A Natural Capital Asset Check and Risk Register for the Anglian Water Combined Services Area

Report to Anglian Water Services Ltd

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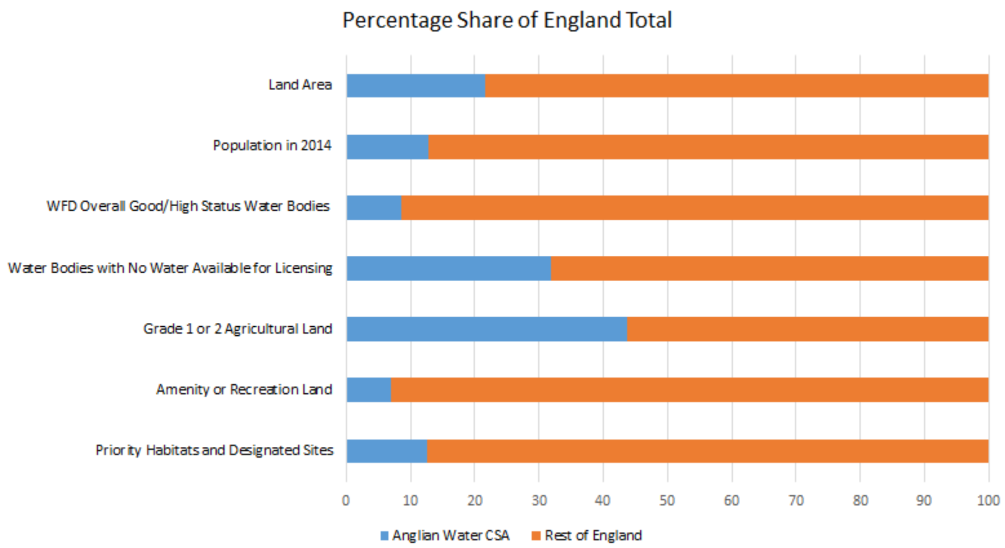
Executive Summary

Natural Capital is a fundamental component of an economy's stock of resources upon which human health, wellbeing and wealth depend. Economic growth and development are conditioned by the economy's overall capital stock which includes produced capital i.e. factories, power stations, infrastructure; human capital i.e. people; social capital i.e. social networks and communities; and natural capital i.e. assets such as landscapes, soils, water, air and ecosystems. The incorporation of natural capital into public and private sector decision-making is now receiving increased attention and the Natural Capital Committee has recently published a workbook which sets out a sequence of steps for the planning and management of natural capital now and in the future. These steps include the development of an evidence base that includes a natural capital asset statement and a risk register. This report summarises research undertaken for Anglian Water Services Ltd to characterise the natural capital assets within the Anglian Water combined water and used water services area (CSA) and then compile a risk register for them. Spatial data on pressures and assets were then used to classify local authorities in the region and highlight those locations where there is likely to be a need for particularly careful spatial and resource planning in the future.

Asset Statement

The Anglian Water CSA covers a region of over 28,000 km^2 and represents approximately 22% of both the land area and coastline length of England. It has a current population of 7 million people projected to increase to 8.3 million by 2039. There are 63 local authorities intersecting the boundary of the CSA and 13 of these have projections of at least 25% population growth by 2039. Another important future pressure is climate change given that the East of England is the driest region in the country with annual rainfall (600mm) at 70% of the national average.

The main types of natural capital assets can be defined as species (including genetic variation), ecological communities, soils, freshwaters, land, minerals, the atmosphere, sub-soil assets, coasts and oceans. To characterise the Anglian Water CSA a series of national spatial data sets on aspects of land use, water resources and key benefits such as the potential for food production, climate regulation, support for biodiversity and recreation use were compiled in GIS software. Attention was deliberately restricted to open data so that the approach adopted could be easily replicated for other geographical areas. The data were then used to compare the profile of the Anglian Water CSA with the remainder of England as shown in the chart below.



The chart includes the shares of total population and land area to provide a baseline against which other indicators can be compared. It shows that there are particular issues with both poor water quality and restrictions on water availability, as well as the significance of the high quality agricultural land in the region and the lower than proportional shares of amenity or recreation land and important sites for biodiversity.

Risk Register

A risk register was constructed to assess the impact of alterations in quantity, quality and spatial configuration of eight categories of habitat upon their capacity to provide ten types of benefit to human populations. The assessment took particular account of the importance of enclosed farmland habitat in the region (86% of total area) and anticipated future pressures resulting from population growth (and associated urban expansion), climate change and uncertainties regarding agricultural markets and policies. In the matrix shown below all of the high risks related to Clean Water or Wildlife benefits, with most of these arising from pressures in Enclosed Farmland or Urban habitats. The Urban and Coastal Margin habitats were associated with over two-thirds of the moderate risks, while many of the benefits were linked to anticipated increases in woodland cover.

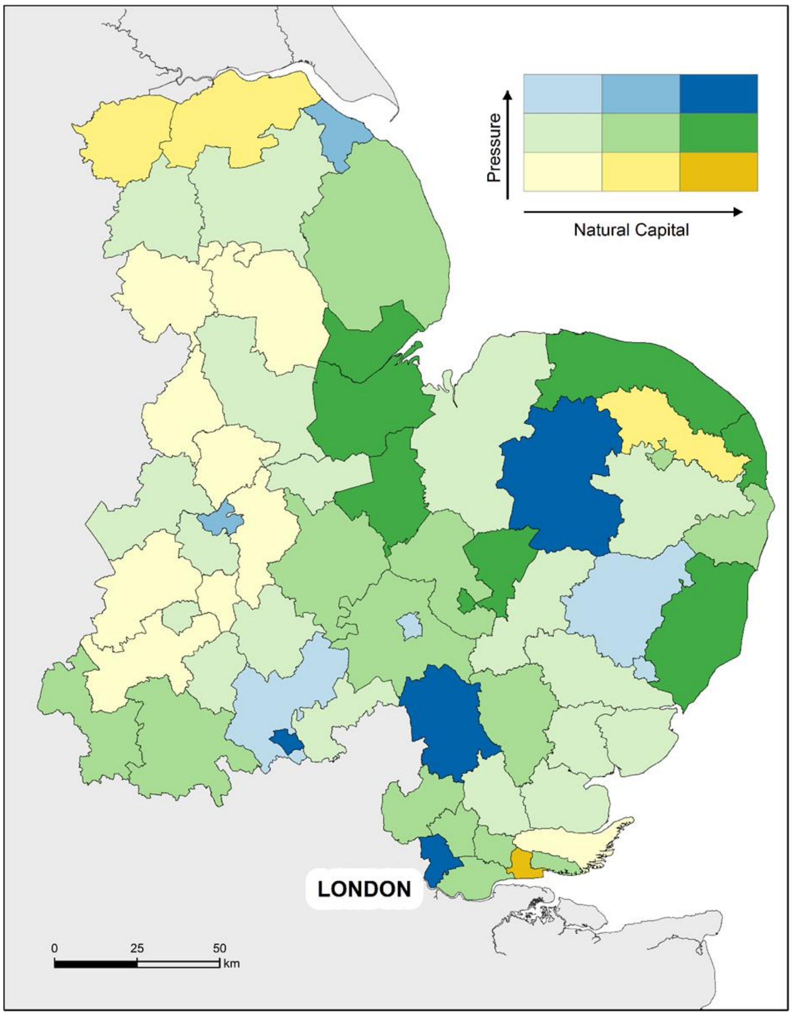
	Mountains, moors and heaths			Enclosed farmland			Semi-natural grassland			Woodlands			Freshwaters			Urban			Coastal Margins			Marine		
	Qun	Qul	Sp.	Qun	Qul	Sp.	Qun	Qul	Sp.	Qun	Qul	Sp.	Qun	Qul	Sp.	Qun	Qul	Sp.	Qun	Qul	Sp.	Qun	Qul	Sp.
Food				-	I	-																	I/D	
Fibre										–														
Energy										I									I	I		I	I	
Clean water	I	I		I	D					I	I		I	D		I	I	I	I	I				
Clean air	-				–					I	I					I	I							
Recreation	I	-			I/D					I	I	I	–	–		I	I/D		I	I				
Aesthetics		-			I/D			-		-	-			–			I		I	I	I		I	
Hazard protection					–					I	I			–		I	I		I	I	I			
Wildlife		I		–	D			-		I	I	I		–		I	I	I	I	I	I		I	
Equable climate					I/D					I	I			–		I	I		I	I				

No Fill	No Information
(grey)	No Significant Risk
(light yellow)	Low Risk
(orange)	Medium Risk
(red)	High Risk

(green)	Positive Impacts
I	Increasing
D	Decreasing
	Constant

Spatial Analysis of Pressures and Assets

The risk register provided an overall perspective regarding pressures on natural capital, but in a region as large as the Anglian Water CSA it is also important to consider the internal variation in the distributions of pressures and assets. These geographical contrasts were assessed by utilising the GIS datasets compiled for the asset statement. Two indicators of pressures (projected population growth and availability of water resources) and five for types of natural assets (potential for food production, pollinator habitat quality, carbon storage in soils and vegetation, extent of land used for amenity or recreation purposes and priority or designated habitats important for biodiversity) were mapped for the 63 local authorities. After the indicators had been standardised (by transforming them to z scores) the maximum pressure and natural capital asset values for each local authority were calculated and then used as the basis of a classification. This divided the local authorities into nine groups which are mapped on the following page. Authorities depicted in the darker green and blue shades had the highest levels of pressures or natural assets and there were four (Breckland, Havering, Luton and Uttlesford) in the top category. These represent areas where there is likely to be a particular need for careful spatial and resource planning in the future, but the main message of the map is the diversity of pressure and natural capital provision combinations that exist within the Anglian Water CSA. This suggests that Anglian Water may need to give particular attention to such geographical contrasts in planning their submission to the 2019 Ofwat price review.



Conclusions and Possible Further Analysis

There are two features of this study that are quite distinctive. One is the compilation of a natural capital risk register at a regional rather than national scale and the second is the spatial analysis of pressures and assets to determine where different combinations of conditions exist. Both of these have applicability elsewhere in the UK or in other countries.

Possible refinements would be to include other indicators of pressures or assets, investigate ways of combining indicators through monetary valuation or another form of weighting, and the construction of regional natural capital accounts. Interviews or focus groups with local experts could be used to enhance the evidence base underpinning the risk register and it would be worthwhile repeating the spatial analysis with other geographical units such as river catchments.

The research summarised in this report does, nevertheless, provide a range of insights into the natural capital assets of the Anglian Water CSA and the pressures they face. The management of water resources, particularly with regard to pressures from population growth and climate change, is clearly central to these concerns and it is evident that the types of challenges faced, and consequently the response measures needed, are likely to vary geographically within the region.

1. Introduction

1.1 Defining Natural Capital: Capital Assets and Ecosystem Services

Natural Capital is a fundamental component of an economy's stock of resources upon which human health, wellbeing and wealth depend. Economic growth and development are conditioned by the economy's overall capital stock which includes produced capital i.e. factories, power stations, infrastructure; human capital i.e. people; social capital i.e. social networks and communities; and natural capital i.e. assets such as landscapes, soils, water, air and ecosystems (see Figure 1). In 2016 the Office for National Statistics (ONS) estimated a monetary value for natural capital in the UK in 2014 of £497 billion (ONS, 2016a).

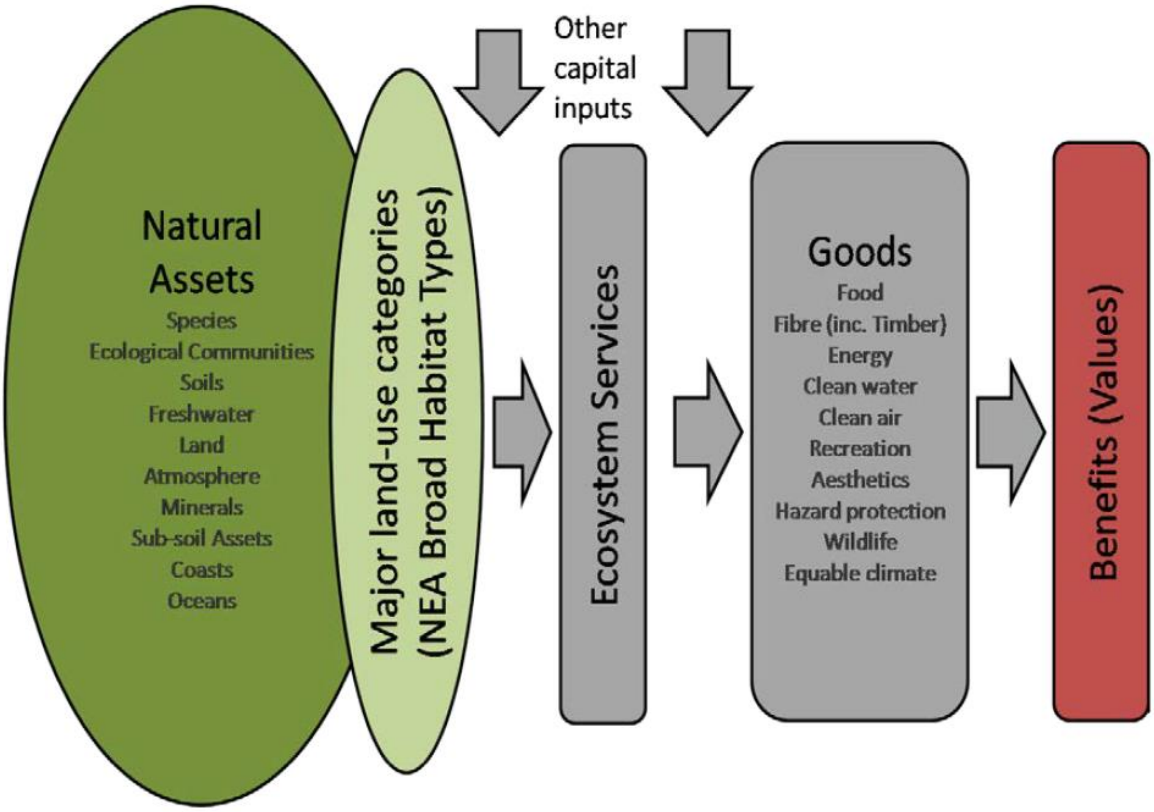


Figure 1: A framework linking natural capital and benefits to people
(Source: Natural Capital Committee, 2014, p. 34).

The combination of natural capital and other forms of capital provides society with so-called ecosystem services, and these services in turn supply welfare benefits. The flows of benefits to people include among others: pollination and food supply; water supply, purification and flood protection; carbon storage; and recreation and amenity experiences (see Figure 2). Individual and societal health and wellbeing are enhanced as the flow of ecosystem services contributes to cleaner water/air, more equitable climates, recreation experiences and cultural enrichment.

Figure 2: A categorisation of ecosystem services (Source: categories from Millennium Ecosystem Assessment (2005), diagram from http://www.metrovancouver.org/services/regional-planning/conserving-connecting/about-ecological-health/ecological-services/Pages/default.aspxin).

Water companies have a profound impact on natural resource assets which is not restricted just to water. They can play an important stewardship role in conserving these resources. Since the 2014 price review Ofwat has encouraged companies to demonstrate that proposed investments are worthwhile and produce positive impacts on customers and the environment. Their asset management processes now need to incorporate a more extensive natural capital management and protection focus (Ofwat, 2017). Water companies can therefore play a role in promoting the re-emergence of the 'Circular Economy' concept and practice (Pearce and Turner, 1990; Ellen MacArthur Foundation, 2017) by focusing not just on recycling and waste management issues (important as they are), but also on improved natural capital use efficiency, supply security and eco-innovation.

1.2 Decision Support Systems for Natural Capital Planning and Management

Environmental change and consequent impacts on human welfare nationally and regionally, can be scoped and assessed using a natural capital approach encompassed within a so-called DPSIWR (Drivers-Pressures-State-Impact-Welfare-Response) framework. This is an indicator-based approach which brings together information (in a causal chain) covering changes in socio-economic systems (drivers and pressures) with consequential state changes and welfare impacts on humans. As illustrated in Figure 3 the loop is completed by policy responses and systems feedback.

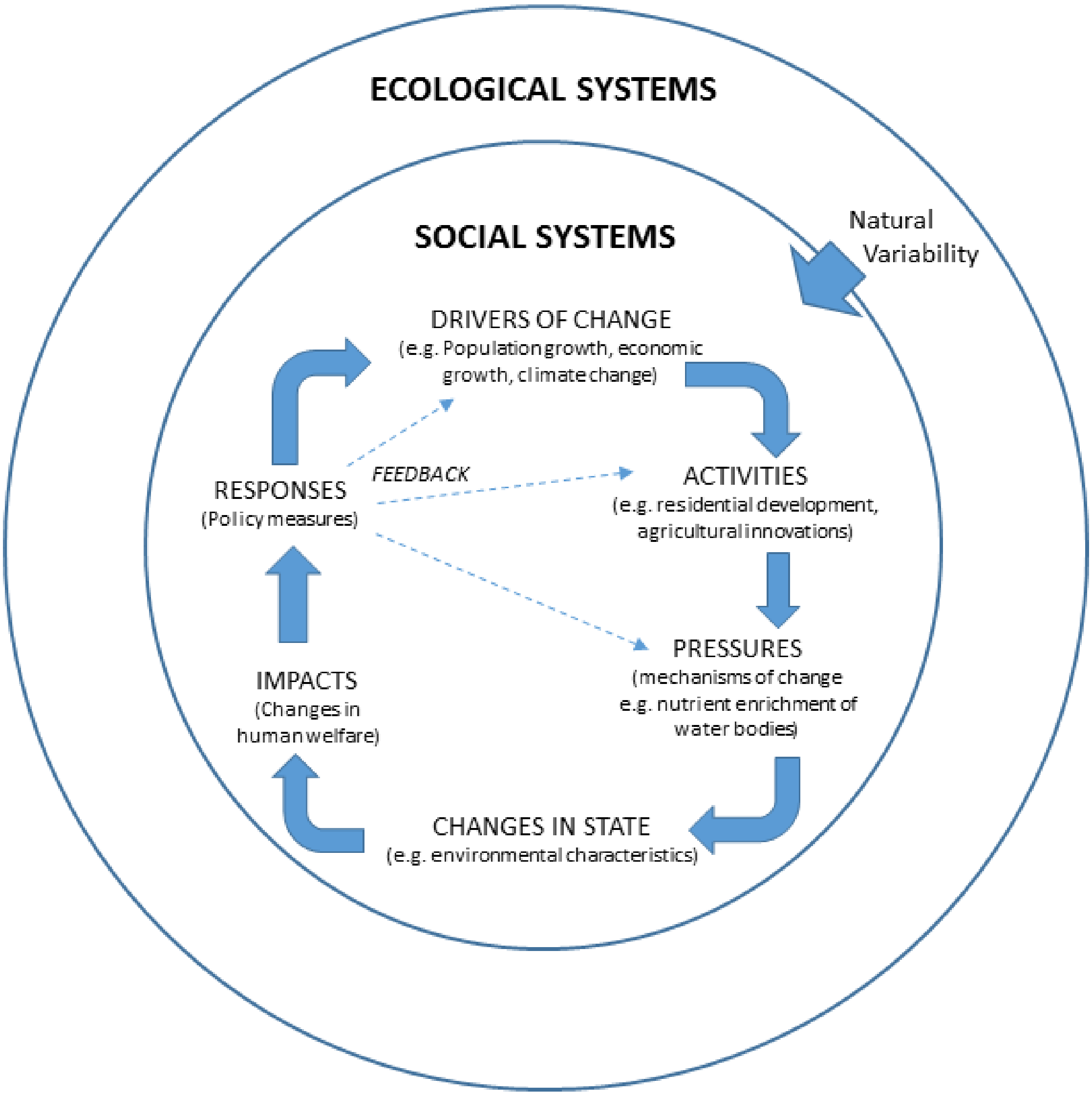


Figure 3: The DPSIWR scoping framework (Source: adapted from Elliott *et al.*, 2017).

The initial DPSIR framework was adopted by the European Environment Agency in 1995 (later expanded to DPSIWR) to link environmental issues and human actions, and has been modified and enhanced over succeeding years (Elliott *et al.*, 2017). It provides a scoping framework to highlight the indicators needed to enable feedback to policy makers on pressures and drivers of environmental quality changes and resulting socio-economic impact of the choices currently made (policy responses), or to be made in the future. Drivers of change can be immediate or more long term such as, for example, population change, economic growth and urban development, agricultural change and climate change. Pressure is a means by which at least one driver causes or contributes to environmental state change. In the water resource context, the DPSIWR assessment could take the following form: drivers such as population growth and food security concerns can stimulate agricultural change activities such as new fertiliser regimes and use rates or more intensive livestock and poultry practices, which lead to increased release of nutrients (N and P) into watercourses. These water courses and their ecosystem services may also be impacted by release of sewage after accidental leakages and storm water overflows. The end result is a change in water quality, increasing the costs of treatment for drinking water, and reducing recreation and amenity benefits with adverse welfare consequences. The water quality impact and flow problems may be further exacerbated by urban and infrastructure expansion with increased demand for water supplies and accentuated rates of runoff.

The Natural Capital Committee (2017) has recently published a workbook which sets out a sequence of steps for the planning and management of natural capital now and in the future. These steps are summarised on the left-hand side of Figure 4.

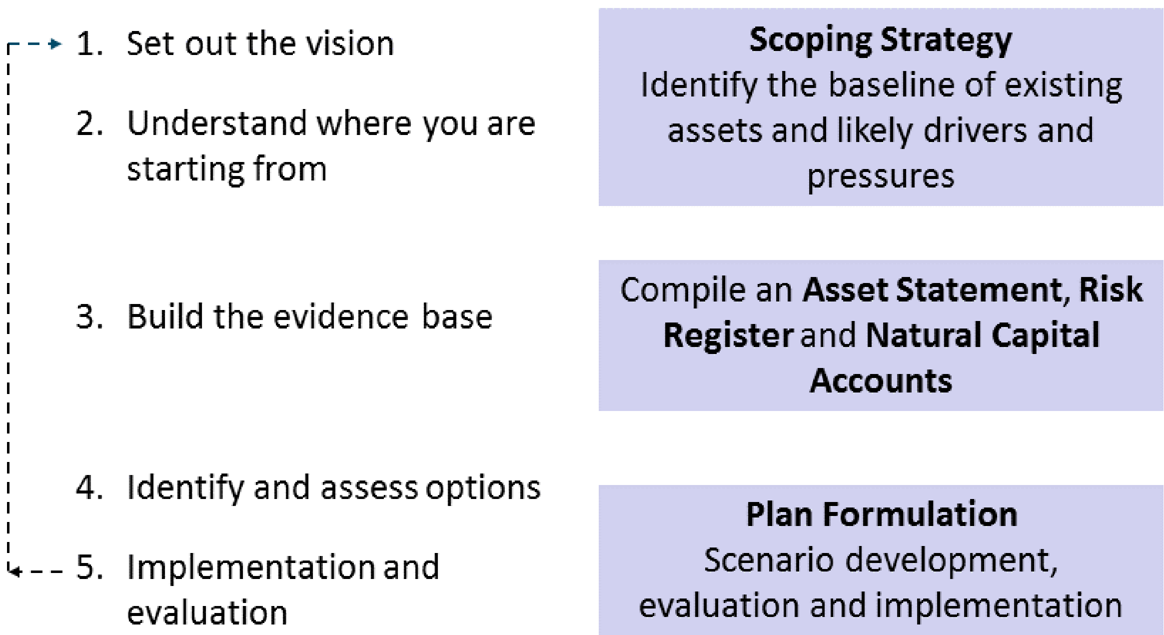


Figure 4: Steps in the planning cycle for a natural capital plan
(Source: adapted from Natural Capital Committee, 2017, p.5).

The first steps involve the creation of a scoping strategy which establishes a vision and baseline starting position for planning and management. This includes establishing the extent and condition of existing natural assets within given spatial boundaries. Likely drivers and pressures which may stimulate socio-economic and environmental change also need to be identified and assessed. These are likely to include among others: housing and urban development, agricultural change and climate change.

Insights from the scoping strategy can then be used to inform the development of an evidence base for policy, planning and management around ecosystem services, including their economic value to society. This evidence base should encompass a natural capital asset statement, a natural capital risk register and, possibly, natural capital accounts. These elements are inter-related in that:

- The asset statement is an inventory of the natural assets in an area and their condition;
- The risk register identifies the likelihood and scale of changes to the natural assets which could impact upon their delivery of benefits;
- Natural capital accounts help address the challenges of comparing assets by expressing their value in monetary terms (Natural Capital Committee, 2017).

Mace *et al.* (2015) describe the development of a natural capital risk register for the UK and examples of natural capital accounts are provided by Office for National Statistics (2017a) and the Natural Capital Committee (2015).

The final stages are to consider options for action, intervention and investment in the form of a plan. This document should set out the goals, measures, milestones and actions, together with the relevant accountabilities and responsibilities. Reporting mechanisms and review procedures also need to be established to review progress, potentially iterating through the earlier steps as part of a periodic plan update (Natural Capital Committee, 2017).

An important point about the process of documentation, assessment and planning discussed above is the need for spatially explicit information. The magnitude of benefits stemming from many natural assets varies appreciably according to their geographical location (e.g. see Bateman *et al.*, 2013) and so the combination of developments in Geographical Information Systems (GIS) and digital map databases (many now public domain) has been very important in facilitating such evaluations.

1.3 The Scope of this Report

This report summarises research undertaken for Anglian Water Services Ltd to implement some initial steps of the sequence presented in Figure 4. It focuses on the Anglian Water combined water and used water services area and for this geographical region characterises the natural capital assets and then compiles a risk register for them. Spatial data on pressures and assets are then used to classify local authorities in the region and highlight those locations where there is likely to be a need for particularly careful spatial and resource planning in the future.

Two features of the research are distinctive. One is the compilation of a natural capital risk register at a regional rather than national scale and the second is the spatial analysis of pressures and assets to determine where different combinations of conditions exist. To the best of our knowledge, neither of these have been previously attempted in a UK context, but they potentially have wide applicability.

The remainder of this report is in four main sections. The first presents a characterisation of the Anglian Water combined services area (hereafter CSA) in terms of population, economic activities and natural assets. This is followed by presentation of a regional risk register, with a particular emphasis on highlighting differences to the national assessment conducted by Mace *et al.* (2015). Insights from the risk register then inform an analysis of geographical variations in pressures and assets within the CSA, leading to the creation of a typology of local authorities. The final section summarises the key findings, reflects on the experience gained and identifies some possible future research directions.

2. An Asset Profile for the Anglian Water Combined Services Area

2.1 Population Trends

The Anglian Water CSA covers a region of over 28,000 km^2 (21.6% of England) in which the company either supplies water and/or treats used water. Several other companies also provide water services in smaller parts of the region. As shown in Figure 5 the area extends from the Humber Estuary in the north to the outskirts of London in the south, and from Northamptonshire in the west to the North Sea coast in the east.

Sixty three local authorities (district and unitary) have boundaries that intersect with the CSA and 56 have the central points of their territories within the region. Using sub-national population projections produced by the Office for National Statistics (2016b) the 56 authorities had a total population of just over 7 million in 2014 and this is projected to increase to 8.3 million by 2039. As a percentage of the 2014 population the projected growth by 2039 is just over 18% compared to 16.5% for the whole of England. However, there are local authorities intersecting the CSA where the estimated increase in much larger, 13 of the 63 having projections of at least 25% population growth by 2039.

Figure 5: The geographical extent of the Anglian Water Combined Services Area.

2.2 Economic Activities

Until very recently, it has been unusual for statistics on economic indicators such as Gross Value Added (GVA, a measure of the value of goods and services produced) to be published at geographical scales below the region or county. In early 2017, however, the Office for National Statistics (2017b) released estimates of GVA by economic sector at a local authority level. There is a need for some caution in interpreting these data at an individual authority scale, particularly because they are income-based and can be subject to distortion due to the effects of commuting and variations in the age structure of populations. Nevertheless, they provide a better basis for economic profiling of a region such as the Anglian Water CSA which spans five statistical regions and 17 counties.

Details from the ONS (2017b) dataset for 2015 were summarised to produce estimates of GVA by economic sector for the 63 local authorities intersecting the CSA and all other authorities in England. The results shown in Table 1 highlight the economic importance of different sectors and also identify those which are particularly significant within the Anglian Water CSA. For instance, while the region accounts for just over 13% of total national GVA it includes nearly 32% of that for agriculture. GVA per head of population in England was £26,159 in 2015 and slightly lower than this at £22,737 in the CSA. However, as shown in Figure 6 there were some appreciable variations within the Anglian Water CSA, with generally higher values in the larger urban centres, as well as a tendency for GVA per head to be greater in the south and west of the region compared to the north and the east. In terms of change over time, GVA in the Anglian Water CSA increased by 34.9% (not adjusted for inflation) between 2005-15. This is slightly lower than the rate for the whole of England (36.6%), but higher than that for any other region except London (52.8%) and the South East (36.7%). These figures therefore highlight that the Anglian Water CSA encompasses a relatively fast-growing regional economy.

Table 1: Economic activity profiles based on local authority GVA data (values in £ million).

Economic Sector (SIC07 Categories)	Anglian Water CSA Local Authorities	Rest of England	England Total	Anglian Water CSA as % of England Total
A: Agriculture	£2,502	£5,400	£7,902	31.7
BDE: Production other than manufacturing	£4,519	£31,159	£35,678	12.7
C: Manufacturing	£23,518	£115,125	£138,643	17.0
F: Construction	£13,841	£71,172	£85,013	16.3
GHI: Distribution	£41,351	£229,135	£270,486	15.3
J: Information and communication	£8,235	£93,114	£101,349	8.1
K: Finance	£7,357	£102,133	£109,490	6.7
L: Real Estate	£24,456	£161,987	£186,443	13.1
MN: Business services	£20,960	£164,200	£185,160	11.3
OPQ: Public administration	£34,103	£220,855	£254,958	13.4
RST: Other services	£8,025	£50,014	£58,039	13.8
Total	£188,867	£1,244,294	£1,433,161	13.2

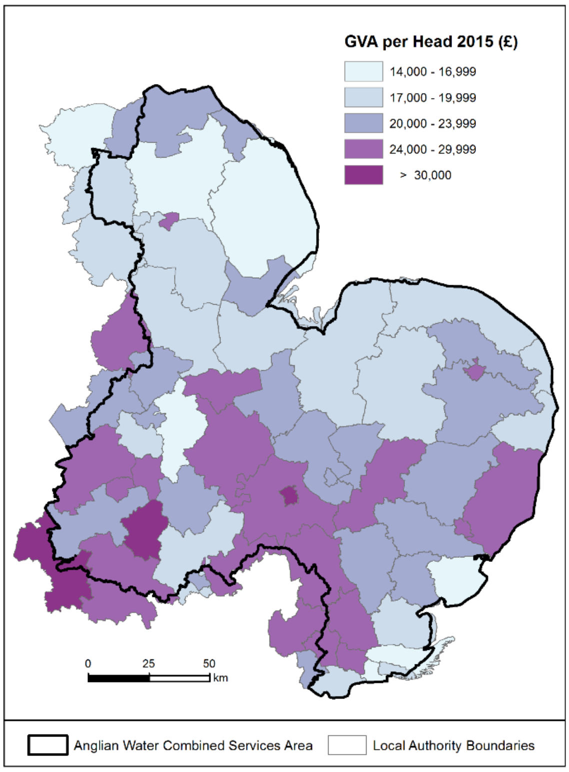


Figure 6: GVA per head in 2015 for local authorities intersecting the Anglian Water CSA.

2.3 Natural Assets

The main types of natural capital assets are defined by Mace *et al.* (2015) as species (including genetic variation), ecological communities, soils, freshwaters, land, minerals, the atmosphere, sub-soil assets, coasts and oceans. As illustrated in Figure 1, these assets combine together in a variety of ways with other forms of capital (e.g. human investments) to deliver ecosystem services and produce goods which are consumed to provide benefits to people. One example of this complexity is the manner in which food is the product of natural assets such as soils, land, water, species and ecological communities, as well as produced and human capital (in the form of equipment and expertise). Partly because of such interdependencies, but also because data on some types of assets (e.g. the status of ecological communities) are relatively limited, it has been common to use major land use categories as a 'lens' through which to investigate the relationships between natural capital and the derived benefits (Natural Capital Committee, 2014). This is reflected within Figure 1 in the intermediate position of land use categories between different capital assets and the delivery of ecosystem services. The approach also has the advantage that the availability of spatial data on aspects of land use is relatively good and facilitates the assessment of contrasts between different areas.

Given this context, the Anglian Water CSA was characterised by compiling a series of spatial data sets on aspects of land and water use for the whole of England. These data sets were imported into the ArcGIS software (ESRI, 2018), converted to raster grids at 100 m cell resolution, and then subsets extracted using the boundary of the Anglian Water CSA so that the region could be compared with the remainder of England. Data sets were selected to include the main categories of land use (following the Broad Habitats framework used by the UK National Ecosystem Assessment, 2011), as well as importance for key benefits such as the potential for food production, climate regulation, support for biodiversity and recreation use. For water resources, information compiled as part of the Water Framework Directive Cycle 2 assessments was used because this provided national coverage along with a high level of geographical detail. Attention was also restricted to open data (i.e. that which 'anyone can access, use or share', Open Data Institute, 2018) so that the approach adopted could be easily replicated for other geographical areas.

Table 2 summarises details of the main data sources used. The following points should be noted about some of the characteristics and processing of the data sets.

- CORINE land cover data for 2006 and 2012 were used to provide information on the extent of Broad Habitats rather than the Centre for Ecology and Hydrology (CEH) Land Cover Map (CEH, 2018). The CEH data have higher spatial resolution but, unlike CORINE, are not open data. In addition, CORINE has more consistent definitions of categories over time and for this reason was preferred by the Office for National Statistics (2015) as a basis for land cover accounts.
- Details of carbon sequestration in soil and vegetation were obtained from two separate datasets created by the Centre for Ecology and Hydrology. These data did not include values for urban land so information from the literature (Edmondson et al., 2012, 2014) was used to assign averages for soil and vegetation in these areas. In addition, the soils information only referred to topsoils (0-15 cm depth) so underestimates the extent of carbon storage in deeper layers of peat. Research by Bradley *et al.* (2005) highlights that within the Anglian Water CSA there are important stocks of such deeper soil carbon within the Fens and the Norfolk Broads. Unfortunately, this map information is not open data and so it was not possible to include it in the analysis.

Table 2: Data sources used in the characterisation of natural assets for the Anglian Water CSA

Source Name	Indicator Details	Source Web Address (URL)
CORINE Land Cover 2006 and 2012	44 categories grouped into 8 Broad Habitat Classes based on details in Mace *et al.* (2015)	https://catalogue.ceh.ac.uk/documents/2fad7f16-6585-438a-9fe3-a7d68ff642f9
Agricultural Land Classification	5 categories of land quality, plus non-agricultural and urban land.	https://data.gov.uk/dataset/provisional-agricultural-land-classification-alc2
Carbon in Soil and Vegetation	Mean estimates of carbon density in topsoil and vegetation (tonnes per hectare)	https://eip.ceh.ac.uk/naturalengland-ncmaps/reportsData
WFD Water Body Status	Information on boundaries and status measures	https://data.gov.uk/dataset/wfd-river-waterbody-catchments-cycle-2
Water Resource Availability	Indicates whether, and for what percentage of time, additional water may be available for consumptive abstraction for each Water Framework Directive Cycle 2 water body (modelled not measured)	https://data.gov.uk/dataset/water-resource-availability-and-abstraction-reliability-cycle-21
Nectar Plant Diversity	Mean estimates of nectar plant species for bees	https://eip.ceh.ac.uk/naturalengland-ncmaps/reportsData
Priority Habitats	Habitats of principal importance under Section 41 of the Natural Environment and Rural Communities Act (2006)	https://data.gov.uk/dataset/priority-habitat-inventory-england2
Sites of Special Scientific Interest	Information on site boundaries and condition	https://data.gov.uk/dataset/sites-of-special-scientific-interest-england3 and http://www.natureonthemap.naturalengland.org.uk/
RAMSAR Sites	Information on site boundaries	https://data.gov.uk/dataset/ramsar-sites
National Parks	Information on park boundaries	https://data.gov.uk/dataset/national-parks-england1
Areas of Outstanding Natural Beauty	Information on AONB boundaries	https://data.gov.uk/dataset/areas-of-outstanding-natural-beauty-england1
OS Open Greenspaces	Locations of publicly accessible parks, playing fields, sports facilities, play areas and allotments	https://www.ordnancesurvey.co.uk/business-and-government/products/os-open-greenspace.html
RSPB Reserves	Information on reserve boundaries	https://www.rspb.org.uk/our-work/conservation/conservation-and-sustainability/mapping-and-gis
Woodland Recreation Areas	National forest estate recreational routes and areas.	http://data-forestry.opendata.arcgis.com/datasets/86267a7cf118493aa8738c0c39a29cd4_0
National Trust Land	National Trust land to which the public has access on foot only	http://uk-nationaltrust.opendata.arcgis.com/
Bathing Waters	Information on monitoring site locations and compliance or classification results	https://data.gov.uk/dataset/bathing-waters-monitoring-locations
Shellfish Waters	Coastal and brackish waters in England designated under the EC Shellfish Waters Directive	http://www.natureonthemap.naturalengland.org.uk/Datasets/Dataset_Download_ShellfishEngland.htm

- The Environment Agency data on water resource availability provide classifications of water bodies at a number of different flow percentiles. For this study the Q95 details were used which represent the flow was equalled or exceeded for 95% of the flow record. Since Q95 is an indicator of low flow conditions it provides a relatively wide definition of where restrictions on abstraction might occur.
- Important areas for biodiversity were defined by identifying sites in the Priority Habitat Inventory or with SSSI or RAMSAR designations. A similar approach was used to map land of amenity or recreational significance. Several, but not all, of the six data sets used were restricted to publically accessible land so it is important to note that the result provides a relatively broad definition of recreation potential.
- Coastal assets were assessed by using information on shellfish waters (as designated under the EU Shellfish Waters Directive, 2006/113/EEC) and bathing water quality. Polygons representing the shellfish waters were converted to lengths of coastline for the purposes of comparing the extent of such resources within the Anglian Water CSA to that in the rest of England. Information on bathing water quality was taken from the monitoring network maintained by the Environment Agency. Data were compared for 49 current coastal or estuarine monitoring sites in the Anglian Water CSA and 352 elsewhere in England.

Details of land cover and agricultural land quality characteristics for the Anglian Water CSA and the remainder of England are summarised in Table 3. Given that the CSA accounts for 21.6% of England, the table highlights that the region has a proportional over-representation of the Enclosed Farmland, Freshwaters and Coastal Margin habitat categories. In contrast, there is relatively little of the national stock of Mountains, Moorlands and Heath, Semi-Natural Grassland, Woodland or Urban habitats.

Table 3: Land cover and agricultural land quality indicators.

	Anglian Water CSA		Rest of England		Total
Indicator	Km^2	% of Total	Km^2	% of Total	Km^2
Broad Habitat Classes					
Mountains, Moorlands & Heath	23	0.4	6,176	99.6	6,198
Semi Natural Grasslands	54	1.5	3,610	98.5	3,664
Enclosed Farmland	24,217	25.5	70,933	74.5	95,150
Woodlands	969	12.1	7,053	87.9	8,022
Freshwaters	201	37.1	341	62.9	543
Urban	2,505	15.3	13,851	84.7	16,356
Coastal Margins	144	36.2	254	63.8	399
Marine	63	27.0	169	73.0	232
Agricultural Land Classification					
Excellent (Grade 1)	2,077	59.1	1,439	40.9	3,517
Very Good (Grade 2)	7,543	40.9	10,900	59.1	18,443
Good (Grade 3)	14,530	23.2	48,060	76.8	62,590
Poor (Grade 4)	1,487	8.1	16,792	91.9	18,280
Very Poor (Grade 5)	18	0.2	10,896	99.8	10,914
Non Agricultural	1,332	20.7	5,112	79.3	6,443
Urban	954	10.2	8,389	89.8	9,343

Information from the agricultural land classification indicates the CSA contains a high share of the very best farmland in England. Over 43% of the Grade 1 or 2 land occurs in the region and this asset is critical to the arable farming economy. It is also often used for growing potatoes or other high value crops where the availability of irrigation is important.

Table 4 summarises information from the inventory of Priority Habitats defined under Section 41 of the Natural Environment and Rural Communities Act (2006). It is important to emphasise that the areas are calculated from a 100 m raster grid and so will underestimate the extent of some narrow or irregularly-shaped features. As might be anticipated, some types of habitat (e.g. related to upland environments) do not occur in the CSA, but it is also apparent that the region is particularly important for Coastal Saltmarsh, Lowland Acid Grassland, Mudflats and Reedbeds. More than 30% of the national extent of these four habitats is in the CSA, with the share for saltmarsh being over 40% and that for reedbeds nearly 56%.

Table 4: Extent of priority habitats in England.

	Anglian Water CSA		Rest of England		Total
Main Habitat	Km^2	% of Total	Km^2	% of Total	Km^2
Blanket bog	0	0.0	2,310	100.0	2,310
Calaminarian grassland	0	0.0	3	100.0	3
Coastal and floodplain grazing marsh	483	22.2	1,695	77.8	2,178
Coastal saltmarsh	104	42.9	139	57.1	243
Coastal sand dunes	15	15.1	85	84.9	100
Coastal vegetated shingle	7	17.5	31	82.5	38
Deciduous woodland	1,112	15.1	6,248	84.9	7,360
Fragmented heath	0	0.0	90	100.0	90
Good quality semi-improved grassland	87	11.8	654	88.2	741
Grass moorland	0	0.0	1,472	100.0	1,472
Limestone pavement	0	0.0	13	100.0	13
Lowland calcareous grassland	45	7.3	573	92.7	618
Lowland dry acid grassland	52	34.1	100	65.9	152
Lowland fens	59	29.2	143	70.8	202
Lowland heathland	55	9.8	508	90.2	563
Lowland meadows	25	11.6	187	88.4	211
Lowland raised bog	0	0.0	78	100.0	78
Maritime cliff and slope	2	1.9	126	98.1	129
Mountain heaths and willow scrub	0	0.0	14	100.0	14
Mudflats	21	35.7	37	64.3	58
Purple moor grass and rush pastures	6	6.2	85	93.8	91
Reedbeds	17	55.9	14	44.1	31
Saline lagoons	3	21.5	10	78.5	13
Traditional orchard	18	11.3	142	88.7	161
Upland calcareous grassland	0	0.0	92	100.0	92
Upland flushes, fens and swamps	0	0.0	100	100.0	100
Upland hay meadow	0	0.0	24	100.0	24
Upland heathland	0	0.0	2,276	100.0	2,276
No main habitat, but additional habitats present	214	15.9	1,128	84.1	1,342
Total	2,324	11.2	18,382	88.8	20,706

Many priority habitats are also protected through some form of designated status. Table 5 summarises information on the condition of SSSIs in 2016. The areas are calculated from a 100 m resolution raster grid so, again, will underestimate the extent of some narrow or irregularly-shaped features. Sites are categorised into six main classes with Favourable status referring to those where the designated features within a unit are being adequately conserved and meeting all the mandatory site-specific monitoring targets (Natural England, 2013). The table indicates that the CSA contains just under 13% of the SSSI area in England, but 19% of that in Favourable condition. Put another way, 47% of the SSSI area in the Anglian Water CSA was in favourable condition, compared to 29% in the remainder of England.

Table 5: SSSI condition information.

	Anglian Water CSA		Rest of England		Total
SSSI Condition	Km^2	% of Total	Km^2	% of Total	Km^2
Favourable	505.2	19.0	2,159.9	81.0	2,665.1
Unfavourable Recovering	494.7	9.4	4,773.3	90.6	5,268.0
Unfavourable No Change	46.5	14.7	268.9	85.3	315.4
Unfavourable Declining	21.9	13.2	144.3	86.8	166.1
Part Destroyed	0.2	7.3	3.1	92.7	3.3
Destroyed	0.3	16.8	1.4	83.2	1.7
Not Classified	0.0	0.0	21.5	100.0	21.5
Total	1,068.8	12.7	7,372.2	87.3	8,441.0

Since there was considerable overlap in the land classed as priority habitat or designated as an SSSI or RAMSAR site an additional summary indicator was created where land meeting any of the three criteria was classed as of biodiversity importance. A similar approach was used to combine the six data sets regarding land of amenity or recreational significance to create an overall measure. Table 6 shows the results and reveals that both types of site are under-represented in the CSA relative to the 21.6% share of total land area. Given the importance of such sites as natural assets, the results also imply there is a regional need to maintain, if not expand, such areas.

Table 6: Distribution of important biodiversity or recreation/amenity land.

	Anglian Water CSA		Rest of England		Total
Indicator	Km^2	% of Total	Km^2	% of Total	Km^2
Land of Biodiversity Importance					
Other Land	25,417	23.4	83,374	76.6	108,791
Priority Habitats, SSSIs or RAMSAR Sites	2,755	12.7	19,018	87.3	21,772
Amenity/Recreation Sites					
Other Land	25,713	26.9	69,705	73.1	95,419
National Parks, AONBs and other amenity access land	2,462	7.0	32,683	93.0	35,145

Table 7 lists water resource and quality indicators. The information on overall WFD status indicates a situation where there is considerable scope for improvement. The CSA includes only 8.6% of the area rated as Good or High status nationally, with just over 70% of the region classed as Moderate and 16% Poor or Bad. There are also obvious issues in terms of water resources, with over 45% of the CSA categorised as having no water available for abstraction licensing (using the Q95 flow measure) and this representing nearly 32% of such land in England. Taken together, these indicators emphasise the very real challenges for water resource management in the CSA.

Table 7: Water quality and resource status indicators.

	Anglian Water CSA		Rest of England		Total
Indicator	Km^2	% of Total	Km^2	% of Total	Km^2
WFD Overall Water Body Status					
Other	2,375	23.1	7,920	76.9	10,295
Bad	567	13.4	3,672	86.6	4,239
Poor	4,042	16.5	20,486	83.5	24,529
Moderate	19,896	24.0	63,112	76.0	83,009
Good	1,261	8.6	13,362	91.4	14,623
High	0	0.0	114	100.0	114
Water Resource Availability					
Water available for licensing	17,569	20.9	66,335	79.1	83,904
No water available	14,864	31.9	31,796	68.1	46,660

The Anglian Water CSA includes approximately 22% of the coastline of England, though it is well-known that this length will vary according to the detail with which it is measured (Mandelbrot, 1967). Within this coastal zone some 49 km are defined as shellfish waters under the EU Shellfish Waters Directive and this represents approximately a third of the extent of such fisheries in England. The quality of coastal waters is clearly important for this activity and is assessed in Table 8 using 2016 information from the bathing water monitoring network maintained by the Environment Agency. Forty nine of the 401 national coastal or estuarine monitoring sites occur on the CSA coast and nearly 96% of these were rated as in Excellent or Good condition in 2016, a slightly higher proportion than in the remainder of England (93%).

Table 8: Bathing water quality assessments for sites in 2016.

	Anglian Water CSA		Rest of England		Total
Status	Sites	% of Total	Sites	% of Total	Sites
Excellent	32	11.5	246	88.5	278
Good	15	15.6	81	84.4	96
Sufficient	1	4.8	20	95.2	21
Poor	1	16.7	5	83.3	6
Total	49	12.2	352	87.9	401

The measures of carbon sequestration and pollinator habitat quality were quantitative rather than categorical so the summaries in Table 9 are in the form of descriptive statistics. The details for carbon show that densities (t/ha) were much higher for topsoil than vegetation, the former typically representing 85% to 95% of the combined total across most of the Anglian Water CSA. Lower contributions from topsoil tended to occur in more urban areas and higher ones in agricultural regions such as the Fens. Average carbon densities for both topsoil and vegetation are lower for the Anglian Water CSA compared to the rest of England but, as shown by the standard deviations and minimum-maximum ranges, there is a lot of variability within the regions. A similar situation with a lower average in the CSA, but substantial regional variability, is also apparent for the nectar plant diversity indicator.

Table 9: Carbon sequestration and pollinator habitat indicators.

Indicator	Anglian Water CSA	Rest of England	Total
Soil Carbon in Topsoil (t/ha)			
Minimum	46	46	46
Mean	51.1	60.8	58.7
Maximum	118	134	134
Standard Deviation	7.7	13.1	12.8
Soil Carbon in Vegetation (t/ha)			
Minimum	0	0	0
Mean	5.0	7.5	6.9
Maximum	73	73	73
Standard Deviation	6.9	8.5	8.2
Nectar Plant Diversity for Bees (species per 2m x 2m plot)			
Minimum	0.0	0.0	0
Mean	4.4	5.2	5.0
Maximum	6.1	11.0	11.0
Standard Deviation	0.5	1.5	1.3

Figure 7 shows a selection of the above results presented in a bar chart format to highlight the importance of certain characteristics of the Anglian Water CSA on a national scale. Depicting the shares of total population and land area provides a baseline against which other indicators can be compared. The issues with both water quality and quantity are apparent, as well as the significance of the high quality agricultural land in the region and the lower than proportional shares of amenity or recreation land and important sites for biodiversity.

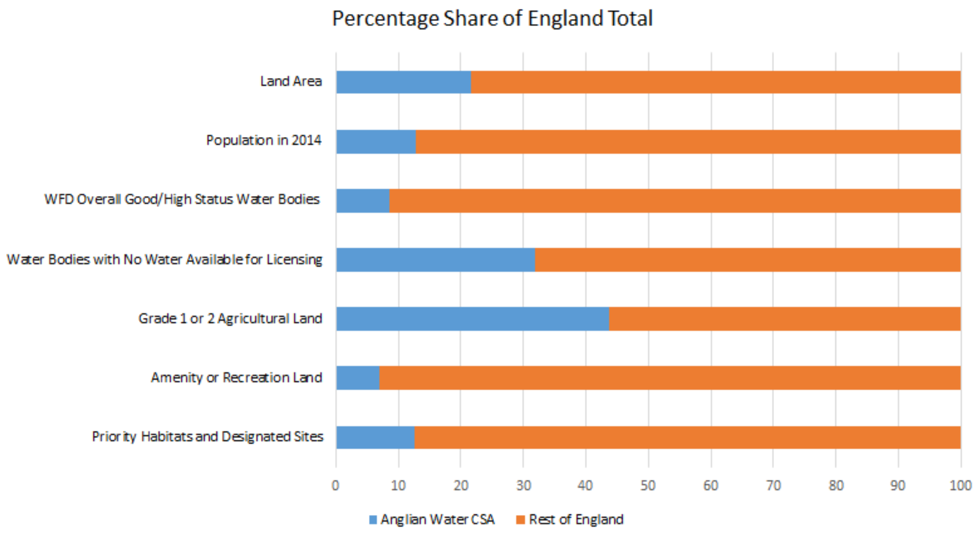


Figure 7: Assets of the Anglian Water CSA compared to the rest of England.

Having identified the main features of the Anglian Water CSA the next section of this report constructs a risk register to assess the importance of trends in different Broad Habitat categories to the future delivery of benefits for the population.

3. Natural Capital Risk Registers

3.1 National Analysis

Mace *et al.* (2015) constructed the first natural capital risk register for the UK, using a combination of existing data and expert judgement to highlight those natural capital assets whose current condition was such as to put at risk a sustainable flow of ecosystem services into the future. The register used eight Broad Habitat types (as adopted in the UK National Ecosystem Assessment and Follow On, 2011, 2014) and ten major benefits. These categories were as follows:

Habitats – Mountains Moorlands & Heaths, Semi-Natural Grasslands, Enclosed Farmlands, Woodlands, Freshwaters, Urban, Coastal Margins and Marine.

Benefits - Food, Fibre, Energy, Aesthetics, Freshwater, Recreation, Clean Air, Wildlife, Hazard Protection and Equable Climates

For each habitat-benefit relationship, Mace *et al.* (2015) explored the influence and modification of quantity, quality or spatial configuration of habitat on the identified benefit (i.e. the provision of a usable service or good to human populations). Quantity was defined as "the amount of an asset, its area, volume or mass", quality as "a range of more specific conditions of the natural asset [that] will be critical where the nature of habitat management or the presence of certain components or processes affects benefits" and spatial configuration referred "to the location of the asset and/or its spatial patterning and fragmentation" (Mace *et al.*, 2015, p.645). This created a total of 240 relationships (8 x 10 x3) as shown in Figure 8.

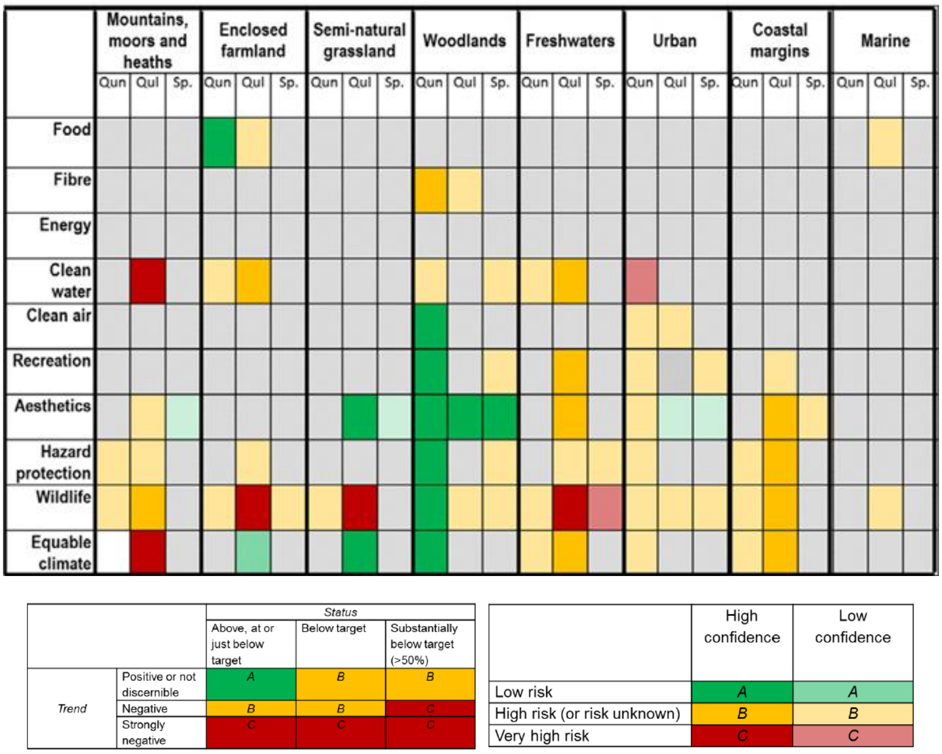


Figure 8: National risk register matrix (source: Mace *et al.*, 2015, p. 648)

In essence, the matrix describes the impact of modifying habitat quantity, quality and spatial configuration upon the capacity to provide a usable service or good to human populations. During the assessments priority was given to 73 relationships where it was thought society had some influence (e.g. on the extent or management of a habitat) and the benefits involved were non-trivial. The assessed relationships were then placed in an institutional context and evaluated against existing societal targets, regulatory limits and policy commitments to derive scores of high, medium or low risk. High risk is indicated in Figure 8 by red shading, medium risk by orange and low by green. Grey shading denotes relationships that were assessed not to be significant or where there was no information on which to base an evaluation. In addition, confidence in the assessed relationships was evaluated and the colour intensity was reduced where uncertainty was greater (see the legend for Figure 8).

The register in Figure 8 identifies seven relationships classed as high risk. These were cases where there was reasonable confidence that the current status of the natural capital assets in the relevant habitats was poor and/or the trends in quantity, quality or spatial configuration were strongly negative. Particular examples included risks to clean water and wildlife. In general, it was the quality of habitats that was most often the cause of a high risk classification and the Mountains, Moorlands and Heaths and Freshwaters categories had the most high or medium risk ratings. However, another feature of the analysis was the substantial degree of uncertainty, either because of substantial gaps in the knowledge base (e.g. regarding marine habitats) or low confidence in assessments (e.g. for urban areas).

3.2 A Risk Register for the Anglian Water CSA

In order to create a regionally-specific natural capital risk register the DPSIWR framework was used to identify the key pressures on habitats that needed to be considered within the methodology outlined by Mace *et al.* (2015). Information from the asset check in Section 2 also informed this process, particularly in terms of highlighting the regional importance of different Broad Habitat categories. Table 10 uses reclassified CORINE land cover data to show changes in the extent of Broad Habitats in the Anglian Water CSA between 2006 and 2012 and also compares the regional profile with that for the whole of England in 2012.

Table 10: Broad habitats in the Anglian Water CSA.

	Area in km^2		Percent of Area		England
Broad Habitat Classes	2006	2012	2006	2012	2012
Mountains, Moorlands & Heath	22	23	0.08	0.08	4.75
Semi Natural Grasslands	54	54	0.19	0.19	2.81
Enclosed Farmland	24,249	24,217	86.06	85.95	72.88
Woodlands	970	969	3.44	3.44	6.14
Freshwater	196	201	0.70	0.71	0.42
Urban	2,480	2,505	8.80	8.89	12.53
Coastal Margins	144	144	0.51	0.51	0.31
Marine	61	63	0.22	0.22	0.18

While the resolution of the CORINE data limits the ability to record changes in small or irregular features it is obvious from Table 10 that there was little alteration in the regional Broad Habitat profiles between 2006 and 2012. The largest shifts were a decline in enclosed farmland and an increase in urban area, but both of these represented not much more than a thousandth of the total regional area. In 2012 nearly 86% of the Anglian Water CSA was classed as Enclosed Farmland and Urban was the only other category with more than a 5% share. Five of the eight Broad Habitat categories represented less than 1% of the region, although two of these (Freshwaters and Coastal Margins) were noticeably more prevalent in the Anglian Water CSA than England as whole.

These details immediately emphasise that changes in the Enclosed Farmland and Urban categories are likely to be of the greatest significance for the delivery of benefits in the Anglian Water CSA and this, in turn, helps to identify relevant pressures. As noted earlier in Section 2, the regional economy is relatively fast-growing and there are a substantial number of local authorities with a projected 25% population growth by 2039. Pressures related to population growth, housebuilding and associated infrastructure developments are therefore important considerations. The importance of farmland, and the uncertainties in markets and policies post-Brexit (Baldock *et al.*, 2017), also means that there is scope for pressures related to agricultural change to be significant. In addition, agricultural demands, coupled with the extent of areas with restrictions on abstraction highlight the stress on water resources. These pressures are only likely to increase with climate change given that the East of England is the driest region in the country with annual rainfall (600mm) at 70% of the national average (ClimateUK, 2012). Furthermore, the most recent assessment by the Committee on Climate Change (ASC, 2016) identifies the following top six areas of inter-related climate change risks for the UK.

i. Flooding and coastal change risks to communities, businesses and infrastructure
ii. Risks to health, well-being and productivity from high temperatures
iii. Risk of shortages in the public water supply, and for agriculture, energy generation and industry
iv. Risks to natural capital, including terrestrial, coastal, marine and freshwater ecosystems, soils and biodiversity
v. Risks to domestic and international food production and trade
vi. New and emerging pests and diseases, and invasive non-native species, affecting people, plants and animals

All of these very applicable to the Anglian Water CSA (e.g. see Anglian Water Services Ltd, 2017, pp. 9-13). The assessment of pressures associated with climate change was therefore given particular attention in the construction of the risk register.

Construction of the register for the Anglian Water CSA used the same habitat type, habitat modification and benefit categories as Mace *et al.* (2015). However, distinctions were made between the no significant risk, lack of evidence and positive benefit categories. In addition, where a risk or benefit was identified, symbols were added to indicate the direction of trend. The symbols used were (-) a constant trend over time, (I) increasing trend and, (D) decreasing trend. For instance, a high risk square (red) with an (I) indicated an increasing high risk, while a (D) denoted that the risk was assessed as decreasing.

While implementing the assessment it was found that the amount of regionally-specific literature was relatively limited so often the approach adopted was to consider the key regional characteristics and pressures and interpret the anticipated trends over time in the light of national evidence about impacts. In some cases where there were considerable uncertainties about future trends (e.g. regarding agricultural land management) a combination of symbols (e.g. I/D) was used to denote the differing possibilities and the reasons for this were noted in the underlying evidence base. A detailed appraisal of the evidence underpinning the category assignments is included in Appendix A and the risk register itself is presented diagrammatically in Figure 9.

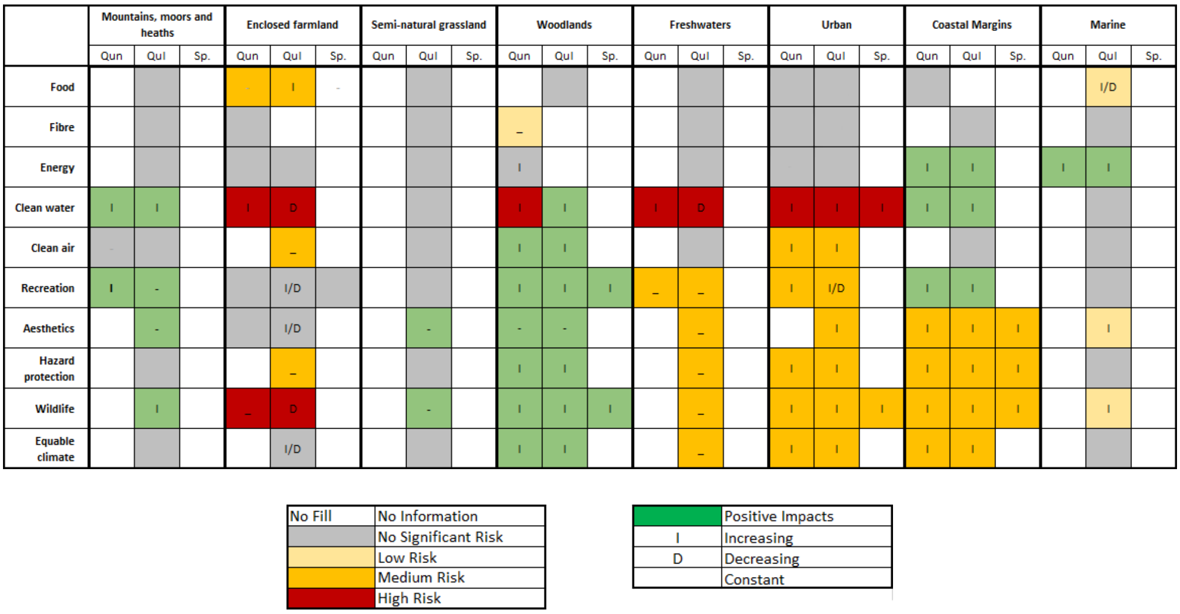


Figure 9: Natural capital risk register for the Anglian Water CSA.

3.3 Differences between the National and Anglian Water CSA Risk Registers

There are a number of differences between the risk register for the Anglian Water CSA in Figure 9 and the UK assessment in Figure 8. The main points to note are as follows:

- More cells are identified as risk or benefits in the register for the Anglian Water CSA than in the national analysis. This is partly a function of the difference in scale because at a regional level it is often easier to judge whether a particular trend will have a noticeable effect. However, it is also a consequence of the more 'interpretative' approach used in the regional analysis and it is important to recognise that some of the assessments do not have specific regional evidence behind them. Many of the risk or benefit assignments in Figure 9 are due to anticipated qualitative changes in habitat characteristics and very few involve alterations in spatial configuration. This is similar to the national assessment.
- Of the 240 relationships in the Figure 9 matrix, 10 were classed as at high risk, 33 medium and four low. Twenty eight cells were evaluated as cases where benefits could increase. All of the high risks related to Clean Water or Wildlife benefits, with most of these arising from pressures in Enclosed Farmland or Urban habitats. The Urban and Coastal Margin habitats were associated with over two-thirds of the moderate risks, while many of the benefits were linked to anticipated increases in woodland cover. This latter point is similar to the national assessment by Mace *et al.* (2015), though as they note the delivery of these benefits will depend not just on the overall quantity of woodland, but also its management and spatial configuration.
- The I/D symbols in Figure 9 highlight a number of cases where risks could either increase or decrease. Many of these are due to policy uncertainties (e.g. regarding agriculture and fisheries post-Brexit) or how planning is implemented (e.g. how new housing estates or settlements are designed). There are also cases where qualitative and quantitative changes in habitats may have different relationships with benefits, one example being that increased woodland cover can be expected to increase the amount of evaporation, but improve the quality of water resources (Nisbet, 2005; Calder, 2007; Nisbet *et al.*, 2011). These examples also make the point that the results of this type of risk register can be quite sensitive to the

habitat or benefit categories used and that changes to these could alter how certain pressures are manifested.

Overall these results suggest a relatively greater degree of pressure on natural asset/benefit relationships in the Anglian Water CSA compared to the national picture. The extent of high risk ratings in the Clean Water row highlights the extent of pressures on water resources in the region, particularly stemming from activities and trends in the Enclosed Farmland and Urban habitats. In the next section these overall findings are investigated further by mapping relevant indicators at a local authority level to assess the geographical coincidence of pressures and natural capital assets within the Anglian Water CSA.

4. Geographical Variations in Pressures and Assets within the CSA

4.1 Introduction

The risk register provides an overall perspective regarding pressures on natural capital, but in a region as large as the Anglian Water CSA it is also important to consider the internal variation in the distributions of pressures and assets.

These geographical variations were assessed by utilising the GIS datasets compiled for the regional assessment discussed in Section 2. Since the data layers were at quite detailed spatial resolutions (typically 100m grid cells) it was straightforward to aggregate and average them to create summary values for larger geographical units. Local authorities were selected for this purpose because they are relevant organisations for communication purposes and since there are 63 intersecting the Anglian Water CSA they show a good level of diversity. However, it should be noted that it would be straightforward to repeat the analysis for other geographical units such as management catchments or water resource zones.

Based on the risk register results two key pressures were identified as projected population growth (and associated urban expansion) and availability of water resources. Trends in these indicators across the local authorities were compared with variables for five types of natural assets. These represented the different categories of ecosystem service shown in Figure 2 and the types of benefits included in the rows of the risk registers.

4.2 Regional Trends in Pressures

Figure 10 shows maps for the two examples of pressures. Details of the projected population increases from 2014-39 come from the Office for National Statistics (2016b) and show a considerable range across the region. There are some authorities (e.g. in Lincolnshire) with projected increases less than 10% of their 2014 population, while in the south of the region and along the A11/M11/A14 corridors there are others with growth rates above 25%.

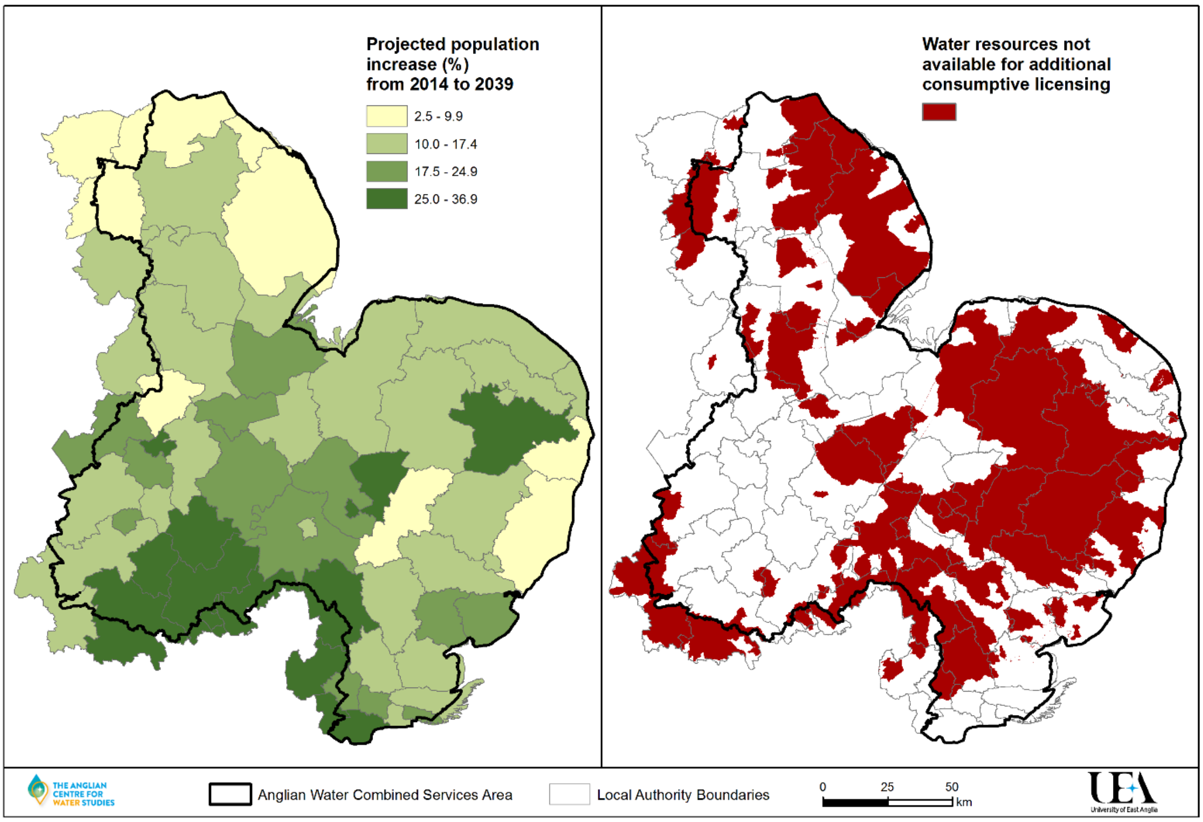


Figure 10: Regional trends in pressures.

The map of water resource availability is based on water bodies classed by the Environment Agency (2016) as areas where the actual flows are below levels needed to support a health ecology (at Q95) and consequently no further consumptive abstraction licenses will be granted. Geographically, the pattern is rather different from that of projected population growth with the main areas of constraint being in eastern Lincolnshire, western Norfolk and Suffolk. When compared in terms of percentages values for local authorities the two variables have a weak negative association as denoted by a Spearman Rank correlation coefficient of -0.23. This coefficient can vary from +1 (perfectly positive), through 0 (no association) to -1 (perfectly negative) (Rogerson, 2015). Nevertheless, despite the overall negative association there are some local authorities such as Forest Heath (around Mildenhall and Newmarket) and Uttlesford (around Saffron Waldon and Stansted) where both pressures are relatively high.

4.3 Regional Trends in Assets

The five maps shown in Figure 11 are of assets linked to the delivery of different types of ecosystem goods and services as summarised below:

- Provisioning service: Grade 1 and 2 agricultural land important for food production
- Supporting service: Nectar plant diversity as an indicator of habitat quality for pollinators
- Regulating service: Carbon storage in soils and vegetation
- Cultural service: Land used for amenity or recreation purposes
- Biodiversity: Areas of priority or designated habitats that are important for delivery of a range of benefits and sometime classed as a supporting service (See Figures 1 and 2)

There are considerable differences in the distributions of high and low provision across the maps and this is confirmed when Spearman Rank correlation coefficients are calculated between the values for local authorities. The results in Table 11 show that Grade 1 and 2 agricultural land is negatively correlated with the other four indicators which, in turn, are all positively associated with each other. In particular, bee plant diversity and total carbon have a significant +0.54 rank correlation, while amenity/recreation areas and priority/designated habitats have a significant +0.52 association. Overall, the results are driven by the underlying geography of land cover, with that for farmland being rather different than those for habitats such as woodland or coastal margins.

Table 11: Spearman rank correlations between asset indicators.

	Grade 1 & 2 Agricultural Land	Soil & Vegetation Carbon	Plant Diversity for Bees	Amenity or Recreation Area	Priority or Designated Habitats
Grade 1 & 2 Agricultural Land	1.00	**-0.60**	**-0.40**	-0.23	-0.14
Soil & Vegetation Carbon	**-0.60**	1.00	**0.54**	**0.40**	**0.56**
Plant Diversity for Bees	**-0.40**	**0.54**	1.00	**0.28**	0.18
Amenity or Recreation Area	-0.23	**0.40**	**0.28**	1.00	**0.52**
Priority or Designated Habitats	-0.14	**0.56**	0.18	**0.52**	1.00

Note: Values in bold indicate statistically significant correlations at the 0.05 significance level.

4.4 Comparing Trends in Pressures and Assets

Due to the negative associations between the geographical patterns of the two pressures and also between some of the natural assets it was not meaningful to compare the two sets of indicators by simply calculating averages of them for the local authorities. There was also a problem that the seven variables were in several different units (i.e. percentages or rates per hectare or survey plot).

In order to address these issues the seven variables were first standardised in terms of units by converting each of them to *z* scores (i.e. (value – mean) / standard deviation). These scores are sometimes referred to as standard normal deviates and transform a variable so that zero represents the average and positive values are greater than the average and negative lower (Rogerson, 2015).

The 63 local authorities were then plotted using their maximum score for one of the two pressures against their maximum for any of the five natural capital indicators. This is an admittedly simple approach because it ignores the scores that the local authorities had on the other pressure or natural capital indicators. On the other hand, it does overcome the problem of which relative weights to assign to the different indicators (e.g. based on some measure of monetary value or societal preference) and serves to provide an initial assessment of where both pressures and the provision of natural assets are relatively high within the Anglian Water CSA. The resulting plot is shown in Figure 12

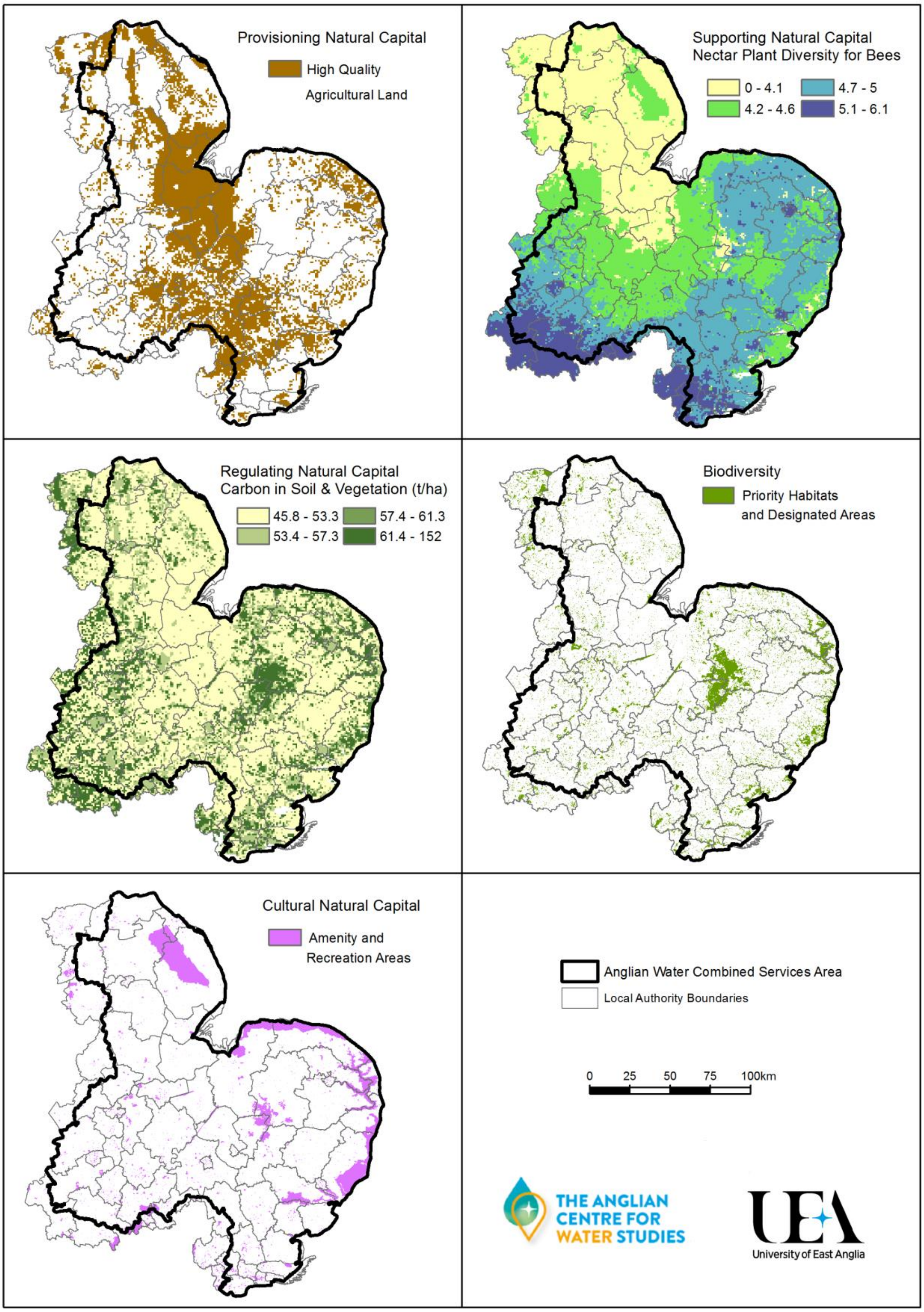


Figure 11: Regional trends in natural capital assets.

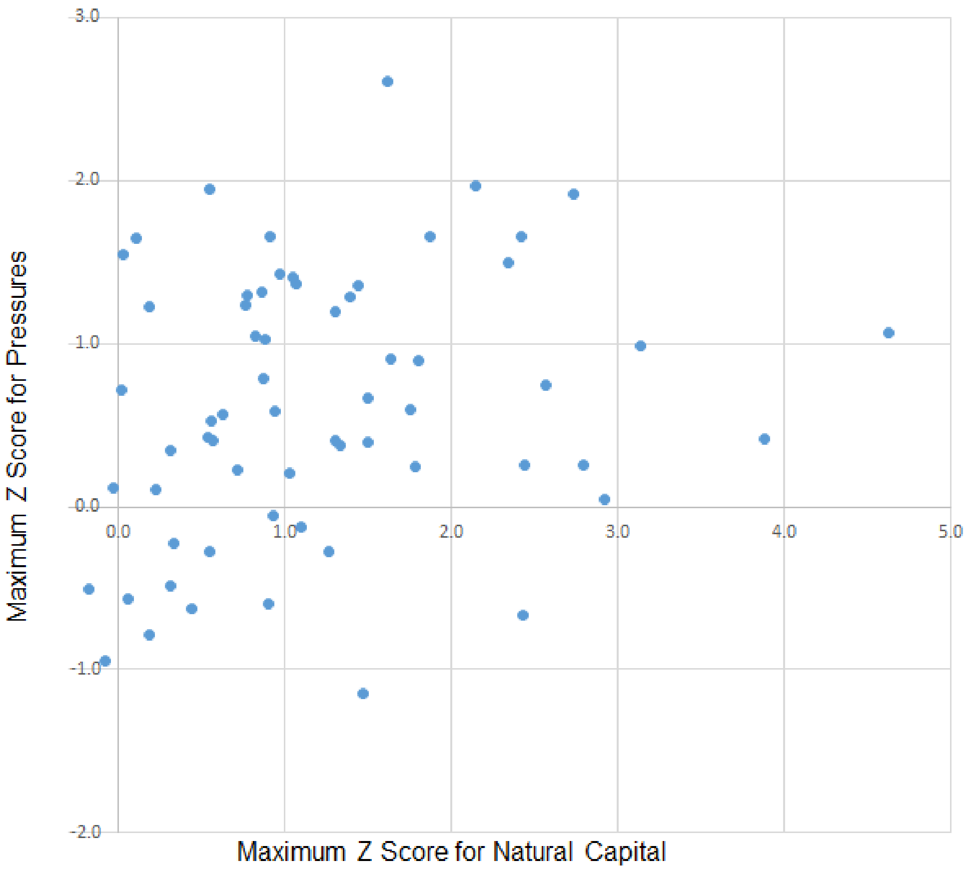


Figure 12: Plot of maximum pressures and natural capital assets for the AW CSA local authorities

Values of less than zero on either axis are below the average for the Anglian Water CSA. Fourteen authorities have such values for pressures, but only three for assets. This implies that nearly all authorities in the CSA have at least one natural capital asset whose provision is above regional average levels. Tables of values for the 63 local authorities in both original and *z* score units are included in Appendix B. A spreadsheet with a larger set of variables for local authorities is available as an Excel file.

The plot in Figure 12 shows a weak positive association between maximum pressure and asset scores (Spearman Rank correlation coefficient of +0.26). This is reflected in the substantial degree of scatter in the association, but there are clearly some authorities towards the top right of the plot who have higher values combinations of both pressures and assets. To assess this situation further the values on each axis were categorised into three groups using the following class intervals:

- Pressures: maximum *z* score less than 0, 0 to 1.49, greater than or equal to 1.5
- Natural capital assets: maximum *z* score less than 1, 1 to 1.99, greater than or equal to 2

Combining these classes generated a classification of the local authorities into nine groups as shown in Table 12. There are authorities in all nine cells of the cross-tabulation, with four in the highest class for both dimensions. In alphabetical order these are Breckland, Havering, Luton and Uttlesford. Details of the classifications for all 63 local authorities are in Appendix B.

Table 12: Numbers of local authorities in different pressure and natural capital categories.

Maximum Pressure z Score	Maximum Natural Capital *z* Score			
	< 1	1 to 1.99	>= 2	Total
>= 1.5	4	2	4	10
0 to 1.49	18	14	7	39
< 0	10	3	1	14
Total	32	19	12	63

A map of the local authority classification is shown in Figure 13 with the nine colours in the legend corresponding to the classes in Table 12. It highlights that many of the authorities with the lowest maximum scores on pressures (denoted by yellow shading) are towards the west of the CSA, whilst many of those with higher maximum scores on natural capital assets (darker blue and green shadings) are towards the north east of the region (e.g. in Lincolnshire, Norfolk and Suffolk). Overall, the map indicates where different combinations of relative pressures and natural capital provision exist within the Anglian Water CSA and also helps to highlight several authorities (such as Breckland and Uttlesford) where there is likely to be a particular need for careful spatial and resource planning in the future. However, it should be noted that the results of this type of analysis can be quite sensitive to the geographical units used (what is known as the modifiable areal unit problem, Harris and Jarvis, 2011) and that using other frameworks (such as river catchments) might well alter the appearance of the map in some parts of the region.

5. Conclusions

5.1 Key Findings

This report presents the results of implementing the initial stages of the approach to assessing natural capital advocated by the Natural Capital Committee (2017) for the Anglian Water CSA. The asset statement in Section 2 highlights the projected population growth (and associated urban expansion), along with the national importance of the high-quality agricultural land present and the challenges that exist in terms of water quantity and quality management. These characteristics, in turn, shape the content of the natural capital risk register compiled in Section 3. This analysis highlights the importance of changes in the Enclosed Farmland and Urban Broad Habitats, especially in terms of their implications for clean water and wildlife benefits. It also flags the uncertainties that exist in parts of the assessment, particularly in regard to the possible consequences of Brexit for agricultural and environmental policies.

The final part of the assessment investigated geographical variations in pressures and natural capital assets within the CSA. This revealed a considerable diversity of situations, something which could have considerable implications for Anglian Water in the context of the 2019 price review. The proposals by Ofwat (2017) place notable emphasis on the use of a natural capital approach and the information included in this report provides a starting point for identifying what the most important natural capital assets are and where they occur. It also suggests that there are certain parts of the region where the pressures on natural capital assets are likely to be particularly acute and therefore these may need to be a focus of future investments or other management initiatives.

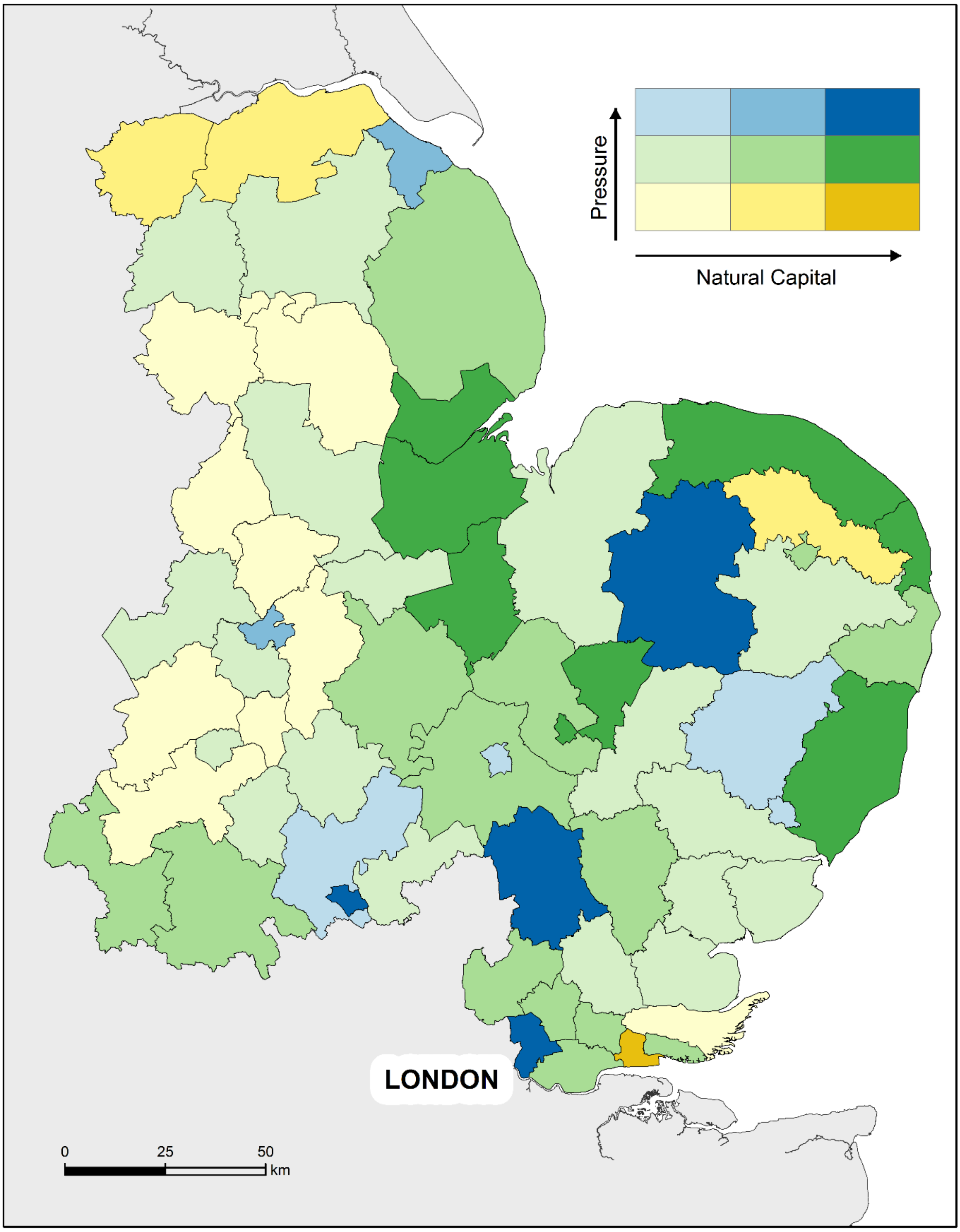


Figure 13: A classification of local authorities based on pressures and natural capital assets.

5.2 Possible Research Directions

There are two features of the research included in this report that are distinctive. One is the compilation of a natural capital risk register at a regional rather than national scale and the second is the spatial analysis of pressures and assets to determine where different combinations of conditions exist. Both of these have applicability elsewhere in the UK or in other countries.

Based on the experience of conducting the research there are a number of ways in which it could be refined or extended. One would be to include other indicators of pressures (e.g. presence of invasive species) or assets (e.g. actual use of recreation sites, presence of carbon in deeper peat deposits), though the scope for doing this would depend on whether the criterion of using open data was maintained. Another possibility would be to investigate different ways of combining indicators on pressures and assets. This could include monetary valuation (Badura *et al.*, 2016) or some other form of weighting (e.g. expert or stakeholder appraisal using an approach such as multi-criteria evaluation, Malczewski, 1999). If monetary evaluation was implemented this would also provide the information base to implement a regional natural capital account, as suggested by the Natural Capital Committee (2017) in their workbook approach. In addition, it would be possible to make more explicit connections between natural assets and business benefits through the type of Landscape Enterprise Networks approach described by Business in the Community (2017).

Two other refinements concern the compilation of the risk register and the spatial analysis of pressures and assets. During the construction of the risk register it became apparent that there was limited regionally-specific literature, but would also be possible to conduct focus groups or interviews with local experts to inform such as assessment. With the spatial analysis one obvious issue is the dependence of the results on the geographical units used (in this case local authorities), so there would be merit in repeating the approach for other geographical units that have particular implications for water resource supply or management (e.g. management or operational catchments).

The research summarised in this report does, nevertheless, provide a range of insights into the natural capital assets of the Anglian Water CSA and the pressures they face. The management of water resources, particularly with regard to pressures from population growth and climate change, is clearly central to these concerns and it is evident that the types of challenges faced, and consequently the response measures needed, are likely to vary geographically within the region.

References

Adams CA, Andrews JE, Jickells T (2012) Nitrous oxide and methane fluxes vs. carbon, nitrogen and phosphorous burial in new intertidal and saltmarsh sediments. *Science of the Total Environment* 434: 240–251.

Allen A, Chapman D (2001) Impacts of afforestation on groundwater resources and quality. *Hydrogeology Journal* 9: 390-400.

Anglian Water (2018) Bathing water performance and awards. http://www.anglianwater.co.uk/environment/our-commitment/performance/bathing-water/performance.aspx.

Anglian Water Services Ltd (2017) *Strategic direction statement 2020–2045*. http://www.anglianwater.co.uk/about-us/thinking-about-our-future/strategic-direction.aspx.

ASC (2016) *UK climate change risk assessment 2017 synthesis report: Priorities for the next five years*. Adaptation Sub-Committee of the Committee on Climate Change, London. https://www.theccc.org.uk/tackling-climate-change/preparing-for-climate-change/uk-climate-change-risk-assessment-2017/.

Badura T, Bateman I, Agarwala M *et al.* (2016) Valuing preferences for ecosystem-related goods and service. In: Potschin M, Haines-Young R, Fish R, Turner RK (eds) *Routledge handbook of ecosystem services*. Routledge, Abingdon, p. 228-242.

Baldock D, Buckwell A, Hart K, Maréchal A (2017) *EU referendum and implications for UK agriculture and the environment*. Report produced for the UK Land Use Policy Group, IEEP, London.

Bateman IJ, Harwood A, Mace GM *et al.* (2013) Bringing ecosystem services into economic decision making: Land use in the United Kingdom. *Science* 341: 45-50, 5th July 2013.

Bradley RI, Milne R, Bell J, Lilly A, Jordan C, Higgins A (2005) A soil carbon and land use database for the United Kingdom. *Soil Use and Management* 21: 363-369.

Broads Authority (2018) Facts and figures. http://www.broads-authority.gov.uk/learning/facts-and-figures.

Brown, I *et al.* (2016) Chapter 3: Natural environment and natural assets. In *UK climate change risk assessment 2017: Evidence report*. Adaptation Sub-Committee of the Committee on Climate Change, London, p. 1-207. https://www.theccc.org.uk/tackling-climate-change/preparing-for-climate-change/uk-climate-change-risk-assessment-2017/.

Bullock JM *et al.* (2011) Chapter 6: Semi-natural grasslands. In UK National Ecosystem Assessment: Technical Report. UNEP-WCMC, Cambridge, p. 161-195. http://uknea.unep-wcmc.org/.

Business in the Community (2017) *Healthy ecosystems East Anglia - A Landscape Enterprise Networks opportunity analysis*. http://awards.bitc.org.uk/reports/healthy-ecosystems-east-anglia-lens.

Calder IR (2007) Forests and water—ensuring forest benefits outweigh water costs. *Forest Ecology and Management* 251: 110-120.

Centre for Ecology and Hydrology (2018) Land Cover Map 2015. https://www.ceh.ac.uk/services/land-cover-map-2015.

ClimateUK (2012) *A summary of climate change risks for the East of England*. http://www.greensuffolk.org/assets/Greenest-County/Adaptation/General/Summary-of-climate-change-risks-to-East-of-England.pdf.

Cooper RJ, Hama-Aziz Z, Hiscock KM *et al.* (2017) Assessing the farm-scale impacts of cover crops and reduced tillage regimes on nutrient losses from an arable catchment. *Agriculture, Ecosystems and Environment* 237: 181-193.

Countryside and Community Research Institute (2010) *Woodland wealth appraisal for the East of England: Update 2010 report to the Forest Commission (East of England)*. http://www.woodlandforlife.net/PDFs/WWApp-2010-(Final%20Nov).pdf.

Davies L *et al.* (2011) Chapter 10: Urban. In *UK National Ecosystem Assessment: Technical Report*. UNEP-WCMC, Cambridge, p. 361-410. http://uknea.unep-wcmc.org/.

Defra (2014) *East inshore and east offshore marine plans*. Defra, London. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/312493/east-plan-executivesummary.pdf

Defra (2017) *Bathing Water Directive 2006/7/EC 2017 classifications for England*. Defra, London. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/659188/bathing-water-classification-2017.pdf.

Defra (2018) *A green future: Our 25 year plan to improve the environment*. Defra, London. https://www.gov.uk/government/publications/25-year-environment-plan.

De Schrijver A, Staelens J, Wuyts K *et al.* (2008) Effect of vegetation type on throughfall deposition and seepage flux. *Environmental Pollution* 153: 295-303.

Destination Research (2017) *Economic impact of tourism – Norfolk 2016*. https://www.visitnorfolk.co.uk/Tourism-info-and-stats.aspx.

East of England Energy Group (2018) Offshore decommissioning. http://www.eeegr.com/offshore-decommissioning.html.

Edmondson JL, Davies ZG, McHugh N *et al.* (2012) Organic carbon hidden in urban ecosystems. *Scientific Reports* 2: 963. DOI: 10.1038/srep00963.

Edmondson JL, Davies ZG, McCormack S *et al.* (2014) Land-cover effects on soil organic carbon stocks in a European city. *Science of the Total Environment* 472: 444-453.

Eglington S, Horlock M (2004) *East of England heathland opportunity mapping project – final report*. https://www.forestry.gov.uk/pdf/eng-ee-heathland-mapping-report.pdf/$file/eng-ee-heathland-mapping-report.pdf.

Ellen MacArthur Foundation (2017) What is a circular economy? https://www.ellenmacarthurfoundation.org/circular-economy.

Elliott M, Burdon D, Atkins JP *et al.* (2017) "And DPSIR begat DAPSI(W)R(M)!" - A unifying framework for marine environmental management. *Marine Pollution Bulletin* 118: 27-40. doi: 10.1016/j.marpolbul.2017.03.049.

Environment Agency (2013) *Water stressed areas – final classification July 2013*. EA and NR Wales. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/244333/water-stressed-classification-2013.pdf.

ESRI (2018) About ArcGIS. http://www.esri.com/arcgis/about-arcgis.

Firbank L, Bradbury R *et al.* (2011) Chapter 7: Enclosed farmland. In *UK National Ecosystem Assessment: Technical Report*. UNEP-WCMC, Cambridge, p. 197-239. http://uknea.unep-wcmc.org/.

Forestry Commission (2017) A snapshot of local heathland restoration across England. https://www.forestry.gov.uk/forestry/infd-6tt9qt.

Forestry Commission (2018) Forestry statistics and forestry facts & figures. https://www.forestry.gov.uk/forestry/infd-7aqdgc.

Harris R, Jarvis C (2011) *Statistics for geography and environmental science*. Pearson, Harlow.

Hattam C, Hooper T, Beaumont N (2015) *Public perceptions of offshore wind farms*. Marine research report, The Crown Estate. https://www.thecrownestate.co.uk/media/501973/ei-public-perceptions-of-offshore-wind-farms.pdf.

Henriques C, Holman I, Audsley E, Pearn K (2008) An interactive multi-scale integrated assessment of future regional water availability for agricultural irrigation in East Anglia and North West England. *Climatic Change* 90: 89–111.

Howden NJK, Bowes MJ, Clark ADJ et al. (2009) Water quality, nutrients and the European union's Water Framework Directive in a lowland agricultural region: Suffolk, south-east England. *Science of the Total Environment* 407: 2966-2979. https://doi.org/10.1016/j.scitotenv.2008.12.040.

Hughes RG, Paramor OAL (2004) On the loss of saltmarshes in south-east England and methods for their restoration. *Journal of Applied Ecology* 41: 440-448.

Knox J, Daccache A, Weatherhead K *et al.* (2013) *Assessment of the impacts of climate change and changes in land use on future water requirement and availability for farming, and opportunities for adaptation*. Defra R&D Technical Report FFG1129/TR, Defra, London.

Luisetti T, Turner RK, Jickells T *et al.* (2014) Coastal zone ecosystem services: From science to values and decision making; a case study. *Science of the Total Environment* 493: 682–693.

Mace GM, Hails RS, Cryle P, Harlow J, Clarke SJ (2015) Towards a risk register for natural capital. *Journal of Applied Ecology* 52: 641-653.

Maltby E, Ormerod S *et al.* (2011) Chapter 9: Freshwaters – openwaters, wetlands and floodplains. In *UK National Ecosystem Assessment: Technical Report*. UNEP-WCMC, Cambridge, p. 295-360. http://uknea.unep-wcmc.org/.

Malczewski J (1999) *GIS and multicriteria decision analysis*. John Wiley, New York.

Mandelbrot B (1967) How long is the coast of Britain? Statistical self-similarity and fractional dimension. *Science* 156 (3775): 636-638. DOI: 10.1126/science.156.3775.636.

Marine Management Organisation (2017) *UK sea fisheries statistics 2016*. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/647482/UK_Sea_Fisheries_Statistics_2016_Full_report.pdf

Millennium Ecosystem Assessment (2005) *Ecosystems and Human Well-being: Synthesis*. https://www.millenniumassessment.org/en/index.html.

Miller JD, Hutchins M (2017) The impacts of urbanisation and climate change on urban flooding and urban water quality: A review of the evidence concerning the United Kingdom. *Journal of Hydrology: Regional Studies* 12: 345–362.

Mokrech M, Nicholls RJ, Richards JA *et al.* (2008) Regional impact assessment of flooding under future climate and socio-economic scenarios for East Anglia and North West England. *Climatic Change* 90: 31–55.

Morris J, D.J.G Gowing DJG, Mills J, Dunderdale JAL (2000) Reconciling agricultural economic and environmental objectives: the case of recreating wetlands in the Fenland area of eastern England. *Agriculture, Ecosystems & Environment* 79: 245-257.

NALEP (2017a) *Norfolk and Suffolk economic strategy*. New Anglia Local Economic Partnership. https://newanglia.co.uk/our-economic-strategy/.

NALEP (2017b) *Economic strategy evidence report*. New Anglia Local Economic Partnership. https://newanglia.co.uk/our-economic-strategy/.

Natural Capital Committee (2014) *The state of natural capital: Restoring our natural assets*. Second Report to the Economic Affairs Committee. https://www.gov.uk/government/groups/natural-capital-committee.

Natural Capital Committee (2015) Natural Capital Committee research: Corporate natural capital accounting. https://www.gov.uk/government/publications/natural-capital-committee-research-corporate-natural-capital-accounting.

Natural Capital Committee (2017) *How to do it: A natural capital workbook version 1*. https://www.gov.uk/government/groups/natural-capital-committee.

Natural England (2012) *Carbon storage by habitat: Review of the evidence of the impacts of management decisions and condition of carbon stores and sources (NERR043)*. http://publications.naturalengland.org.uk/publication/1412347.

Natural England (2013) SSSI monitoring and reporting operational standard. http://publications.naturalengland.org.uk/publication/6232097035386880.

Natural England (2014) 27. Coastal saltmarsh. In: *Climate change adaptation manual - Evidence to support nature conservation in a changing climate (NE546)*. http://publications.naturalengland.org.uk/publication/5629923804839936.

Nisbet T (2005) *Water use by trees*. Forestry Commission Information Note. https://www.forestry.gov.uk/pdf/FCIN065.pdf/$file/FCIN065.pdf.

Nisbet T, Silgram M, Shah N, Morrow K, Broadmeadow S (2011) *Woodland for water: Woodland measures for meeting Water Framework Directive objectives*. Forest Research Monograph 4, Forest Research, Surrey. https://www.forestry.gov.uk/pdf/FRMG004_Woodland4Water.pdf.

Office for National Statistics (2015) *UK natural capital – Land cover in the UK*. https://www.gov.uk/government/statistics/uk-natural-capital-land-cover-in-the-uk.

Office for National Statistics (2016a) *UK natural capital: Monetary estimates, 2016*. https://www.ons.gov.uk/releases/uknaturalcapitalpartialmonetaryestimates2016.

Office for National Statistics (2016b) Subnational Population Projections for Local Authorities. https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationprojections/bulletins/subnationalpopulationprojectionsforengland/2014basedprojections/relateddata.

Office for National Statistics (2017a) *Methodology: Natural capital*. https://www.ons.gov.uk/economy/nationalaccounts/uksectoraccounts/methodologies/naturalcapital.

Office for National Statistics (2017b) Dataset: Regional GVA(I) by local authority in the UK. https://www.ons.gov.uk/economy/grossvalueaddedgva/datasets/regionalgvaibylocalauthorityintheuk.

Ofwat (2017) *Delivering water 2020: Our final methodology for the 2019 price review*. https://www.ofwat.gov.uk/publication/delivering-water-2020-final-methodology-2019-price-review/.

Open Data Institute (2018) What is open data? https://theodi.org/what-is-open-data.

Pearce DW, Turner RK (1990) *Economics of natural resources and the environment*. John Hopkins University Press, Baltimore, USA.

Quine C *et al.* (2011) Chapter 8: Woodlands. In *UK National Ecosystem Assessment: Technical Report*. UNEP-WCMC, Cambridge, p. 241-293. http://uknea.unep-wcmc.org/.

Ravetz J (2015) *The future of the urban environment and ecosystem services in the UK*. Future of cities: working paper, Foresight, Government Office for Science. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/469798/gs-15-34-future-cities-ecosystems.pdf

Ridding LE, Redhead JW, Pywell RF (2015) Fate of semi-natural grassland in England between 1960 and 2013: A test of national conservation policy. *Global Ecology and Conservation* 4: 516-525.

Robinson RA, Sutherland WJ (2002) Post-war changes in arable farming and biodiversity in Great Britain. *Journal of Applied Ecology* 39: 157–176. DOI: 10.1046/j.1365-2664.2002.00695.x

Rogerson PA (2015) *Statistical methods for geography*. 4th Edition, Sage Publications, London.

Selman P (2010) Learning to love the landscapes of carbon-neutrality. *Landscape Research* 35: 157–171.

Spray CJ, Arthur S, Bergmann A *et al.* (2015) *Land management for increased flood resilience*. CREW CRW2012/6. http://www.crew.ac.uk/publications.

Uberoi E (2017) *UK sea fisheries statistics*. House of Commons Library Briefing Paper Number 2788, 5 December 2017. http://www.parliament.uk/commons-library.

UK National Ecosystem Assessment (2011) *UK National Ecosystem Assessment: Technical Report*. UNEP-WCMC, Cambridge. http://uknea.unep-wcmc.org/.

UK National Ecosystem Assessment (2014) *UK National Ecosystem Assessment Follow On: Synthesis of the key findings*. UNEP-WCMC, Cambridge. http://uknea.unep-wcmc.org/.

Appendix A. Evidence Underpinning the Anglian Water Risk Register

This evidence summary is organised in sections for the eight broad habitat categories. In each section there is a short introduction, particularly highlighting differences between the category at a UK scale and within the Anglian Water CSA. A table then summarises relationships between status and trends in that habitat and delivery of benefits. Each table includes one column based on supplementary information from Mace *et al.* (2015) to summarise their UK assessment and a second with the evaluation for the Anglian Water CSA. In both cases the actual category assignments are indicated in *italics*.

A1 Mountains, Moorlands and Heaths

This habitat type is identified by Mace *et al.* (2015) as one of the two facing the greatest threats to its natural capital benefits. The UK register identifies the benefit of clean water at a high risk, mainly due to the loss and degradation of blanket bog over the last 60 years. Other benefits such as aesthetics, hazard protection, wildlife and equable climate are judged as at medium risk.

The situation in the Anglian Water CSA is rather different because the area of such habitat is small (less than a thousandth of the region, see Table 6) and consists almost entirely of heathland. Indeed, there are a number of heathland restoration initiatives across the region (Eglington and Horlock, 2004; Forestry Commission, 2017) which are increasing the provision of clean water, recreation, aesthetics, wildlife and equable climates.

Benefit	UK Assessment	Anglian Water CSA Assessment
Food	*No significant risk or insufficient information.*	*No significant risk* due to small extent of habitat.
Fibre	*No significant risk or insufficient information.*	*No significant risk* due to small extent of habitat.
Energy	*No significant risk or insufficient information.*	*No significant risk* due to small extent of habitat.
Clean Water	*Major risk* due to significant impact of degraded peatland on clean water.	*Positive impact* arising from heathland restoration. Rates of groundwater recharge are greater under heathland compared to woodland (Allen and Chapman, 2001; De Schrijiver *et al.*, 2008).
Clean Air	*No significant risk or insufficient information.*	*No significant risk* due to small extent of habitat.
Recreation	*No significant risk or insufficient information.*	*Positive impact* due to increasing heathland sites in the region, including some with public access, thus increasing recreational opportunities (Forestry Commission, 2017).
Aesthetics	*Medium risk* due to degraded habitats reducing scenic quality.	Some *positive impact* due to heathland restoration enhancing landscape appearance and aesthetics.
Hazard Protection	*Medium risk* due to greater potential for fires or flooding, but uncertainty about relationships.	*No significant risk* due to small extent of habitat.
Wildlife	*Medium risk* due to threats to habitats.	Some *positive impact* due to heathland restoration improving habitats for specialist species (Forestry Commission, 2017).
Equable Climate	*Major risk* due to improper management detrimental to carbon storage.	*No significant risk* due to small extent of habitat.

A2 Enclosed Farmland

Over 85% of the Anglian Water CSA is enclosed farmland and this has changed little in recent years (see Table 6). Hence what happens within this habitat is disproportionally important for a range of environmental outcomes (Baldock *et al.*, 2017). Enclosed Farmland is subject to a multitude of external drivers and pressures (e.g. market conditions, national/international policy changes and climate change), as well as a diversity of land uses (arable, pastoral, horticulture, semi-natural habitats e.g. hedgerows and farm woodlands etc.) and management practices. The principal output/benefit from enclosed farmland is food production and the EU Common Agricultural Policy along with nationally instigated agri-environment schemes have been major influences over food production enterprises and the farmed landscape in recent years. Changes in market conditions and agricultural support due to Brexit will be an important future consideration and source of uncertainty. In addition, adequate water supply is vital to food production and existing water stress in the region is only likely to be accentuated by climate change (Environment Agency, 2013; Brown *et al.*, 2016).

Benefit	**UK Assessment**	**Anglian Water CSA Assessment**
Food	*Medium risk* because of the importance of such land for food production. Although the total area nationally is unlikely to experience major change, there are threats to quality e.g. soils, crop pollinators.	*Medium risk* since pressure from urban expansion will increase in the coming decades, but this is likely to make a small overall impact on the availability of land for food production in the region. However, there are various risks to the potential quantity of food that could be produced from enclosed farmland, with climate change impacting yields or driving changes in the crops produced (Brown *et al.*, 2016).
Fibre	*No significant risk or insufficient information.*	*No significant risk* or could be a positive impact if government policy drives major increases in the extent of farm woodland.
Energy	*No significant risk or insufficient information.*	*No significant risk* or could be a positive impact if the quantity of renewable energy generation on farmland (e.g. from anaerobic digestion, solar farms; wind farms and biomass crops) undergoes major expansion.
Clean Water	*Medium risk* because agricultural land is an important source of sediment and some chemical pollutants (e.g. nitrates, pesticides).	*High risk* because agriculture is a major consumer of water in the region and demands are likely to increase with climate change (Henriques *et al.*, 2008; Knox *et al.*, 2013). Farmland is also a significant source of pollutants in watercourses and few than half the water bodies in the region currently meet good ecological status standards for the Water Framework Directive (Brown *et al.*, 2016, 87). Measures are slowly improving water quality, but it is likely to take many years for effects to be realised (e.g. Howden *et al.*, 2009; Cooper *et al.*, 2017).
Clean Air	*No significant risk or insufficient information.*	*Low risk* due to the importance of pig and poultry units in parts of the region, these are an important source of ammonia (Firbank and Bradbury *et al.*, 2011).
Recreation	*No significant risk or insufficient information.*	*No significant risk* or possible positive impact on recreational opportunities arising from government policies to support the provision of public goods on farmland (Defra, 2018).
Aesthetics	*No significant risk or insufficient information.*	*No significant risk* or possible positive impact dependent on changes in agricultural policy

		and public attitudes to increased renewable energy developments (Selman, 2010).
Hazard Protection	*Medium risk* because degraded habitats are more likely to loose soil and sediment to river networks, increasing flooding risk downstream.	*Medium risk* because the management of farmland can have an important influence on flood risk. Initiatives to support natural flood management through agri-environment schemes could increase in the future (Mokrech *et al.*, 2008; Spray *et al.*, 2015)
Wildlife	*High risk* because the quality of the habitat can significantly affect the value for wildlife.	*High risk* because of the impact of intensive farming on wildlife (Robinson and Sutherland, 2002) though this is now being tackled through agri-environment schemes. Agricultural water abstraction can also pose a risk to fen wildlife (Morris *et al.*, 2000).
Equable Climate	*Low risk* because agriculture generates net greenhouse gas emissions, being a particularly important source of nitrous oxide and methane.	*No significant risk* or possible positive impact dependent on farm management (e.g. use reduced tillage methods) because this will influence levels of atmospheric emissions and carbon sequestration (Firbank and Bradbury *et al.*, 2011).

A3 Semi-natural grasslands

Semi-natural grasslands cover less than 0.2% of the Anglian Water CSA, compared to 2.8% of England (see Table 6). There were substantial losses of such habitats across lowland England during the second half of the twentieth century, but where they remain they are sites of considerable conservation importance (Bullock *et al.*, 2011; Ridding *et al.*, 2015).

Benefit	UK Assessment	Anglian Water CSA Assessment
Food	*No significant risk or insufficient information.*	*No significant risk* due to small extent of habitat.
Fibre	*No significant risk or insufficient information.*	*No significant risk* due to small extent of habitat.
Energy	*No significant risk or insufficient information.*	*No significant risk* due to small extent of habitat.
Clean Water	*No significant risk or insufficient information.*	*No significant risk* due to small extent of habitat.
Clean Air	*No significant risk or insufficient information.*	*No significant risk* due to small extent of habitat.
Recreation	*No significant risk or insufficient information.*	*No significant risk* due to small extent of habitat.
Aesthetics	*Low risk* because of the cultural and heritage associations of this type of habitat.	*Positive impact* due to the cultural value of such habitats (Bullock *et al.*, 2011).
Hazard Protection	*No significant risk or insufficient information.*	*No significant risk* due to small extent of habitat.
Wildlife	*Low risk* because although many remaining areas are now protected to some degree they are key habitats for certain species.	*Positive impact* because such habitats support an array of specialist species (Ridding *et al.*, 2015).
Equable Climate	*Low risk* because topsoils in these habitats are important carbon stores.	*No significant risk* due to small extent of habitat.

A4 Woodlands

Woodlands represent 3.4% of the Anglian Water CSA compared to 6.1% of England. However, the afforested area in the region has increased in recent decades and is likely to expand further as a consequence of government initiatives to support woodland and forest creation as part of the 25 Year Environment Plan (Defra, 2018).

Benefit	UK Assessment	Anglian Water CSA Assessment
Food	*No significant risk or insufficient information.*	*No significant risk*.
Fibre	*Medium risk* due to the role of woodlands in timber supply.	*Low risk* because timber production is limited and managed with a goal of sustainable use. The number of sawmills and their output in the region has significantly reduced over the last 50 years and is now at a stable level (Forestry Commission, 2018).
Energy	*No significant risk or insufficient information.*	*No significant risk* at present, but could change if use of wood fuels for home heating becomes more common.
Clean Water	*Medium risk* due to potentially reducing the yield of water downstream, but woodland also provides a purification role by reducing runoff and intercepting pollution so some uncertainty about overall effect.	*High risk* in terms of increased woodland and forest cover reducing recharge, but there is also a potential benefit in terms of improved water quality (Allen and Chapman, 2001; Nisbet, 2005; Calder, 2007; Nisbet et al., 2011).
Clean Air	*Medium risk* due to the role of woodland in absorbing air pollutants and producing oxygen.	*Positive impact* because increased woodland cover will help improve air quality (Quine *et al.*, 2011).
Recreation	*Medium risk* due to woodlands being one of the most popular destinations for countryside visits.	*Positive impact* in terms of providing enhanced recreation benefits (Countryside and Community Research Institute, 2010).
Aesthetics	*Low risk* because there is some association between perceptions of landscape value and woodland characteristics.	*Positive impact* in terms of enhancing landscape quality (Countryside and Community Research Institute, 2010).
Hazard Protection	*Medium risk* because woodland provides protection from flooding and soil failure by regulating the quantity of water downstream and stopping soil erosion.	*Positive impact* in terms of increased woodland cover helping to ameliorate flooding by slowing down surface runoff (Countryside and Community Research Institute, 2010).
Wildlife	*Medium risk* because woodland provides important habitat for many species.	*Positive impact* due to increased woodland cover enhancing habitat diversity (Quine *et al.*, 2011).
Equable Climate	*Medium risk* because woodland is a carbon store, taking up and locking carbon dioxide through photosynthesis.	*Positive impact* in terms of increased carbon sequestration (Countryside and Community Research Institute, 2010).

A5 Freshwaters

Freshwaters are identified by Mace *et al.* (2015, 648) as the second broad habitat category with 'most benefits at risk'. This is because, despite many improvements and initiatives, they continue to be affected by other land uses, such as on farmland and in urban areas. This national situation is replicated in the Anglian Water CSA and, if anything, is accentuated because of the extent of agricultural activities, the anticipated urban expansion, and the implications of climate change in a relatively dry part of the country (ASC, 2016).

Benefit	UK Assessment	Anglian Water CSA Assessment
Food	*No significant risk or insufficient information.*	*No significant risk*.
Fibre	*No significant risk or insufficient information.*	*No significant risk*.
Energy	*No significant risk or insufficient information.*	*No significant risk*.
Clean Water	*Medium risk* due to the threats to wetland habitats and their role in water purification.	*High risk* because of increasing demands, reduced recharge due to climate change and pollution from agricultural and urban sources (Maltby and Ormerod *et al.*, 2011; Brown *et al.*, 2016).
Clean Air	*No significant risk or insufficient information.*	*No significant risk*.
Recreation	*Medium risk* due degradation of water quality reducing opportunities for swimming, angling,	*Medium risk* because freshwaters play a critical role for tourism in the region. The Broads

	or walking.	alone have approximately 8 million visitors per year with an economic impact estimated at £568 million (Broads Authority, 2018). Deterioration of water quality could have major implications for recreation opportunities and tourism.
Aesthetics	*Medium risk* due to degradation of habitats reducing their visual appeal.	*Medium risk* due to degradation of habitats reducing their visual appeal.
Hazard Protection	*Medium risk* because of the importance of functioning floodplains and wetlands in reducing flooding risk.	*Medium risk* because of the importance of functioning floodplains and wetlands in reducing flooding risk (Maltby and Ormerod *et al.*, 2011)
Wildlife	*Medium risk* because many freshwater species are sensitive to changes in water supply and quality.	*Medium risk* due to possibility of wetlands drying out, or habitats experiencing poorer water quality, with negative effects on flora and fauna (Maltby and Ormerod *et al.*, 2011).
Equable Climate	*Medium risk* because of threats to lowland fen which is important for carbon sequestration.	*Medium risk* because of threats to lowland fen which is important for carbon sequestration (Natural England, 2012).

A6 Urban

Much of the Anglian Water CSA is rural, with the region accounting for 12.8% of England population in 2014, compared to 21.6% of the land area (See Section 2.1). However, urban land in the region expanded by 25 km^2 in 2006-12 and there are projections of a 22% increase in housing demand across the East of England by 2039 (NALEP, 2017b). In addition, this urban expansion will be unevenly distributed, with particular growth anticipated along the A11/M11 and A14 road corridors.

Benefit	UK Assessment	Anglian Water CSA Assessment
Food	*No significant risk or insufficient information.*	*No significant risk* because the anticipated increase in urban area is unlikely to impair food production potential.
Fibre	*No significant risk or insufficient information.*	*No significant risk*.
Energy	*No significant risk or insufficient information.*	*No significant risk* because the anticipated increase in urban area is unlikely to impair energy generation potential.
Clean Water	*High risk* due to increased demand arising from urban expansion and potential for pollution (e.g. from sewage treatment works or runoff during storm events).	*High risk* because many of the areas targeted for urban expansion coincide with those where pressures on water resources already exist. Increased demand will have implications for the quantity of water available and urban sources of pollution may degrade water quality (Ravetz, 2015; Miller and Hutchins, 2017).
Clean Air	*Medium risk* due to increased emissions from buildings and vehicles.	*Medium risk* due to greater urban areas increasing pollutant emissions (Davies *et al.*, 2011).
Recreation	*Medium risk* due to the potential for urban expansion to reduce the quantity of available greenspace or degrade the quality of such environments.	*Medium risk* due to loss or degradation of current recreational spaces due to greenfield site development. However, there is the possibility of increased urban green infrastructure (Davies *et al.*, 2011).
Aesthetics	*Medium risk* due to the scope for the visual appeal of open landscapes to be impaired by buildings and infrastructure developments.	*Medium risk* due to the scope for the visual appeal of open landscapes to be impaired by buildings and infrastructure developments.
Hazard Protection	*Medium risk* because an increase in the extent of impermeable surfaces (concrete, compacted soils) is likely to increase the risk of surface water flooding.	*Medium risk* because an increase in the extent of impermeable surfaces is likely to increase the risk of flooding (Miller and Hutchins, 2017).
Wildlife	*Medium risk* because urban expansion is likely	*Medium risk* because urban expansion is likely

	to decrease the quantity, quality and connectivity of wildlife habitats.	to decrease the quantity, quality and connectivity of wildlife habitats (Ravetz, 2015).
Equable Climate	*Medium risk* because an expansion in built environment is likely to led to an associated increase in atmospheric emissions, heat islands and wind tunnelling.	*Medium risk* because an expansion in built environment is likely to led to an associated increase in atmospheric emissions, heat islands and wind tunnelling (Davies *et al.*, 2011).

A7 Coastal Margins

Coastal margins only account for 0.5% of the land area in the Anglian Water CSA, but this is substantially greater than the 0.3% share for England as a whole (see Table 6). In particular, more than a third of the English saltmarsh priority habitat is in the CSA and this supports an important range of benefits (Luisetti *et al.*, 2014). Coastal habitats are also an important asset for tourism in the region. For instance, research commissioned by Visit Norfolk estimated that in 2016 there were 5.8 million day visitors to coastal locations in the county, with an associated spend of £180 million (Destination Research, 2017).

Benefit	UK Assessment	Anglian Water CSA Assessment
Food	*No significant risk or insufficient information.*	Crab fishing and samphire harvesting occur in the region but the scale is small and localised so there is *no significant risk* or benefit.
Fibre	*No significant risk or insufficient information.*	*No significant risk*.
Energy	*No significant risk or insufficient information.*	*Positive benefit* because parts of the regional coastline have been prioritised for tidal energy development in the East Marine Plans (Defra, 2014) though no such projects exist at present.
Clean Water	*No significant risk or insufficient information.*	*Positive benefit* because bathing water and standards in the region are good and have improved over time (see Table 8; Defra, 2017; Anglian Water, 2018).
Clean Air	*No significant risk or insufficient information.*	*No significant risk*.
Recreation	*Medium risk* because the quality of coastal margins significantly affects the active enjoyment of them e.g. problems of litter, poor bathing water standards.	*Positive benefit* because bathing water and beach standards in the region are good and have improved over time (see Table 8; Defra, 2017; Anglian Water, 2018).
Aesthetics	*Medium risk* due to the scope for the visual appeal of open landscapes to be impaired by buildings or other developments.	*Medium risk* due to potential for landscape alteration by onshore infrastructure associated with existing and anticipated offshore or tidal energy developments.
Hazard Protection	*Medium risk* because damage to many coastal habitats (e.g. dunes and saltmarsh) will increase flooding risk.	*Medium risk* due to loss and degradation of dune and saltmarsh habitats in recent decades (Hughes and Paramor, 2004; Natural England, 2014).
Wildlife	*Medium risk* due to potential for land use change to eliminate or degrade habitats for specialised species.	*Medium risk* due to loss and degradation of dune and saltmarsh habitats in recent decades (Hughes and Paramor, 2004; Natural England, 2014).
Equable Climate	*Medium risk* due to the importance of habitats such as saltmarsh for carbon sequestration.	*Medium Risk* due to the threat to saltmarsh from sea level rise or infrastructure developments and the importance of this habitat for carbon sequestration (Adams *et al.*, 2012)

A8 Marine

The eastern coast of England has a long tradition of marine fishing, but the size of the industry has been in progressive decline since the 1970s (Uberoi, 2017). The two main fishing ports in the Anglian

Water CSA are Grimsby and Lowestoft which now account for 13% of the registered fishing vessels in England (Marine Management Organisation, 2017). A much more important economic sector now is the marine energy industry. East Anglia is a national centre for the offshore oil and gas industry and has 70% of UK offshore wind energy capacity (East of England Energy Group, 2018). Further investments in wind energy and decommissioning of existing North Sea offshore oil and gas infrastructure are likely to be worth an estimated £50 billion over the next 30 years (NALEP, 2017a).

Benefit	UK Assessment	Anglian Water CSA Assessment
Food	*Medium risk* due to potential for marine pollution to impact fish and shellfish yields.	*Low risk* since although the local fishing industry is small more than half the catch in UK waters is by boats from other UK countries (Uberoi, 2017). It is currently unclear how access to UK waters will change with Brexit.
Fibre	*No significant risk or insufficient information.*	*No significant risk*.
Energy	*No significant risk or insufficient information.*	*Positive benefit* due to the large contribution of offshore wind turbines to energy supply and decarbonisation.
Clean Water	*No significant risk or insufficient information.*	*No significant risk*.
Clean Air	*No significant risk or insufficient information.*	*No significant risk*.
Recreation	*No significant risk or insufficient information.*	*No significant risk*.
Aesthetics	*No significant risk or insufficient information.*	*Low risk* due to the anticipated scale of marine energy developments. Public attitudes to offshore wind turbines are generally favourable but some concerns have been reported about impacts on coastal tourism and views (Hattam *et al.*, 2015)
Hazard Protection	*No significant risk or insufficient information.*	*No significant risk*.
Wildlife	*Medium risk* because water quality will be a major influence on the abundance and diversity of marine wildlife.	*Low risk* due to the anticipated scale of marine energy developments and potential for disturbance or pollution of habitats.
Equable Climate	*No significant risk or insufficient information.*	*No significant risk.*

Appendix B. Local Authority Pressure and Natural Capital Indicators

The first table on the following pages lists the original values for the two pressure and five natural capital asset indicators used. A second table contains these variables transformed to *z* scores. These two tables are sorted by local authority ID code. The third table includes the maximum pressure and natural capital scores and their classification into the categories used in Table 12 and Figure 13. This table is sorted according to the categories in Figure 13 to enable easier identification of individual local authorities.

B1 Original Variable Values

Key to Variable Names			
PCH_PC	% population change 2014-39	BPLANTS	Bee plant species diversity
WNA_PC	% no water available for licensing	AREC_PC	% amenity or recreation land
AL12_PC	% land grades 1 and 2	PHAB_PC	% priority or designated habitats
TCB_THA	Carbon in soils and vegetation		

ID CODE	NAME	AREA_HA	POP2014	PCH_PC	WNA_PC	AL12_PC	TCB_THA	BPLANTS	AREC_PC	PHAB_PC
E06000012	North East Lincolnshire	20,355	160	2.5	100.0	19.1	51.7	4.04	24.1	3.3
E06000013	North Lincolnshire	87,568	169	6.5	39.6	54.5	53.9	3.84	1.3	7.3
E06000017	Rutland	39,375	38	7.9	11.3	9.0	56.3	4.30	1.4	9.5
E06000031	Peterborough	34,344	191	20.4	25.2	41.8	55.6	4.03	4.4	8.5
E06000032	Luton	4,335	211	27.0	99.9	8.8	57.6	5.67	10.9	6.3
E06000033	Southend-on-Sea	6,790	178	20.2	0.0	18.6	58.9	5.17	10.6	4.9
E06000034	Thurrock	18,432	163	27.6	0.0	20.9	59.0	5.06	6.5	11.2
E06000042	Milton Keynes	30,863	259	26.6	7.2	12.7	57.1	4.92	3.4	6.4
E06000055	Bedford	47,641	164	28.1	0.0	51.3	52.6	4.55	2.9	5.7
E06000056	Central Bedfordshire	71,567	269	32.0	22.5	28.4	56.3	4.82	11.8	9.9
E07000004	Aylesbury Vale	90,275	185	27.6	43.0	6.9	62.2	5.22	6.9	6.7
E07000008	Cambridge	4,070	129	14.7	96.4	20.3	56.8	4.59	7.3	6.2
E07000009	East Cambridgeshire	65,172	87	21.8	47.7	70.0	55.3	4.27	2.9	8.0
E07000010	Fenland	54,736	98	16.3	69.1	89.6	51.7	4.04	3.0	5.5
E07000011	Huntingdonshire	91,255	174	19.0	41.8	52.7	51.6	4.23	1.5	7.6
E07000012	South Cambridgeshire	90,169	153	24.2	65.0	67.4	53.3	4.43	2.5	6.4
E07000066	Basildon	11,045	181	20.4	15.7	0.0	62.4	5.16	10.3	12.1
E07000067	Braintree	61,171	150	17.3	57.1	64.1	53.5	4.75	1.6	5.9
E07000068	Brentwood	15,312	76	22.4	51.8	10.3	63.3	5.21	7.9	10.5
E07000069	Castle Point	6,370	89	12.4	0.0	0.0	65.8	5.11	17.0	25.7
E07000070	Chelmsford	34,300	172	16.9	88.4	34.9	58.5	4.96	4.0	8.2
E07000071	Colchester	34,671	180	23.3	37.7	37.3	57.8	4.65	10.3	15.6
E07000072	Epping Forest	33,898	129	26.4	31.8	41.5	62.5	5.15	6.2	11.1
E07000074	Maldon	42,669	63	12.7	61.6	17.0	57.0	4.69	2.6	13.7
E07000075	Rochford	26,341	85	12.9	0.0	31.0	57.6	4.80	6.2	15.8
E07000076	Tendring	36,582	140	18.6	51.5	45.2	54.7	4.55	2.8	11.8
E07000077	Uttlesford	64,118	84	32.1	79.6	79.5	52.1	4.87	1.3	5.3
E07000099	North Hertfordshire	37,538	131	25.2	79.2	26.9	56.9	4.94	8.7	7.2
E07000131	Harborough	59,269	88	18.2	0.0	4.2	58.2	4.57	1.1	3.8
E07000133	Melton	48,138	51	13.7	6.1	12.2	58.5	4.19	0.9	5.1
E07000136	Boston	39,779	67	14.9	52.5	94.9	50.8	3.86	3.0	5.8
E07000137	East Lindsey	183,107	138	9.4	74.3	38.5	52.0	3.99	23.4	6.8
E07000138	Lincoln	3,569	96	11.5	8.0	4.0	56.8	3.95	7.7	11.3
E07000139	North Kesteven	92,247	111	15.3	28.6	41.4	52.5	3.84	0.9	3.2
E07000140	South Holland	81,550	90	17.8	5.9	97.9	50.8	3.95	0.3	3.1
E07000141	South Kesteven	94,259	138	17.4	47.9	27.4	53.7	4.04	1.4	5.2
E07000142	West Lindsey	115,765	92	13.0	55.6	21.9	54.1	3.83	10.9	5.4
E07000143	Breckland	130,512	134	16.4	94.7	7.9	61.1	4.66	8.3	25.1
E07000144	Broadland	55,324	126	12.7	34.2	25.4	60.5	4.64	16.3	18.2
E07000145	Great Yarmouth	18,233	98	10.2	58.0	39.2	58.8	4.65	40.9	22.6
E07000146	King's Lynn and West Norfolk	152,760	150	12.7	63.1	43.2	56.5	4.34	13.3	10.7
E07000147	North Norfolk	99,144	103	13.6	52.5	33.8	59.2	4.64	28.8	15.5
E07000148	Norwich	4,055	138	16.7	91.4	0.0	61.5	4.99	11.5	11.9
E07000149	South Norfolk	90,891	129	25.6	85.4	10.3	54.3	4.66	8.3	11.1
E07000150	Corby	8,028	65	36.9	0.0	0.0	63.8	4.54	6.9	10.5
E07000151	Daventry	66,560	79	12.7	20.8	5.8	57.6	4.77	1.7	4.0
E07000152	East Northamptonshire	50,979	89	15.7	0.0	8.7	58.6	4.35	5.5	10.8
E07000153	Kettering	23,349	97	20.6	0.0	9.6	59.5	4.61	1.4	6.4
E07000154	Northampton	8,077	220	21.8	0.0	6.4	60.1	5.00	9.6	7.3
E07000155	South Northamptonshire	63,402	88	17.1	24.4	7.8	57.7	4.99	2.5	7.0
E07000156	Wellingborough	16,304	76	13.2	0.0	21.7	56.0	4.60	2.5	6.5
E07000171	Bassetlaw	63,949	114	7.0	68.0	20.0	57.4	3.81	4.7	8.2
E07000175	Newark and Sherwood	65,184	118	13.6	21.1	14.6	56.6	3.90	5.9	7.8
E07000177	Cherwell	58,874	145	14.5	87.3	15.2	60.1	5.20	2.8	7.7
E07000200	Babergh	61,204	89	10.1	78.7	40.6	54.5	4.64	15.7	8.9
E07000201	Forest Heath	37,771	63	25.4	47.8	20.7	68.8	4.37	15.8	39.8
E07000202	Ipswich	4,030	135	11.1	100.0	5.8	56.4	4.99	12.7	5.3
E07000203	Mid Suffolk	87,107	99	14.1	99.8	17.9	50.6	4.62	0.8	4.6
E07000204	St Edmundsbury	65,697	112	9.8	87.6	46.6	56.5	4.65	4.6	12.9
E07000205	Suffolk Coastal	92,070	125	7.2	77.1	17.6	59.7	4.57	34.7	19.8
E07000206	Waveney	37,479	116	7.8	52.2	12.5	56.6	4.66	23.3	15.6
E08000017	Doncaster	56,855	304	3.3	4.7	27.5	59.7	3.73	2.9	19.5
E09000016	Havering	11,446	246	31.7	0.0	14.3	68.3	5.29	13.9	10.7

B2 Original Variable Values Transformed to z Scores

Key to Variable Names			
ZPCH_PC	Z score % population change 2014-39	ZBPLANTS	Z score bee plant species diversity
ZWNA_PC	Z score % no water available for licensing	ZAREC_PC	Z score % amenity or recreation land
ZAL12_PC	Z score % land grades 1 and 2	ZPHAB_PC	Z score % priority or designated habitats
ZTCB_THA	Z score carbon in soils and vegetation		

ID CODE	NAME	AREA_HA	POP2014	ZPCH_PC	ZWNA_PC	ZAL12_PC	ZTCB_THA	ZBPLANTS	ZAREC_PC	ZPHAB_PC
E06000012	North East Lincolnshire	20,355	160	-2.0	1.7	-0.4	-1.4	-1.2	1.9	-1.1
E06000013	North Lincolnshire	87,568	169	-1.5	-0.1	1.1	-0.9	-1.6	-0.8	-0.4
E06000017	Rutland	39,375	38	-1.3	-1.0	-0.8	-0.3	-0.6	-0.8	-0.1
E06000031	Peterborough	34,344	191	0.4	-0.5	0.6	-0.4	-1.2	-0.5	-0.2
E06000032	Luton	4,335	211	1.3	1.7	-0.8	0.1	2.4	0.3	-0.6
E06000033	Southend-on-Sea	6,790	178	0.4	-1.3	-0.4	0.4	1.3	0.3	-0.8
E06000034	Thurrock	18,432	163	1.4	-1.3	-0.3	0.4	1.1	-0.2	0.2
E06000042	Milton Keynes	30,863	259	1.2	-1.1	-0.7	0.0	0.8	-0.6	-0.6
E06000055	Bedford	47,641	164	1.4	-1.3	1.0	-1.2	-0.1	-0.6	-0.7
E06000056	Central Bedfordshire	71,567	269	2.0	-0.6	0.0	-0.3	0.6	0.4	0.0
E07000004	Aylesbury Vale	90,275	185	1.4	0.0	-0.9	1.2	1.4	-0.2	-0.5
E07000008	Cambridge	4,070	129	-0.4	1.6	-0.3	-0.1	0.0	-0.1	-0.6
E07000009	East Cambridgeshire	65,172	87	0.6	0.1	1.8	-0.5	-0.7	-0.6	-0.3
E07000010	Fenland	54,736	98	-0.1	0.8	2.6	-1.4	-1.2	-0.6	-0.7
E07000011	Huntingdonshire	91,255	174	0.2	-0.1	1.0	-1.4	-0.8	-0.8	-0.4
E07000012	South Cambridgeshire	90,169	153	0.9	0.6	1.6	-1.0	-0.3	-0.7	-0.6
E07000066	Basildon	11,045	181	0.4	-0.8	-1.2	1.3	1.3	0.2	0.3
E07000067	Braintree	61,171	150	0.0	0.4	1.5	-1.0	0.4	-0.8	-0.7
E07000068	Brentwood	15,312	76	0.7	0.2	-0.8	1.5	1.4	-0.1	0.1
E07000069	Castle Point	6,370	89	-0.7	-1.3	-1.2	2.1	1.2	1.0	2.4
E07000070	Chelmsford	34,300	172	-0.1	1.3	0.3	0.3	0.9	-0.5	-0.3
E07000071	Colchester	34,671	180	0.8	-0.2	0.4	0.1	0.2	0.2	0.9
E07000072	Epping Forest	33,898	129	1.2	-0.4	0.6	1.3	1.3	-0.3	0.2
E07000074	Maldon	42,669	63	-0.6	0.5	-0.5	-0.1	0.3	-0.7	0.6
E07000075	Rochford	26,341	85	-0.6	-1.3	0.1	0.1	0.5	-0.3	0.9
E07000076	Tendring	36,582	140	0.2	0.2	0.7	-0.7	-0.1	-0.7	0.3
E07000077	Uttlesford	64,118	84	2.0	1.1	2.2	-1.3	0.7	-0.8	-0.7
E07000099	North Hertfordshire	37,538	131	1.0	1.1	-0.1	-0.1	0.8	0.1	-0.4
E07000131	Harborough	59,269	88	0.1	-1.3	-1.0	0.2	0.0	-0.9	-1.0
E07000133	Melton	48,138	51	-0.5	-1.1	-0.7	0.3	-0.9	-0.9	-0.8
E07000136	Boston	39,779	67	-0.3	0.3	2.8	-1.6	-1.6	-0.6	-0.7
E07000137	East Lindsey	183,107	138	-1.1	0.9	0.4	-1.3	-1.3	1.8	-0.5
E07000138	Lincoln	3,569	96	-0.8	-1.1	-1.0	-0.1	-1.4	-0.1	0.2
E07000139	North Kesteven	92,247	111	-0.3	-0.4	0.6	-1.2	-1.6	-0.9	-1.1
E07000140	South Holland	81,550	90	0.1	-1.1	2.9	-1.6	-1.4	-1.0	-1.1
E07000141	South Kesteven	94,259	138	0.0	0.1	0.0	-0.9	-1.2	-0.8	-0.8
E07000142	West Lindsey	115,765	92	-0.6	0.4	-0.3	-0.8	-1.7	0.3	-0.7
E07000143	Breckland	130,512	134	-0.1	1.5	-0.9	0.9	0.2	0.0	2.3
E07000144	Broadland	55,324	126	-0.6	-0.3	-0.1	0.8	0.2	1.0	1.3
E07000145	Great Yarmouth	18,233	98	-1.0	0.4	0.5	0.4	0.2	3.9	2.0
E07000146	King's Lynn and West Norfolk	152,760	150	-0.6	0.6	0.6	-0.2	-0.5	0.6	0.1
E07000147	North Norfolk	99,144	103	-0.5	0.3	0.2	0.5	0.2	2.4	0.9
E07000148	Norwich	4,055	138	-0.1	1.4	-1.2	1.1	0.9	0.4	0.3
E07000149	South Norfolk	90,891	129	1.1	1.2	-0.8	-0.8	0.2	0.0	0.2
E07000150	Corby	8,028	65	2.6	-1.3	-1.2	1.6	-0.1	-0.2	0.1
E07000151	Daventry	66,560	79	-0.6	-0.7	-0.9	0.1	0.4	-0.8	-0.9
E07000152	East Northamptonshire	50,979	89	-0.2	-1.3	-0.8	0.3	-0.5	-0.3	0.1
E07000153	Kettering	23,349	97	0.4	-1.3	-0.8	0.5	0.1	-0.8	-0.6
E07000154	Northampton	8,077	220	0.6	-1.3	-0.9	0.7	0.9	0.2	-0.4
E07000155	South Northamptonshire	63,402	88	-0.1	-0.6	-0.9	0.1	0.9	-0.7	-0.5
E07000156	Wellingborough	16,304	76	-0.6	-1.3	-0.3	-0.3	0.1	-0.7	-0.6
E07000171	Bassetlaw	63,949	114	-1.4	0.7	-0.3	0.0	-1.7	-0.4	-0.3
E07000175	Newark and Sherwood	65,184	118	-0.5	-0.7	-0.6	-0.2	-1.5	-0.3	-0.4
E07000177	Cherwell	58,874	145	-0.4	1.3	-0.5	0.7	1.4	-0.7	-0.4
E07000200	Babergh	61,204	89	-1.0	1.0	0.5	-0.7	0.2	0.9	-0.2
E07000201	Forest Heath	37,771	63	1.1	0.1	-0.3	2.9	-0.5	0.9	4.6
E07000202	Ipswich	4,030	135	-0.8	1.7	-0.9	-0.2	0.9	0.5	-0.7
E07000203	Mid Suffolk	87,107	99	-0.4	1.7	-0.4	-1.7	0.1	-0.9	-0.9
E07000204	St Edmundsbury	65,697	112	-1.0	1.3	0.8	-0.2	0.2	-0.5	0.4
E07000205	Suffolk Coastal	92,070	125	-1.4	1.0	-0.4	0.6	0.0	3.1	1.5
E07000206	Waveney	37,479	116	-1.3	0.3	-0.7	-0.2	0.2	1.8	0.9
E08000017	Doncaster	56,855	304	-1.9	-1.2	0.0	0.6	-1.9	-0.7	1.5
E09000016	Havering	11,446	246	1.9	-1.3	-0.6	2.7	1.6	0.7	0.1

B3 Maximum z Scores and Classification Results

Key to Variable Names			
MAX_Z_PRESS	Maximum pressure z score	MAXZ_NC_CAT	Classes of maximum natural capital z score
MAX_Z_NCAP	Maximum natural capital z score	FINAL_CAT	Final nine class classification
MAXZ_P_CAT	Classes of maximum pressure z score		

ID CODE	NAME	MAX_Z_PRESS	MAX_Z_NCAP	MAXZ_P_CAT	MAXZ_NC_CAT	FINAL_CAT
E07000143	Breckland	1.5	2.3	3	3	9
E09000016	Havering	1.9	2.7	3	3	9
E06000032	Luton	1.7	2.4	3	3	9
E07000077	Uttlesford	2.0	2.2	3	3	9
E07000150	Corby	2.6	1.6	3	2	8
E06000012	North East Lincolnshire	1.7	1.9	3	2	8
E07000008	Cambridge	1.6	0.0	3	1	7
E06000056	Central Bedfordshire	2.0	0.6	3	1	7
E07000202	Ipswich	1.7	0.9	3	1	7
E07000203	Mid Suffolk	1.7	0.1	3	1	7
E07000136	Boston	0.3	2.8	2	3	6
E07000010	Fenland	0.8	2.6	2	3	6
E07000201	Forest Heath	1.1	4.6	2	3	6
E07000145	Great Yarmouth	0.4	3.9	2	3	6
E07000147	North Norfolk	0.3	2.4	2	3	6
E07000140	South Holland	0.1	2.9	2	3	6
E07000205	Suffolk Coastal	1.0	3.1	2	3	6
E07000004	Aylesbury Vale	1.4	1.4	2	2	5
E07000066	Basildon	0.4	1.3	2	2	5
E07000067	Braintree	0.4	1.5	2	2	5
E07000068	Brentwood	0.7	1.5	2	2	5
E07000177	Cherwell	1.3	1.4	2	2	5
E07000009	East Cambridgeshire	0.6	1.8	2	2	5
E07000137	East Lindsey	0.9	1.8	2	2	5
E07000072	Epping Forest	1.2	1.3	2	2	5
E07000011	Huntingdonshire	0.2	1.0	2	2	5
E07000148	Norwich	1.4	1.1	2	2	5
E07000012	South Cambridgeshire	0.9	1.6	2	2	5
E06000033	Southend-on-Sea	0.4	1.3	2	2	5
E06000034	Thurrock	1.4	1.1	2	2	5
E07000206	Waveney	0.3	1.8	2	2	5
E07000200	Babergh	1.0	0.9	2	1	4
E07000171	Bassetlaw	0.7	0.0	2	1	4
E06000055	Bedford	1.4	1.0	2	1	4
E07000070	Chelmsford	1.3	0.9	2	1	4
E07000071	Colchester	0.8	0.9	2	1	4
E07000131	Harborough	0.1	0.2	2	1	4
E07000153	Kettering	0.4	0.5	2	1	4
E07000146	King's Lynn and West Norfolk	0.6	0.6	2	1	4
E07000074	Maldon	0.5	0.6	2	1	4
E06000042	Milton Keynes	1.2	0.8	2	1	4
E07000099	North Hertfordshire	1.1	0.8	2	1	4
E07000154	Northampton	0.6	0.9	2	1	4
E06000031	Peterborough	0.4	0.6	2	1	4
E07000141	South Kesteven	0.1	0.0	2	1	4
E07000149	South Norfolk	1.2	0.2	2	1	4
E07000204	St Edmundsbury	1.3	0.8	2	1	4
E07000076	Tendring	0.2	0.7	2	1	4
E07000142	West Lindsey	0.4	0.3	2	1	4
E07000069	Castle Point	-0.7	2.4	1	3	3
E07000144	Broadland	-0.3	1.3	1	2	2
E08000017	Doncaster	-1.2	1.5	1	2	2
E06000013	North Lincolnshire	-0.1	1.1	1	2	2
E07000151	Daventry	-0.6	0.4	1	1	1
E07000152	East Northamptonshire	-0.2	0.3	1	1	1
E07000138	Lincoln	-0.8	0.2	1	1	1
E07000133	Melton	-0.5	0.3	1	1	1
E07000175	Newark and Sherwood	-0.5	-0.2	1	1	1
E07000139	North Kesteven	-0.3	0.6	1	1	1
E07000075	Rochford	-0.6	0.9	1	1	1
E06000017	Rutland	-1.0	-0.1	1	1	1
E07000155	South Northamptonshire	-0.1	0.9	1	1	1
E07000156	Wellingborough	-0.6	0.1	1	1	1