0%	65,141	0.0%	65,141	0.0%	0	
Total GVA	**69,651**	**69,313**	-0.5%	**69,521**	-0.2%	**70,844**	1.7%	1,531	2.2%
Other impacts (all sectors) for average Year									
Flood damages		-1,095		-1,095		-679		416	
Flood disruption to economy		-263		-263		-163		100	
Health - avoided sick days & Health costs		-18		0		66		84	
Productivity - urban trees		-4		0		22		26	
GHG Impacts - Peat bogs		-66		-66		0		66	
GHG Impacts - Soil carbon		-163		-163		397		560	
GHG Impacts - Woodland creation						34		34	
Property Uplift (Tree planting & GI)						57		57	
Total Impacts/Risks		-1,608	-2.3%	-1,586	-2.3%	-265	-0.4%	1,343	1.9%
Total Value Change		**67,705**	**-2.8%**	**67,935**	**-2.5%**	**70,579**	**1.3%**	2,874	4.1%

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Final Report | May 2020