Reimagining the Levels, Making the Connections

Technical Annex
to the main project report

October 2016

Reimagining the Levels – Making the Connections

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1. Introduction

This document provides background evidence and analysis to support the main 'Reimagining the Levels, Making the Connections' project report. That report assesses the main drivers of change affecting the Catchment of the Somerset Levels and Moors, proposes a set of thematic and spatial objectives and makes 11 recommendations for consideration by local organisations and communities.

This Technical Annex adopts a different style, using maps, graphs, tables and text to set out the analysis that the Reimagining the Levels group has used to draw up their objectives and recommendations for the area. Sources of information are referenced in footnotes and listed in a bibliography.

1.1. Background to the project

The 'Reimagining the Levels' project emerged following an Open Space event held in Glastonbury in June 2014, exploring a sustainable future for the Somerset Levels. The project was established by a small group of individuals who live on the Levels and Moors and who, as members of community organisations such as Red Brick Enterprise (Glastonbury), Transition Athelney and Green Wedmore, have an interest in developing what they see as a sustainable long term future for the area.

Early in 2016, the group were successful in raising a budget from two small grants to undertake a short research programme and publish and disseminate its findings. The group engaged Robert Deane of Rural Focus Ltd to undertaken background research and consultation and draft the project outputs. The purpose of the project and the research topics it has sought to address are described in **Figure 1**.

Figure 1. Purpose and scope of the project

- To investigate precedents in both policy and practice which would help implement the vision for water and land management across the whole catchment supplying the Levels and Moors, which would reconcile the needs for conservation and livelihood and also contribute to global sustainability objectives.
- To present information on these issues in an accessible format that informs and stimulates dialogue between communities, landowners and decision-makers about priorities for future action.

  Note: The project took the vision prepared in January 2014 by the Levels and Moors Task Force as its starting point, and reviewed its current relevance and achievability.

The project was guided by the following research questions:

1. What is currently happening / known?	What are the issues facing the future of the area and what research and other information is available to shed light on these?
2. What needs to happen?	What are the practical solutions, in terms of land use and water/land management, that are likely to be best at producing an appropriate balance of conservation, farming and flood risk management? (these are listed alphabetically not necessarily in precedence)
3. What will it look like?	Where will these practical solutions be most effective and how might they change the existing patterns of land use and management across the catchment?
4. Who decides?	Who needs to be involved to reach agreement and what decision-making mechanisms will be needed? Are existing democratic structures suitable or will new approaches be needed?

At the outset of the project, it was intended that the key focus of the work should be the growing risk of flooding to people and the environment on the Levels, and the approaches that should be adopted to address this in a sustainable manner, taking account of the need to influence climate change, as a key causes of

flooding. Half way through the project, the UK referendum vote to leave the EU inevitably broadened the scope of the work. While not wishing to dilute the attention the project gave to flooding, it was decided to widen its remit to consider the potential impacts of Brexit to the landscape and communities of the area.

1.2. The Project Area

The focus on flooding, and the groups' firm belief that action to reduce flood risk must take place across the whole catchment, meant that the project area was defined by the watershed of the rivers Parrett, Tone, Axe and Brue that drain into Bridgwater Bay (**Figure 2** on the following page). As the inset on Figure 2 shows, there is a relatively strong coincidence between these river catchments and the county of Somerset, with the exception of West Somerset District which has only a small area in the catchment and Mendip District, the southern half of which is in the catchment.

Figure 4 on page 5 shows how the full catchment can be sub-divided into the watersheds of the main rivers, based on the catchment boundaries developed by the Environment Agency for the EU Water Framework Directive. The lower catchments of the Parrett, Tone, Brue and Axe occupy just over a third of the area (35%).

Key land use data for full catchment and its sub-catchments, along with comparable data for England as a whole, are shown in **Figure 3**. These show that the southern half of the catchment is dominated by arable cropping, particularly the Lower Parrett and Tone, and Upper Isles, Cary and Yeo, whereas the Brue and Axe catchments north of the Polden Hills tend to be pasture dominated.

1.3. Structure of this Annex

As part of its work to prepared the main report, the project group chose to subdivide the issues and opportunities facing the catchment of the Somerset Levels and Moors into six topics. Each of these topics has a separate section in this document.

- Section 2 summarises the issues relating to **water and flood risk management** in the Catchment. It describes the rivers and weather patterns of the area and the factors that lead to flooding. It reviews the likelihood of future flooding and the development of flood defence measures and looks at how the risk of flooding is currently managed.

- Section 3 examines the effects that the **changing climate**, particularly sea level rise, are likely to have on the Catchment. It also looks at what types of activity in the Catchment are contributing to climate change and the types of mitigation and adaptation actions that are taking place.

- Section 4 describes the **natural environment** of the Levels Catchment, covering its landscapes, wildlife and natural resources and sources of energy. It examines their current condition and health as a way of identifying opportunities for better protecting the area's natural capital.

- Section 5 reviews **agricultural land use and production** in the Catchment, looks back at recent changes in farming and examines the types of environmental management taking place on farms.

- Section 6 describes the **socio-economic characteristics** of the Catchment, looking at the characteristics of the people and communities who live in the area and also its economy. It focusses on the land-based sectors of farming and forestry and on the tourism and hospitality sectors as key drivers in the area's rural economy.

- Section 7 provides a brief description of the **history of drainage and flood management** on the Levels and Moors.

Finally, a bibliography lists sources of information which have been referenced in the main report and this annex or which provide valuable background information.

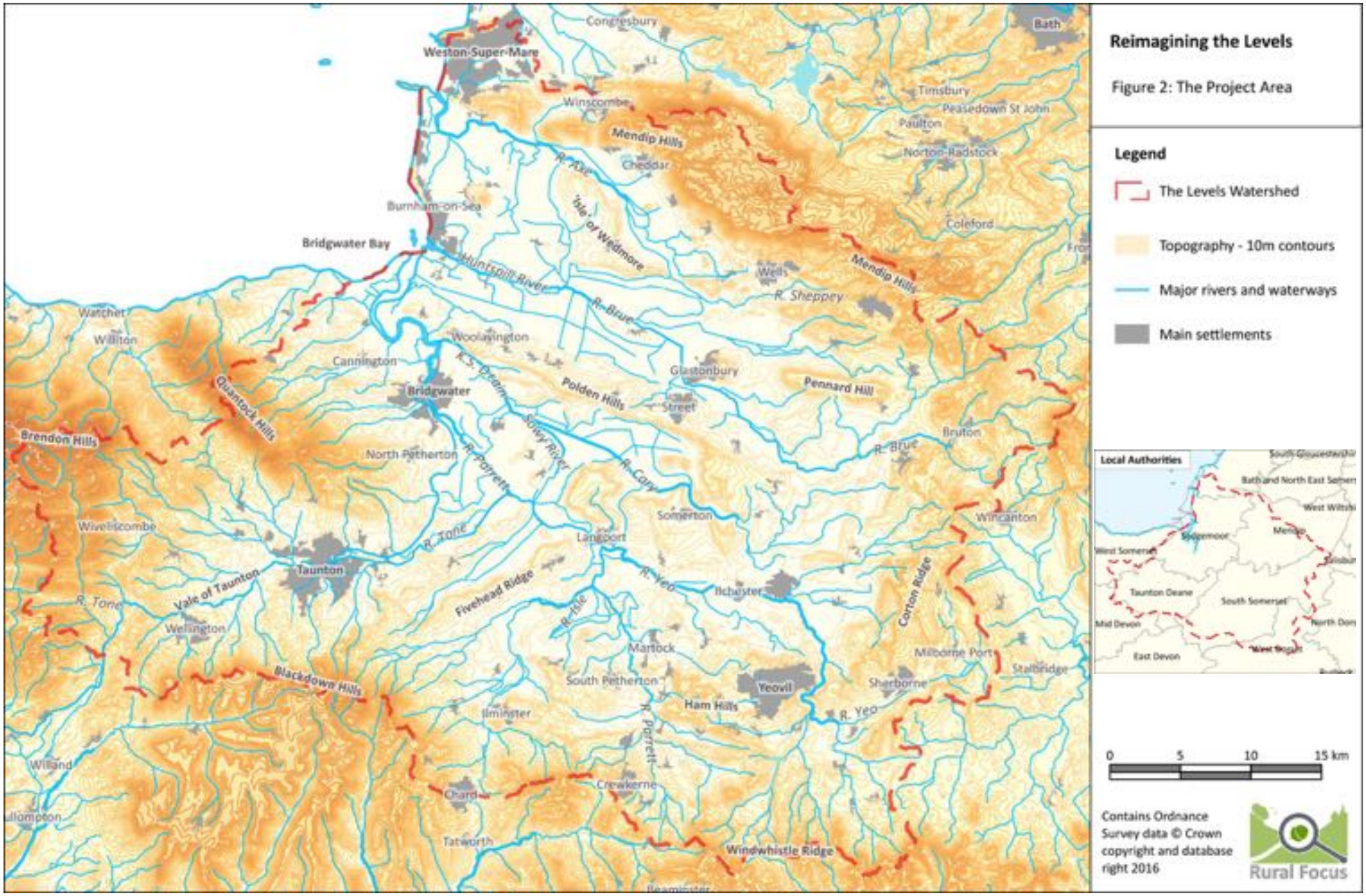

Reimagining the Levels
Figure 2: The Project Area
Legend
The Levels Watershed
Topography - 10m contours
Major rivers and waterways
Main settlements
Local Authorities
0 5 10 15 km
Contains Ordnance Survey data © Crown copyright and database right 2016
Rural Focus
Weston-Super-Mare
Congresbury
Bath
Timsbury
Peasedown St John
Paulton
Norton-Radstock
Winscombe
Mendip Hills
Cheddar
Burnham-on-Sea
Bridgwater Bay
Coleford
Wells
R. Sheppey
R. Axe
Isle of Wedmore
Huntspill River
R. Brue
Watchet
Williton
Woolavington
Cannington
Glastonbury
Pennard Hill
Polden Hills
Street
Bridgwater
Quantock Hills
Brendon Hills
North Petherton
R. Parrett
Sowy River
R. Cary
Bruton
Somerton
Wincanton
Wiveliscombe
Langport
R. Tone
Taunton
Vale of Taunton
Fivehead Ridge
R. Yeo
Ilchester
Corton Ridge
Wellington
Martock
Milborne Port
Stalbridge
Blackdown Hills
South Petherton
Yeovil
Sherborne
Ham Hills
Ilminster
Willand
Crewkerne
Chard
Tatworth
Windwhistle Ridge

Figure 3. Key Land Use Data by Sub-catchments

(See Figure 4 on page 5 for location map)

Data from GIS analysis. Percentages show proportion of subcatchment area in each land use category. Shading indicates high values within each dataset.	Levels and Moors		Middle and Upper Catchments									Whole Catchment	England comparison
	Lower Brue/Axe	Lower Parrett/Tone	Upper Axe	Upper Sheppey	Upper Brue	Upper Cary	Upper Yeo	Upper Parrett	Upper Isle	Upper Tone	Quantock Streams		
Proportion of whole catchment	17.8%	17.3%	4.9%	3.4%	7.4%	3.5%	14.0%	6.3%	6.1%	15.1%	4.2%	**100.0%**	n/a
DOMINANT LANDCOVER based on aggregated data in 1km squares (Land Cover Map 2007)													
Arable	16.2%	56.8%	10.5%	31.5%	27.8%	68.9%	45.7%	62.2%	74.5%	39.7%	60.7%	**42.2%**	48.6%
Improved grassland	72.4%	39.4%	81.6%	63.1%	69.5%	24.3%	45.0%	30.8%	19.5%	50.4%	20.5%	**49.7%**	27.6%
Other landcover	11.5%	3.8%	7.9%	5.4%	2.7%	6.8%	9.3%	7.0%	6.1%	9.9%	18.9%	**8.1%**	23.9%
PRIORITY HABITATS (Natural England)													
Coastal and floodplain grazing marsh	45.2%	28.2%	6.7%	0.0%	1.5%	2.2%	1.7%	1.2%	1.5%	1.7%	9.5%	**14.5%**	1.6%
Deciduous woodland	1.3%	2.3%	5.8%	6.0%	2.8%	4.9%	4.7%	2.6%	4.3%	5.9%	5.3%	**3.7%**	5.6%
Good quality semi-improved grassland	0.5%	0.3%	3.6%	0.4%	0.7%	0.2%	0.4%	0.4%	0.6%	0.7%	0.4%	**0.6%**	n.a.
Lowland calcareous grassland	0.5%	0.4%	3.9%	0.9%	0.6%	0.4%	0.3%	0.3%	0.0%	0.0%	0.0%	**0.5%**	0.5%
Lowland dry acid grassland	0.0%	0.0%	2.3%	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	0.2%	0.1%	**0.2%**	0.1%
Lowland heathland	0.1%	0.0%	2.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.2%	**0.2%**	0.4%
Lowland meadows	0.5%	5.3%	0.5%	0.3%	0.2%	1.0%	0.3%	0.7%	0.3%	0.2%	0.0%	**1.2%**	0.3%
Purple moor grass and rush pastures	0.5%	0.1%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.1%	0.0%	**0.1%**	0.1%
Traditional orchards	0.7%	0.9%	0.3%	0.7%	1.0%	0.5%	0.4%	1.1%	0.4%	0.4%	0.2%	**0.6%**	0.1%
All priority habitats (incl some not listed above)	53.6%	38.5%	27.2%	8.5%	7.1%	9.7%	8.6%	6.5%	8.1%	10.0%	22.5%	**23.2%**	14.1%
WOODLAND (National Forestry Inventory 2014)													
Broadleaved	2.0%	2.5%	7.0%	6.5%	3.1%	6.0%	5.2%	3.0%	4.5%	6.6%	5.4%	**4.2%**	5.9%
Conifer	0.1%	0.4%	1.3%	0.7%	1.2%	0.7%	1.7%	0.6%	1.3%	1.6%	5.9%	**1.1%**	2.4%
Mixed	0.1%	0.2%	0.2%	0.3%	0.3%	0.5%	0.3%	0.2%	0.6%	0.7%	0.3%	**0.3%**	0.4%
Other woodland	0.3%	0.3%	1.0%	0.3%	0.7%	1.0%	0.6%	0.3%	0.4%	0.7%	1.2%	**0.5%**	1.1%
All woodland	2.4%	3.3%	9.6%	7.9%	5.4%	8.2%	7.9%	4.1%	7.0%	9.7%	13.0%	**6.3%**	9.8%
AREAS AT RISK OF FLOODING FROM RIVERS AND THE SEA (Environment Agency)													
High (>1 in 30 year risk)	1.9%	26.7%	6.9%	0.9%	3.8%	7.0%	4.4%	3.4%	4.4%	3.4%	11.0%	**7.9%**	4.8%
Medium (1 in 30 to 1 in 100 yr risk)	9.4%	7.6%	2.8%	1.5%	3.5%	3.0%	2.1%	1.6%	2.7%	1.9%	5.8%	**4.6%**	3.9%
Low (1 in 100 to 1 in 1,000 yr risk)	23.0%	8.3%	1.0%	0.8%	1.2%	1.3%	1.3%	1.0%	1.1%	1.6%	2.7%	**6.4%**	3.8%
BUILT UP AREAS (ONS, 2011)	10.1%	6.0%	5.6%	8.7%	3.2%	8.8%	6.8%	6.2%	4.9%	7.2%	1.7%	**6.8%**	10.4%
LARGE SETTLEMENTS	Weston-S-M Highbridge & Burnham Street Glastonbury	Bridgwater	Cheddar	Wells Shepton Mallet		Somerton	Yeovil Sherborne	Crewkerne	Chard Ilminster	Taunton Wellington			

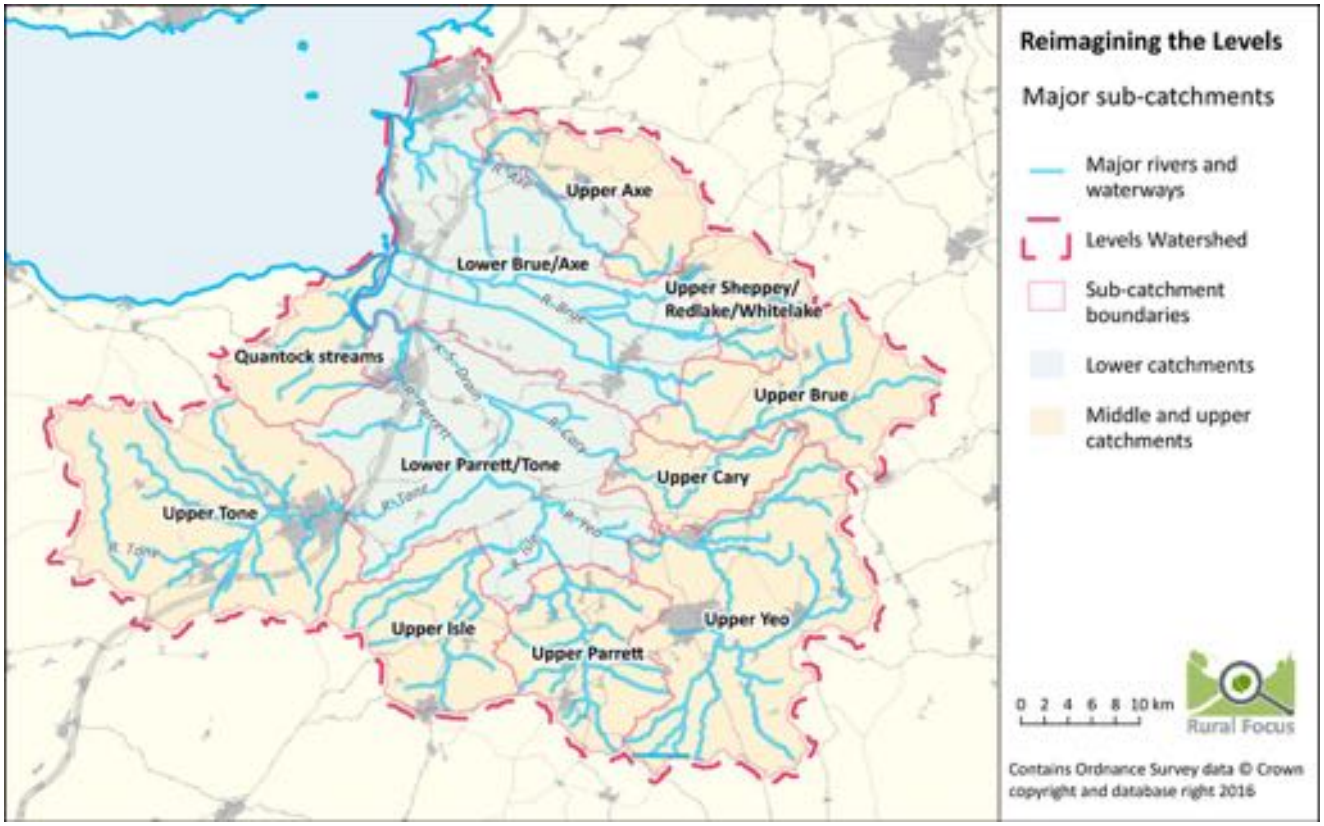
2. Water and flood management

This section summarises the issues relating to flooding and flood risk management in the Catchment. It describes the rivers and weather patterns of the area and the factors that lead to flooding. It reviews the likelihood of future flooding and the development of flood defence measures and looks at how the risk of flooding is currently managed. Section 7 of this Annex summarises the history of drainage and flood management on the Levels and Moors.

2.1. Rivers, weather and the causes of flooding

The rivers that flow through the Somerset Levels drain a catchment that is 2,464 km^2 in size. South of the Polden Hills, the River Parrett and its tributaries the Tone, Isles and Yeo reach the sea at Bridgwater and the River Cary flows out at Dunball. North of the Poldens, the River Brue and its tributaries the Sheppey, Redlake and Whitelake, and the River Axe, reach the sea at Weston-super-Mare and Highbridge respectively. As explained further below, the lower sections of these rivers have been modified with new cuts and rhynes to improve drainage and the Parrett is now connected to the Cary/King's Sedgemoor drain via the Sowy River. The Parrett/Cary river system covers two thirds of the Catchment, carrying about 750 million m^3 of water a year, compared to the 375 million m^3 carried by the Brue and Axe.

Figure 4. Major sub-catchments within the Somerset Levels Watershed



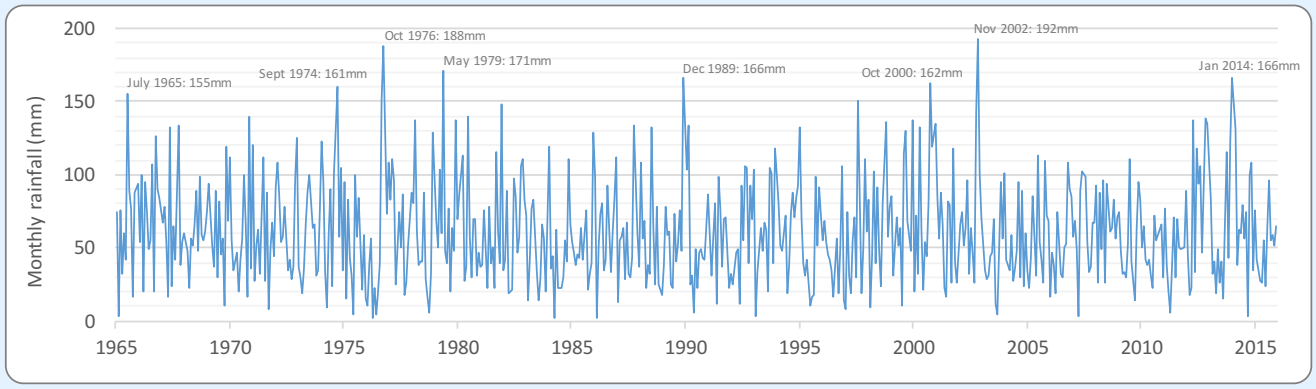
Rainfall

Annual rainfall across the Catchment is around 750mm a year, with about 80mm monthly in the winter and 50mm monthly in the summer[1]. These average amounts are often exceeded by periods of heavy rain and the records kept at Yeovilton show that there have been 37 months in the last 50 years where monthly rainfall has exceeded 120mm (which is twice the monthly average of 60mm) (**Figure 5**). Often it is a period of several

[1] Met Office online data for Cannington, Yeovilton and Weston-super-Mare. www.metoffice.gov.uk/public/weather/climate accessed 23/05/16.

months of high rainfall which lead to the worst flood events, such as between December 2013 and February 2014 when the Yeovilton records show that 419mm of rainfall fell, which was more than half of the annual average.

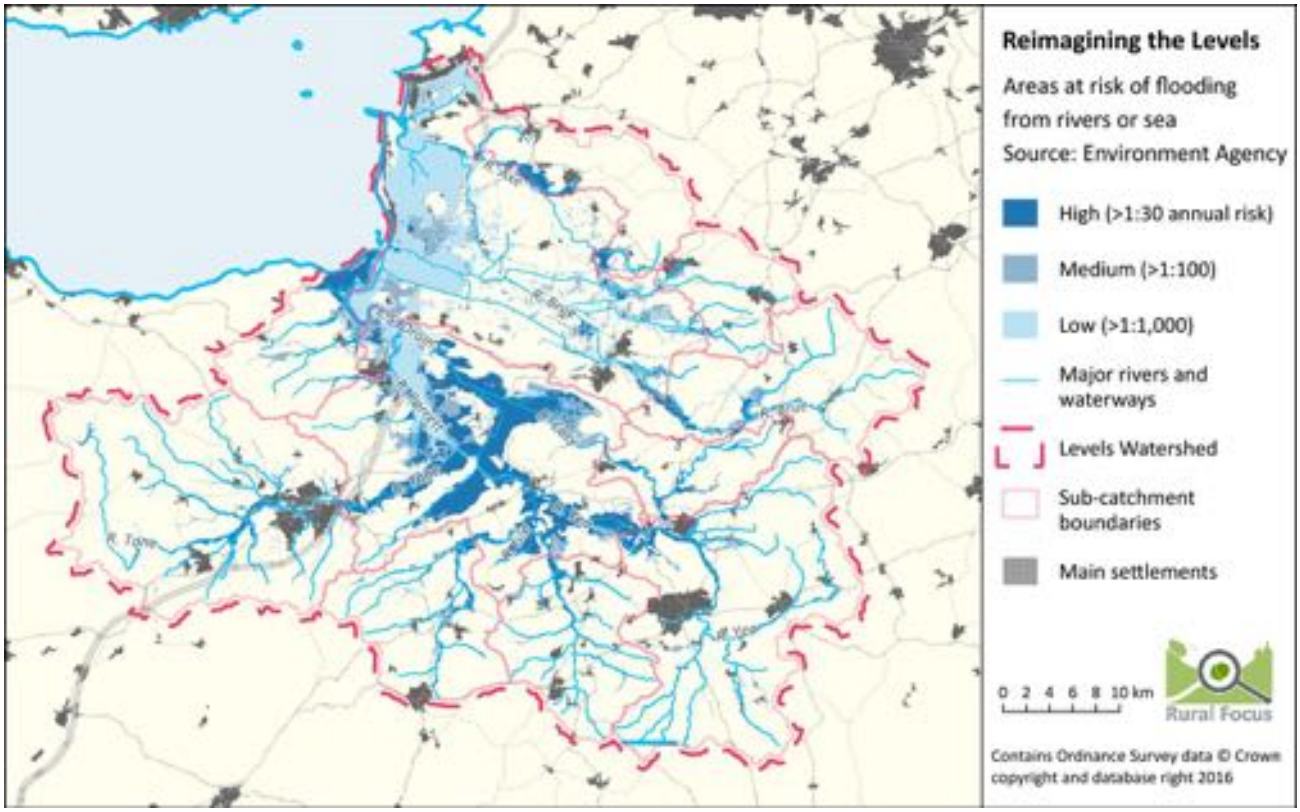
Figure 5. Monthly rainfall totals at Yeovilton 1965 to 2015, highlighting peak months



Source: Historical monthly data for meteorological station Yeovilton, Met Office. Accessed at www.data.gov.uk, April 2016

Flooding is, and has always been, a natural phenomenon of the Levels. Nearly a quarter (22%) of the Catchment is less than 10m above mean sea level and 8% is classified as being at high risk (1 in 30 annual risk) of flooding from rivers or the sea by the Environment Agency. The areas classified as being at high, medium and low risk of flooding are shown in **Figure 6**.

Figure 6. Areas in the Catchment at risk of flooding from rivers or the sea



Causes of flooding

Flooding occurs from a combination of four sources of water:

- Firstly, rain falling onto the land saturates the upper surfaces of the soil and lies on the surface or runs-off downslope. This **surface water flooding** is exacerbated by urban development that replaces porous soil with less porous surfaces such as tarmac and concrete and also by damage to the soil structure which can occur from intensive farming practices.

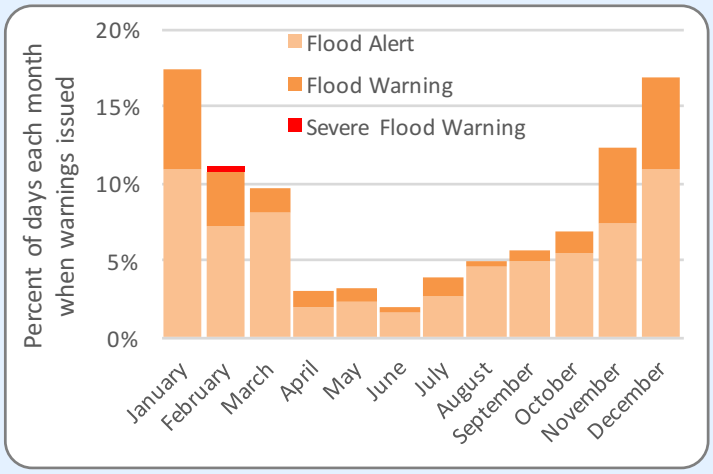
- Secondly, the channels of water courses and rivers become full and water over-tops the river banks and spreads out over the available flood plain. This **fluvial flooding** can be exacerbated by a build-up of silt in the river channel (from soil eroded higher up the catchment) and reductions in the area of the functional flood plain (from flood protection schemes of urban areas or farmland).

- Thirdly, high sea tides and waves can cause **marine flooding** at the coast and, most significantly on the Levels, restricting the amount of water that discharges from the rivers to the sea and backing-up water inland. This is discussed further below.

- Finally, prolonged periods of high rainfall can raise the water table to the level of the ground surface, causing **ground water flooding**. This also significantly increases the risk of **surface water flooding.**

The influence of sea level on flooding of the Levels is significant. The tides at Bridgwater regularly rise to 6.4m above mean sea level and atmospheric pressure and wind can increase this to 8m (levels that are projected to increase with the changing climate). Although sea walls and tidal sluices/locks (called clyses on the levels) across most of the rivers prevent sea water from flowing up the rivers (only the River Parrett is tidal inland to Oath Lock on the Parrett and to New Bridge on Curry Moor on the Tone), the height of the tide still determines the outflow from all the rivers. 'Tide-lock' occurs when the sea level prevents the level of water in rivers from discharging to the sea and all the water flowing down the rivers must accumulate within the river channel or, if there is no room for it, must flood over the river banks to the surrounding land. The volumes of water involved during tide-lock can be enormous. If tide-lock occurs for 4.5 hours around each high tide, the river channel must be able to accommodate 16,200 times its normal river flow in order to avoid flooding[2].

Figure 7. Monthly frequency of flood warnings for the Catchment 2006 to 2015



Source: Historic Flood Warnings data from the Environment Agency. www.data.gov.uk

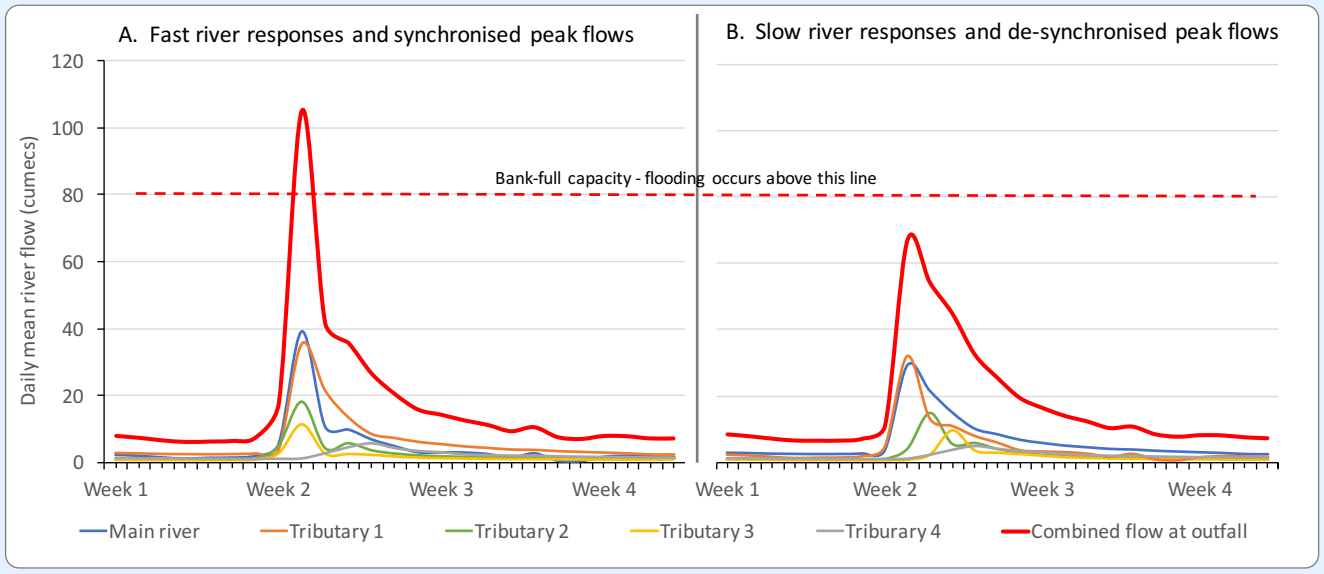
Rainfall tends to be concentrated in the winter months and, as soils in the Catchment become saturated, flooding is much more likely to occur between November and February than during the drier summer months. **Figure 7** shows the monthly frequency of flood warnings issued by the Environment Agency in the Catchment since 2006.

Another key influence that affects flooding is the speed with which rainfall is carried into the rivers and flows downstream (known as the 'flashiness' of the Catchment) and also the way that peak flows of flood water from different tributaries combine where the rivers join. **Figure 8** compares river flows from two theoretical river systems over a four-week period, both of which receive the same amount of rain. Graph A on the left shows rivers with a relatively fast ('flashy') response where most of their peak flows occur at the same

[2] Williams (1970). The Draining of the Somerset Levels. Cambridge University Press Page 10.

time ('synchronised')) while the graph on the right shows rivers with slower responses and desynchronised peak flows. The overall effect on flooding is shown with the dashed red line, showing how flooding occurs in Graph A but is avoided in Graph B.

Figure 8. Theoretical graphs comparing responses of different rivers systems to the same amount of rain



The rivers and catchments flowing through the Somerset Levels have response curves that are typical of those in lowland farmed catchments and the peak flows tend to be synchronised, similar to the situation in Graph A above. The speed with which catchments respond to rainfall depends on a range of factors including the underlying geology and topography and the use and management of land. Run-off occurs much faster on compacted soils with sparse vegetation, compared to soils with open structures and closed vegetation. The scope for management interventions to move from Graph A to Graph B are discussed below.

Data on the daily mean flow of rivers in England has been collected at a series of flow stations since the mid 1960s, now available online at the National River Flow Archive[3], and this provides a means of examining how often high river flows occur. **Figure 9** presents data from river stations on the River Parrett and its tributaries, showing the annual frequency with which particularly high river flows (ten times the mean daily flow) have taken place. It shows that these high river flow events, which usually lead to flooding, have occurred much more frequently in the fifteen years since 2000 than they did in the 15 years between 1970 and 1985. Whether this is evidence of a long term trend which will carry on in the future, or whether the high river flows in 2001, 2001, 2013 and 2014 are chance events, is not known.

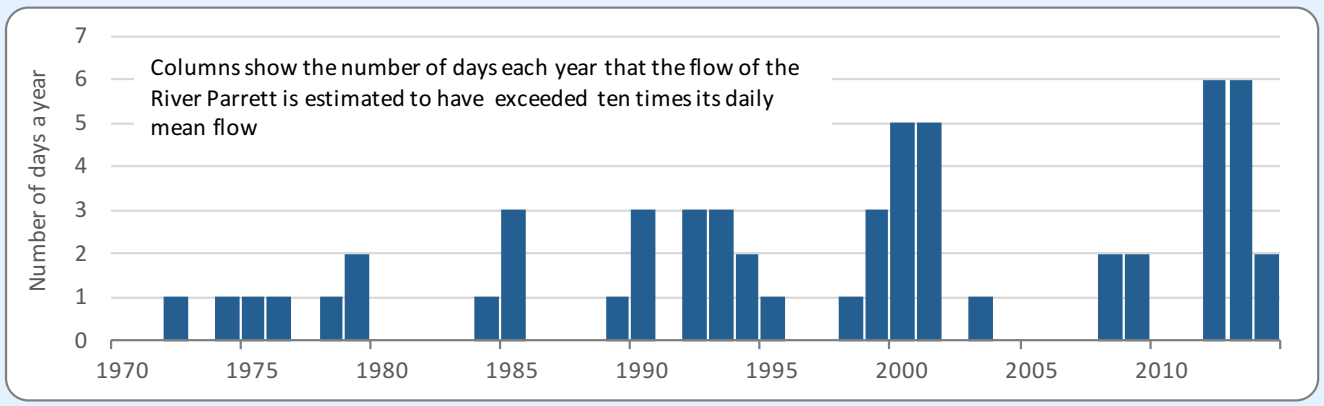
It is interesting that a similar trend in the increased frequency of severe rainfall events is not evident from Figure 5, above. This poses the question of whether changes in land use and management in recent decades, particularly in the middle and upper catchment, have played a role in the growing frequency of high peak flows of the Parrett. It is possible, even likely, that trends such as declining organic matter content and declining soil structure in arable soils and compaction of pasture soils[4], could be increasing the 'flashiness' of catchments. While this issue has been raised nationally by acknowledged experts and researchers[5] the link between land use and management and the response of river flows at a whole catchment scale has not been established conclusively. The role of land management across the whole catchment in flood risk management is covered further later in this section (2.5. Natural Flood Management on page 14)

[3] See: http://nrfa.ceh.ac.uk

[4] Trends have been demonstrated nationally by the National Soils Inventory http://www.landis.org.uk/data/nsi.cfm. Trends in the South West are analysed in Palmer RC and Smith RP (2013). *Soil structural degradation in SW England and its impact on surface-water runoff generation*. Soil Use and Management, DOI: 10.1111/sum.12068.

[5] See for instance the paper by Howard Wheater from Imperial College London, analysising data from flooding that took place in 2001: Wheater H (2006). *Flood hazard and management: a UK perspective*. Phil. Trans. R. Soc. Lond. A., 365: 2135-2145.

Figure 9. Estimated frequency of high river flows in the River Parrett 1970 to 2015



Source: Analysis by this project of data from the National River Flow Archive

The economic impacts of flooding

Flood events can have significant and far-reaching economic impacts. A study of the effects of the 2013/14 flooding of the Levels commissioned by Somerset County Council put the total cost of the impacts at £118 million (the central estimate), with £75 million of this being incurred in direct impacts, £9 million in indirect impacts and £35 million in qualitatively assessed impacts. Direct impacts included £17 million of costs to local government and the emergency services, £16 million to residential property owners or their insurance companies, £12 million to businesses and individuals as a result of highway and other travel disruption (plus £17 million for rail repairs) and £6 million losses to farmers.[6] These figures acknowledge the wider regional impacts that the event had. With the water taking up to 12 weeks to recede, there was significant impact on transport (road and rail closures), business and tourism at a regional level. The A361 was closed for almost three months and the mainline railway from Taunton to Bristol was closed at Fordgate for three weeks, causing significant disruption to the millions of journeys that take place through the Levels and Moors.

In recent years, other parts of the UK, such as Tewkesbury, York and Carlisle, have experienced severe flooding. These have caused economic and social impacts that have been just as harmful, if not more so, than those which have occurred in the Catchment in recent years.

2.2. The likelihood of future flooding

As already stated, flooding is a natural phenomenon, particularly on the Levels and Moors. It is not a case of 'if' severe flooding occurs again in Somerset, but 'when', for 'how long' and 'how severe'.

It is estimated by this study that around 120,000 people live in areas that are less than 10m above current mean sea level, the large majority of them in the towns of Weston-super-Mare, Bridgwater and Burnham-on-Sea, and around 20,000 in villages, hamlets and open countryside. Flood banks and other infrastructure currently provide protection but, as occurred most recently in 2013/14, these can be overwhelmed following severe rainfall and high tides.

Somerset County Council states that there are "*approximately 19,000 properties which are at risk from surface water flooding*"[7]. The town with the greatest number of properties at risk properties from surface water flooding is Taunton (1,300 households) but significant numbers of properties higher up the catchment are also threatened including 1,100 in Yeovil, 900 in Shepton Mallet and 500 in Ilminster[8].

Marine and tidal flooding poses a threat to communities along the coast, particularly Burnham-on-Sea and Highbridge. The risks to these communities may be compounded by bottle necks in the evacuation routes in

[6] Parsons Brinkoff (2015) Somerset Economic Impact Assessment of the winter 2013/14 Flooding. Report commissioned by Somerset County Council on behalf of the Somerset Rivers Authority. February 2015. http://www.somersetriversauthority.org.uk/useful-info/
[7] http://www.somerset.gov.uk/environment-and-planning/flooding/preparing-for-flood/
[8] Somerset County Council. Flood Map for Surface Water. Preliminary Flood Risk Assessment.

the event of a serious storm surge. Flooding from rivers overtopping their flood banks, exacerbated by high tides, is a threat to other communities such as Langport and Burrowbridge. Towns like Bridgwater and Taunton are at risk from a combination of surface water, marine and fluvial flooding. Flooding can also have serious impact on the wider regional economy by disrupting transport networks such as the Taunton to Bristol rail line and the M5 motorway.

The risk of flooding occurring in future is affected by a number of issues, some of which we have control over (such as the role that soils and vegetation play in slowing water runoff and flood generation) and others which we do not (such as the rate at which the land surface is falling in response to the last ice age – around 5cm every century in Somerset[9]). The changing climate, which is covered in more detail in the following section, is undoubtedly the most significant factor, both as a result of rising global sea levels (as warming temperatures cause glaciers and ice sheets to melt) and more extreme weather consisting of periods of more intense rainfall and storm surges of sea level.

The Met Office's UK Climate Projections 2009 (UKCP09) indicate that average sea level in Bridgwater Bay will increase by 36cm over the next 70 years and by nearly half a meter by 2100 (although recent research suggests these may be conservative estimates[10]). UKCP09 estimates that average annual rainfall in the South West of England will stay roughly the same but with significantly more falling in the winter and less in the summer. Critically, the number of days of heavy rain (exceeding 25 mm) are projected to increase by a factor of between 2 and 3.5 in winter, and 1 to 2 in summer by the 2080s. As a result, one-in-100 year flood events are likely to become twice as frequent by the 2050s and three to five times more frequent by the 2080s[11]. The recently published 'Projections of future flood risk' prepared for the forthcoming UK Climate Change Risk Assessment 2017, identified the Somerset coast as being one of areas most vulnerable to a 1m rise in sea level (with 22,000 properties in Weston-super-Mare and 11,000 properties in Bridgwater at risk from a 1-in-200 year event)[12].

As part of the Somerset WAVE project, JBA Consulting undertook hydraulic modelling of flood risk covering fluvial, tidal and surface water flooding. Existing models were used to generate new flood extent and flood depth maps under different scenarios for the present day (2010) and for the future year 2060 taking account of projected climate change. The scenarios modelled included both defended (with the existing flood defences in place and maintained to the present day levels), and undefended (with the existing flood defences breached) situations.

The results of the modelling are illustrated through a series of photo- visualisations from different locations. **Figure 10** shows the view looking south from Brent Knoll. It compares two 1-in-200 year events (a 0.5% chance of occurrence in any year). The top photo-visualisation shows relatively little flooding in this area under the current climate characteristics with current flood defences in place. The bottom photo-visualisation shows the extensive flooding that would take place if the climate projections for 2060 take place and if the current flood defences failed (for instance by breaches to sea walls)[13].

The lesson of the flood risk modelling scenarios is that it is the combination of extreme weather events (such as a tidal surge in the Bristol channel or a period of unusually intense rainfall in the upper catchment), coming on top of the long term rises in sea level and winter rainfall, that poses the greatest risk of overwhelming flood defences and causing catastrophic flooding in the future.

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[9] Bradley, S., Milne, G.A., Teferle, F. N., Bingley, R. M., & Orliac, E. J. (2008). *Glacial isostatic adjustment of the British Isles: New constraints from GPS measurements of crustal motion*. Geophysical Journal International, doi:10.1111/j.1365- 246x.2008.04033.x.

[10] For instance, analysis of historic sea levels shows that sea levels were around 6m higher when global temperatures were 2°C higher than they are now. 2°C is the target for limiting global average temperature rise. A Dutton, A E Carlson, A J Long, G A Milne, P U Clark, R DeConto, B P Horton, S Rahmstorf, M E Raymo. (2015). *Sea-level rise due to polar ice-sheet mass loss during past warm periods*. Science 10 Jul 2015: Vol. 349, Issue 6244, DOI: 10.1126/science.aaa4019

[11] United Kingdom Climate Projections 2009 (UKCP09). These are average UK estimates based on the medium emissions scenario and 50% probability estimate.

[12] Sayers and Partners LLP (2015). *UK Climate Change Risk Assessment 2017: Projections of future flood risk*. Report to the Climate Change Committee. October 2015

[13] See http://www.somersetwave.co.uk/managing-flood-risk.php

Figure 10. Visualisations of '200 year' tidal flooding events looking south from Brent Knoll over the coastal areas of the Levels and Moors

Source: http://www.somersetwave.co.uk/managing-flood-risk.php

2.3. Current policy and practice to address flood risk in the catchment

The approach of public bodies to flood protection and dealing with flood risk is set out in a number of policy documents. These include the Environment Agency's Catchment Flood Management Plans (those for the Parrett and North/Mid Somerset catchments were last revised in 2011); the County Council's Surface Water Management Plans (including Taunton in 2013 and Weston-Super-Mare in 2014); and other technical documents such as the 2014 Flood Risk Management Review for Bridgwater and the Levels and Moors[14]. However, during the last two years most of the strategic planning by bodies such as the Environment Agency, County Council and Drainage Boards has gone into developing the **Somerset Levels and Moors 20 Year Flood Action Plan**.

During the flooding in 2013/14, the Environment Secretary, Owen Patterson, challenged organisations working in Somerset to prepare a single overarching plan that will guide water and land management policies and investment in the Parrett, Tone, Axe and Brue catchments for the next twenty years.

The resulting 20 Year Flood Action Plan describes the work that is needed to address six objectives. These objectives are reducing flood duration and frequency; maintaining access for affected communities; ensuring regional transport connectivity; maintaining the special characteristics of the Levels and Moors; increasing resilience to flooding; and enhancing business confidence and growth.

The actions in the Flood Action Plan are grouped under five themes, the first three of which aim to reduce flood risk and the final two to mitigate the impact of flooding that does occur. The actions proposed under these themes and the objectives to which they relate are summarised in **Figure 11**. The work of co-ordinating the delivery of the Flood Action Plan has fallen to the Somerset Rivers Authority, formed in 2015 (described further below).

Another important initiative that is currently taking place in the catchment is the **Hills to Levels Project**. This is a partnership between Somerset farming and nature charities that is helping landowners and farmers to farm in a way that reduces flood risk throughout the county while enhancing wildlife and producing high quality food. The project is administered by the Royal Bath and West Society and is currently funded by players of People's Postcode Lottery. The project is being delivered by the Royal Society for the Protection of Birds (RSPB), Farming and Wildlife Advisory Group (FWAG SW) and Somerset Wildlife Trust. Their work is contributing to the land management strand of the Somerset Rivers Authority's Flood Action Plan.

One thread of the Hills to Levels project is exploring the establishment of a **Land Trust** to own, lease or otherwise rent land at high risk of flooding, and to support the management of similar land by others, so that these areas can bring a wide range of benefits to the local communities, businesses and the environment of the Levels and Moors for years to come. This work is being taken forward by a farmer at Pawlett, Will Barnard.

2.4. Risks of drought

Although the main issue of concern in the Levels and Moors has understandably been flooding, it is important not to forget that periods of low rainfall and high temperatures can also cause problems. The UKCP09 projections of climate change suggest that by 2080 (under the medium emissions scenario), summer temperatures will be nearly 4°C higher compared to the average between 1961 and 1990 and that summer rainfall will be less by nearly a quarter, with more periods of extreme hot dry weather. This is likely to have impacts on agricultural productivity (causing periods of heat and drought stress to crops and livestock) and to wetland habitats and soils (particularly on peat which decomposes when it dries out). In future, it will therefore be even more important to maintain water levels in summer as well as deal with flooding which occurs mainly, but not exclusively, in the winter.

[14] Black and Veatch (2014). *Protecting Bridgwater and the Somerset Levels & Moors from Tidal Flooding - Flood Risk Management Review*. Report for the Environment Agency and Sedgemoor District Council. November 2014

Figure 11. Summary of action proposed in the 20 Year Flood Action Plan

Themes and Actions	**Objectives** (see text above) Reduce flooding	Local Access	Connect-ivity	Special character	Resilience	Economy
DREDGING AND RIVER MANAGEMENT						
River dredging and other channel maintenance	●	●	●	●		
Enhancing pumping capacity (Dunball Sluice, Northmoor, Bridgwater Taunton Canal)	●					
Repair and reinstate river and flood banks and spillways	●	●				
Local riparian maintenance	●					
Sowy/Kings Sedgemoor Drain Capacity Improvements	●	●	●	●		
Design and evaluate a Bridgwater tidal barrier	●	●		●	●	●
Evaluation, research, strategy development and governance	●	●		●	●	
LAND MANAGEMENT						
Pilot advice, grants and other measures to deliver natural flood management	●			●	●	
Install woody debris dams in watercourses to slow the flow	●					
Review current and influence future agri-environment agreements	●			●		
Introduce simplified approvals process for works on minor watercourses by landowners	●					
Pilot a local Payment for Ecosystem Services scheme (flood risk, peat soils and water quality)	●			●		
Examine further innovative mechanisms (e.g. Community Land Trust)	●			●		
URBAN WATER MANAGEMENT						
Increase the use of sustainable drainage systems (SuDS) by planners and developers	●					
Deliver flood alleviation/ mitigation schemes in hotspots	●					
Review planning policies with regard to flooding, incl. development in flood plains and mitigation measures	●					
Improve storm water infrastructure in Bridgwater	●					
RESILIENT INFRASTRUCTURE						
Maintain and enhance storm water infrastructure	●	●				
Repairs and improvements to roads and key rights of way	●	●				
Assess risk and implement measures to protect electricity supplies					●	●
Assess risk and implement measures to protect mains water supplies					●	
BUILDING LOCAL RESILIENCE						
Improve online sources of information for the public					●	
Support locally-led action to increase resilience, preparedness and adaptation					●	●
Ensure households, businesses and neighbourhoods can obtain affordable and comprehensive insurance					●	
Promote Somerset as a good place for business and tourism						●

Source: Summarised from The Somerset Levels and Moors 20 Year Flood Action Plan

2.5. The role of natural flood management

The history of the drainage and flood protection of the Somerset Levels (covered in more detail in Section 7 of this Annex) has been dominated by 'hard engineering' solutions to managing water. These include raising the height of river banks to prevent water flooding adjoin land, pump drainage to evacuate water from low lying land into the high water levels in rivers, creating new river channels to allow water more direct access to the sea, and building tidal sluices to stop high tides backing water up in the rivers. These interventions have successfully turned what was (for humans) an inhospitable wetland into a productive farmed and inhabited landscape.

This approach to land drainage and flood protection has tended to resist or oppose the natural habits of rivers and floodplains and it paid little attention to the way water and land was managed higher up the river catchments. However, concern has been growing about the rising cost of maintaining this 'hard engineering' infrastructure and about whether increasing investment in this infrastructure can, on its own, keep up with increasing flood risk.

The merits of harnessing the ways that soils, vegetation, floodplains and estuaries naturally cope with water, ('natural flood management' – see **Figure 12**) has received growing attention in the UK since 2000. The Parrett Catchment Project and its 2001 report subtitled '*A Future when it Rains*'[15] was one of the first initiatives in the UK to identify natural flood management across the whole catchment as an essential part of the solution to flooding[16]. Since then, a number of national policy documents have recognised the role of a catchment based approach and natural flood management. These include the Foresight Future Flooding Report (2004), Defra's Making Space for Water strategy (2005) and the Pitt Review into the 2007 flood. The Flood and Water Management Act 2010, which established primary flood risk management policy for England and Wales, lists "*maintaining or restoring natural processes*" as a way of managing flood risk, and permits the designation of natural features that can reduce this risk.

Figure 12. The components of Natural Flood Management

Natural Flood Management seeks to work with the following natural processes:

- Increasing soil infiltration, reducing periods when surface runoff and soil erosion occurs.
- Slowing the movement of water over land and along water courses by increasing resistance to its flow
- Temporarily holding back water in wetlands, ponds, ditches, channels and floodplains

Key techniques in Natural Flood Management include:

- Blocking drainage channels in upland bogs and mires, reducing the 'flashiness' of headwater streams
- Maintaining vegetation cover on arable soils to slow runoff and erosion and enhance soil structure and infiltration
- Adopting best management practices on all soils to maintain and enhance soil structure, so improving infiltration
- Maintaining margins of rough vegetation beside watercourses and planting hedges across slopes to stop or slow overland flow
- Planting woods on steep slopes and floodplains to stop or slow overland flow
- Increase the resistance to water in the channels above flood risk areas by leaving marginal vegetation and woody debris in place and encouraging natural meanders
- Reconnecting rivers with their flood plains, allowing water to spill out over a wide area, reducing the peak flow that moves downstream

[15] LUC (2001). *A future when it rains: The Parrett Catchment Project Strategy*.
[16] It is notable that the Parrett Catchment Project predated national policy documents such as the Foresight Future Flooding Report (2004), Defra's Making Space for Water strategy (2005) and the Pitt Report to the flooding

There has been growing scientific research into the effectiveness of natural flood management techniques. At issue has been the extent to which small changes in land use and management over large areas can have measurable impacts on flood risk at a catchment scale.

On the one hand there is a strong consensus that reconnecting rivers to large areas of floodplain (previously separated by land drainage schemes) can significantly reduce downstream flooding[17]. Projects in the UK that have pursued this include the Knepp Castle Floodplain Restoration Project on the River Adur in West Sussex[18] and the Milton Keynes floodplain forest on the River Great Ouse[19]. On the other hand, the large scale effects of middle and upper catchment work on the channels of water courses or condition of soils are more difficult to detect. Projects such as the Pontbren experiment in West Wales[20] (in which farmers fenced off and planted up land beside steep streams) and the Exmoor Mires project in the headwaters of the River Exe[21] (where drainage ditches in upland bogs have been blocked) have shown local effects.

There are interesting lessons from the Pontbren experiment on how natural flood management can be undertaken[22]. The project was initiated by a group of farmers who decided that action was needed to re-establish a local landscape structure which they felt would have multiple benefits to their farming practice. The results of the work were monitored by a team of scientists at Imperial College London and Bangor Universities. Based mainly on fencing off narrow strips of land that had little agricultural value, the resulting interception of water run-off and increased percolation into subsoil after less than ten years was dramatic and more significant than the farmers and researchers had anticipated. All the planning and the work itself was carried out by the group of farmers with little or no advice or financial help from the various authorities. Although limited in the area it covered, it shows what can be achieved by small-scale, low-cost measures which are based on local knowledge and common sense.

There have been a number of reviews of published research which have examined evidence on the impacts on flood generation across whole catchments arising from changes to land and watercourse management[23]. These reviews have found little evidence that relatively modest adjustments to land use or management have a material benefit on large-scale flood events affecting whole river systems. However, computer modelling has suggested that major land use change can do so. A recent paper used hydrological modelling to show that extensive land use change (planting between 20% and 40% of a catchment with woodland) would be needed to reduce the magnitude of flood peaks by 19%, and only where this succeeded in desynchronising the timing of peaks from tributaries[24]. The lack of evidence about less radical changes in land use and management is at least partly due to the complexity of the water cycle at large scales and the difficulty of proving cause and effect. It does not necessarily mean that such effects do not take place.

More recent research[25] has focussed on the wider 'ecosystem service' benefits that natural flood management can provide, including conservation of biodiversity and landscape features, improvements in water quality, aquifer recharge and protection of soil organic carbon. **It is these broad and holistic benefits that natural flood management is capable to providing that are the strongest justification for its use, rather than expecting it to dramatically cut the risk of flooding. In an area such as the Somerset Levels catchment, the research and guidance suggests that flood risk management strategies should include both 'hard**

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[17] This is the focus of much work in the Mississippi in the United States. See: Opperman J J, Galloway G E, Fargione J, Mount J F, Richter B D and Secchi S (2009) *Sustainable Floodplains Through Large-Scale Reconnection to Rivers*. Science 11 Dec 2009:Vol. 326, Issue 5959, pp. 1487-1488. Also Christine A. Klein, Sandra B. Zellmer. *Mississippi River Tragedies: A Century of Unnatural Disaster*. New York University Press, 2014. ISBN 978-1-4798-2538-7

[18] See http://www.ecrr.org/Portals/27/Knepp%20Castle%20Floodplain%20Restoration.pdf

[19] Environment Agency (2013). *Rivers By Design – Rethinking development and river restoration*. A guide produced by the RESTORE project.

[20] Wheater H et al (2008). *Impacts of upland land management on flood risk: multi-scale modelling methodology and results from the Pontbren experiment*. FRMC Research Report UR 16.

[21] University of Exeter (2016), Mires Monitoring Results, March 2016. http://www.southwestwater.co.uk/media/pdf/l/7/Mires_Monitoring_Results_Annual_Report_2016_University_of_Exeter.pdf

[22] Wheater H et al (2008) (above)

[23] For instance, Environment Agency (2007). R&D Update review of the impact of land use and management on flooding

[24] Dixon S J, Sear D A, Odoni N A, Sykes T and Lane S N (2016) *The effects of river restoration on catchment scale flood risk and flood hydrology*. Earth Surface Processes and Landforms DOI: 10.1002/esp.3919

[25] For instance Dixon S J, Sear D A, Odoni N A, Sykes T and Lane S N (2016) *The effects of river restoration on catchment scale flood risk and flood hydrology*. Earth Surface Processes and Landforms DOI: 10.1002/esp.3919

engineering' works at critical locations in the hydrological pathway, together with natural flood management techniques adopted as the norm for land and water management across the whole catchment.

Natural flood management is increasingly being accepted as an essential component of flood risk management strategies. In 2013, the Environment Agency initiated a new research and development framework called 'Working with natural processes to reduce flood risk' to identify future research priorities which should attract funding in future.[26] In December 2015, the Scottish Environmental Protection Agency (SEPA) published its guide to Natural Flood Management[27], describing the different techniques available and emphasising the multiple benefits that many of these can provide.

2.6. Governance and funding of water management

Over the last 150 years, there have been a series of changes to the organisational responsibilities for land drainage and water level management on the Somerset Levels. The medieval Court of Sewers, with its *ad hoc* interventions, has been replaced by the national, regional and local bodies that exist today, underpinned by the legislation such as the Water Act 1989, the Land Drainage Act 1991 and Flood and Water Management Act 2010. Throughout this process, critical issues have been the democratic accountability of the bodies that make decisions and the resources and powers available to them. **Figure 13** summarises the responsibilities of the organisations that currently play a role in flood defence and risk management in Somerset.

Figure 13. The flood risk management responsibilities of bodies covering the Levels Catchment

Organisation	Key responsibilities
Environment Agency	• Provides the strategic overview of the management of sources of flooding & coastal erosion • Has operational responsibility for managing the risk of flooding from main rivers, reservoirs, estuaries and the sea • Acts as a coastal erosion risk management authority
Somerset County Council	Is the Lead Local Flood Authority responsible for: • Developing, maintaining and applying a strategy for local flood risk management • Maintaining a register of flood risk assets • Managing the risk of flooding from surface water, groundwater & ordinary watercourses • Administers the Somerset Water Management Partnership
District Councils	Sedgemoor, Mendip, South Somerset, Taunton Deane and West Somerset District Councils: • Are partners with the EA and SCC in planning local flood risk management • Can carry out flood risk management works on minor watercourses • Prepare the Local Plan and control development to ensure effective risk management • Act as coastal erosion risk management authorities (where they have a coast)
Highways Authorities	The Highways Agency are responsible for maintaining drainage ditches on their network. The responsibilities of Somerset County Council for maintaining other road ditches are less clear.
Somerset Consortium of Drainage Authorities	The Axe Brue and Parrett Internal Drainage Boards are local public authorities with permissive powers to manage water levels within their Internal Drainage Districts, undertaking works to reduce flood risk to people and property and manage water levels to meet local needs.
Water and Sewerage Companies	Wessex Water and other local water companies are responsible for managing the risks of flooding from water and sewerage systems draining buildings and yards. They also have responsibility for water quality emanating from sewage treatment works.
Somerset Rivers Authority	Is not (yet) a statutory body. Acting through the powers of the County Council, it was established in January 2015 to work with other Flood Risk Management Authorities as an unincorporated association.

Source: Adapted from https://www.gov.uk/guidance/flood-risk-management-information-for-flood-risk-management-authorities-asset-owners-and-local-authorities#managing-flood-risks-who-is-responsible

[26] http://evidence.environment-agency.gov.uk/FCERM/en/Default/FCRM/Project.aspx?ProjectID=4A57166C-F63F-46BC-B179-E01E92B6D8D4&PageId=a0fe6dfc-506a-452c-9bff-a7ec06b4e6b0

[27] SEPA (2015). SEPA (2015.) Natural Flood Management Handbook. ISBN: 978-0-85759-024-4 https://www.sepa.org.uk/media/163560/sepa-natural-flood-management-handbook1.pdf

This shows a complex situation with at least six different levels of organisations that have statutory responsibility for flood risk management (the Environment Agency, County Council, District Council, Highways Agencies, Internal Drainage Boards and utility companies). In addition, these bodies meet in a variety of different forums to co-ordinate their work, as follows:

- **The Wessex Regional Flood and Coastal Committee** covers Somerset, Dorset, Wiltshire and the Avon Unitary Authorities. It has a statutory role to oversee and advise on the work of the EA and others by ensuring there are coherent plans to address flood and coastal erosion risks and encouraging efficient, targeted and risk-based investment in flood and coastal erosion risk management. It has a voting membership of 23 consisting of the Chairman, Environment Agency (9 members) and the county or unitary local authorities (13 members)

- **The Somerset Rivers Authority**. As noted above, it is not yet a statutory body but works by agreement of the constituent bodies which are the County and District Councils and Environment Agency (one seat each) and the two Internal Drainage Boards (two seats each). Its purpose is to provide the strategic overview and coordination of the delivery of the 20 Year Flood Action Plan, and to identify and prioritise further work across the whole of Somerset, where possible securing third-party funding for this work.

- **The Somerset Water Management Partnership** is a forum administered by the County Council which has met since 2007 to act as an informal sounding board and debating chamber on water management issues in the Parrett, Brue and Axe catchments. The following bodies are represented Somerset County Council, the Environment Agency, Taunton Deane District Council, Sedgemoor District Council, South Somerset District Council, National Farmers Union, Farming and Wildlife Advisory Group, Somerset Wildlife Trust, Royal Society for the Protection of Birds, Somerset Consortium of Drainage Boards, South West Association of Drainage Authorities, Somerset Waterways Development Trust, Wessex Water, Natural England and 'catchment reps' representing local communities.

- **The Somerset Catchment Partnership** (SCP) comprises a range of organisations dedicated to advancing the Catchment Based Approach. This approach was launched nationally in 2013 with the support of Defra with two main aims; to work in partnership and work at the catchment scale. Each catchment in England is represented by a Catchment Partnership. The SCP is hosted by FWAG SW and also includes the Somerset Consortium of Drainage Boards, Somerset Wildlife Trust, RSPB, Wessex Water, Areas of Outstanding Natural Beauty (AONBs), Environment Agency, National Trust, West Country Rivers Trust, Somerset County Council, West Country Rivers Trust, Forestry Commission, National Farmers' Union and the Country Land and Business Association (CLA).

- **The Multi-Agency Project** to achieve favourable status on the Sites of Special Scientific Interest on the Levels and Moors. This is led by Natural England and includes the Environment Agency and Internal Drainage Boards.

Funding for flood risk management in Somerset comes from a variety of sources which can be summarised as follows[28]:

- **The Environment Agency** receives most of its funding from central government (Defra) in its grant-in-aid settlement, which ring-fences spending on flood defence projects and flood and coastal risk management. The Agency also co-ordinates partnership funding for projects (with funding from Defra, local authorities and others) and raises other income from IDB precepts and General Drainage Charges.

[28] Source: Defra (2015) Central Government Funding for Flood and Coastal Erosion Risk Management in England. December 2015

- **The Wessex Regional Flood and Coastal Committee** receives funding from a levy on local authorities.

- **Somerset County Council** receives funding for its work as the Lead Local Flood Authority from central government through the Local Services Support Grant (via Defra) and the Settlement Funding Assessment (DCLG) and also allocates parts of its general income to flood risk management work

- **The Somerset Consortium of Drainage Authorities** is funded from drainage charges paid by occupiers of agricultural land and a special levy paid by the District Councils in respect of non-agricultural land . It also receives funding from the Environment Agency and other sources.

- **The Somerset Rivers Authority** has received initial funding for 2015/16, mostly from Defra and the County Council, and is pursuing more secure long term funding that is likely to require primary legislation (see below).

- In addition, **The Catchment Sensitive Farming Initiative** provides capital grants for small-scale work on farms, primarily to reduce water pollution but which may also reduce flood generation such as watercourse fencing and rainwater storage tanks.

2.7. Future funding and governance of the SRA

In 2014, a review of longer term funding options for the SRA was drafted by Defra, DCLG and the SRA[29]. These included the local authorities funding the SRA from the Council Tax, the creation of a new levying body, extending the boundaries or levy of the IDBs, and creating a new precepting authority.

In November 2014, members of the Somerset Levels and Moors Flood Action Plan Leaders' Implementation Group agreed that their preferred option was the precepting authority. This would establish the SRA as an independent tax-raising authority (requiring primary parliamentary legislation), allowing it to raise funds directly from households through the Council Tax (in the same way as the police and fire service). Parliamentary time must be found to pass the necessary primary legislation. It is hoped that the Government will draft and support the legislation although parliamentary time and civil service expertise may be at a premium following the Brexit referendum. Defra is considering legislation to enable the establishment of Rivers Authorities in England and it is likely that the Somerset Rivers Authority would be amongst the first.

No change to the membership of the SRA Board was considered in the 2014 review. The paper states: "*Under the proposal put forward by local authorities in Somerset it would not be directly elected, relying on the local authority representation on the SRA board for its democratic accountability*". It is understood that the SRA is currently (Summer 2016) considering only minor changes to its Board membership if/when it becomes a precepting authority and expects that oversight of its decisions and activities will be undertaken by an independent Scrutiny Committee, as defined under the Local Government Act. The membership of the Scrutiny Committee will be two nominees from each local authority and two from the Internal Drainage Boards, with the chair and deputy chair taken by local authority members[30].

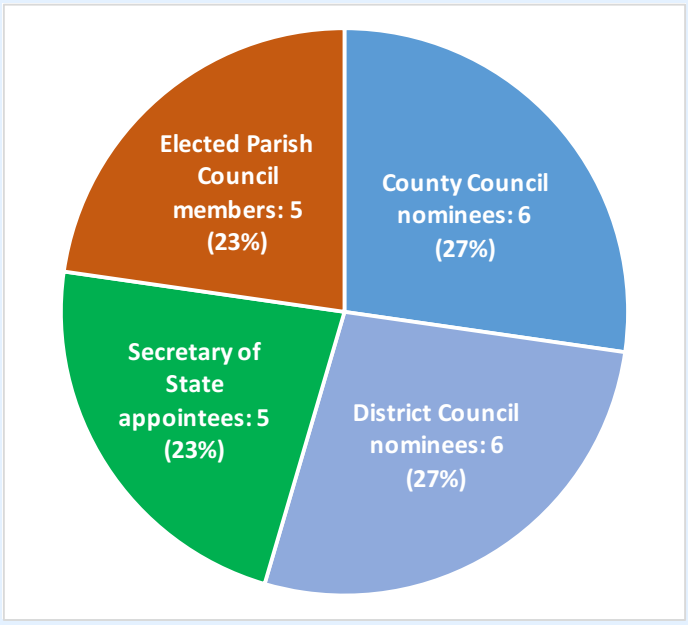
In view of the new tax-raising powers that the SRA is expecting to take on, there is an important issue of whether the governance structure being proposed will give the SRA the necessary legitimacy and accountability. The constitution of the SRA, adopted when it was created in January 2015, makes clear that its Board members represent the organisations they are nominated by and that these organisations are parties to the SRA because of their role as Flood Risk Management Authorities (FRMAs). To be clear, this means that SRA Board members nominated by the County and District Councils are there primarily to uphold their authorities' statutory role as FRMAs and not to represent the communities who should benefit from the SRA's work and who, in future, are likely to be paying for it.

[29] SRA Funding Review Options. http://www.somersetriversauthority.org.uk/EasySiteWeb/GatewayLink.aspx?alId=103441
[30] Item 11 of the meeting of the SRA held on 27 July 2016. http://www.somersetriversauthority.org.uk/about-us/board-meetings-and-papers/somerset-rivers-authority-board-meeting-27-july-2016/

There are other governance models for locally devolved public bodies like the SRA that provide clearer democratic accountability. The best example is provided by National Park Authorities. The members of National Park Authorities are drawn from three different groups.

- A majority are nominated by the constituent local authorities (equivalent to the local authority members on the SRA).
- A second group are nominated to the Authority by the Secretary of State for Environment, Food and Rural Affairs for their technical experience and expertise (similar to the Environment Agency role on the SRA).
- A third group are Parish Council members who are elected for their local knowledge and to ensure that the views of all local communities across the National Park are represented and considered. These parish councillors are chosen following an election process by the appropriate Association of Local Councils who recommends these appointments to the Secretary of State for approval.

Figure 14. Structure of Exmoor National Park Authority



Source: http://www.exmoor-nationalpark.gov.uk/about-us/who-we-are-and-what-we-do

The structure of the Exmoor National Park Authority is shown graphically in **Figure 14**.

City Mayors and Police and Crime Commissioners are other examples of public institutions which are now directly elected. The creation of Mayors has been encouraged by Government because, as David Cameron remarked, they are "accountable" and can "galvanise action"[31], two qualities which could describe the SRA.

[31] BBC News, 16 April 2010. Manchester 'should have elected mayor'. http://news.bbc.co.uk/1/hi/uk_politics/election_2010/england/8624987.stm

3. Climate Change

This section examines the effects that the changing climate, particularly sea level rise, are likely to have on the Catchment. It also looks at what types of activity in the Catchment are contributing to climate change and the types of mitigation and adaptation actions that are taking place.

3.1. Introduction

Climate change, along with biodiversity loss and the nitrogen cycle, has been defined by the Stockholm Resilience Centre (Johan Rockstrom et al) as one of the "Earth Boundaries" which humanity has transgressed, thereby threatening both human civilisation and the global ecosystem. Any suggestions of alarmism emanating from climate science are the reverse of the truth, with numerous observations now demonstrating that actual change is occurring faster than consensus forecasts.

Human responsibility for this trend, primarily through the burning of fossil fuels and deforestation, is beyond reasonable doubt. Barring a dramatic breakthrough in unproven negative emissions technology, reversing the trend is a *sine qua non* for sustainable living on our planet.

The 2015 Paris accord has transformed the diplomatic backdrop, but national commitments to date leave us on course for 2.7 to 3.5^{o}C of heating, far above the 1.5 to 2.0^{o}C target to give a high chance of averting catastrophic change. At current heating of around 1.0^{o}C, we are already witnessing widespread and damaging disruption to the climate system. Further heating is "locked in" (due to the time lag between emissions and heating) and various feedback loops (methane release, Arctic albedo) have already been activated. Adaptation measures as well as mitigation of further heating are therefore beyond urgent.

The science-policy disconnect alluded to above and the complexity of political processes creates an imperative for mobilised, carefully directed action within civil society, rather than relying solely on a top-down response to bring about the changes needed.

After power generation, agriculture has been identified as the second biggest source of emissions globally and farming is obviously relevant to all of the boundaries mentioned above. As with power generation, there is demonstrably scope for agriculture to lower its carbon footprint and under the right circumstances and techniques the land can in fact be turned back into a net sequesterer of carbon. There is therefore scope for farming and agriculture to play a major part in creating a sustainable future.

Visible consequences of global heating are sea level rise (due to thermal expansion and melting land ice) and extreme weather (due to increased evaporation and precipitation, also more energy trapped in the climate system).

The Somerset levels are an exceptionally vulnerable area in the face of climate change, due to their closeness to sea level and the volume of water their rivers are required to carry at times of high rainfall. The Summer 2012 and Winter 2013-14 floods demonstrated this vulnerability in stark terms. Flooding, storms and severe droughts are occurring with increased frequency globally. Whilst it is impossible to predict the timing, duration or severity of events in our area, what we do know is that the odds of such events occurring are shortening. Objectively, there is therefore a powerful incentive to play our part in mitigation and to explore all possible measures to alleviate the consequences of extreme weather when it does occur.

3.2. The likely impacts of climate change

There is widespread agreement amongst the world's scientists that the climate is changing and that human activity, in the form of emissions of greenhouse gases, are the main cause[32.] The Intergovernmental Panel on Climate Change (IPPC) has stated that "*Human influence on the climate system is clear, and recent anthropogenic emissions of greenhouse gases are the highest in history … Continued emission of greenhouse gases will cause further warming and long-lasting changes in all components of the climate system, increasing the likelihood of severe, pervasive and irreversible impacts for people and ecosystems*".[33] A team led by the Met Office's Hadley Centre has calculated a series of projections on the changes that are likely to take place in the UK. The UK Climate Projections 2009 (UKCP09 for short) take account of the uncertainty and natural variability of future change and present a range of figures according to different levels of future greenhouse gas emissions and different probabilities. The 'central' set of projections (medium emissions scenario and 50% probability) for the South West Region are shown in **Figure 15**. Average annual temperatures are projected to rise by 3.5°C over the next 70 years, with a 3.9°C rise in average summer temperatures. Average annual rainfall is projected to stay roughly the same but with significantly more falling in the winter and less in the summer. Average sea level is projected to increase by 36cm over the next 70 years and by nearly half a meter by 2100 (some sources anticipate a rise of closer to 1m over this period).

Figure 15. Projected changes to the South West's climate (medium emissions scenario and 50% probability)

Change compared to 1961-1990 baseline	2020s	2050s	2080s
Mean winter temperature	+1.3°C	+2.1°C	+2.8°C
Mean summer temperature	+1.6°C	+2.7°C	+3.9°C
Mean winter precipitation	+7%	+17%	+23%
Mean summer precipitation	-8%	-20%	-24%
Sea Levels	+10cm	+22cm	+36cm

© Crown Copyright 2009. The UK Climate Projections (UKCP09) have been made available by the Department for Environment, Food and Rural Affairs (Defra) and the Department of Energy and Climate Change (DECC) under license from the Met Office, UKCIP, British Atmospheric Data Centre, Newcastle University, University of East Anglia, Environment Agency, Tyndall Centre and Proudman Oceanographic Laboratory. These organisations give no warranties, express or implied, as to the accuracy of the UKCP09 and do not accept any liability for loss or damage, which may arise from reliance upon the UKCP09 and any use of the UKCP09 is undertaken entirely at the users risk.

What these average figures don't reveal is the occurrence and effect of extreme weather and climate events. Critically for the Levels Catchment, extreme events are projected to become more frequent and severe, increasing the risk of both flooding from rainfall and from the sea and also increasing the risk of drought and heat stress. UKCP09 projections are for the number of days of heavy rain (exceeding 25 mm) to increase by a factor of between 2 and 3.5 in winter, and 1 to 2 in summer by the 2080s. One-in-100 year flood events are likely to become twice as frequent by the 2050s and three to five times more frequent by the 2080s[34]. The recently published 'Projections of future flood risk' prepared for the forthcoming UK Climate Change Risk Assessment 2017, identified the Somerset coast as being one of areas most vulnerable to a 1m rise in sea level (with 22,000 properties in Weston-super-Mare and 11,000 properties in Bridgwater at risk from a 1-in-200 year event)[35].

The outcomes for people and the environment in the South West of England as a result of the changing climate were examined in a report prepared to coincide with the publication of the 2012 UK Climate Change Risk Assessment. **Figure 16** summarises the key threats that are likely to occur in the Catchment, based on that report.

[32] IPPC (2014). Climate Change 2014 Synthesis Report. Summary for Policy Makers. https://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_SPM.pdf
[33] Ibid.
[34] These are average UK estimates based on the medium emissions scenario and 50% probability estimate.
[35] Sayers and Partners LLP (2015). *UK Climate Change Risk Assessment 2017: Projections of future flood risk*. Report to the Climate Change Committee. October 2015

Figure 16. Likely threats to the Catchment arising from climate change

Human health	• An increase in UVB radiation increases the incidence of skin cancers by up to 20% by the end of the century • Flooding from sewers risks spread of pathogens
The economy	• Flooding of transport increases, affecting both urban and rural access routes. • Lost production doubles by the 2020s
The natural environment	• Low river base flows and water tables in the summer harm wetland habitats and species • Stormier weather likely to increase peak river flows by 20% by the 2050s leading to greater channel erosion and turbidity • Natural ranges of species move north, meaning that some will be lost from the Catchment
Farming and forestry	• Drier summer conditions (and restrictions on agricultural abstraction) cause heat stress in crops and forestry • New pests and diseases become acclimatised, threatening crops and livestock

Source: Adapted from Climate UK (2012), extracting findings from the UK Climate Change Risk Assessment. All the projections relate to the medium emissions scenario and 50% probability.

The changing climate would also be likely to produce some opportunities in the Catchment, including lower cold-related winter deaths, a more favourable summer climate for tourists and increases in the yields of some crops due to the longer growing season. However, the overall message is that the future will have greater uncertainties and the potential for significant harm to the things we value most now.

3.3. How activity in the Catchment is contributing to climate change

It is the emission of greenhouse gases into the atmosphere that is responsible for the climate change that is now taking place. The three most significant greenhouse gases are carbon dioxide which account for 82% of UK emissions, methane (10% of UK emissions) and nitrous oxide (5%)[36]. The chlorofluorocarbon (CFC) refrigerants, that were responsible for the hole in the ozone layer in the 1980s and 90s, are now a relatively minor source of emissions.

- The main source of **carbon dioxide** emissions is the burning of fossil fuels and deforestation. Ninety-six percent of UK emissions in 2013 came from the energy supply, transport and residential sectors. Minor sources are from industrial processes and changes in land use (where carbon stored in soils or vegetation is oxidised). The carbon dioxide emitted within the UK decreased by 22% from 1990 to 2013[37], but this takes no account of emissions in other countries such as China from the manufacture of goods imported into and consumed in the UK.

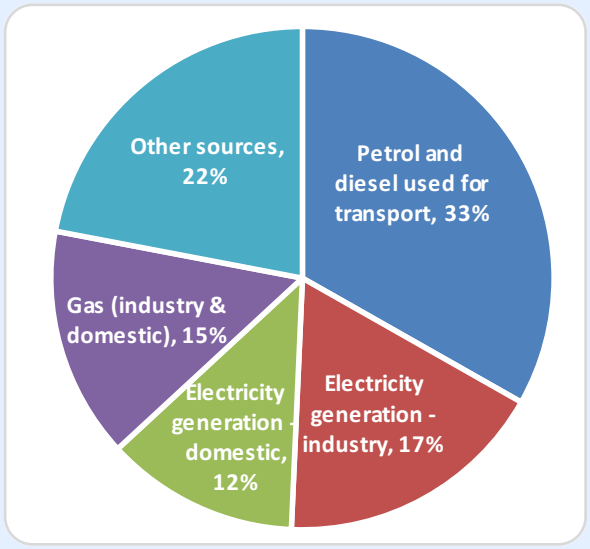
- The main sources of **methane** in the UK are from livestock and agricultural waste, landfill waste and leaks from pressurised gas supplies. Whereas emissions from landfill and gas supplies have been falling since 1990, emissions from farming have stayed the same[38]. 'Exported' emissions arising from UK consumption, such as overseas livestock production and from global warming of arctic tundra, are significant exclusions from the UK data.

- The main sources of **nitrous oxide** emissions are agricultural (69% comes from cultivated soils and 7% from agricultural wastes) and electricity production (4%). Until the 1990s, the chemical industry was

[36] DECC GHG Inventory overview factsheet. https://www.gov.uk/government/publications/uk-greenhouse-gas-inventory-summary-factsheets
[37] DECC Carbon Dioxide GHG Inventory factsheet. https://www.gov.uk/government/publications/uk-greenhouse-gas-inventory-summary-factsheets
[38] DECC Methane GHG Inventory factsheet. https://www.gov.uk/government/publications/uk-greenhouse-gas-inventory-summary-factsheets

a significant source but this is no longer the case. Emissions from agriculture have been falling but by a smaller amount than other sources[39].

Figure 17. CO2 emissions in Somerset, 2013



Source: https://www.gov.uk/government/statistics/uk-local-authority-and-regional-carbon-dioxide-emissions-national-statistics-2005-2013

The now superseded Department of Energy and Climate Change produced a breakdown of the emissions of carbon dioxide by UK local authority, distinguishing between different sources of emissions. **Figure 17** shows the latest data (2013) for Somerset. It should be noted that this does not include emissions of methane and nitrous oxide and so under-represents emissions form agriculture. Vehicles accounted for a third of CO2 emissions (with the M5 being 8% of the total), and electricity used by businesses and homes 30%, followed by the use of gas for heating. Other sources included other fuels (mainly oil) and emissions from land use.

When compared to equivalent figures for England as a whole, Somerset uses less gas and more 'other fuels' (probably reflecting greater reliance on oil in rural areas off the natural gas grid) and has higher CO2 emissions from land use. This latter difference is almost certainly due to the areas of peat soils under agriculture on the Levels and Moors, the oxidation of which releases CO2.

3.4. Current action to mitigate and adapt to climate change

The Government is a signatory to the Kyoto Protocol which commits 192 countries across the globe, including the UK, to reductions in greenhouse gas emissions. The Government has recently committed to ratifying, before the end of 2016, the international agreement that was made in Paris in December 2015 under the Kyoto Protocol. Within the Government, the Department for Business, Energy & Industrial Strategy (which took over the work of the Department for Energy and Climate Change in July 2016) leads on policy to reduce emissions, while the Department for Environment and Rural Affairs (Defra) leads on the adaptation policy.

The Government passed the Climate Change Act in 2008, then a world-leading initiative. This commits the UK to reducing emissions by at least 80% in 2050 from 1990 levels and requires the Government to set legally binding 'carbon budgets' which set a cap on the UK's greenhouse gases emission over a five-year period.

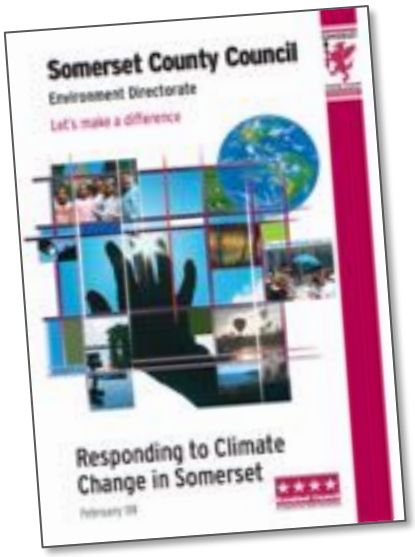
The UK has also signed up to targets set by the European Union. The EU Emissions Trading System sets a degressive (falling) cap on emissions from key industry and energy sectors and uses a 'cap-and-trade' scheme that allows businesses to buy and sell allowances in order to meet their cap. Emissions trading shows little sign of delivering the deep cut in emissions that are required, to avoid catastrophic climate change. A carbon pricing system (such as carbon fee and dividend as proposed by Jim Hansen) is almost certainly necessary, despite the political hurdles. The EU Renewable Energy Directive sets targets at the level of Member States for the proportion of energy for heat, transport and power that should be generated from renewable sources by 2020. The UK's renewables target is 15%.

Measures designed to meet these targets include subsidies to promote generation of renewable energy (such as the Feed In Tarrifs paid by energy companies to members of the public and businesses who generate renewable electricity) and schemes to reduce emissions such as the Government's Green Deal. In recent years, the Government has removed or reduced the funding for these Schemes. Despite these measures (or perhaps because of the poor funding), in 2014 the UK was less than half way to meeting its 15% target, with

[39] DECC Nitrous Oxide GHG Inventory factsheet. https://www.gov.uk/government/publications/uk-greenhouse-gas-inventory-summary-factsheets

only 5% of energy used for heating and transport coming from renewable sources[40]. Although the use of renewable energy for electricity generation rose sharply in 2015 (to 25% of electricity generation), the UK is at significant risk of missing the 2020 target.

This study estimates that renewable energy generation in the Catchment (mostly from solar photovoltaics – see Section 4.4) has an operational or consented capacity of 286 MW which contributes 0.8% of the UK's renewable energy[41] and is enough to power around 40,000 homes.



A National Adaptation Plan has been prepared which requires the Government to assess the UK's risks from climate change, prepare a strategy to address them, and encourage critical organisations to do the same. The Government has placed the onus on public service organisations to produce reports on what they are doing to adapt to climate change, a requirement which is now voluntary.

Somerset County Council prepared a strategy and action plan in 2008 entitled 'Responding to Climate Change in Somerset'. The actions in the plan focussed on the co-ordinating and leadership role of the Council with other public bodies and opportunities to reduce emissions arising from its own activities. Cuts to staff and a reordering of priorities in the Environment Directorate meant that most of the actions have lapsed. Furthermore, in view of the international agreements on action to combat climate change reached since 2008, most recently at the Paris climate conference in December 2015, these actions have a very limited scope and can be considered unambitious and out-of-date.

[40] Digest of UK Energy Statistics (DUKES) 2015. Table 6.7 Renewable sources data used to indicate progress under the 2009 EU Renewable Energy Directive.
[41] Based on analysis by this study of the Department of Energy and Climate Change's Renewable Energy Planning Database for May 2016.

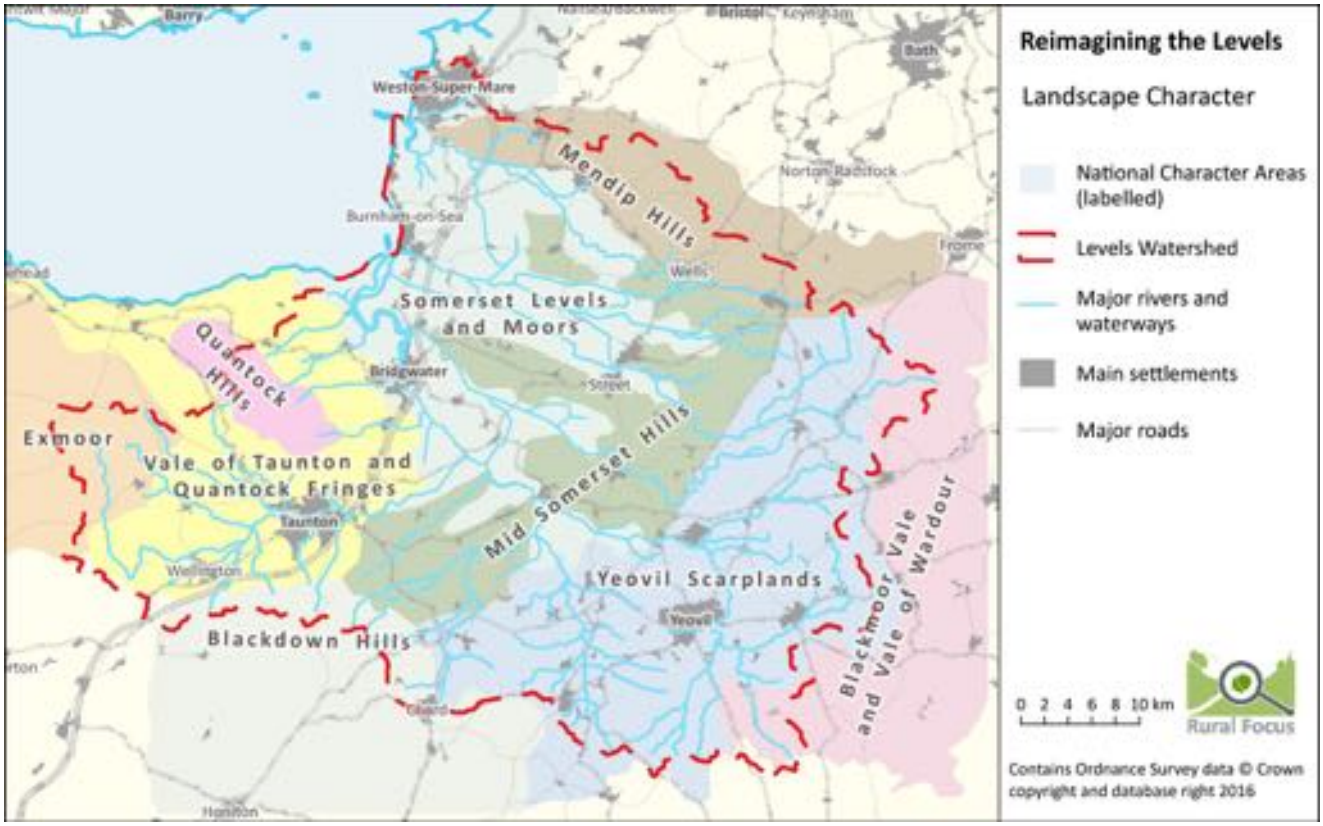
4. Landscape, wildlife and natural resources

This section describes the natural environment of the Levels Catchment, covering its landscapes, wildlife and natural resources and sources of energy. It examines their current condition and health as a way of identifying opportunities for better protecting the area's natural capital.

4.1. Landscape

The character of the landscape in which people live is an essential element in what gives them their sense of place and belonging. The landscapes of the Catchment are varied and distinctive, from the flat wetlands of the Levels and Moors to the rolling mixed farming to the east and south, rising to the prominent ridges and hills of the Mendips, Quantock and Blackdown Hills. **Figure 18** shows the different areas of landscape character that are defined by Natural England's National Character Areas[42]. The largest part of the Catchment is covered by the Yeovil Scarplands, followed by the Levels and Moors, the Mid Somerset Hills and the Vale of Taunton and Quantock Fringes. The distinctive features of the main landscape areas are described in **Figure 19**.

Figure 18. National Character Areas covering the Somerset Levels Watershed



[42] See https://www.gov.uk/government/publications/national-character-area-profiles-data-for-local-decision-making

Figure 19. Distinctive features of the main landscape areas of the Catchment

Somerset Levels and Moors	• Flat grazing marsh populated by cattle and sheep and a summer soundtrack of calling wading birds such as curlew and lapwing • Chequer-board pattern of rectilinear fields, ditches, rhynes, & engineered rivers, often bordered by lines of pollard willows (withies) and sometimes by roads and droves • Distinctive skyline views to hills (e.g. Burrow Mump and Glastonbury Tor) and ridges (e.g. Polden Hills)
Mid Somerset Hills	• A series of low hills, islands and ridges dividing the Moors and Levels characterised by mixed farmland • A strong wooded feel from hedgerows, small woods and orchards, although woodland cover is low overall • Small villages, with older buildings constructed of locally quarried blue Lias limestone
Yeovil Scarplands	• Contrasting pattern of scarps and vales running west (main valleys) and north-south (tributaries) • A mixture of pastoral and arable land use with dairy farming predominant in many areas • Winding rural lanes connecting villages and hamlets constructed of limestone and sandstone (hamstone in the south)
Vale of Taunton and Quantock Fringes	• A mixed-farming landscape, dominated by arable in many places, rising to the Blackdown, Brendon and Quantock Hills • A strong tradition of cider orchards and market gardening • Sunken lanes wind between villages constructed of red sandstone or grey Lias stone

Source: Natural England's National Character Area Profiles

4.2. Wildlife

The Levels and Moors include one of the largest and biologically richest areas of traditionally-managed wet grassland and fen habitats found anywhere in the UK. Elsewhere, in the middle and upper parts of the Catchment, there is a more dispersed but also more varied distribution of habitats.

Figure 20 maps the areas recorded on Natural England's Priority Habitat and Ancient Woodland Inventories. This map shows the following concentrations of habitats:

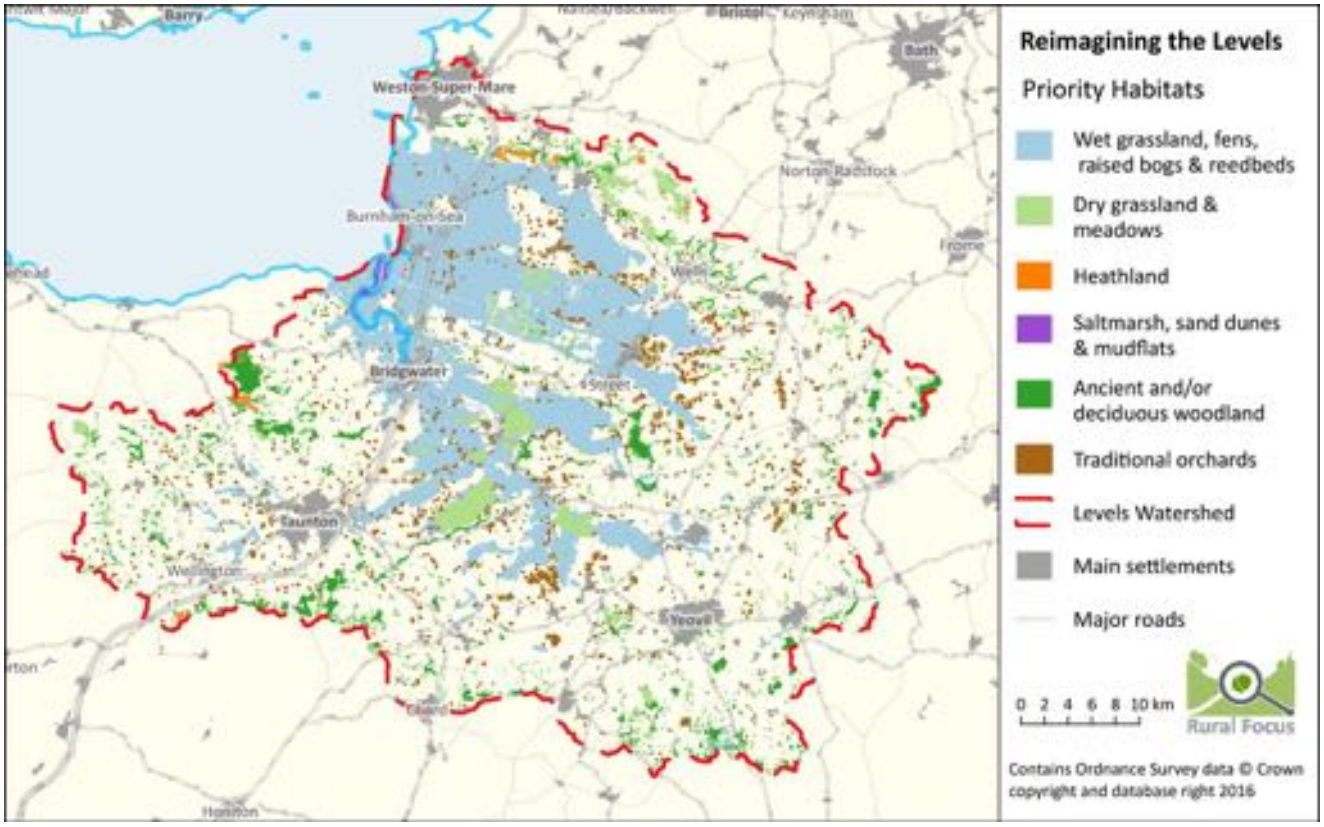
- **Seasonally-wet grassland and associated wetland habitats** such as fens, raised bogs and reed beds make up the majority of the Levels and Moors landscape character area (Figure 18) and occupy over 37,300 ha or 15% of the whole Catchment. As noted further below, many of these sites are designated as being internationally important for wildlife because of their large populations of waterfowl and wading birds.
- **Species-rich drier grassland** (not subject to regular flooding) also occurs on the Levels and Moors and in other areas such as the Mendip Hills, the slopes of the Blackdown Hills and Polden Ridge and at locations such as Ham Hill Country Park, an iron age hillfort near Yeovil.
- **Woodland** that is classified as being ancient (having existed since at least 1600) or deciduous occupies 4,800 ha and occurs throughout the Catchment with large blocks on the Quantocks (oak woodland), the slopes of the Blackdown Hills (the ancient Forest of Neroche), Copley Woods north of Somerton and on ancient parkland sites such as Melbury Park near Yetminster in the south of Catchment. Woodland cover over the Catchment as a whole is low at 6% (compared to 10% for England) and many of the smaller woodlands undermanaged (habitats such as coppice needing regular management). There is scope for sensitive woodland management to benefit wildlife and also provide jobs and products such as firewood.
- **Traditional orchards** are common throughout most of the Catchment but most are small, often occurring on the edges of villages and hamlets where they are a valued feature of the local landscape. There are 2,440 separate orchards in the Catchment recorded on Natural England's Priority Habitat Inventory, occupying a total area of over 1,500 ha. Many of these orchards contain old and locally

distinctive varieties of cider and eating apples and they can support many species of birds and insects. The location of orchards around the edge of settlements has made them vulnerable to being lost to development. The year-round availability of apples from overseas has undermined the market for seasonal Somerset apples. Most commercial cider production comes from large plantations of 'bush' trees not the traditional standard trees.

- **Coastal habitats** are found on the edge of Bridgwater Bay, including saltmarsh along the Stert Peninsula, sand dunes between Burnham and Brean and mudflats in the Parrett estuary.
- **Heathland**, with its characteristics vegetation of heather and gorse, occurs on the Quantock and Mendip Hills

The map does not show hedgerows, but these are a valuable habitat and landscape feature in much of the Catchment (with field sizes varying considerably between different areas). Hedgerow removal is now far less common than it was (regulations limiting removal having been introduced in 1997). However, hedgerow trees, which contribute greatly to the appearance of the farmed landscape, have little protection from felling and many are likely to be threatened by ash dieback disease.

Figure 20. Priority Habitats and Ancient Woodland in the Catchment



Source: Natural England's Priority Habitat Inventory and Ancient Woodland Inventory. Categories of Priority Habitats have been combined to produce a simpler and more easily 'readable' map. The size of traditional orchards has been enhanced to make them more visible.

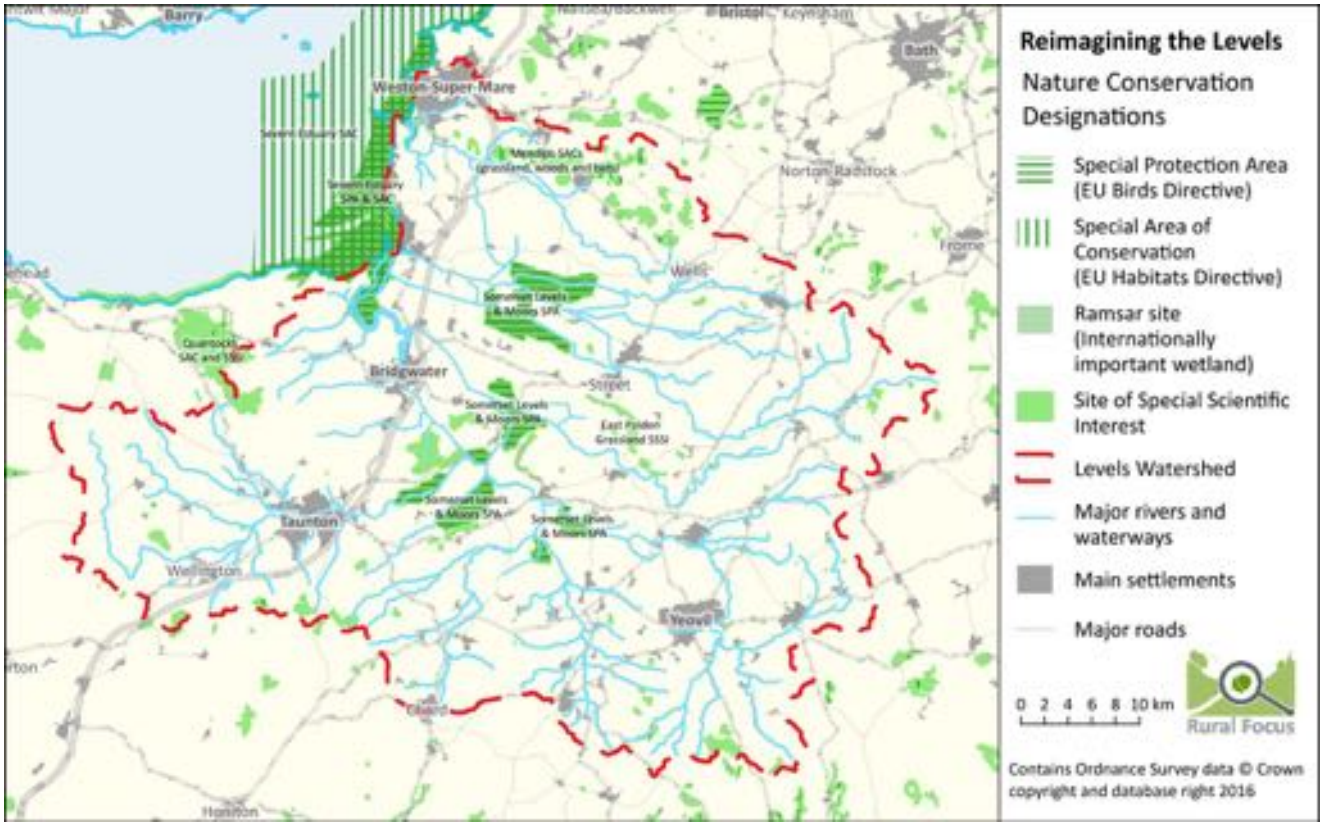
Legally protected sites

Many of these areas have legal protection because the wildlife that lives there is nationally or internationally rare. Nearly 6,400 ha is regarded as being of international importance and is designated as The Somerset Levels and Moors Special Protection Area (SPA). This area is recognised for its large overwintering populations of waterfowl including Bewick's swan, golden plover, shoveler duck, teal, wigeon, snipe and lapwing.

Offshore, large parts of Bridgwater Bay are part of the Severn Estuary Special Area of Conservation and Special Protection Area, of international importance for the mud flats and saltmarsh habitats and large populations of overwintering wading birds such as curlew, and dunlin.

Other large designated sites in the Catchment area are found on the Mendips (limestone grassland, woodland and cave systems including rare bats), Quantock Hills (woodland and heathland) and along the eastern side of the Poldens (meadows and pastures). **Figure 21** maps the designated sites.

Figure 21. Areas designated for their international or national nature conservation interest



On all these designated sites there are legal restrictions on what landowners are able to do in order to maintain the conditions that the wildlife need. On the wet grassland sites on the Levels and Moors this includes retaining a relatively high water table close to the surface which is often much higher than the agriculturally drained land surrounding it. These 'summer pen' water levels are implemented through Water Level Management Plans prepared by the Internal Drainage Boards with the landowners and Natural England.

Many of the designated sites are managed as publicly accessible nature reserves by bodies like the RSPB (e.g. West Sedgemoor and Ham Wall reserves) and Somerset Wildlife Trust (e.g. Catcott Heath and Lows). Several of these wetland reserves have been created from restored peat workings such as Shapwick Heath (managed by Natural England) and Westhay Moor (managed by the Somerset Wildlife Trust). The areas under conservation protection and management are summarised in **Figure 22**.

Figure 22. Areas under conservation protection and management

Designation / type	Area (ha)	% of catchment
Sites of Special Scientific Interest (SSSIs)	12,528	5.1%
Natura 2000 sites (Special Protection Areas and Special Areas of Conservation)	9,557	3.9%
Plus Severn Estuary SAC (outside catchment)	46,945	N/A
National Nature Reserves	1,742	0.7%
Plus Bridgwater Bay (outside catchment)	2,639	N/A
RSPB Reserves	2,902	1.2%
SWT Reserves	1,720	0.7%
Holdings with Higher Level Environmental Stewardship agreements	34,085	13.8%

Note: Land may lie in more than one designation / type

4.3. Soils

The importance of soils to our national wellbeing (for agricultural productivity, the nutritional content of food, the water and carbon cycles and for biodiversity) is receiving increasing attention[43]. There are two important aspects of the soils of the Catchment that deserve attention in this study. The first is the presence of significant areas of peat soils in the lower Catchment. The second is the ability of soils throughout the Catchment to store rainfall, reducing the risk of flooding downstream.

Peat soils

The long history of the Levels and Moors as a marshy wetland, before they were drained from the medieval period onwards, led to the accumulation of partly-decayed organic matter from fenland vegetation such as sedges, reeds and moss, forming peat soils. The greatest accumulations of peaty soils, which can be more than 4m thick, occur in the Lower Brue and Axe catchment (around 12,500 ha of deep peaty soils, covering about a quarter of this area) and the Lower Parrett catchment (around 7,500 ha or 15% of this area) – See **Figure 23**. The total volume of peat in the Levels and Moors (including smaller areas in the northern Levels which are not covered by this study) is estimated to be over 200 million cubic metres.[44]

Peat has been used as a source of fuel by people living on the Levels for hundreds (probably thousands) of years. In the 20th century, an extraction industry developed, centred in the Brue Valley between Street and Burtle, to supply peat as a growing medium to the horticultural industry and gardeners. Extraction continues at a few sites under existing permissions (estimated at 9% of annual UK peat production) but the quantity of peat extracted is small compared to the total resource (about 0.01% of the resource in the Levels is extracted a year)[45]. The environmental value that is now attached to peat as a store of atmospheric carbon means that the peat production zone defined in planning policy is very unlikely to be extended. As noted above, several worked-out areas are now nature reserves, providing diverse wetland habitats. As the remaining areas in the peat production zone are worked out, many are likely to be restored as wetland nature reserves.

The peat soils of the Levels and Moors are a significant store of organic carbon (estimated at 3.7 million tonnes[46]). If the peat was allowed to dry out and decompose, it would release huge amounts of carbon dioxide into the atmosphere which would contribute to climate change. Over the Levels as a whole it is likely that drainage and cultivation by agriculture is currently a more significant cause of peat loss than its extraction for horticulture and gardening.

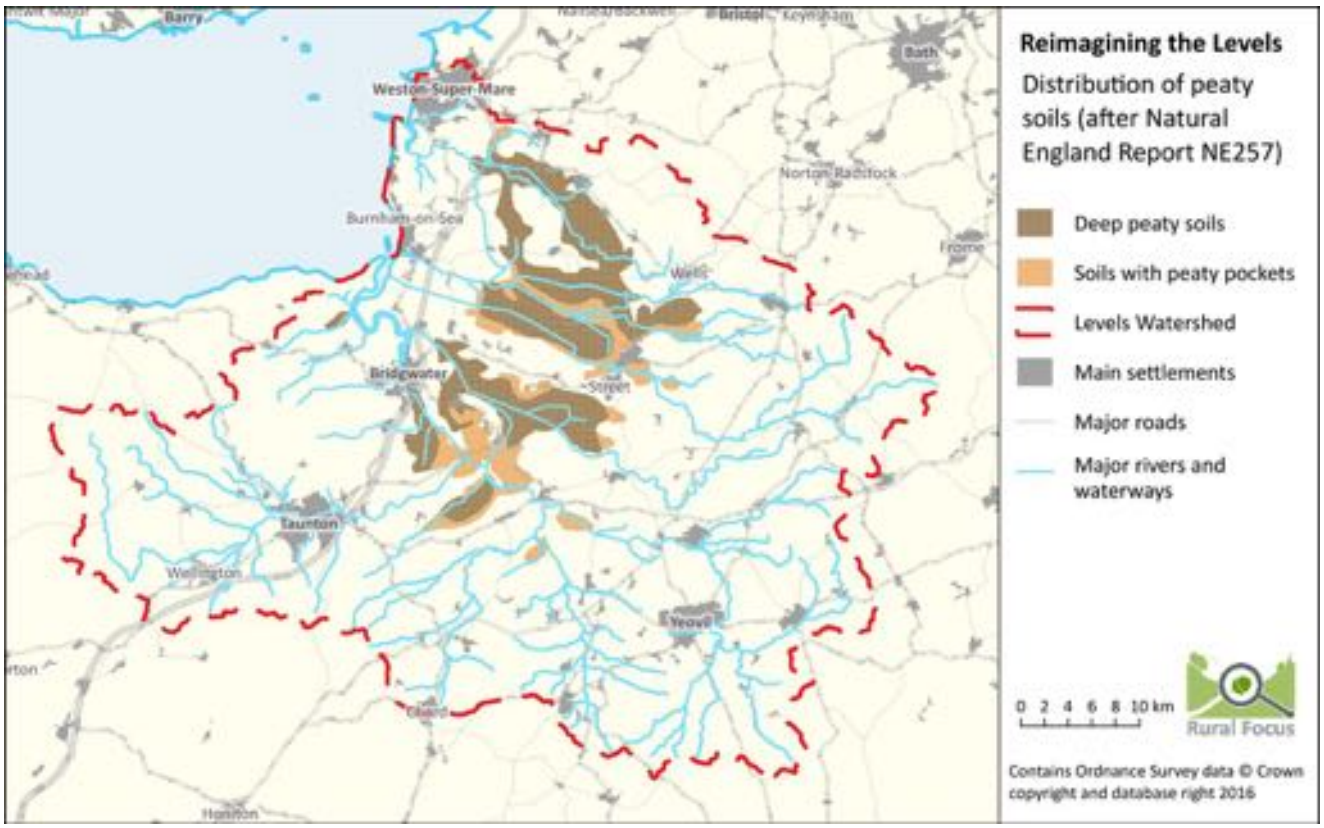
[43] See for instance, the House of Commons Environmental Audit Committee' recent Inquiry into soil health and the Government's response (HC650, published 13 September 2016). http://www.parliament.uk/business/committees/committees-a-z/commons-select/environmental-audit-committee/inquiries/parliament-2015/soil-health/

[44] Brown, A.G. (2009) *Carbon storage and sequestration in the Somerset Levels*. Desk-based Assessment and Report for Somerset County Council. November 2009. The exact amount quoted in that paper is 202.32 million cubic metres.

[45] Ibid.

[46] Ibid.

Figure 23. The approximate extent of peaty soils in the Catchment



Source: Natural England (2010). England's peatlands: carbon storage and greenhouse gases. Natural England Research Report NE257. http://publications.naturalengland.org.uk/publication/30021

The effect of soils on flooding

Soil, and the rock beneath it, have an essential role in the water cycle. Soils that have an open structure and rocks that are porous 'soak up' rainfall which filters through into the water table where it is released slowly into the river system. On the other hand, rain that falls on soils that are impermeable due to their composition or compaction tends to run-off straight into the river system, causing peak river flows and the risk of flooding, as well as erosion of soil which is deposited in river channels, reducing their capacity to carry water.

The soils and bedrock under nearly a third of the Catchment are capable of storing high amounts of winter rainfall. A research paper on soil water storage capacity in the Catchment, prepared for the Hills to Levels Project and Natural England[47], shows that soils with 'very high' winter storage capacity are "*widespread in areas underlain by Triassic sandstones in the west and associated with the Yeovil Sands in the south and east*" (making up 13% of the catchment). Soils with 'high capacity' "*occur chiefly on the Mendip Hills, in the east and on the Quantock Hills and fringes of Exmoor in the west*" (making up 17% of the catchment). All these soils overlie important aquifers which are used to supply our water.

4.4. Energy production

Somerset has contributed two significant sources of energy to the nation: Coal from the Somerset Coalfield north of the Mendips (production ceased in the 1970s); and nuclear power from the Hinkley Point power station (Hinkley B, with a capacity of 1250 MW, is due to be decommissioned in or after 2023 and replaced by the 3,200 MW Hinkley C). Both of these are outside the Levels Catchment.

[47] Palmer, R.C. (2015). *Soil water storage capacity in the Somerset Levels and Moors catchment*. Report commissioned by Natural England as part of the 20-year Flood Action Plan for Somerset. April 2015.

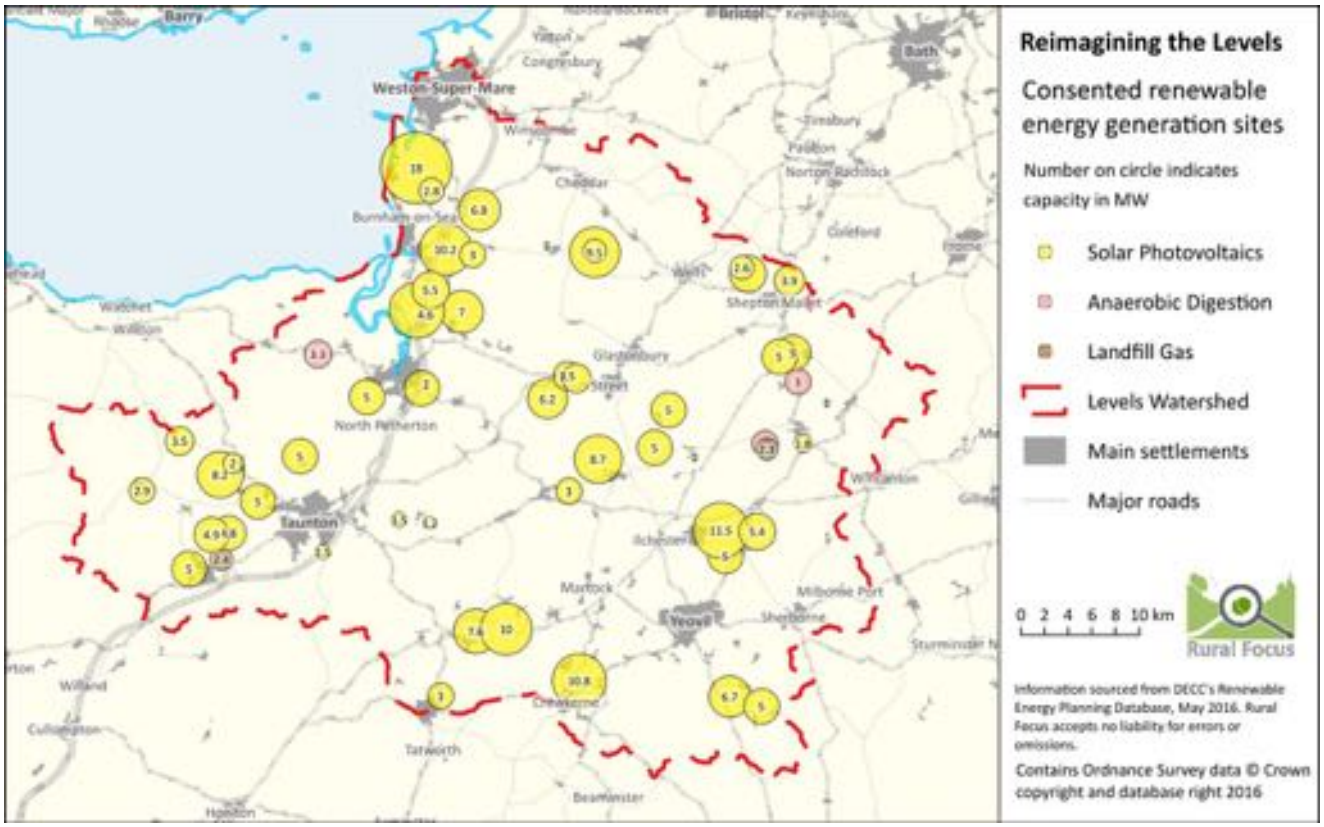
In the last ten years there has been major growth in renewable energy generation in the Catchment, most of it from solar farms, with smaller contributions from anaerobic digestion and landfill gas (see **Figures 24** and **25**). The total operational electricity generating capacity from renewable sources in May 2016 was 209.4 MW, with a further 76.6 MW under construction or consented. Although this capacity is less than a quarter of that of Hinkley B, it is still capable of powering 40,000 homes or around 18% of the families in the Catchment.

Figure 24. Renewable energy generation capacity in the Catchment, May 2016

Technology	Operational capacity (MW)	Capacity under construction (MW)	Other consented capacity (MW)	Total capacity (MW)
Anaerobic Digestion	8.9		3.0	11.9
Landfill Gas	8.2			8.2
Solar Photovoltaics	192.3	23.8	49.8	265.9
Total capacity	**209.4**	**23.8**	**52.8**	**286.0**

Source: Data generated from DECC's Renewable Energy Planning Database, May 2016

Figure 25. Location of consented renewable energy generation plants in the Catchment, May 2016



Wood fuel from woods and hedges is a traditional form of renewable energy used for domestic heating in rural parts of the Catchment. Biomass crops such as Miscanthus (popularly known as elephant grass) have been planted recently in some areas, such as around Taunton, but relatively little of this is processed into pellets for burning in biomass boilers. There is potential for harvesting wood and other unwanted biomass from nature reserves in the Catchment, such as the Shapwick Heath National Nature Reserve, for use as wood fuel. Discussions are taking place over the establishment of a Community Benefit Society to develop this as a social enterprise.

The rocks under the western parts of the Catchment may hold reserves of shale gas that could be exploited by hydraulic fracturing ('fracking'). In December 2015, the Government issued licenses giving rights of exploration over these areas to Wales-based South Western Energy Ltd.

4.5. The condition of landscape and nature in the Catchment

The loss of habitats such as lowland meadows, hedgerows and heathland in England over the last eighty years has been well-documented[48]. The same causes of change, in the form of improvements in agricultural productivity, pollution and urbanisation, have been present in the Catchment. Agricultural drainage, which was granted-aided by Government until the 1980s, has reduced the area of wet grassland and flower-rich meadows. Other forms of agricultural improvement such as the ploughing of permanent pasture, the use of chemical fertilisers and pesticides and removal of hedgerows to enlarge fields, have changed the landscape across the Catchment. Peat extraction to supply the horticultural industry and domestic gardeners has reduced the area of fens in the Lower Brue Valley. Traditional orchards have been removed (again with Government subsidies) or been neglected as the market for the cider and table apples has declined.

Some of these threats have diminished as the forces for change have reduced or as funding has been provided from agri-environment schemes to encourage sympathetic management. However, a number of negative pressures remain. Some of these come from agriculture such as the cultivation or fertilisation of undesignated flower-rich grassland, pollution of rivers from slurry, or erosion of soils left bare in winter. Some come from urban development such as loss of land or pollution; and some come from neglect such as the invasion of scrub or loss of diseased trees.

The health of wildlife

An indication of the current health of habitats on legally protected (designated) sites is provided by the condition assessments that Natural England undertakes on Sites of Special Scientific Interest (SSSI). Data for the lowland SSSI habitats in Somerset shows that 58% of this area is assessed as being in favourable condition (i.e. meeting the conservation objectives that Natural England has set for them based on the reasons for the SSSI's designation). A third (34%) of the area is assessed as in unfavourable but recovering condition (improving, usually as a result of improved management being introduced), and the remaining 8% is in unfavourable condition with no change or with continuing declines[49]. There are many reasons given for the unfavourable condition of these sites but common reasons are inappropriate water levels or agricultural pollution for wet grassland (usually summer water levels being too low) and undergrazing and/or scrub invasion of other grassland sites.

The health of water

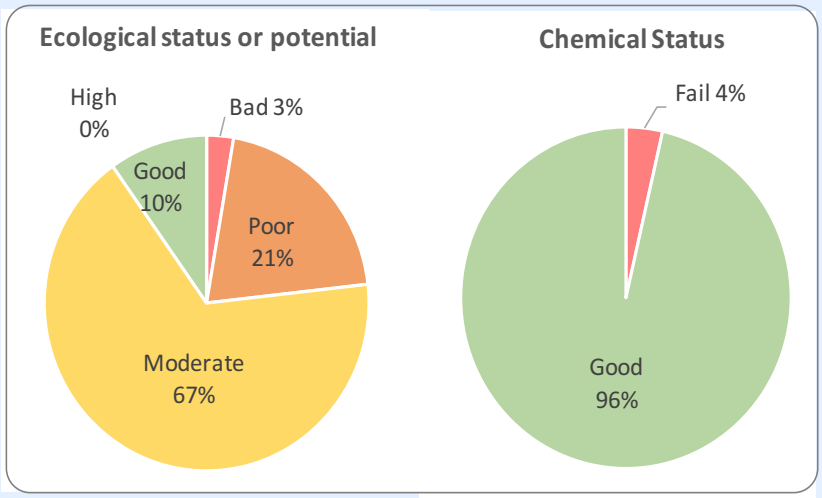
Measurements of the ecological and chemical status of rivers and lakes are collected by the Environment Agency to meet the requirements of the EU Water Frameworks Directive. **Figure 26** shows the latest data for the South and West Somerset catchments (which include the West Somerset streams as well as the Levels Catchment). The left hand graph shows that two thirds of water bodies are judged to be in moderate ecological status, 21% in poor condition, 10% in good condition and 3% in bad condition. Compared to the whole of the South West, the Somerset catchments contain significant fewer water bodies in good condition and more in poor condition. These results reflect the tighter standards required for those areas that are designated under the EU Habitats Directive. Agricultural and rural land management is given as the main reason for not achieving good status (35% of water bodies), followed by dirty water treatment by water companies (25%), and urban and transport pollution (10%), with other reasons accounting for the rest. The right hand graph shows that the large majority of water bodies are judged to have a good chemical status, which is similar to the South West as a whole.

[48] See for instance, RSPB et al (2016). The State of Nature 2016. http://www.rspb.org.uk/forprofessionals/science/research/details.aspx?id=363867

[49] Data accessed from https://designatedsites.naturalengland.org.uk/SearchCounty.aspx on 31 May 2016. Upland habitats (found mainly on Exmoor) have been excluded since they are outside the Catchment area.

Figure 26. Ecological and chemical classification for surface waters, South and West Somerset catchments

Source: Environment Agency WFD (2015 Cycle 2) http://environment.data.gov.uk/catchment-planning/ManagementCatchment/3080/Summary



The health of soils

Analysis of soil records gathered by the Environment Agency and Natural England in South West England provides a picture of the effect that the degradation of soil structure has on surface-water runoff[50]. The research on soil water storage capacity in the Catchment referred to above[51] states that "*Structural degradation has been found to be widespread in SW England. Over 55% of cultivated fields are degraded by compaction and soil structural change to such a degree that surface runoff becomes likely during winter rain unless remediation is carried out. Soils under maize, potatoes and other late harvested crops have an 80- 90% chance of suffering this degree of degradation*."

The research on soil water storage capacity identifies the soils in the Catchment that are most prone to damage[52]. Soils on the Yeovil sands have an inherently fragile structure which can break down following arable cultivation. In addition, the clay-rich soils on the reddish Triassic mudstone and grey Jurassic clays, which are found in the Upper Tone Catchment and Quantock Fringes as well as other areas, are particularly susceptible to compaction which can occur from farming operations undertaken in wet periods, such as ploughing and slurry spreading and also from high stocking densities. Compaction and surface slaking of soils that have high or very high winter storage capacity (covering 30% of the catchment – see above) can reduce this capacity by more than 65%, making it highly likely that the soils will be unable to absorb sustained rainfall, resulting in overland flow[53].

The research goes on to recommend that some naturally heavy wet soils in the Catchment should not be used for regular arable cropping and that others are only suited to early autumn harvest and cultivation. Following degradation, some soils will gradually recover their storage capacity naturally, provided damaging operations do not continue. However, others are much less likely to recover on their own, requiring remedial action. It is significant that it is the soils of the Yeovil sands which, when in good condition, can provide the very high winter storage of rainfall, are also least likely to recover naturally following compaction. The soils that are likely to require remedial action to recover their potentially high storage capacity are found in the Upper Parrett, Upper Yeo and Upper Upper Isle catchments[54]. These are also soils that have the potential for high agricultural productivity (see **Figure 27** – Agricultural Land Classification on the following page).

[50] Palmer RC and Smith RP (2013). *Soil structural degradation in SW England and its impact on surface-water runoff generation*. Soil Use and Management, DOI: 10.1111/sum.12068.
[51] Palmer, R.C. (2015). *Soil water storage capacity in the Somerset Levels and Moors catchment*. Report commissioned by Natural England as part of the 20-year Flood Action Plan for Somerset. April 2015.
[52] Ibid.
[53] Ibid.
[54] Ibid.

5. Farming and food production

This section describes agricultural land use and production in the Catchment, looks back at recent changes in farming land use and management and examines the types of environmental management taking place on farms.

5.1. Farming at the present time

Agriculture is the dominant land use in the Catchment, accounting for around 79% of the land area. There are an estimated 3,000 agricultural holdings employing around 7,500 people, 3,600 of them full-time. Nearly three quarters of farmland is pasture, grazed by around 200,000 cattle and 210,000 sheep. Most of the rest is cropped, with cereals (wheat and barley) accounting for half of the cropped area, forage maize (grown for animal feed) about a quarter and other arable crops such as oilseed rape and field beans the rest[55].

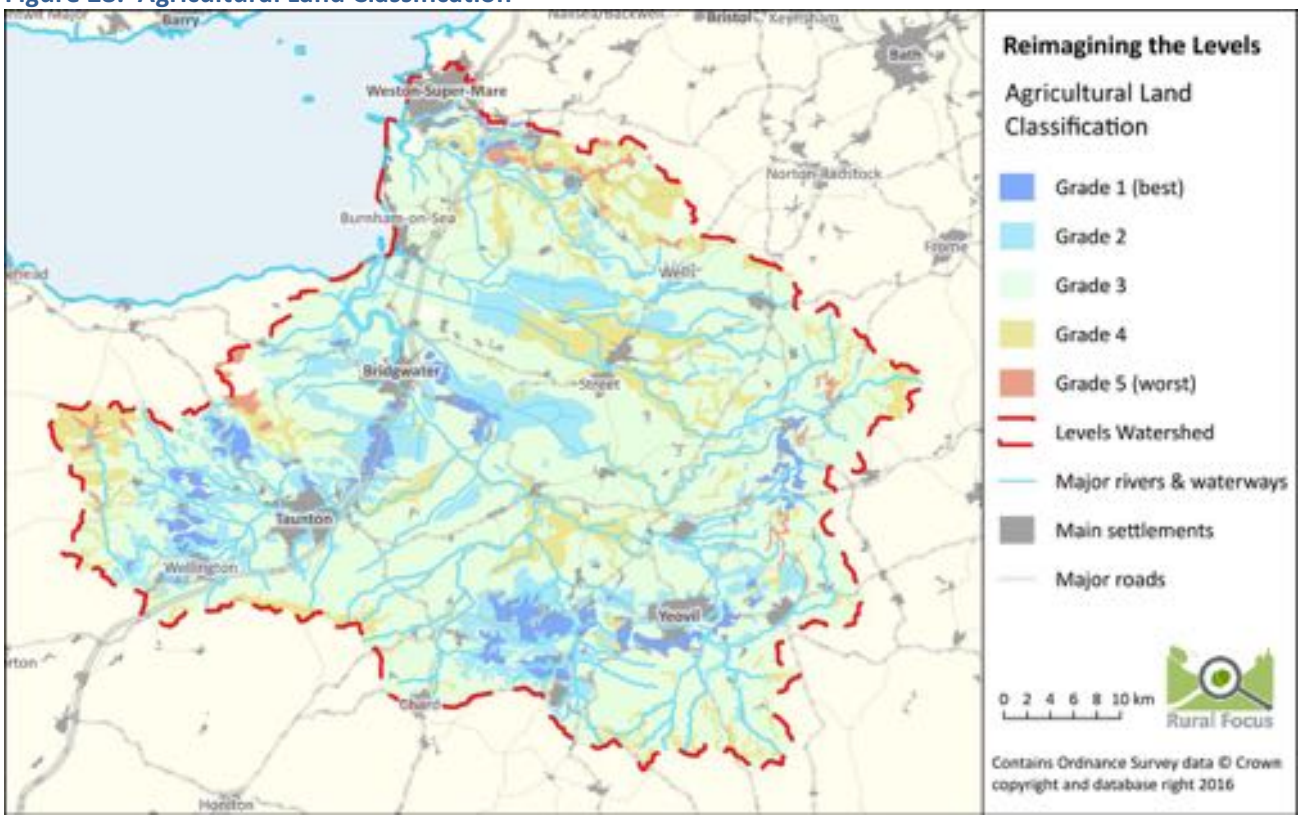
Figure 27. Summary of farming land use for the Catchment, 2013

Type of agricultural land use	Hectares	% farmed area
Permanent grass & rough grazing	106,892	55%
Temporary grass	26,790	14%
Cereals	27,997	14%
Maize	12,417	6%
Other arable crops and fallow	11,278	6%
Other land on farms	8,480	4%

Source: Estimates based on analysis of Defra June Agricultural Survey

The type of farming varies across the Catchment, reflecting the productivity of the soils and other factors such as the risk of flooding. As **Figure 28** shows, the best agricultural land occurs in the Upper Tone and Upper Parrett catchments. Overall, the Catchment contains the same proportion of the best agricultural land (17% of Grades 1 and 2) as for England as a whole. The effect of these grades, and other factors, is that grassland farming and livestock grazing dominate in the northern and western parts (for instance the Brue and Axe catchments and the Quantock Hills). Arable farming is more common in the southern and eastern areas (for instance the Tone, Parrett and Yeo catchments).

Figure 28. Agricultural Land Classification

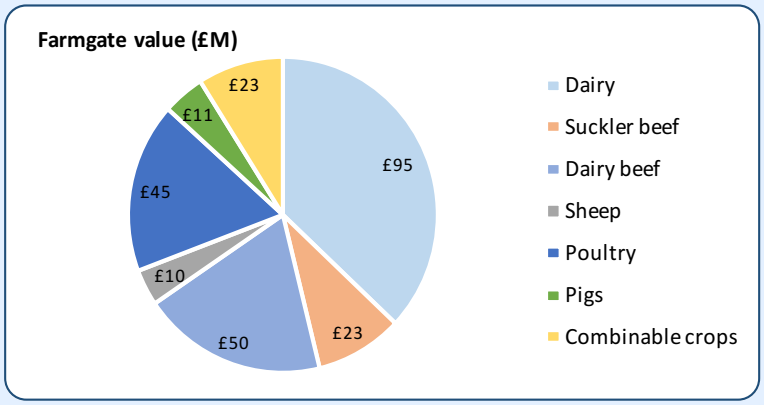


[55] Source: Analysis of Defra June Agricultural Survey data for 2013

The main agricultural outputs are milk from the 65,000 dairy cows (producing an estimated 450 million litres a year), beef from the dairy and suckler cow sectors (producing an estimated 31,000 tonnes of beef a year), lamb (an estimated 2,500 tonnes), wheat (115,000 tonnes) and barley (60,000 tonnes).

Based on the 'farmgate' value (the price that farmers receive when they sell their produce) of these and other commodities, farming in the Catchment has an annual output worth around £257 million. This does not include value that is added to these 'raw' commodities by processing and retailing (covered further in Section 6.2).

Figure 29. Estimated value of primary agricultural production, 2015



Source: Based on 2013 crop areas and livestock numbers (Defra June 2013 Agricultural Survey) and October 2015 prices (Farmers Weekly).

In addition to money they earn from agricultural production, farmers also receive substantial sums from the Common Agricultural Policy (CAP). There are two main parts to the CAP as far as payments to farmers are concerned. 'Pillar 1' provides basic income support through the Basic Payment Scheme in 2016 (previously the Single Farm Payment) and 'Pillar 2' provides rural development payments, including for environmental management. Receipts from the Basic Payment Scheme by farmers in the Catchment in 2016 will amount to around £33.3 million[56] and in 2014, farmers were paid £8.7 million[57] for undertaking environmental management through the Environmental Stewardship scheme (described further below). Many farms also have non-agricultural enterprises such as farmhouse B&Bs.

Despite the high 'farmgate' value of what they sell, farmers have high costs (such as the rental of land, purchase of machinery and cost of fuel, crop inputs and animal feeds) and the profitability of many farm businesses in the Catchment is low. For some, the payments they receive from the 'Pillar 1' Basic Payment Scheme are currently all that prevents them making a financial loss or a very low profit.

Figure 30 uses the results of the Farm Business Survey for farms in the South West of England to show the average Farm Business Income received by different types of farm in the 2014/15 financial year. Farm Business Income (FBI) is a measure of the money produced from agricultural activity by the business after all its costs have been met, but before any drawings by the farmer. The table also shows the amount received by the different types of farm from the 'Pillar 1' Single Farm Payment (which is included in the FBI figure). The final column shows the value of the FBI if the SFP is excluded. This is of interest because, following Brexit, it is possible that the UK Treasury will seek to reduce farm income support payments.

The data show that the average farm in the survey in the SW had an FBI of a little over £32,000 but that over £21,000 of this came in the form of income support from the Single Farm Payment (SFP) scheme. The figures for the different farm types show that some types tend to be larger, with more money invested and higher incomes (for instance dairy farms) and others tend to be small, relying on non-agricultural income which is not shown in the table (for instance general cropping farms). The table shows that the average cereal, general cropping, grazing livestock (i.e. beef and sheep) and mixed farms in the South West all relied on the Single Farm Payment to provide any significant management income to the farmer.

[56] Assuming the payments were made on 85% of the farmed area

[57] Source: Analysis of ES agreement data from Natural England. £4 million came from the Entry Level tier and £4.7 million from the Higher Level tier of the scheme.

Figure 30. Farm income figures for the South West of England from the Farm Business Survey, 2014/15

Farm types	Farm Business Income (FBI)	Of which, income from Single Farm Payment (SFP)	Hence, FBI without SFP
All farm types	**£32,119**	**£21,134**	**£10,985**
Cereals	£45,810	£47,825	-£2,014
General cropping	-£6,254	£20,245	-£26,499
Horticulture	£24,758	£1,926	£22,832
Dairy	£86,392	£27,012	£59,380
Grazing livestock (lowland)	£16,010	£14,413	£1,597
Grazing livestock (Less Favoured Areas)	£16,973	£16,719	£253
Pigs*	£49,420	£8,490	£40,930
Poultry	£54,163	£7,090	£47,072
Mixed	£12,972	£20,239	-£7,267

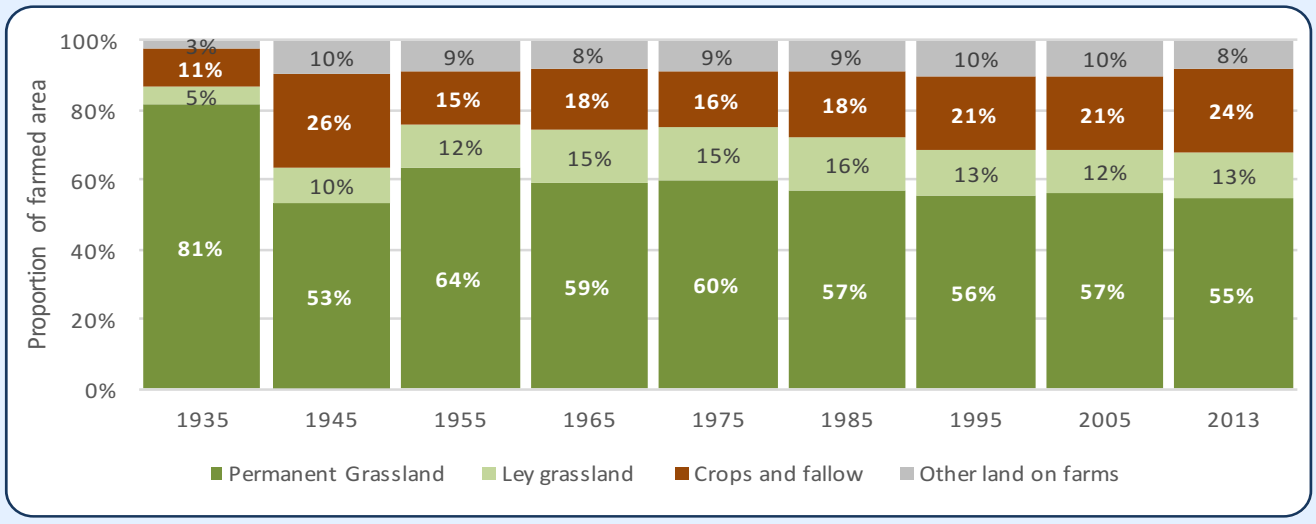
Source: Farm Business Survey 2014/15. http://www.farmbusinesssurvey.co.uk. © Rural Business Research, Department of Land Economy, Cambridge CB3 9EP. The Farm Business Survey is conducted on behalf of, and financed by, Defra and the data collected in it are Crown Copyright.
* Note: data for Pig farms are national since the sample of farms in the SW is too small.

It is important to note that, as well as producing food, farming continues to play an essential role in maintaining the countryside landscape and, particularly on the wet grassland of the Somerset Levels, conserving wildlife. The environmental impacts of recent changes in farming practice are covered further below.

5.2. Recent changes in farming land use and management

Overall, agricultural land use has remained relatively stable over the last 60 years. The chart below, shows that, following a substantial increase in cropped land during WWII ('Dig for Victory') which was partly reversed after the War, the area under crops has gradually increased and the area of permanent grassland has reduced.

Figure 31. Changes in farming land use in Somerset since 1935

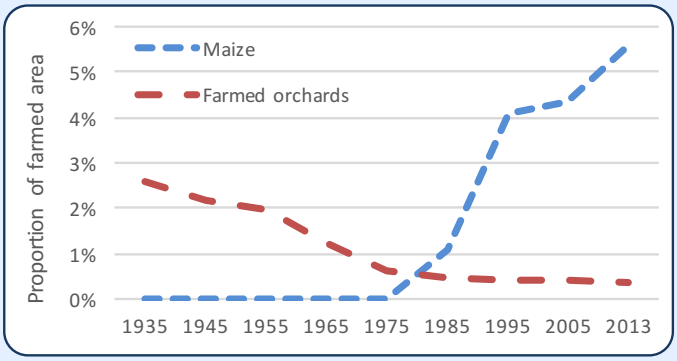


Source: Defra June Agricultural Surveys

These changes mask major changes in farming practices and output. Farming has mechanised (in 1935 there were still 18,000 working horses on Somerset farms), introduced new breeds of livestock and crops and made use of chemical fertilisers and pesticides. This has resulted in large increases in productivity but has also resulted in major changes to the farmed landscape and biodiversity (particularly as a result of land drainage, pasture improvement and hedgerow removal). Farms have grown larger and more specialised and the number of people working on farms has shrunk (from 20,500 in Somerset in 1950 to around 10,000 today).

Certain crops have become much more common and others that were once common have declined. Maize, grown for animal feed, was virtually unknown in Somerset until the 1980s but new varieties that suit the climate are now grown on a quarter of cropped land, being most common in dairy farming areas. The crop is harvested in late autumn and this can lead to compaction of the soil structure and to erosion. On the other hand, apple orchards, grown for eating and for cider, have declined dramatically in the last 80 years, as shown in the chart.

Figure 32. Changes in maize and farmed orchard areas in Somerset, 1935 to 2013



Source: Defra June Agricultural Surveys

The way in which farmers are supported through the Common Agricultural Policy has changed significantly over the last 20 years. Direct price support and production subsidies that led to unwanted 'milk lakes' and 'grain mountains' in the 1980s and 1990s were phased out from 2004 onwards. Farmers now receive a 'decoupled' basic payment linked to the area they farm but must rely on market prices, which fluctuate based on global supply and demand, for most of their income. In recent years, the low price that dairy farmers receive for their milk, compared to rising farming costs (e.g. energy and land), has resulted in sharp falls in their income, causing significant numbers to give up dairy farming (retiring or changing to other farming sectors).

5.3. Environmental management on farms

The majority of farmers in the Catchment have signed up to the Government's Environmental Stewardship scheme (which replaced the earlier Environmentally Sensitive Area Scheme and is now being succeeded by the new Countryside Stewardship Scheme). Farms that were in the Environmental Stewardship scheme in May 2016 are shown in **Figure 33**, on the following page.

Three quarters (74%) of farmland in the Catchment is covered by in the Entry Level tier of the scheme which pays a flat rate area payment in return for relatively simple and low cost environmental management options. Examples of the most popular options chosen by farmers in the Catchment are shown in **Figure 34**. The management agreements under this tier will be finishing during the next eight years, after which they will not be renewed since the successor scheme (Countryside Stewardship) does not include an equivalent tier. It remains to be seen what will happen to the land and environmental features (such as field buffer strips) that are currently being managed under this Scheme.

A smaller proportion of land (18% of farmland or 14% of the Catchment) is also covered by the Higher Level tier of Environmental Stewardship which had a competitive application process (i.e. only applications offering the greatest environmental benefits were selected). This tier pays higher levels of annual payments for management options which seek to deliver greater environmental conservation or enhancements. Again, examples of the most popular options adopted in the Catchment are shown in **Figure 34**. The high environmental quality of the Levels and Moors (the lower parts of the Catchment) mean that a large proportion of the land in the Higher Level tier is in this area. The most frequent management options in this area are the maintenance of wet grassland for wintering waders and wildfowl and the maintenance of grassland for 'target features' (such as wetland habitats and species).

Figure 33. Farms in the Environmental Stewardship scheme, 2016

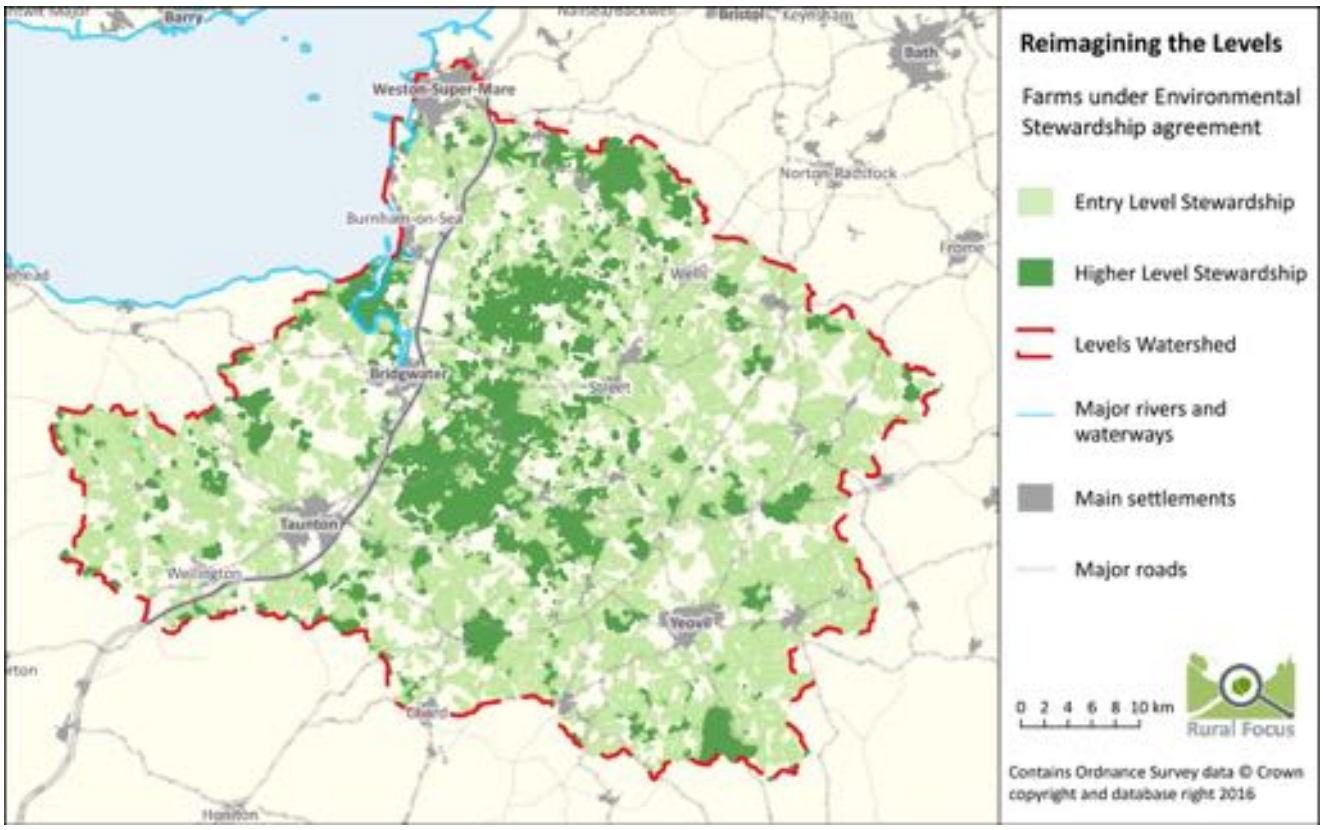


Figure 34. The most common options (ranked in declining order) included in Environmental Stewardship agreements in the Catchment

Entry Level Stewardship options	No. of agreements
EK2: Permanent grassland (low inputs)	3,576
EK3: Permanent grassland (v. low inputs)	1,547
EC2: Protecting in-field trees (grassland)	664
EE3: 6m buffer strips on cultivated land	570
EE1: 2m buffer strips on cultivated land	527
UX2: Grassland and arable	489
EK5: Mixed stocking	484
ED5: Management of archaeological features on grassland	418
EB2: Hedgerow management for landscape (on one side of a hedge)	408
EE2: 4m buffer strips on cultivated land	398

Higher Level Stewardship options	No. of agreements
HR1: Grazing supplement for cattle	281
HR6: Supplement for small fields	251
HK15: Grassland maintenance for target features	216
HK10: Maintenance of wet grassland for wintering waders and wildfowl	205
HK6: Maintenance of species-rich, semi-natural grassland	138
HK7: Restoration of species-rich, semi-natural grassland	132
HK19: Raised water levels supplement	113
HR2: Grazing supplement for native breeds at risk	88
HK9: Maintenance of wet grassland for breeding waders	86
HC7: Maintenance of woodland	84

6. Communities and Economy

This section describes socio-economic aspects of the Catchment, looking at the characteristics of the people and communities who live in the area and also its economy. It focusses on the land-based sectors of farming and forestry and on the tourism and hospitality sectors as key drivers in the area's rural economy.

6.1. People and communities

The Catchment is home to over half a million people, living in over 200,000 households[58]. Three quarters of these people live in towns and nearly half live in the four largest towns of Weston-super-Mare, Taunton, Yeovil and Bridgwater. Of the 126,000 people who live in rural areas, two thirds live in villages and one third live in hamlets and isolated dwellings in the countryside[59].

The demographic characteristics of people living in the Catchment are similar to those in the wider South West region. **Figure 35** shows the economic activity levels of people aged 16 to 74, comparing the Catchment to the South West region as a whole. It shows that the Catchment has a slightly higher proportion of retired people (with concentrations in Weston-super-Mare and Burnham-on-Sea) and fewer students but is otherwise very similar to the South West.

Figure 35. Economic activity of people living in the Catchment compared to the SW Region, 2011

Categories of economic activity Percentages of people aged 16-74	Levels Catchment	SW Region	Difference Levels catchment to SW
All economically active people aged 16-74	70.4%	70.3%	+0.1%
Employees (Full and part-time)	53.3%	52.6%	-0.1%
Self-employed	11.3%	11.2%	+0.1%
Unemployed	3.1%	3.3%	-0.2%
All economically inactive people 16-74	29.6%	29.7%	-0.1%
Retired	16.9%	15.8%	+1.1%
Looking after home or family	3.7%	3.7%	+0.0%
Long-term sick or disabled	3.8%	3.6%	+0.2%
Other inactive people	1.6%	1.7%	-0.1%
Students (both economically active and not)	6.3%	8.1%	-1.8%

Source: ONS Dataset QS601EW. Census Output Areas cut to Catchment

Just over a third (36%) of people work in managerial positions which is slightly less than the level for the South West as a whole. Concentrations of people in these 'higher' occupations occur in villages and countryside around Taunton, Wells and Yeovil. The Catchment also has its share of areas which are recognised as suffering from social and economic deprivation, with concentrations in Weston and Burnham and pockets in rural areas such as between Langport and Ilminster[60]. Analysis by this study shows no significant overall differences between the characteristics of people living in the Levels and Moors (the lower catchment) compared to those living in the middle and upper parts of the Catchment.

[58] Precise figures, based on analysis of census output areas from the 2011 census (ONS) are 516,843 residents in 222,593 households.
[59] These figures use the Government's Urban-Rural classification of census output areas in the Catchment. https://www.gov.uk/government/collections/rural-urban-definition
[60] Department of Communities and Local Government (2015). The English Index of Multiple Deprivation 2015. Analysis by this study of 'File 7' (All ranks, deciles and scores for the Indices of Deprivation, and population denominators) as Lower Super Output Area level.

6.2. Economy

A picture of the economic activities taking place in the Catchment can be derived from the sectors that people work in, recorded by the 2011 census. **Figure 36** shows a breakdown of employment in the Catchment and in the South West region by 'Broad Industry Groups'[61]. It shows that the economic structure of the Catchment is similar to that for the region as a whole, but with slightly higher levels of employment in manufacturing and the wholesale and retail trades and slightly lower levels of employment in sectors such as accommodation and food service and information and communication.

Figure 36. Employment by industrial sector in the Catchment compared to the SW Region, 2011

Broad Industry of Employment Percentages of employed people aged 16-74	Levels Catchment	SW Region	Difference Levels catchment to SW
Wholesale & Retail Trade including Motor Vehicles	18.2%	16.2%	+2.0%
Human Health and Social Work Activities	13.6%	12.9%	+0.7%
Manufacturing	11.1%	9.1%	+2.1%
Education	9.6%	9.7%	-0.1%
Construction	8.1%	8.0%	+0.1%
Public Administration and Defence	6.7%	7.1%	-0.4%
Accommodation and Food Service Activities	5.4%	6.3%	-0.9%
Professional, Scientific and Technical Activities	5.1%	5.9%	-0.8%
Administrative and Support Service Activities	4.1%	4.4%	-0.3%
Transport and Storage	3.9%	4.0%	-0.2%
Information and Communication	2.4%	3.3%	-0.9%
Agriculture, Forestry and Fishing	2.1%	1.6%	+0.4%
Other activities	9.7%	11.5%	+0.4%

Source: ONS Dataset KS605EW. Census Output Areas cut to Catchment

Two sectors that are particular interest to this study, because of their relationship with the land and environment, are agriculture/forestry and tourism.

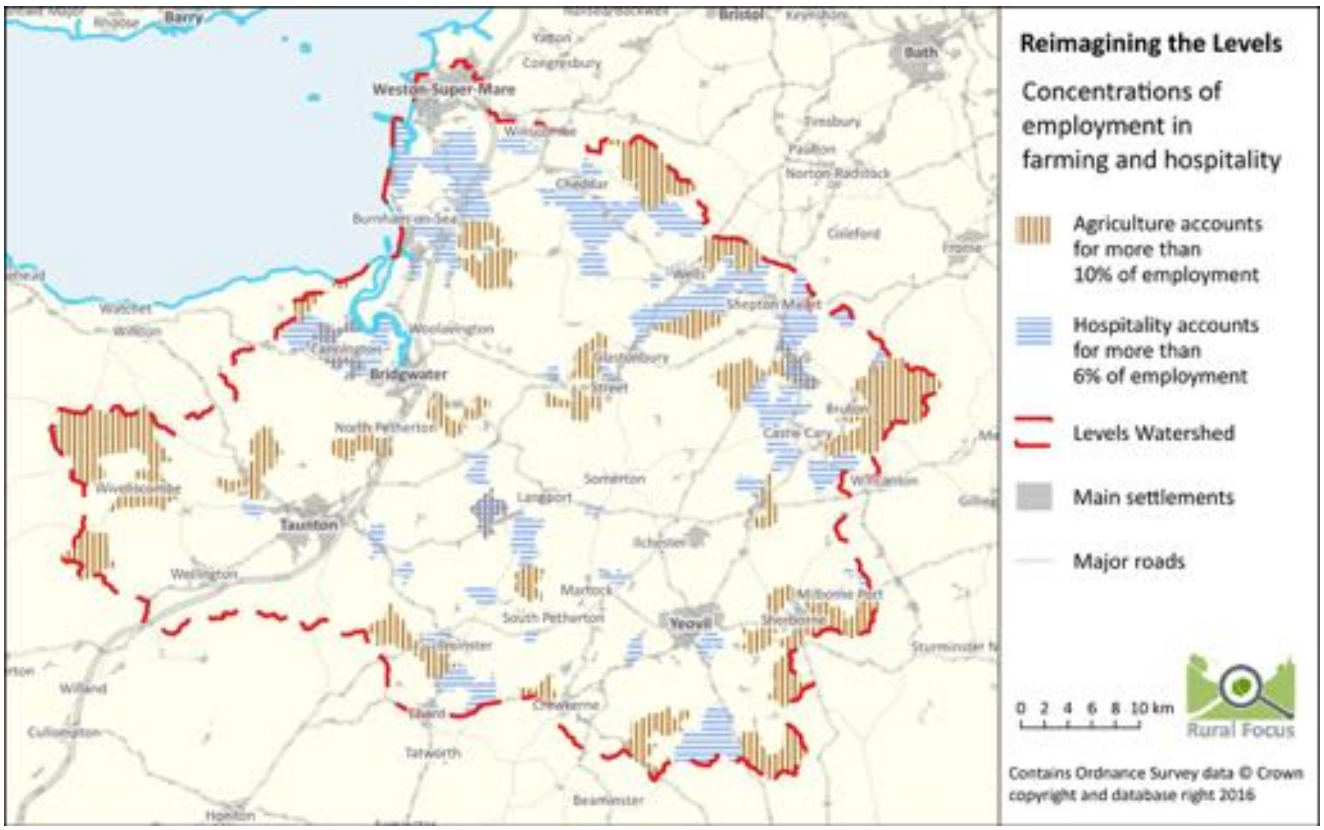
Agriculture and forestry

The later section on Farming and Food Production examines the contribution of farming in more detail, estimating that primary agricultural production in the Catchment generates around £257 million a year from sales, receives a further £42 million a year (2014) in subsidies and payments and directly employs 7,500 people on farms. Although farmwork accounts for only 2% of all employment in the Catchment as a whole, it is much more significant in rural areas. **Figure 37** shows the areas where it exceeded 10% of employment in 2011. Agriculture also supports significant levels of employment off-farms in supplies and services to farming (e.g. machinery dealers, vets and contractors) and in the processing and sale of products from farms (e.g. abattoirs, cheese makers, food retailers) and much of this is likely to take place in towns and villages rather than the countryside.

The forestry sector is likely to be much smaller in comparison to farming, both because woodland covers only 6% of the land area, compared to 79% for farmland and also because forestry is less economically productive.

[61] Broad Industry Groups are a standard classification used by the Office for National Statistics.

Figure 37. Concentrations of employment in farming and hospitality, 2011



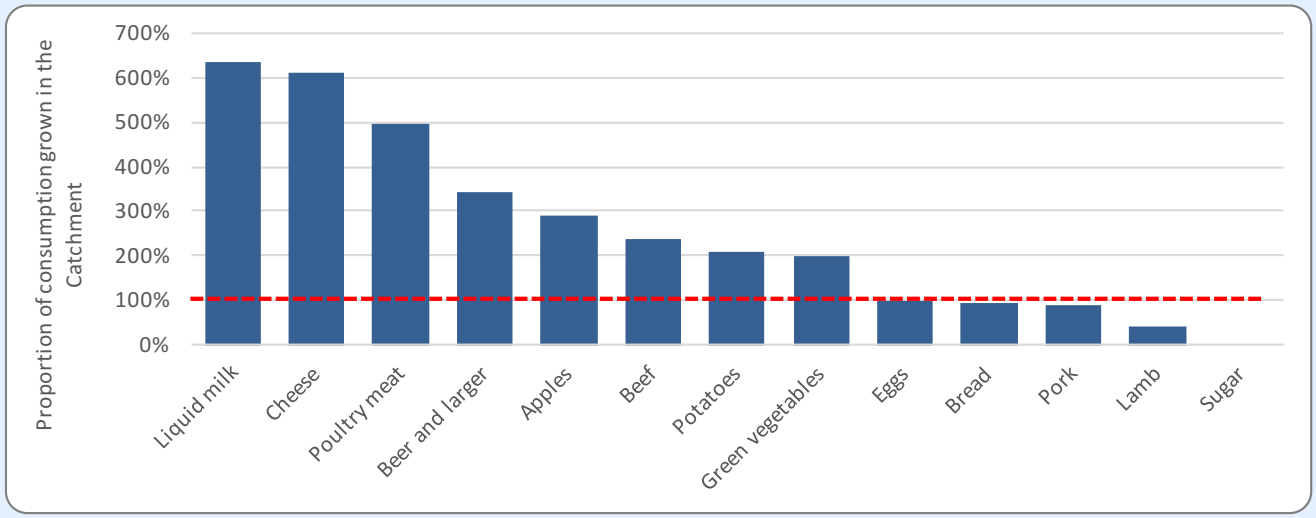
Source: ONS Dataset KS605EW. Census Output Areas cut to Catchment

Local self-sufficiency in food and drink

Strong local supply chains, where consumers are able to source much of what they need from local producers, have many advantages. For instance, people become more aware of how their purchasing decisions affect the local environment and their communities; more economic value and employment is retained by local businesses (the local economic multiplier); and fewer natural resources tend to be used (and greenhouse gases emitted) in the transport and storage of goods.

An indication of the potential self-sufficiency of the Catchment in 'indigenous' foods (those which can be grown in the area) is shown in **Figure 38**. This is based on estimates of current farm-based food production using Defra's annual agricultural survey (excluding cereals grown for animal feed) and from estimates of consumption per head from the UK Family Food Survey. It shows that the Catchment is theoretically self-sufficient in many types of food and drink, with large surpluses of the amount of milk, cheese, poultry meat, barley for beer and larger, apples, beef, potatoes and green vegetables. This is not surprising given that the Catchment has agriculturally productive pasture and arable and a relatively low population density. Sugar is the only main indigenous food stuff that is not produced in the Catchment.

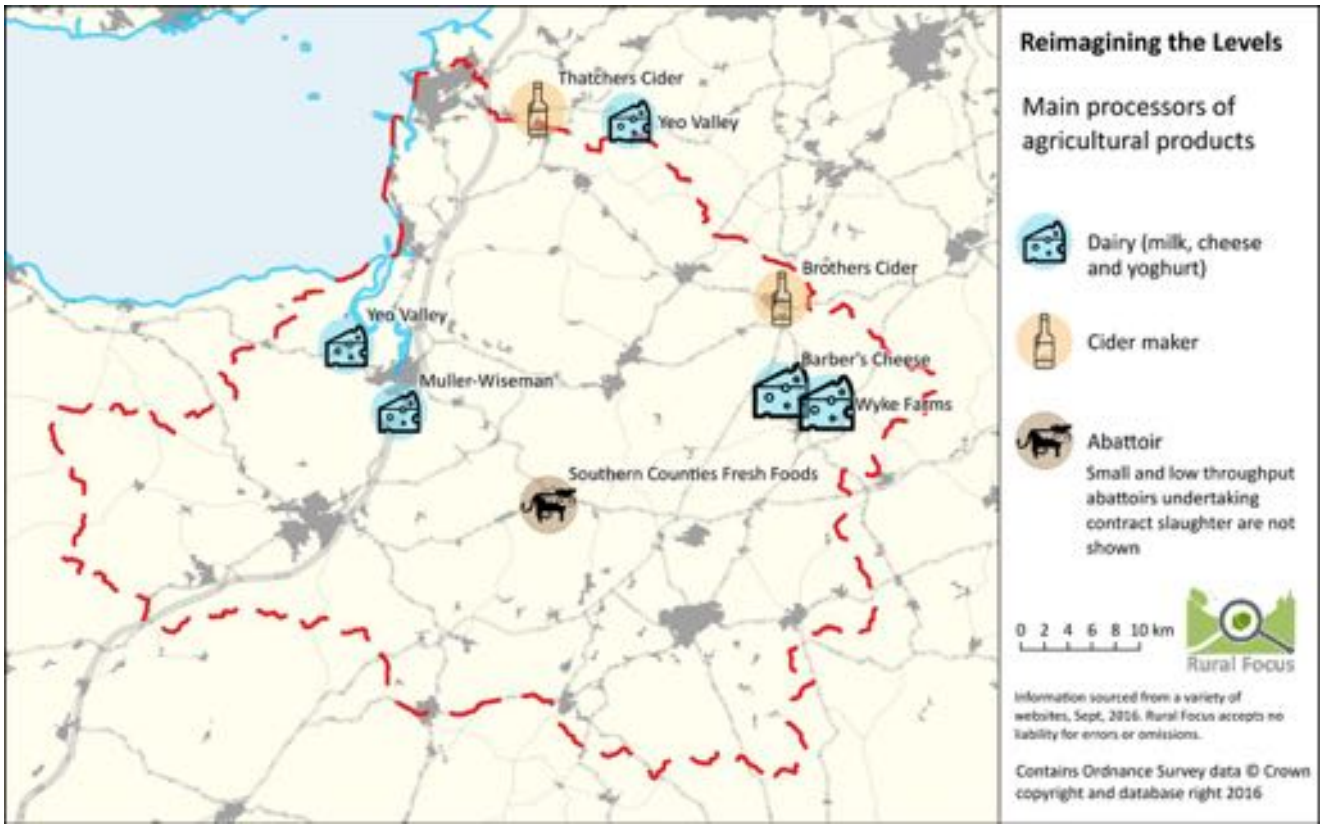
Figure 38. Local self-sufficiency in major types of foods and drink



Source: Analysis by this study using data from Defra's annual agricultural survey and the UK Family Food Survey

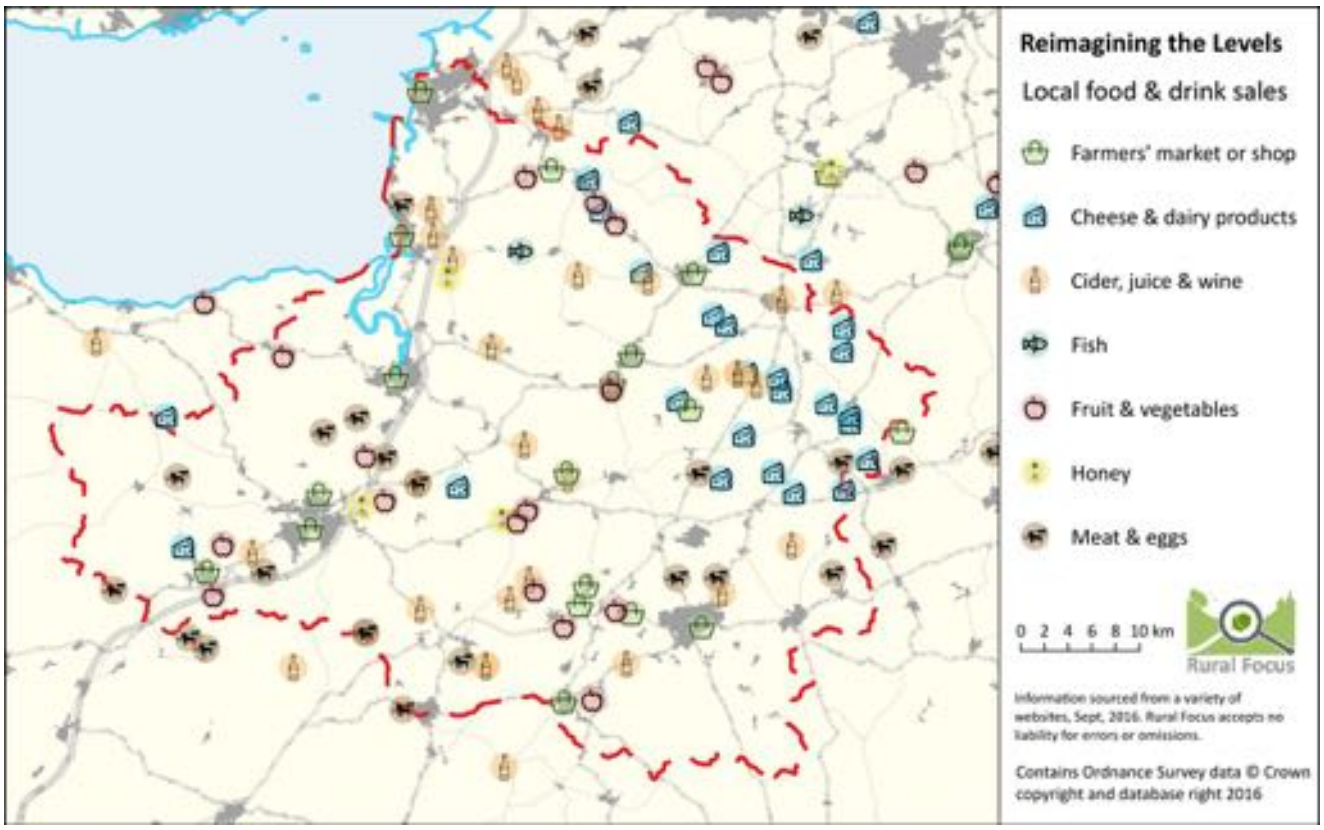
Figure 38 only shows a theoretical position since, for many of the food and drink groups, the components of the supply chain (e.g. suitable processing, storage and retailing) do not exist to allow consumers to source what they need locally. **Figure 39** illustrates this by identifying the location of the main processing sites for the agricultural commodities produced in the Catchment (e.g. abattoirs and dairies). Much of what is produced in the area travels long distances to be processed, before entering undifferentiated national and international supply chains. In order for strong local supply chains to be established, a greater diversity of food processing plants would be needed in or close to the area. A truly responsive and sustainable local supply chain would also need to change the types and amounts of food being produced on farms to reflect ecological efficiency and demand by local people. This issue is examined further below, under the section on bioregionalism.

Figure 39. The location of major sites processing farm products produced in the Catchment



There are however, a significant number of farms and other food producers in the Catchment who process and sell their products direct to the public. **Figure 40** shows the location of Farmers' Markets, farm shops and businesses selling direct to the public or through local outlets. It shows a concentration of farmhouse cheese markers in the north east of the Catchment, fruit and vegetable producers in the southern half of the Catchment and farms selling their own meat in the west, with farmhouse cider makers distributed throughout the area.

Figure 40. Examples of local food and drink sales, direct form the producer



Note: This map is not comprehensive. The 'Reimagining the Levels' group welcomes feedback on omissions or errors.

Hospitality and tourism

A study on tourism in Somerset's Districts in 2008 (the most recent year for which data is available) can be used to estimate tourism employment and spending in the Catchment. On a pro-rata basis by area, tourism in the Catchment accounted for 14,000 jobs, or 9% of the workforce. Spending by tourists staying in the Catchment was worth around £230 million a year and spending by day visitors a further £311 million.

Most of this spending took place in the towns and large villages (on things like accommodation, food and drink) with relatively small amounts in the countryside (although visits to nature reserves and use of footpaths, where no charge is made, also make up an important part of what the area provides for visitors). Nevertheless, it is widely accepted that the distinctiveness and quality of the landscape in the countryside and coast are a major reason why many tourists visit the area[62].

There is a therefore a close economic link between the condition of the landscape and the jobs and spending sustained by visitors. However, this link tends to be one-way, with tourism benefiting from landscape quality, but with little of the spending by tourists findings its way back to cover the costs of maintaining the landscape (farm-based tourism being an exception). This issue is addressed again in the next section.

[62] http://www.visitsomerset.co.uk/explore-somerset/countryside

As with farming, employment in tourism tends to be concentrated in certain areas. **Figure 37** on page 41 shows the parts of the Catchment where 'accommodation and food service activities' accounted for more than 6% of jobs in 2011. It shows relative concentrations in the rural areas along the coast and along the north eastern part of the Catchment (in the Brue and Axe catchments).

6.3. Bioregionalism

A key issue for this project has been the disconnections that exist in the Catchment in the food supply chain (between farming and consumers), in the environment (between the way land, energy and waste are managed) and in the economy (for instance the low profitability of farming and the poor return from tourism to the landscape).

These are all issues that are addressed by the concept of bioregionalism. This emphasises the importance of natural boundaries and cycles (for instance the water cycle within catchments). It emphasises the cultural importance of places to people. And it highlights the economic and social connections between the people who produce and consume goods and services. It recognises the hidden costs borne by the environment (such as pollution of water supplies or loss of biodiversity) and advocates more sustainable and equitable use of natural resources by people. In many respects it is the antithesis of globalisation.

The concept arose in the 1970s, from analysis such as British economist E F Schumacher's influential book '*Small Is Beautiful: A Study of Economics As If People Mattered*'[63]. More recently, aspects of the concept were adopted by the Welsh Government in its One Wales, One Planet Sustainable Development Scheme (2009)[64]. The relevance of the concept was brought up to date in 2012 in a book by green economist and MEP for the South West, Molly Scott Cato, entitled '*The Bioregional Economy: Land, Liberty and the Pursuit of Happiness*'.[65] Advocates of the approach argue that it is the only way to address issues like climate change, the declining availability of natural resources and growing economic inequalities in society.

The Levels Catchment is well-suited to a bioregional approach. It is an area that is recognised as being culturally distinct and, as shown earlier in this document, is capable of providing much of the food and energy needed by its residents, often with surpluses for nearby urban areas like Bristol. However, as this document has shown, the physical infrastructure and policy frameworks needed to make environmentally and socially efficient use of these resources are weak or lacking. These are issues that the main project report seeks to address.

6.4. Community engagement and Knowledge co-production

Another issue that is highlighted by this project is the gap that exists between the organisations charged with taking decisions about flooding and water management in the catchment, and the communities who should benefit from these decisions.

Most people receive their information about issues such as flooding, and what is being done to reduce it, from the popular media. Media attention tends to be brief, following periods of severe flood events and focuses on the immediate 'rescue' actions rather than the long term adaptation and solutions. Somerset County Council, through the Somerset Rivers Authority, has responded to this by producing regular updates on its work, involving interested parties through the Somerset Water Management Partnership (see page 17) and consulting, with its partners, on major projects such as the Bridgwater Barrier. Nevertheless, the opportunities for dialogue and explanation with ordinary citizens are rare.

The winter flooding of 2013/14 led to a new level of community activism on the Levels and Moors, with the creation of the Flooding on the Levels Action Group (FLAG). This arose from a frustration and lack of trust felt

[63] Schumacher E F (1972) *Small Is Beautiful: A Study of Economics As If People Mattered*. ISBN: 978-0061997761.
[64] Welsh Government (2009). One Wales: One Planet. The Sustainable Development Scheme of the Welsh Assembly Government. May 2009. http://gov.wales/docs/desh/publications/090521susdev1wales1planeten.pdf
[65] Scott Cato M (2012). The Bioregional Economy: Land, Liberty and the Pursuit of Happiness. ISBN: 978-0-41550-082-1 http://www.greeneconomist.org/files/greeneconomist/general/1The_Bioregional_Economy_discount_flyer.pdf

by local people. Bodies like the Environment Agency and Natural England were perceived as distant, unaccountable and technocratic. For their part, staff in these organisations may have felt frustrated by the rigid legal processes they were required to operate in, by their limited budgets, and by the lack of understanding that most ordinary people have of the complex issues their organisations were dealing with.

This issue of the gap between the organisations charged with delivering public services and the public who use these services has been recognised in other sectors in the UK. In the health and social care sectors, it has been recognised that 'top down' solutions designed by doctors and social workers do not necessarily meet the needs of people needing care[66]. Similarly, universities and other research bodies have recognised that they need to engage with the public about what future research priorities should be, rather than allowing the research community to decide[67].

This approach to designing policy delivery around the needs of the service users and beneficiaries, rather than those of the provider, has been given the rather ambiguous term '**knowledge co-production**' (or just co-production)[68]. The core elements of the approach are that the intended beneficiaries are involved in designing the solutions (rather than simply being consulted on a pre-prepared course of action) and that the dialogue should be two-way and genuine (meaning neither too technical nor 'dumbed-down'). A range of different techniques can be used including the use of focus groups or citizen panels, pop-up exhibitions and surveys, and Open Space meetings.

An example of co-production at work locally is the Somerset Community Justice Partnership which has received national recognition for its work promoting restorative justice (where victims and perpetrators meet in a controlled environment facilitated by trained volunteers to resolve local social harms). See http://scjp.org.uk

Advantages of the approach are that it:

- Improves knowledge and understanding, both by the professionals and by citizens, increasing trust and providing a firm foundation that can be built upon
- Improves the legitimacy and accountability of the use of public resources
- Reduces a dependency culture where people look to public bodies to 'solve their problems', instead giving them a stake in creating solutions.
- Provides a way of developing and testing out ideas before they are put into effect, reducing the risk of unintended consequences and wasted effort.
- Creates more holistic and joined-up interventions which should be more cost-effective

All these advantages would apply to work undertaken by the Somerset Rivers Authority and its partners and should address the frustrations and gaps identified earlier.

[66] For instance, see the work of the Scottish Co-production Network http://www.coproductionscotland.org.uk

[67] The recent report published by the Economic and Social Research Council (ESRC) demonstrates this. http://www.n8research.org.uk/knowledge-that-matters-realising-the-potential-of-co-production-launch-of-final-report/

[68] A good introduction and explanation of the concept is provided in a report by the New Economics Foundation published in 2008 entitled: '*Co-production. A Manifesto for growing the core economy*'. http://b.3cdn.net/nefoundation/5abec531b2a775dc8d_qjm6bqzpt.pdf . A more recent guide to the use of co-production in the health sector has been prepared by Nesta http://www.nesta.org.uk/sites/default/files/co-production_catalogue.pdf

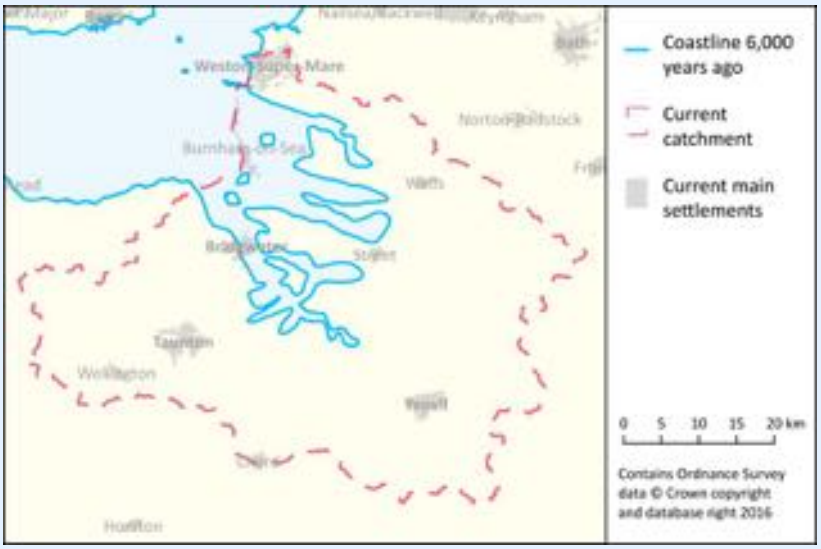
7. The history of drainage and flood management

Michael Williams' book 'The Draining of the Somerset Levels'[69] provides a detailed description of the history of the Levels and Moors and the following paragraphs draw on this information, supplemented by other sources[70]. The historical record reveals that people have always struggled to keep flood water at bay from the land and that, like the tide, efforts to reclaim the land from the sea have ebbed and flowed. There have been periods when ingenuity and investment have advanced the drainage of the Levels and reduced the risk of flooding, but these have been interspersed with periods of inactivity, stagnation and complacency.

Prehistory

Until relatively recently, in historical terms, the Levels were an inhospitable wetland that has discouraged settled occupation by people. The position of the coastline has varied over the millennia, depending on global sea levels and the response of the land surface to the ice age. **Figure 41** shows that 6,000 years ago, the coastline ran many miles inland of where it does today as far as Glastonbury and Muchelney, with Brent Knoll, Pawlett and Westonzoyland being islands. The Polden Ridge and 'Isle' of Wedmore were long promontories extending into a shallow sea of mudflats and saltmarsh.

Figure 41. The Coastline 6,000 years ago



Adapted from:
www.bgs.ac.uk/discoveringGeology/climateChange/general/seaLevelChangeCaseStudies.html

The earliest evidence of permanent settlement by people comes from the lake villages and trackways at Meare and Glastonbury that were occupied between the third century BC and first century AD, later being abandoned by rising water levels. There is also evidence for coastal settlements at this time near Alstone south of Highbridge which were built on the higher ridge of clay that exists near the current coastline.

During this period, the inland sea behind this clay ridge probably consisted of intertidal mudflats and saltmarsh near the coast, merging into freshwater reed swamp and fens inland. These wild habitats would have provided rich fishing and hunting grounds and it is likely that salt was also produced and traded with inland communities.

The Dark Ages

During the late Roman period, embankments were built along the coast and beside the major tidal rivers to reclaim land as pasture. From the fourth century, the solitude and tranquillity of the area attracted the early Celtic church to establish monastic centres on 'islands' within the Levels first at Glastonbury and later at Athelney and Muchelney. Outside the low-lying Levels, Saxon colonisation and agricultural improvement of the landscape from the fifth to seventh centuries resulted in the patterns of villages and market towns we see today but the Levels themselves remained largely untouched. During the ninth century, the Levels provided King Alfred a safe haven from which to rally his forces and expel the Vikings from Wessex, producing the well-

[69] Williams M (1970). The Draining of the Somerset Levels. Cambridge University Press. pp. 8–9. ISBN 0-521-07486-X.
[70] For instance, Rippon, S (2004). *Taming a wetland wilderness: Romano-British and medieval reclamation in the Somerset Levels and Moors*. A report for the Somerset Archaeology and Natural History Society.

known story of Alfred burning the cakes he was asked to look after while his mind was distracted with military planning.

The medieval period to the mid C17th

During the early medieval period, the Levels became of increasing value as a source of fish, fuel (wood and peat turves) and summer pasture for the people living on the 'island' villages. As in other parts of England, the monastic centres were at the forefront of the land improvement, enclosure and drainage activity, accelerating during the 13th and 14th centuries. Focussing on the alluvial soils in the lower Parrett (and avoiding the deep peat soils in the lower Brue Valley), a piecemeal process took place in which the monasteries organised rhynes to be dug across common land pasture and earth banks (or 'walls') to be erected beside the rivers to extend the grazing season or allow cultivation. In a few places, rivers were straightened or diverted such as the lower Tone south of Salt Moor, and the Brue, Hartlake and Sheppey near Glastonbury.

After the dissolution of the monasteries in the mid 16th century, the Crown, through the 'Court of Sewers' took the lead in organising flood control and drainage, particularly following a major flood event in 1607. From the 17th century onwards, the use of pumps and other techniques imported from Holland increased the scope for drainage, including peat moors, although attempts to drain King's Sedgemoor by the Dutch engineer Sir Cornelius Vermuyden were not successful. By 1638, a survey organised by the Crown shows that just over a third of the land liable to flooding on the Levels had been reclaimed as productive 'meadow', with remaining areas classed as common-grazing marsh and fen.

The shared use of the resources provided by the Levels, under systems of common grazing and fuel gathering, were important to all the communities surrounding the Levels. Although there is little common land left on the Levels today, the complex patterns of land ownership and grazing rights, and the shared use of droves that provide access onto the moors, reflect these medieval systems.

The mid C17th to mid C18th

In contrast to the transformations that took place to England's other large lowland wetland, the Fens in Cambridgeshire and Lincolnshire, little progress was made on the Levels between 1640 and 1770 and two thirds remained unreclaimed at the end of this period. One reason for this lack of activity was local opposition. The drainage of the Levels has always been controversial, and during this period, it seems that opposition from communities who lost their rights of common grazing when land was enclosed, and from neighbouring land owners who experienced increased flooding as water moved faster off drained areas, was a significant factor in slowing the process of drainage and reclamation.

The mid C18th to mid C19th

In 1760s and 1770s, the national enthusiasm for agricultural improvement and the rising economic and technological incentives to drain land restarted efforts on the Levels. The Bath and West of England Agricultural Society was founded in 1777 and its members were influential 'improvers'. The Society has taken a close interest in the drainage of the Levels ever since. Using Parliamentary Enclosure Acts, the peat moors in the Brue valley and King's Sedgemoor were enclosed. Drainage Acts established large-scale co-ordinated schemes for managing water levels, including the construction of major new drains, cuts and clyses. Steam pumps started to be introduced during the first part of the 18th century, organised by local drainage boards and funded by a levy from landowners. New roads were constructed on the spoil beside the rhynes, enabling the building of new farmsteads and cottages.

The mid C19th to 1930

The second half of the 19th century and first two decades of the 20th century saw another period of stagnation in investment in flood management, with regular and prolonged flooding of the Levels both from rivers and, less frequently, from the sea. Compared to what we are used to today, winter flooding that rendered roads

impassable and communities isolated was the norm. Particularly severe floods that inundated thousands of acres for many months occurred in 1853, 1872-73, 1891 and 1929.

1930 to the 1970s

Following the Land Drainage Act of 1930, new governance and funding measures brought a revival of activity. New powerful diesel pumps were installed in the 1940s and 50s and these were replaced by automatic electric pumps in the 1960s. In 1940 the Huntspill River was created at the seaward end of the River Brue, dramatically reducing flooding of the Lower Brue Valley. The Sowy River was constructed in the late 1960s and early 1970s to take flood water from the River Parrett at Langport and Aller Moor north to the King's Sedgemoor Drain which was also enlarged.

The last 30 years

The period since 1980 has, arguably, seen a reversal of the progress of flood risk management made in the previous decades. A number of factors are likely have contributed to this:

- The dredging of the river channels in the Levels and Moors was not given priority in maintenance budgets. Silt deposited in the channels (which may have increased due to erosion from cultivated land) was not removed to the dimensions of the channels that had been designed in the 1960s and the capacity of the rivers to store water during 'flood lock' was reduced.
- The intensity of agricultural management across the whole Catchment, particularly a decline in the structure of soils under arable cultivation (with the introduction of crops such as maize) and under high livestock densities may have increased the speed with which rainfall reaches the rivers, increasing their peak flows. Soil eroded from arable land is likely to have contributed to a reduction in the capacity of the rivers.
- Urban and industrial development, and the use of impermeable surfaces in these developments, is likely to have further reduced the capacity of the middle and upper Catchment to hold back rainfall, leading to 'flashier' river responses.

Today

Starting in the 2000s, following a series of flood events on the River Parrett, there has been growing interest in 'whole catchment' planning. The Parrett Catchment Project, which was one of the first such projects in the UK, ran from 2000 until 2007 and identified 12 objectives or priorities for action (**Figure 42**). These objectives have continued to guide policy and a series of projects such as Wise Use of Floodplains, WAVE (Water Adaptation is Valuable for Everybody) and the Brue Valle Living Landscapes Project have taken place.

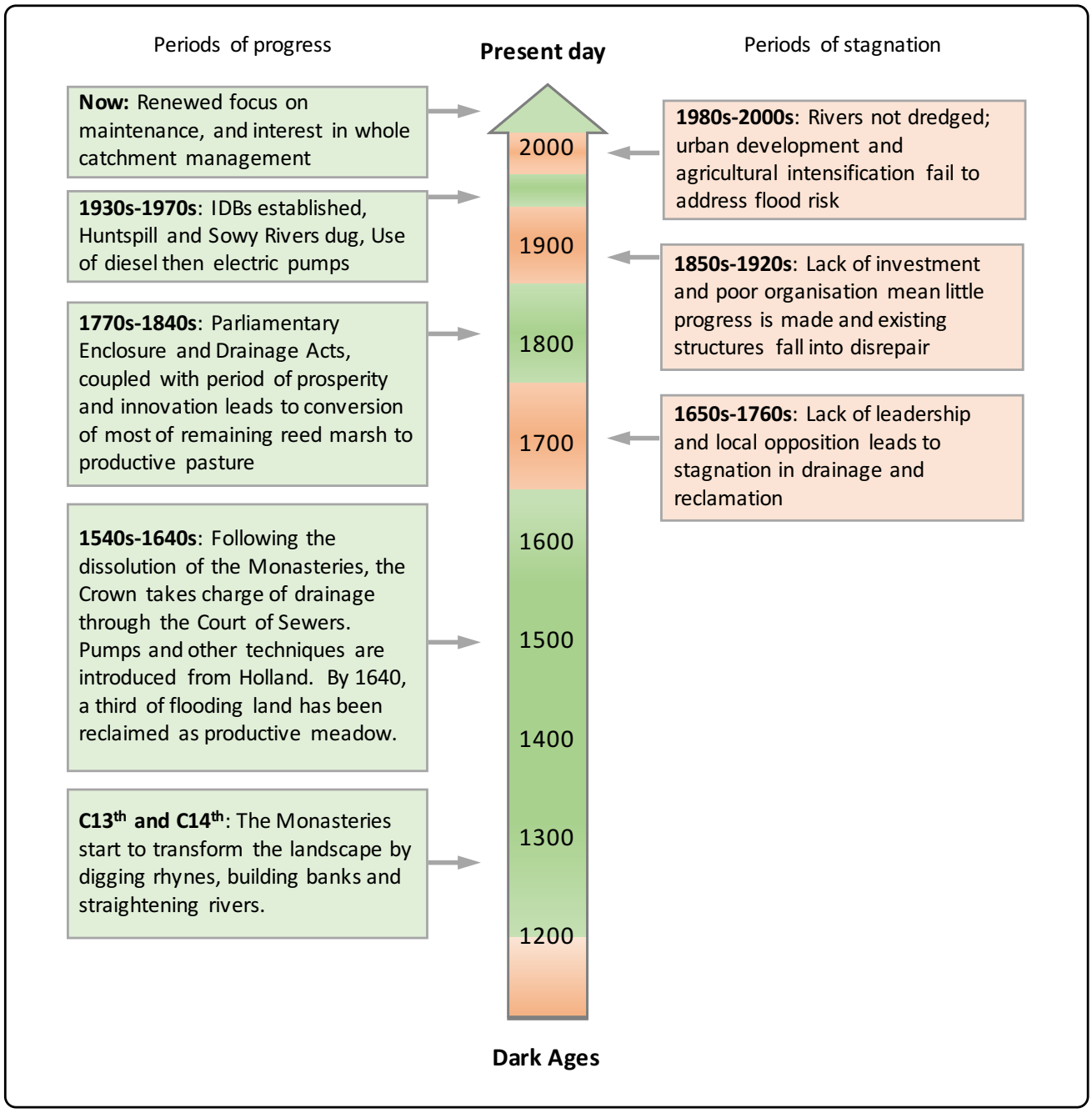
Figure 42. The 12 objectives identified by the Parrett Catchment Project

- Changes to agricultural land management
- Woodland development
- Temporary flood storage on farmland
- Controlling run-off from development
- Creating new wetland habitats
- Spreading floodwater across the moors
- Upgrading channels to enhance gravity drainage
- Restricting new development on the floodplain
- Dredging and maintaining river channels
- Raising river banks
- Upgrading pumping stations
- Building a tidal sluice downstream of Bridgwater

However, progress on the ground was slow until the severe flood events of November 2012 and December 2013 to March 2014. These received national attention and led to renewed Government commitments and funding. As described earlier (Section 2.3 on page 12), a 20 Year Flood Action Plan was prepared and funding was provided to establish a new Somerset Rivers Authority to implement the Action Plan. Several of the ambitions set out in the Parrett Catchment Project, including the tidal sluice across the Parrett at Bridgwater and enlargement of the Sowy River and King's Sedgemoor Drain to increase the gravity drainage from the Parrett, are now being taken through the planning and design stages.

An overall timeline of the different phases of activity, showing those in which most progress towards land drainage and flood control was made, is shown in **Figure 43**.

Figure 43. Timeline summarising key periods of activity



Changes in governance and administration

Over the last 150 years, there have been a series of changes to the organisational responsible for land drainage and water level management on the Somerset Levels, gradually producing the structure of local, regional and national bodies that exist today[71] (**Figure 44**). Throughout this process, critical issues have been the democratic accountability of the bodies that make decisions and the resources and powers available to them.

Figure 44. The history of governance of drainage and flood management on the Levels and Moors

- The Land Drainage Act of 1861 replaced the medieval Court of Sewers with Internal Drainage Districts in most of the Levels; and the Somerset Drainage Act of 1877 introduced a new system of funding from rates paid by the benefiting landowners.
- The Land Drainage Act of 1930 established a Somerset Catchment Board to control the main rivers and Internal Drainage Boards to management water levels off the main rivers, providing funding for both through enforceable precepts or levies.
- The Somerset Catchment Board was replaced by the Somerset Rivers Board in 1948 and then the Somerset Rivers Authority in 1963 (each change adding to the responsibilities of the organisations).
- In 1974 the River Authority was replaced at a regional level by the Wessex Water Authority and locally by the Somerset Local Land Drainage Committee.
- The 1989 Water Act led to the Water Authorities being privatised to create the regional water utility companies, with their statutory responsibilities passed to a new National Rivers Authority (NRA) which was in turn replaced by the Environment Agency in 1996.
- The 1989 Water Act also replaced the Somerset Local Land Drainage Committee with the Somerset Local Flood Defence Committee. This was replaced by the Wessex Regional Flood Defence Committee in 2005.
- Most recently, in 2016, the Somerset Rivers Authority was created to oversee development and delivery of the 20 Year Flood Action Plan following the flooding of 2013/14.
- At the time of writing, the Somerset Rivers Authority and its partners are working with Defra with a view to establishing the Authority as a statutory precepting authority (Section 2.7 on page 18).

[71] Williams, M (1970), Porter, E (1978). *Water Management in England and Wales*, Cambridge University Press and Environment Agency (2005). Somserset Local Flood Defence Committee, Handover Document March 2005.

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