Environment Agency

Evidence

Delivering sustainable river basin management: plausible future scenarios for the water environment to 2030 and 2050

Report B: Full scenarios

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We can't do this alone. We work with government, local councils, businesses, civil society groups and communities to make our environment a better place for people and wildlife.

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Professor Doug Wilson
Director, Research, Analysis and Evaluation

Executive summary

This project developed a long-term, strategic approach to assess plausible changes to the management of water and the water environment over a 35-year period. Futures research, specifically scenario analysis, was adopted to investigate possible developments within water and the water environment, thus providing the government, its arm's length bodies and stakeholders with additional information to support decisions on management strategies, skills, resources, institutions, positions and policies required to deal with the range of plausible outcomes.

'Futures thinking' has been applied to revise and elaborate the Environment Agency's existing 4 socioeconomic scenarios (uncontrolled demand, innovation, sustainable behaviour and local resilience), as well as to introduce a new reference scenario that examines the impact of developing trends in future intervention. This revision has been shaped by experts from a wide range of disciplines (including social science, water sciences, river basin management and risk management) from the Environment Agency and project partners to establish the implications for managing water and the water environment.

The report outlines the process used to develop the scenarios and explains the framework used to analyse the complex issues associated with the future of water and the water environment and for supporting thinking and discussion around long-term strategic options and objectives. This analytical framework takes a broad view of the catchments in England and Wales, and the wide context in which management operates. The analysis considered the most important aspects of river catchments, ranging from upland to urban catchments.

This report described the scenarios in detail. It is one of 3 reports produced by the project. The other 2 present an overview of the scenarios and discuss the implications of each scenario for the water environment and water users, respectively.

Note that the scenarios and the environmental consequences described in these reports reflect the collective views of a set of stakeholders at the time the work was undertaken (2012 to 2014). The work was completed before a number of significant political changes occurred, not least the outcome of the referendum on the UK exit from the EU. Although this affects some of the specifics in the scenarios (notably the reference scenario), the generalities of the scenarios are still valid.

The project was led by the Environment Agency and delivered through joint working with Defra and its arm's length bodies (Environment Agency, Natural England, Forestry Commission England) and the Scottish Environment Protection Agency and Natural Resources Wales through the Defra Futures Partnership initiative, led by Cranfield University.

Acknowledgements

The Cranfield Centre for Environmental Risk and Futures (CERF) (now called the Cranfield Institute for Resilient Futures (CIRF)) Futures Partnership is a futures research organisation hosted by Cranfield University which comprises organisations including Defra, the Scottish and Welsh Governments, Department for Energy and Climate Change, Department for Transport, Natural England, Forestry Commission, Environment Agency, Scottish Environment Protection Agency, Marine Management Organisation, Food Standards Agency and the Natural Environment Research Council.

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1 Introduction

Water and the water environment provide essential benefits for human survival, prosperity and well-being. Historically and currently there are significant pressures on these environments (Environment Agency 2013), which have resulted in a significant decline in many of these essential benefits (see, for example, UK National Ecosystem Assessment 2011). When considering the future, societal and environmental changes such as population and climate changes are likely to put increasing pressures on these environments. If we are to continue to receive the essential benefits we need and desire from the water environment we need to manage them more sustainably as we move into the future.

1.1 About the project

This work develops a number of alternative future scenarios for water and the water environment for river basin management. It explores the consequences of these scenarios for the water environment and its management. The work is intended to support the work of government, its arm's length bodies and stakeholders in assessing the long-term challenges posed to the water environment and in identifying implications for its future management.

The project involved nearly 50 experts from government agencies, complemented with expertise from Cranfield University, and drew on a number of key research reports and evidence from experts with relevant expertise and knowledge of water and the water environment (Appendix B). The questions underpinning the project were:

- How robust are current and planned management approaches for river basin districts for the future under a set of plausible scenarios for the natural environment at 2030 and 2050?
- What are the implications for the aims and objectives of river basin management?

The research questions were reviewed and approved by the Environment Agency and The Cranfield Centre for Environmental Risk and Futures (CERF) (now called Cranfield Institute for Resilient Futures (CIRF)) Futures Partnership.[1] The project produced 3 reports (Table 1.1). Report A presents an overview of the scenarios. Taken together, reports B and C provide a framework for analysing a complexity of issues associated with the research questions and envisioning solutions to the problems revealed.

[1] The Cranfield Centre for Environmental Risk and Futures (CERF) (now called The Cranfield Institute for Resilient Futures (CIRF))) Futures Partnership is a futures research organisation hosted by Cranfield University which comprises organisations including Defra, the Scottish and Welsh Governments, Department for Energy and Climate Change (now part of the Department for Business, Energy and Industrial Strategy), Department for Transport, Natural England, Forestry Commission, Environment Agency, Scottish Environment Protection Agency, Marine Management Organisation, Food Standards Agency and the Natural Environment Research Council.

Table 1.1 Outline of the reports produced for this project

Report	Description
Report A: Overview	This report presents an overview of the scenarios and key outputs of the analysis, looking at the consequences for the water and the water environment and its management. It is not intended as a summary of the scenarios and the overall analysis.
Report B: Full scenarios **THIS REPORT**	This report explains the scenarios in detail. It describes the process of their development, documents the progression from current day to 2030 and from 2030 to 2050, and illustrates how the main drivers develop.
Report C: Consequences for water and the water environment	This report examines the implications of each scenario for the water environment, and for water users. It describes the implications of the scenarios for different generic types of catchments representing contrasting parts of England and Wales and across a range of sectors including the general public, manufacturing industries, leisure industries, utility companies (water and energy), and farming and fisheries.

1.2 About this report

This report draws on evidence from the academic literature, published reports and the knowledge of experts to build on the Environment Agency's existing socioeconomic scenarios, making them more relevant to the wider context of the water environment and water management in England and Wales.

The analysis of source pressures, exposure pressures, impacts and consequences to water users and the water environment draws on a number of policy documents including the Water Framework Directive (2000/60/EC), the Water White Paper (HM Government 2011a), the Natural Environment White Paper (HM Government 2011b) and 'Biodiversity 2020' (Defra 2011a).

'Futures thinking' has been applied to revise and elaborate the Environment Agency's 4 socioeconomic scenarios, as well as to introduce a new reference scenario that examines the impact of developing trends in future intervention. This revision has been shaped by experts within the Environment Agency and through stakeholder workshops to establish the implications for managing water and the water environment.

When reading the report, it is important to note that plausible futures were developed through the design of qualitative scenarios. These are not intended to predict the future, but do include explicit 'storytelling' pieces that illustrate a progression from the current state of affairs to the future created in the scenarios. These provide:

- plausible 'views' on the future based on past trends and knowledge
- assumptions about the future
- insights garnered from a wide range of experts and the pervasive literature

The 'real' future is unlikely to be identical to any of these futures, but it is likely to be contained somewhere within this 'envelope' of future scenarios. The scenarios are 'think pieces', designed to fuel discussion and debate. The aim is to consolidate reflections about future developments into coherent depictions of potential courses of events leading up to 2030 and 2050. Seen from this perspective, they aim to provide a basis for reflecting on the long-term impact and significance of the management of water and the water environment.

These scenarios are a useful starting point to frame discussions among water managers, policymakers and other stakeholders. They may be further updated to maximise their utility in the review of policies, strategies or management practice.

The scenarios do not represent UK government policy nor the policy or position of the Environment Agency and Cranfield University. Their utility is to provide a strategic tool from which objectives and action plans may be developed to 'future-proof' current and emerging policies and strategies.

The scenarios and the environmental consequences described in these reports reflect the collective views of a set of stakeholders at the time the work was undertaken (2012 to 2014). The work was completed before a number of significant political changes occurred, not least the outcome of the referendum on the UK exit from the EU. Although this affects some of the specifics in the scenarios (notably the reference scenario), the generalities of the scenarios are still valid.

The process of embellishing the scenarios involved a range of experts from government and government agencies, each with unique views, insights or priorities on the evolution and interpretation of the scenarios. Scenarios analysis results from the consensus of the multiple expert views brought into the work, but are limited by the collective experiences represented in the panel of experts. As such, not all implications associated with the water and water environment were analysed and additional work is required to assess those not mentioned in these reports.

2 Background

'Water is essential for human life, nature and the economy...The current pressures on our water environment such as pollution, over-use of water, physical modification of water bodies and extreme events such as floods & droughts are forecast to increase unless we take action.

...It is essential to address these challenges to preserve our resource base for life, nature and the economy and protect human health.'

Source: 'A Blueprint to Safeguard Europe's Water Resources' (European Commission 2012a)

2.1 Uses of water and the water environment

The average person in the UK uses 150 litres of water daily (Defra 2008). In 2006 to 2007, about half the 12.7 billion cubic metres of water abstracted directly from the environment was used for public water supply (Defra 2012a). Of the remainder, 98% was abstracted by 4 sectors (Kowalski et al. 2011):

- energy generation, water and waste
- agriculture, forestry and fishing
- manufacturing
- mining/quarrying

If the water utilised in growing and manufacturing products or goods used or consumed in the UK (so-called 'virtual water') is included in the daily personal consumption estimate above, then this increases to about 4,500 litres of water per day per person (Chapagain and Orr 2008).

It is not only water taken from the environment for domestic, industrial and commercial use that provides benefits to society. The water environment such as rivers, lakes, estuaries, coasts and wetlands provide opportunities for fishing, walking, exercise, art, bird watching and swimming – activities which are enjoyed daily by millions. Water landscapes help define our nation and provide inspiration for great art, poetry and spiritual reflection. These uses have been shown to have valuable social, cultural, physical and mental health, and economic benefits. Healthy water environments also perform important natural regulating functions protecting us from floods and droughts, helping to regulate air quality and climate, ensuring the cycling of nutrients and helping to clean water, thus ensuring a supply of affordable good quality water for use.

All of these benefits come, primarily, as a result of the cycling of water through 'natural systems'. These natural cycles and the natural structures, systems and other processes within it are critical to supplying the benefits identified above to society at reasonable cost and in a sustainable way. Therefore it is important to ensure the environment is managed effectively to continue to deliver these benefits and that we better understand the risks to their long-term provision.

2.2 Current situation

Uses of water and water environments, if not managed sustainably, can have significant impacts on both them and on their use. For instance, domestic, agricultural or industrial activities that use water cause pollution or degrade water habitats may have long-term impacts on water environments, either directly or indirectly, as a result of these activities taking place in the water catchment.

Water scientists, managers and regulators in government and industry suggest that, across the broad range of terrestrial and aquatic habitat types, about 30% of the benefits obtained from the environment are declining and many others have reduced or degraded (Defra 2008). Other sources of evidence indicate that less than 30% of rivers, lakes, estuaries and coastal waters meet the good ecological status objective and less than 65% of groundwater sources meet the required quality objectives under the Water Framework Directive (European Commission 2012b).

The vast majority of UK freshwaters have been affected by human activity, principally by changes in land cover and land use, by extensive land drainage, physical modification and by atmospheric deposition (for example, acidification), though management systems have been put in place to help control these impacts (Defra 2008). Nonetheless, research suggests that 57% of freshwater and wetland species, for which there are sufficient data, have declined (RSPB 2013). Likewise, the extent of coastal margin habitats (for example, sand dunes, machair, saltmarsh, shingle, sea cliff and coastal lagoons) have declined by about 10% and their quality has diminished due to development and coastal squeeze (Defra 2008). The UK National Ecosystem Assessment report (2011) stated that habitat loss and deterioration associated with the use of freshwater ecosystems is vastly increasing across England and Wales. This may be related to the fragmented and disconnected state of ecosystems and their catchments (Defra 2008).

Water quality in English rivers has improved with lower levels of phosphorous and nitrates in rivers and improvements in compliance with ammonia standards, largely as a result of more effective management systems. However, there remain a significant portion of water environments that are experiencing impacts from a number of pressures. An Environment Agency consultation paper in 2013 indicated that approximately 45% of rivers and 76% of monitored lakes in England did not achieve ‘good’ status for phosphorous standards under the Water Framework Directive (Environment Agency 2013). It was also reported that approximately 10% of water bodies assessed in England and Wales did not achieve ‘good’ status for ammonia or dissolved oxygen, due to slow movement in the ground. The same source suggests that a number of other water bodies are also at significant risk of not achieving standards for common persistent chemicals.

The drivers of change in English and Welsh ecosystem services over the past 60 years include (Defra 2008):

- conversion and intensification of natural habitats to farmland
- conversion of grassland to arable
- exploitation of natural resources, particularly marine fish
- pollutant emissions to air and the water environment, particularly nitrogen, sulphur and phosphorus
- climate change (to a lesser extent)
- invasive species, including plant pests and animal diseases

These direct drivers have largely been influenced by:

- an increasing and ageing population
- the economic liberalisation of trade
- increased mechanisation and use of agrochemicals
- policy changes and reform
- behavioural changes, particularly consumption patterns

In response, there are increased expectations regarding the breadth and quality of services provided by the ecosystem for:

- the public (for example, recreational opportunities)
- farmers (for example, rivers to remove nitrate)
- business (for example, water abstraction free of pesticides)
- industry (for example, dilution capacity for effluents)

This has ultimately influenced the way natural resources are managed.

2.3 Future outlook: role of scenarios

The population of England and Wales is likely to rise to 70.5 million by 2050, based on current trends (ONS 2012), which puts pressure on demand for food and hence production from agriculture, as well as other basic services. Growth is likely to be particularly strong in areas that already experience water stress (for example, south-east England). The increase in single person households over the past few decades (from 12% in 1961 to nearly 30% in 2012) is likely to continue, resulting in pressure to convert more land to housing and increasing per capita demand for water and energy.

These changes will significantly influence the pressures on water and the water environment. For instance, forecasts provide predictions on the significant numbers of water bodies that will be at risk from nutrient pollution, invasive non-native species and sediments going into the future. While climate change has had relatively small impact on biodiversity and ecosystems to date in England and Wales, this is likely to increase over the coming decades, with more severe weather events and changes to rainfall.

Other political, social, technological, environmental and economic influences will also have an effect on water management and the state of water and the water environment in the future. For instance, international technological innovation is evident in the development of ‘vertical pink-houses’ (stacked hydroponic greenhouses running under blue and red florescent LED lights) with systems of plants growing on conveyor belts. These are already in use in some parts of the world and may become a common feature of the urban skyline. Other example of innovative systems include laboratory grown ‘meat cells’ that have been converted into textured meat and are likely to be developed into a variety of meat products and joints. Additionally, kitchen gadgets that grow insects are currently on the market in the USA and may prove to be a viable source of protein in the future. These examples illustrate the rate of progress of food and other technologies.

Understanding the uncertainty in these drivers of change, and the consequences posed to water and the water environment, are important for making good decisions. This understanding comes about by making reasonable assumptions about the development of the most important drivers that may have an impact (positively or negatively) on environmental outcomes. These assumptions are subsequently used to

inform and construct a range of coherent, internally consistent and plausible scenarios, encompassing a likely range of futures.

Scenarios are a useful tool to better understand the inherent uncertainties about the future and, in turn, help to reveal more innovative and successful management strategies for adapting to change. They are based on propositions about the future that explore the consequences of a range of driving force assumptions as well as the resulting pressures, states and impacts/implications of those futures. Scenarios provide policymakers with a tool for strategic planning. They allow the assessment of the robustness of strategies, and policy and delivery approaches in different situations (Wright et al. 2008) and enable decision-makers to address the underlying drivers of change in broader policies, strategies, programmes and actions (Alcamo 2008). For instance, identifying the implications for river catchments from uplands to urban areas is useful for analysing the success of future policies and strategies, thus mitigating the occurrence of unexpected consequences and ensuring there are more resilient responses to uncertainties of the future (Maack 2001, Bradfield et al. 2005, Wright et al. 2008).

2.4 How to use the scenarios for strategic decision-making

The scenarios in this report are intended to be used as a tool to guide government, its arm's length bodies and stakeholders in considering the implications for the success of their current or future policies, strategies and management of water and the water environment.

Contingency plans may be developed for each potential future. They often focus on answering the following strategic questions:

- How will the current (or intended) strategies fare in a range of plausible futures?
- What contingency plans are required to ensure the success of current (or intended) strategies?
- Are there any knowledge gaps or issues around organisational competence to implement future strategies?
- Are there alternative management strategies that could perform better than current strategies?

These and other questions could be explored with stakeholders to assess the robustness of strategies going forward. Table 2.1 summarises the proposed key stages of such an approach and outlines the goals and intentions at each stage.

Table 2.1 Using scenarios as a decision-making tool

Strategic questions	Stages of the process	Goals and intentions
How will the current (or intended) strategies perform in the range of plausible futures?	Identify the implications of the scenario	The implications of each scenario for the strategies considered are of primary interest. An assessment of the vulnerabilities that exist within the system is needed, along with the elements that are likely to experience the most change in each scenario.
	Outline the risks or opportunities presented by each scenario	The risks and opportunities affect how well strategies are positioned moving forward. The focus should be on assessing how different sectors are affected by changes in each scenario, and identifying the winners and losers among a range of stakeholders.
	Identify interventions to either safeguard against risks or exploit opportunities	Intervention is needed where strategies are likely to fail. While the focus may be on identifying necessary action to hedge against some of the risks presented in the scenarios, opportunities should be seized to maximise the success of strategies.
What contingency plans are required to ensure the success of current (or intended) strategies?	Future proofing plans for plausible eventualities	Looking at the connections and interactions across the scenarios will help identify solutions and strategies to address multiple issues, offering some reassurance that the current strategic direction is both future-proof and resilient.
	Rethinking the strategic orientation of existing plans	Identifying critical areas of uncertainty, risk and opportunity may prompt a re-think of existing plans based on the need to avoid critical risks or maximise resilience.
	Moving existing plans forward towards a targeted future	Create a roadmap for the strategies that work best in a particular scenario. This may allow you to champion plans in the interest of innovation.
Are there any knowledge gaps or issues around competence to implement future strategies?	Identify evidence/knowledge gaps and develop internal capacity	The organisation's ability to assess how the future is unfolding and how to adapt plans to dynamic situations is important. This requires identifying the evidence/knowledge, common across all the scenarios, that will need 'to be' in place to capitalise on opportunities and protect against risks. Undertaking a gap analysis of current evidence/knowledge 'as is' compared with the commonalities that will need 'to be' in the future will form the basis for assessing internal capacity and capabilities to implement future plans.
Are there alternative management strategies that could perform better than current strategies?	Develop alternative management strategies	If current strategies do not perform well against the futures than alternative strategies can be explored to see if they perform better. This has the advantage of being fairly risk free in relation to live piloting of approaches. As resource requirements to do this are fairly low multiple strategies can be tested.
	Test alternative strategies against alternative futures	

Strategic questions	Stages of the process	Goals and intentions
	to assess their performance	

Sources: Pillkahn (2008), Wright et al. (2008), Maack (2001), Northrop Grumman Corp. (2000)

3 Scenario development method: an overview

The project adopted a participatory approach including workshops, telephone interviews and dedicated desk research to take account of the perspective of relevant expertise and interests in managing water and the water environment in England and Wales.[2] The project was completed as illustrated in Figure 3.1 and as outlined below.

3.1 Establishing the project aims

Both the project and the scenarios building process were guided by the purposes and aims defined by a project steering group from the CERF (now called CIRF) Futures Partnership. The steering group was responsible for deciding on the relevance of the topics to be included and non-essential topics to screen out. The members of the project steering group are listed in Appendix B.

Key objectives and intent from policy and strategy documents (for example, the Water White Paper, Water Framework Directive and the Natural Environment White Paper) were raised as the basis for elaborating the Environment Agency's existing socioeconomic and water scenarios, making them more relevant to the wider context of management of water and the water environment in England and Wales.

[2] The full list of participants is available in Appendix B.

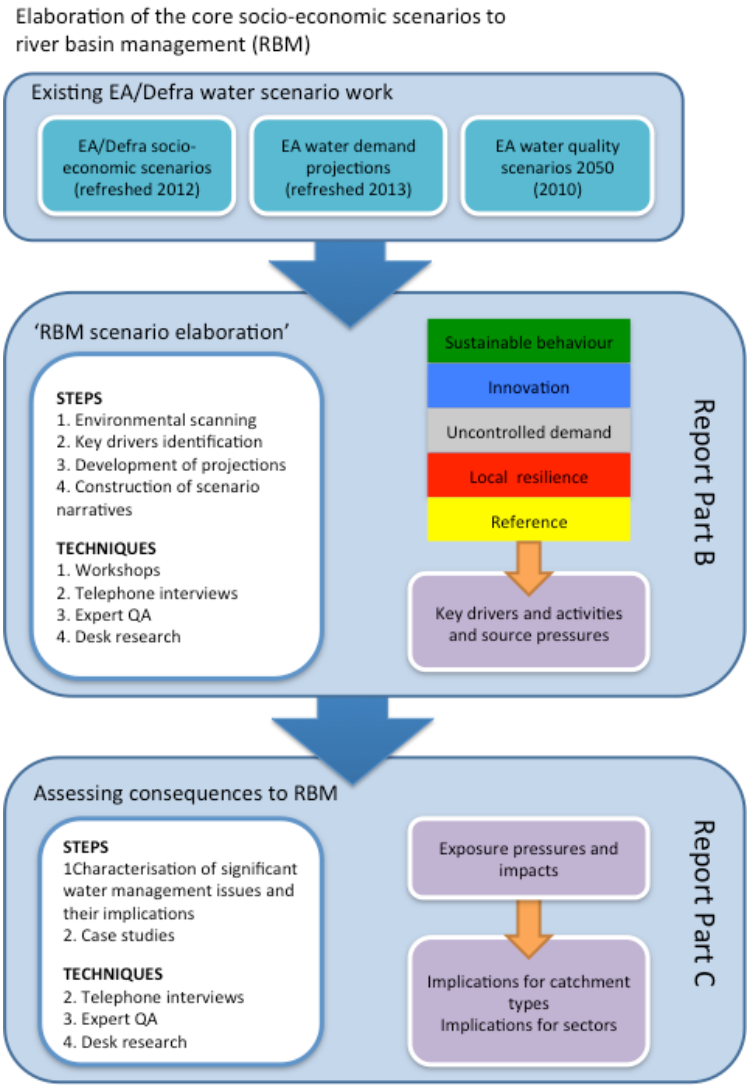

Figure 3.1 Graphic overview of the scenario development method

3.2 Defining key drivers and projections (environmental scanning)

The scenario building process involved outlining an initial range of key factors. These are topical areas with significant influence on the future of water and the water environment and on catchment management.

To expand on the list of existing key factors, a range of experts were consulted through workshops and telephone interviews (for example, water science and river management experts) to assess varying assumptions about water and other resource conditions so as to reveal areas of uncertainty. Projections that indicate the future development of important drivers were scoped out and defined to establish a context for the scenarios (Figure 3.2).

3.3 Elaborating the scenarios

The key factor projections were developed into initial storylines (or 'raw scenarios'). The key factor information in these was analysed to ensure that there would be

consistency in the final storylines developed. The implications were then outlined for water and the water environment under each scenario.

The elaborated scenarios present the state of water and the water environment influenced by a framework for the assessment of drivers, pressures, status and impacts (DPSI). As shown in Figure 3.2, the framework used in this document includes:

- drivers and activities
- source pressures
- exposure pressures
- impacts

The plausibility of the scenarios and changes to environmental indicators, which describe the state of river catchments, was informed through a series of expert interviews with Environment Agency experts and further supplemented by expertise from Cranfield University's Water Science Institute.

Elaboration of the scenarios was guided by the framework and assumptions adopted in the Environment Agency's core socioeconomic scenarios and full water scenarios (Environment Agency 2011a, The Futures Company 2012).

Climate change is happening under all the scenarios, namely as increased extreme events causing flooding and droughts, challenging future water management.

Because of the lag between greenhouse gas emission and their climate warming effect, the change in climate until 2030s has already been determined by past greenhouse gas emissions. Beyond 2030s, the different governance approaches to mitigating climate change in each scenario are not likely to make a significant change to the global extent of climate change by 2050. But how people react to it, and how challenging more extreme weather events and rising sea levels are, may vary between scenarios.

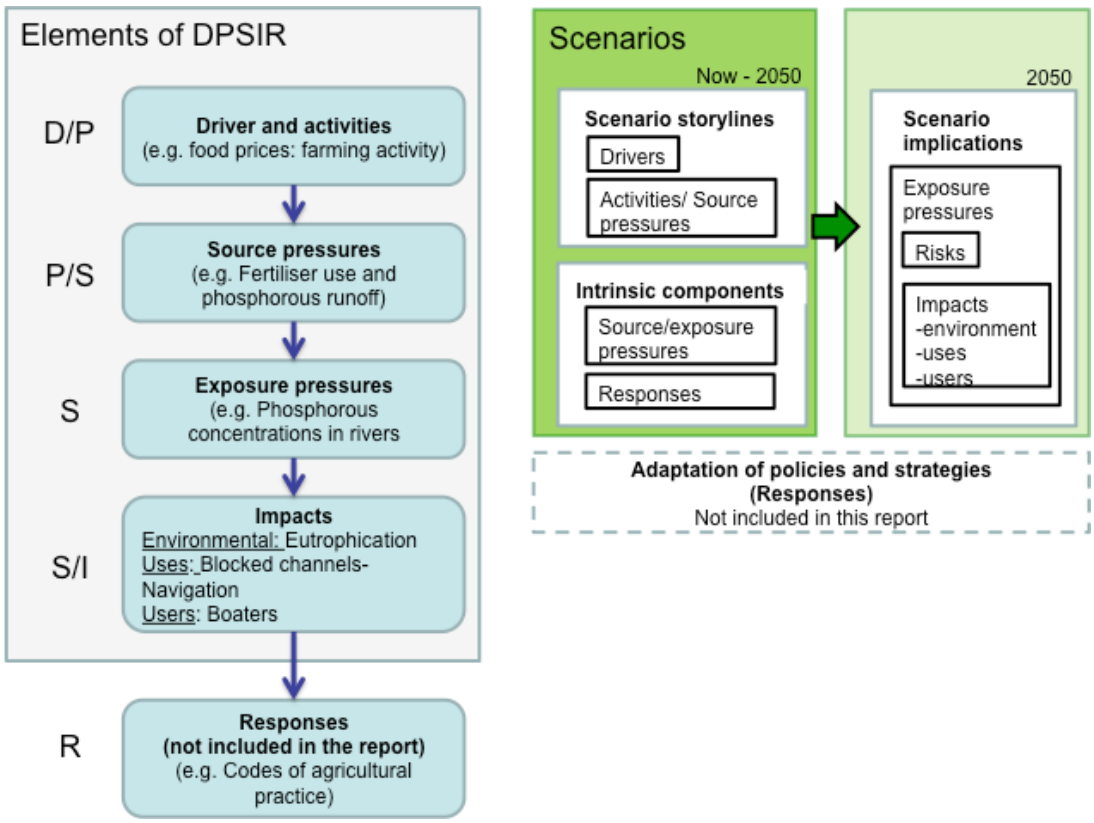

Figure 3.2 Framework used to assess the impact of the scenarios on the environment and water environment

3.4 Constructing scenario narratives

The 'core scenarios' were elaborated to produce a series of draft scenarios. Feedback from earlier workshops and expert interviews was integrated to produce a final narrative for each scenario.

The explicit storytelling nature of the scenarios presented describe how the future is planned and shaped through fixed events (including strategies and policies) that illustrate a progression from current state of affairs to the future created in the scenarios (Pillkahn, 2008, Bowman et al. 2012). The progressions illustrate a path to the future depicted in each scenario, showing travel from the current time to the future (that is, 2030 and 2050), though the description of scenario drivers and pressures reflecting the state at a specific time, usually the target year (that is, in this case 2050).

3.5 Assessing the scenario implications

An analysis of the 5 scenarios was made to explore the exposure pressures and impacts for water and the water environment. See Appendix A for details of the process adopted for this analysis.

Preliminary work was conducted to describe the implications for generic river catchment types typical of particular parts of England and Wales (that is, uplands, lowland grasslands, lowland arable and lowland urban) and on important sectors in society, that is, general public, manufacturing industries, leisure industries, utility companies (water and energy) and farming and fisheries. The analysis does not

present a comprehensive analysis of all catchments and sectors, but is intended to be illustrative to stimulate further discussion and analysis.

4 Interpreting the scenarios

The 5 scenarios present an integrated picture of developments spanning a wide range of drivers and activities of change associated with managing water and the water environment.

The scenarios show different rates of progress (or development) of the system along paths that are defined by 2 axes of uncertainty (Figure 4.1), and mapped using consistent projections of the key drivers of change.

The reference scenario builds on current trends and measures of change, reflecting a trajectory of the current system, as it exists today and assuming a similar policy and governance context. That is, a future in the absence of additional environmental and water-related policies, which presents a relatively non-threatening environment with no extremes or unpredictable events and relatively consistent development of the system. The reference scenario should not be mistaken for a 'baseline' that other scenarios can be measured against, as it does not assume 'no change'. Rather, it describes a constant progression of current conditions, providing a reference point for assessing the opportunities and risks associated with policies, or conversely, not adopting policies. Other scenarios illustrate projected change from the current trajectory (that is, the reference scenario) and show divergence on the rate of progress or development of the system. The conditions in these scenarios describe radically different futures that may unfold; for instance, an optimistic future (innovation scenario) and a pessimistic one (uncontrolled demand scenario).

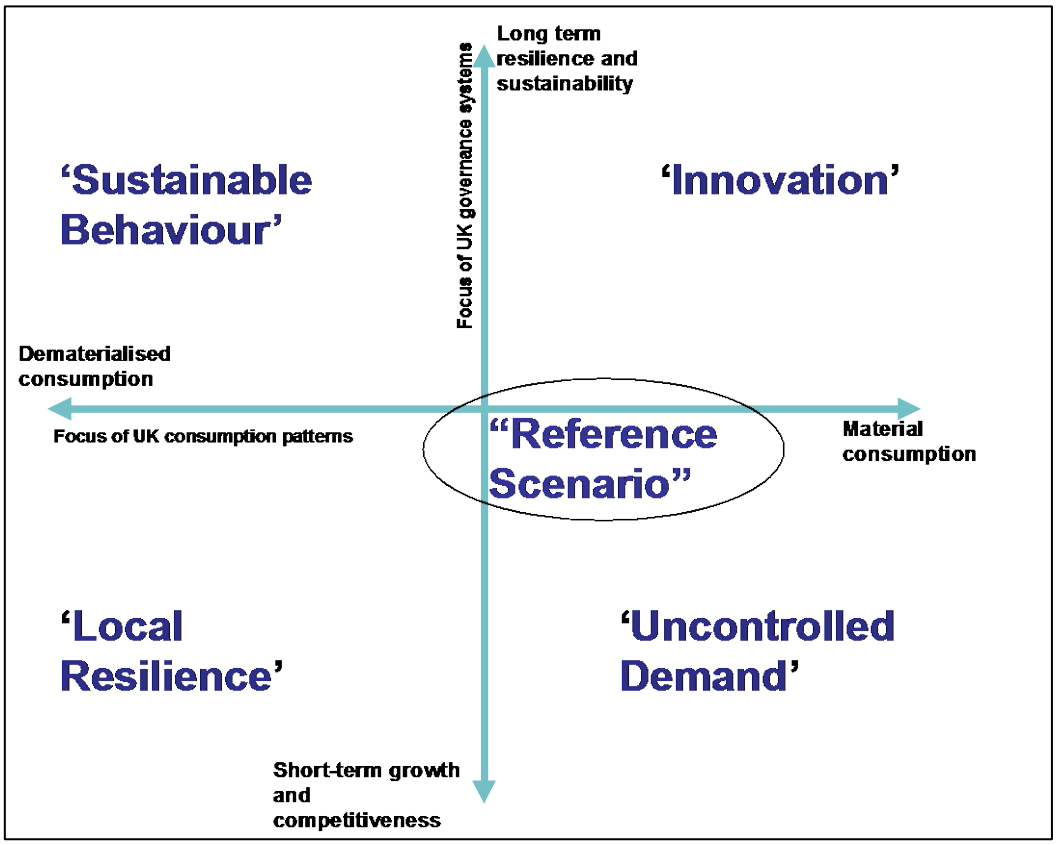

Figure 4.1 Axis of uncertainty representing the dominant drivers defining the scenarios

Notes: Based on scenarios developed for the Environment Agency by The Futures Company
Source: The Futures Company (2012)

5 Scenario 1: Uncontrolled demand

This scenario describes England and Wales in a self-interested world driven by a desire for economic growth at both the national and individual scale, with little concern for the environment and social equity.

5.1 Scenario overview

The political agenda is driven by a desire for economic growth at both national and individual scales. Personal and national attitudes are generally focused on self-interest and income. There is a wide divide between the very rich and the very poor; the majority of the population live on a middle income but are finding economic life increasingly challenging. The environment has low priority within the political agenda and is considered a commodity for the very rich, who can afford to pay to access and maintain areas of high environmental quality. Environmental regulation is perceived to hinder economic growth; therefore, there is a relaxation of regulation to a minimal level and lower standards to ensure compliance.

5.2 Drivers and activities

The drivers and activities for water and the water environment for the uncontrolled demand scenario are presented in Table 5.1.

Table 5.1 Uncontrolled demand: important drivers and activities for water and the water environment

Key factors	Drivers and activities for water and the water environment
Political attitudes	The government's priorities are influenced strongly by ambitious economic goals over the short term. Policies ensure resources are available for industry and the greatest environmental concern is preventing illegal access to water and other natural resources.
Governing priorities	Lobbyism and personal interest rule the political agenda. Environmental issues are not a priority unless they provide economic gain.
Economy	The UK prospers economically, that is, gross domestic product is in line with the strongest global economies, successfully marketing specialised products overseas, but only for the benefit of a few. Developments to convert natural capital into measures of prosperity were abandoned long ago. The economic disparity between the rich and poor causes underground and parallel economies (for example, black markets) to thrive among those on low incomes.
Price of resources	Water security is an issue, making water a costly commodity that only the affluent are able to consume without restriction. Land is also expensive and its use for food production and housing is maximised. Limited innovation and lack of economies of scale around renewables make energy more expensive.

Key factors	Drivers and activities for water and the water environment
Demographics	The population in England and Wales increases significantly to over 78 million, driven by high levels of immigration and fertility. The affluent tend to live or have a second home in tributary sub-catchments or upland areas in gated communities with better environmental conditions. In contrast, those with less income are exposed to poor environmental conditions in downstream catchments.
Attitudes and behaviour	Society's awareness and interest in the environment and its significance is poor. Awareness of the link between environment and health is forgotten with health more closely linked to short-term prosperity. Social and economic disparities cause those on low incomes to struggle for access to a minimal provision of water, energy and health services.
Technology approaches	Investment has a short-term focus and funding for resource efficient systems requiring long-term commitments are ignored. Economic drivers influence decisions in favour of technologies that promote growth (for example, desalination and fertilisers) over those with lower environmental impacts.
Green technology	Green and water-saving technologies are not pursued or adopted if economic gain is not possible in the short-term.
UK legislation	There is a strong perception that environmental regulation hinders economic growth and other political aspirations. Consequently, there is a relaxation of regulation and standards in favour of economic growth. Politically motivated initiatives lower the level of regulatory enforcement, resulting in environmental and water protection laws that are only marginally effective.
EU legislation	The EU plays a small role in the implementation and enforcement of policies. Emerging economies resist the implementation of international environmental regulation (for example, carbon dioxide emission limits).
Climate change	There is little progress in the implementation of mitigation measures for climate change. Flood defences fail to use natural structures and processes (for example, restored wetlands and flood plains) and engineering measures are implemented to protect productive industrial and agricultural land, and urban areas at risk. Water is over-abstracted when it provides economic benefits during drought periods.
Land use changes	Land use conflicts materialise as the industrial and agricultural sectors expand as well as the urban areas, leading to a reduction of 'green' spaces. Available land close to urban areas is converted for subsistence agriculture.

5.3 Progression from the present to 2050

5.3.1 Present to 2030

Increasingly, the poorest in society struggle to make ends meet and resort to tapping grids, illegally, for power, communications and entertainment. There are also widespread pockets of subsistence agriculture (horticulture and livestock), illegal harvesting of wood as a source of heat for the winter, poaching of food (for example, small mammals, birds and fish) and abstraction of water. All of these have an impact on the environment overall and also directly on the ecological condition of many protected areas.

5.3.2 2030 to 2050

The progression of the government strategy over the previous 20 years had a significant impact on available water resources, leading to a steady decrease in water availability due to excessive abstraction and to deterioration of water quality. The effects of climate change, such as drought and floods, aggravate the state of water resources. England and Wales are now faced with the challenge to provide a stable supply of good quality water to their populations, industry/commerce and agriculture. Upland catchments become national strategic water resources and are protected; a water strategy to augment supplies is implemented, which involves catchment water transfers, high capacity reservoirs and desalination plants.

The price of land is, to some extent, directly associated with the quality of water bodies. At one extreme, there are the ‘pristine’ catchments and private beaches reserved for the wealthy and those willing to pay for good environmental management which achieves the desired water quality. This is typical in remote and upland areas, where there is less pressure from the poor of society, and in headwater or tributary catchments that are not exposed to poor water quality resulting from upstream degradation. At the other extreme are the degraded catchments of the urban poor. These are typically lowland catchments where fly-tipping, direct disposal and poor sewerage services have led to a major decline in water and ecological quality, with these hotspots of degradation producing downstream impacts.

Industry moves to regions where cheap land is available and urban centres are now heavily industrialised, further affecting the receiving water bodies. ‘Sacrificial’ catchments arise, where water quality has degraded substantially, to protect upstream areas with higher value. These catchments are typically a primary target for the discharge of effluents from industry and urban areas.

In between the pristine and the urban/industrial areas, all available productive land is used for intensive agriculture, while less- and non-productive land is used for livestock production. These farmed rural catchments increase diffuse source pollution, also leading to degraded water quality and ecology. Heavily engineered flood protection measures are built in high income and economically productive areas.

In catchments where water is available for abstraction, sophisticated water treatment processes ensure water is potable. Development of these additional infrastructure and treatment processes causes the price of water to rise.

5.4 Influence of important drivers and activities on water management and land use in 2050

The 42% growth in the population of England and Wales (Table 5.2) is accompanied by record levels of demand for water, food and energy. There is an expansion of irrigated land for agriculture, land allocated for industrial development and land for urbanisation. There is also a marked increase in water demand across all sectors and leakage increases by 140% to levels similar to those in the 1980s (Table 5.3). Household water demand increases despite per capita consumption being marginally reduced (Table 5.2). The limit on consumption is restricted by the amount of income available and there is no concern for the impact of increased abstraction pressures on the environment.

The driver for industry is to produce cheap goods for the national market and luxury goods and services supporting an export-led economy. Environmental legislation is relaxed and enforcement is low, leading to deterioration of the water environment. Moreover, where profit margins are small, there is reduced investment in measures to minimise or mitigate the environmental impacts of production. Although the price of water increases, water-saving technologies are generally not implemented as these do not permit cost recovery in the short term.

Food production systems intensify to provide cheap food to a growing population. This intensification is achieved through land management practices (for example, tillage) and increased use of chemicals (for example, fertilisers and pesticides) and water for irrigation (Table 5.3). This is not accompanied by technological developments to offset the resulting environmental impacts. There is little growth in livestock production. Those on low incomes struggle to access low cost industrial and agricultural products that are increasingly more expensive as a result of rising water prices.

Table 5.2 Uncontrolled demand: population size for England and Wales and total water demand for 2050 considering changes from baseline values

	Baseline	2050	Change from baseline
Population (thousands)	55,250	78,340	↑↑ (42%)
Household per capita demand (litres per day)	156	151	↓ (-3%)
Total demand (million litres per day)	19,699	29,347	↑↑ (49%)

Notes: Total water demand includes leakage and freshwater for electricity generation. Change is characterised as an increase (red arrow up) or decrease (green arrow down). The extent of change is characterised as weak (one arrow), moderate (2 arrows) or strong (3 arrows).
Source: Environment Agency and Natural Resources Wales (2013)

Table 5.3 Uncontrolled demand: estimated change in land use and water demand from current values and water demand in 2050 for household, industrial/commercial, agriculture, electricity generation and leakage

	Land use change	Demand (million litres per day)	Change from baseline on water demand
Household	↑↑	11,812	↑↑ (37%)
Industrial and commercial		8,369	↑↑ (17%)
Agriculture (irrigated crops)	↑↑↑	513	↑↑↑ (167%)

	Land use change	Demand (million litres per day)	Change from baseline on water demand
Electricity generation (freshwater only)	Not applicable	1,129	↑↑↑ (93%)
Leakage	Not applicable	7,524	↑↑↑ (140%)

Notes: Change is characterised as an increase (red arrow up) or decrease (green arrow down). The extent of change is characterised as weak (one arrow), moderate (2 arrows) or strong (3 arrows).
Source: Environment Agency and Natural Resources Wales (2013), Knox et al. (2013)

5.5 Pressures on water management issues

5.5.1 Water supplies and wastewater services

The profit maximisation goals of the highly competitive water industry are poorly restrained due to a combination of weak enforcement of environmental regulations by national bodies and deteriorating hydrological and hydrogeological monitoring systems (due to poor investment). Water prices are high and water is over-abstracted (especially during periods of drought). In the more deprived areas, people who cannot afford their water bills resort to consuming illegally abstracted water from hand dug wells or boreholes, as opposed to drinking the water directly available from rivers which is more contaminated. Public health concerns arise where sources are polluted from heavy metals, chemicals or microbiological contaminants.

Expansion of urban areas and increasing population density intensifies pressure on available sewage infrastructure, exposing its weaknesses and having a significant impact on the receiving water bodies. The need to maximise profits by water companies leads to reduced investment in sewage infrastructure. This, combined with increased winter rainfall and periods of high intensity rainfall associated with climate change, results in increased incidences of pollution from combined sewer overflows and overloading of sewage treatment works. On the other hand, discharge consents for sewage treatment works are relaxed from those currently set by the Urban Waste Water Treatment Directive. Secondary treatment becomes the norm and is extended to discharges into sensitive areas and from agglomerations of more than 10,000 population equivalents, having a further detrimental effect in the receiving water bodies.

A lack of space in urban areas leads to a proliferation of poor quality ‘affordable’ housing in rural areas. These houses are not connected to the sewerage system and rely on septic tank systems. Low levels of regulation and enforcement, associated with little if any, environmental concern, results in widespread installation of poor quality drainage and ‘inadvertent’ connections into surface water systems.

5.5.2 Intensification of agriculture

Intensification of agriculture and expansion of irrigated agricultural land, mainly for the production of potatoes and for horticultural crops (Knox et al. 2013), occurs in response to pressures posed on food resources. Water and fertiliser are used, maximising the potential of each crop but increasing environmental risks. Water demand for irrigation increases by 167% in the 2050s (Knox et al. 2013), with potatoes accounting for nearly half of its use for agriculture (Knox et al. 2013). Where sewer overflows and run-off from animal farms are frequent, farmers avoid using contaminated water from rivers

and prefer to irrigate food crops with groundwater or from their winter storage reservoirs.

The price of fertiliser increases, despite new methods adopted for extracting and manufacturing phosphate. This steady increase in phosphorus prices, combined with incremental demand, prompts widespread application of sewage sludge on agricultural land. Less stringent environmental regulations allow farmers to disregard slurry/manure application limits and spreading windows, which may contribute to the saturation of arable soil with nutrients, the build-up of heavy metals and pollution of the receiving water bodies with sediments and nutrients (for example, soluble nitrogen leaching into groundwater).

Increased agricultural production is also reflected in the expansion of agricultural land in some areas. Following the conversion of all unused land on farms to production, land under agri-environment schemes was brought into production. Field sizes increase on some farms as 'unproductive' hedgerows continue to be removed, leading to a loss of traditional habitats for farmland birds. Nevertheless, some farmers keep hedges as part of the farm heritage schemes. Woodland clearance around the urban fringe increases as the demand for land to grow food also increases. The rural population living in areas where soil is particularly fertile are relocated to urban areas where space is available to free up land for production. There is a surge in demand for hydroponic production and for crops grown under plastic or polytunnels. Unsustainable agricultural practices are common, such as excessive tillage and deep ploughing that increase the rate of soil erosion associated with potato crops. This is associated with lower emphasis placed on Good Agricultural and Environmental Condition within cross-compliance in the EU Common Agricultural Policy and less attention is paid to codes of good agricultural practice for farmers, growers and land managers.

Subsistence agriculture is now a widespread practice among the poorest of society. This leads to an increase in the use of crop chemicals in urban areas, including herbicides and pesticides. In some cases, contaminated land is used to meet the demand for cheap agricultural produce, posing public health issues in terms of contaminated food and exposure for those using this land.

Livestock production is maintained at current levels. There is a reduction in average meat consumption per capita (especially by those on lower incomes), which is offset by population growth. Nevertheless, livestock production is a cause of greater concern due to increased pollution from livestock systems (both outdoor and housed), typically associated with increased incidents of cryptosporidiosis. A steady reduction in agricultural investment in infrastructure linked to decreased capital grant availability through Rural Development Plans of the Common Agricultural Policy leads to reduced usage of riverside fencing on livestock farms. Livestock production contributes to the erosion of riverbanks, where animals are allowed to graze on riparian areas. Moreover, livestock producers, subject to less stringent controls, release contaminated effluent into the environment, for instance, as a result of deterioration in slurry, manure and silage storage. Furthermore, there is increased use of veterinary products to ensure growth and parasite controls.

5.5.3 Energy, industry and services

To satisfy the 11% total increase in electricity demand, there is a higher demand for energy from wind, shale gas and biomass plants while nuclear power becomes more established. There is a move away from coal and the coal mines are de-activated, which leads to improved environmental conditions at some locations (for example, no contaminants from mine drainage water). Energy security is an issue that does not tend to affect the affluent that live in areas driven by renewables with storage.

Poorer communities increasingly gather wood or fell trees for firewood for domestic heating, leading to deterioration in the condition of urban and urban fringe woodlands. There is widespread electrification of private vehicles and internal combustion engines have been redesigned, leading to a significant reduction in atmospheric pollution (sulphur dioxide and nitrogen oxides), which in turn leads to improvements in terms of acidification and nitrogen enrichment.

Regulation is relaxed and the consents applied to industry are less stringent, leading to increases in pollution and impacts on the receiving water bodies. Moreover, there is a significant increase in the quantity of chemicals imported for manufacturing. Nanotechnology is a particular concern, causing heavy metal pollution. The most advanced manufacturers begin to reuse materials if it provides short-term economic advantages, but industrial treatment technologies are slow to advance. Pollution by hazardous substances and priority hazardous substances (as defined in the Water Framework Directive for instance) are an increased concern.

There is an increase in water demand for services. This is due to higher levels of water needed for private services such as security and domestic staff. As there is little incentive for efficiencies, there are limited water-saving opportunities in the services sector.

5.5.4 Flooding policy and practice

Changes in policies for flood risk management activities associated with application of more locally developed catchment flood management plans cause investment in flood defences to vary with location. The plans themselves usually focus on areas associated with higher income, and high agricultural and industrial outputs. Coastal flooding risk increases in areas of low population density and of low quality agricultural land.

Surface water management schemes in urban areas are generally non-existent and new developments have largely failed to incorporate sustainable drainage systems to mitigate their hydrological impacts, so there is an increase in the quantity of urban run-off entering the sewerage systems and water bodies directly. Furthermore, floodplains see the rapid development of poor quality homes reducing the area available for water storage during large run-off events. Soil compaction due to increased agricultural intensification and heavy machinery also enhances levels of run-off generation. Locations that suffer from regular flood incidents are concentrated in deprived housing areas with impacts compounded by the lack of resilience measures within the housing stock.

Flood protection measures are based on river modification, with little consideration for natural mechanisms, as floodplains are converted into urban areas. Nationally, uncoordinated efforts lead to investment in flood defences in rural areas being generally limited and concentrated in wealthy rural communities and areas classified as high-grade agricultural land (that is, Grades 1 and 2). The most common flood and coastal erosion control measures include hard engineering practices, including raised banks and structural stabilisation such as stone reinforcements. Where commercial forests are developed, a reduction in run-off and flooding is observed in the long term. In the short term, establishment of new commercial plantations involves deep ploughing and high density drainage systems to ensure quick establishment and rapid early growth, thereby sharply increasing run-off. Increased use of fertilisers and pesticides has similar consequences to that in agriculture. As regulation declines, commercial forestry practice declines with recommendations in the UK Forestry Standard being ignored.

5.5.5 Relaxation of environmental standards

Political drive and regulatory development focuses on economic growth in England and Wales, supported through a trend of deregulation and relaxation of existing standards. The environmental and social implications are not considered a priority, which has a negative impact on all risks to the water environment identified through the river basin management planning process (for example, within the significant water management issues analysis for the Water Framework Directive).

There is a reduction in the government's ability to meet the objectives of the EU Habitats Directive (92/43/EEC) for listed fish species (principally salmon, shads and lampreys). The lack of public funding and omissions in local development planning for the removal of in-river obstacles to fish migration and the maintenance or installation of new fish passages has led to significant and continuous limitations in the fishing industry. Similarly, this hinders the government in meeting the objectives of the Water Framework Directive and the EU Eel Regulations. The exception is in catchments associated with more prosperous communities, which invest privately in improvements to their local area. However, local community efforts are hindered by the more general deterioration in the overall catchment.

Lack of funds also affect the ability of environmental bodies to achieve their statutory fisheries duty to protect migratory and freshwater fish under the Marine and Coastal Access Act, which extended this duty to additional migratory fish species. Furthermore, invasive non-native species have increased their prevalence, further downgrading the ecological status of the water bodies under the Water Framework Directive.

There is reduced compliance with protection for Special Areas of Conservation designated under the EU Habitats Directive. Floodplain wetlands are degraded due to enhanced run-off of nutrients from agricultural sources and urban sources (combined sewer overflows and overloaded sewage treatment works). Increased abstraction of groundwater impacts groundwater-fed wetlands. Rain-fed wetlands (that is, blanket bogs) are not negatively impacted, unless there is an increase in drainage of such sites for agricultural conversion or a return to coal for energy generation, which leads to an increase in acid deposition in these weakly buffered environments.

Reduced compliance with conditions set out in the Nitrates Directive and fertiliser manual guidance (Defra 2010) means that farmers are disregarding fertiliser and slurry/manure application limits and spreading windows, along with storage requirements for slurry under the Nitrate Vulnerable Zone regulations.

6 Scenario 2: Innovation

This scenario describes a future where England and Wales have developed rapidly by relying on innovation and technology to maintain the population's usual lifestyle while protecting the environment as a source of resources.

6.1 Scenario overview

The government and business invest successfully in research and development (R&D) and in initiatives for implementing new knowledge and technology to tackle the problems posed by climate change and water scarcity. There is tighter environmental regulation, associated with high compliance from industry and farmers. Society and the political agenda embrace risk when adopting new developments, with the drawback of the occasional unexpected impacts.

6.2 Drivers and activities

The drivers and activities for water and the water environment for the innovation scenario are presented in Table 6.1.

Table 6.1 Innovation: important drivers and activities for water and the water environment

Key factors	Drivers and activities for water and the water environment
Political attitudes	Government strategy focuses on improving the efficient use of resources based on economic drivers, prioritising investment in R&D, improving infrastructure (energy, transport and water) and efficient technology (reuse and recycle).
Governing priorities	The government has very clear priorities, which involve the long-term protection of those environmental resources providing tangible economic benefits.
Economy	Investment in technology and high-end manufacturing provides the basis for strong economic growth. Innovation provides resource efficiency.
Price of resources	Technology eases pressure on energy, land and water resources. Prices generally increase from those current due to the cost of technology. Energy prices are relatively low.
Demographics	The population in England and Wales increases to 73 million due to high life expectancy and an influx of skilled immigrants driven by economic growth. There is a higher level of equity between the richest and poorest in society. The majority of the population has a high level of education and are part of a skilled workforce. There is discontentment among the minority unskilled members of society as they struggle to find work.
Attitudes and behaviour	Society is aware of the value of the environment, but is unwilling to change lifestyles to preserve it. Instead, it believes in the government's ability to deal with issues of resource shortfall and environmental impacts as well as in innovation to provide solutions.

Key factors	Drivers and activities for water and the water environment
Technology approaches	Research is heavily funded and actively promoted. Numerous initiatives are implemented for the adoption of new knowledge. There is significant investment in infrastructure for improving resource efficiency. Education and the development of a skilled workforce is a priority.
Green technology	The legal conjecture provides benefits for those who are efficient in using their resources – reducing raw material use and recycling resources. Natural processes are pursued when providing economic advantages and win-win solutions are pursued.
UK legislation	The EU is the central regulatory body for policy for management of the environment. Its strategy moves away from the Lisbon strategy – information and communications technology (ICT) and digital networks – to developing a circular economy, using an approach open to calculated risk but contributing to the quick adoption of new innovations.
EU legislation	Regulation is established in support of circular economies and closed loop systems. This holds industry and farmers accountable for negative water-related environmental impacts, but supports these stakeholders in pursuing profitable initiatives with environmental improvement.
Climate change	Priorities focus both on minimising the losses and optimising the gains associated with changing climatic conditions; heavy engineering to prevent impacts from floods, and crop selection and agricultural practices are adapted to a changing climate and water availability.
Land use changes	Population growth results in an agricultural technology response – intensification of agricultural and livestock production – that eases the pressure for land resources. Land is valued for its productive potential, influencing the cost and level of protection provided; the valuation is based on an economic perspective, often ignoring the ecosystem services provided.

6.3 Progression from the present to 2050

6.3.1 Present to 2030

Together England and Wales developed a strategy to overcome the difficult political and economic conditions (including sluggish growth, rising unemployment and growing social discord) of the 2010s and the decline in resource availability seen through the mid-2020s. This strategy involved a radical plan to ramp up investment by focusing on technology and R&D platforms that would reduce costs and promote growth. The public and the government adopted a low risk-based approach to ensure quick uptake of new developments, while accepting the occurrence of occasional environmental disasters.

A focus on education ensured that a workforce with the necessary skill set was available to propagate the innovation movement. The ability to deploy new technologies and apply these at large scales was crucial and large successful

corporations with the power to influence public policy were an important source of fiscal incentives for innovation.

People, as heavily taxed individuals, expect technology to provide an affordable good quality environment and to solve any environmental problems. The EU and UK government, with a long-term strategy to protect the environment as a source of natural resources, push for stricter regulation and higher environmental standards. The heavy regulatory approach adopted placed responsibility for negative environmental externalities on businesses; however, there was strong government support for those who practised sustainable behaviours. This heavy focus on monitoring and compliance became an area of job creation (the 'greencoats').

A slow but steady process to revolutionise resource use in England and Wales resulted in closed loop systems where waste is used as resource through use of 'cradle to cradle' schemes. This included water and energy systems within homes and alleviated resource shortage issues to a certain extent. Tighter regulation required improvement of infrastructure. The government was influential in this infrastructure upgrade and in ensuring that houses were retrofitted for resource efficiency, as it was considered that market forces could not achieve the same application of technologies at scale. Widely adopted developments included aerated showerheads and toilet flushing technologies that reduce water use.

The innovation drive sought to achieve sustainability without inconveniencing consumers or expecting them to change their behaviour. Consequently, quality of life did not diminish and there was no incentive for behavioural change or reduced consumerism. Increased efficiency of utilising resources and a reduction in waste production through less carbon-intensive end-of-pipe technology offset the impacts of population growth to a certain extent.

6.3.2 2030 to 2050

England and Wales do not aim for self-sufficiency; however, considering the cost of resources in international markets, the current strategy allows for greater independence and reduced reliance on foreign sources of food and energy crops. Food prices have increased, especially for protein, driven by population growth and rising demand from the developing world. Cropping systems have been revolutionised to optimise resources (for example, land, fertilisers and water) and technology allows for a 15% increase in crop yields from 2035 to 2050. The trend of the 2020s to expand land for the production of energy crops is now reversed, with the development of second generation biofuels that are manufactured from algae and residues of food crops. Precision farming means that water is used more efficiently. Genetically modified crops that require less water and fertilisers have boomed, particularly for animal feed, and have been implemented with consumer support. Synthetic meat, vastly consumed, uses less water than livestock production and is the reason that meat remains affordable for most.

A twin track approach is used to balance water supply and demand. Investment for enhancing and expanding water infrastructure was completed during the late 2030s and early 2040s, bringing water from where supplies are plentiful (for example, north-west England) to areas where demand is higher (for example, south-east England) through a network of water transfers and reservoirs. Technological advances allow people to carry out their daily routines using less water. The green homes refurbishment programme, a government initiative completed in 2045, had most homes built or retrofitted with water-saving devices. All homes are equipped with water meters, informing areas for further research and innovation.

6.4 Influence of important drivers and activities on water management and land use in 2050

The increasing population is associated with the expansion of urbanised land; urban areas are larger and more densely populated, and the elderly move to rural areas. High technology manufacturing causes the expansion of industrial areas. Demand for food has driven sustainable intensification of agriculture and livestock, although England and Wales are not self-sufficient. Farming is mainly run on a large scale; however, widespread vertical farms, hydroponics, aquaponics and other high-tech urban agriculture mean that the share of land used for agricultural purposes remains at current levels.

Under the innovation scenario, there is a marginal reduction in total water demand (Table 6.2). Innovation provides solutions to alleviate water stress during drought periods, for instance, by improved weather forecasting, cheaper desalination with lower energy consumption and cloud seeding technologies.

Domestic water consumption reduces by 7% (Table 6.3), as the increasing demand from a growing population is offset by water-saving household appliances retrofitted in most dwellings. Examples include smart meters, rainwater harvesting and greywater reuse. There is a substantial reduction of leakage, by 70%, which is strongly regulated through improvements in materials, techniques, solutions for repair and metering. There is an increase in industrial and commercial water use by 21% driven by an increase in water demand associated with manufacturing, namely in the food and drink industry (Table 6.3). Nevertheless, this increased demand is partially offset by a small reduction in demand as a result of moving away from oil-based fuels and towards electrification and biofuels.

England and Wales are among the world leaders in efficient water use technologies for agriculture; for example, smart irrigation systems, greywater recycling and selection of water-efficient genetically modified crops. Despite these efficiencies, water use for agriculture increases by 157% to ensure high quality and yields as rain-fed production is deemed too risky, namely for potatoes and horticulture (Knox et al. 2013).

Table 6.2 Innovation: population size for England and Wales and total water demand for 2050 considering changes from baseline values

	Baseline	2050	Change from baseline
Population (in thousands)	55,250	72,770	↑↑ (32%)
Household per capita demand (litres per day)	156	110	↓↓ (-29%)
Total demand (million litres per day)	19,699	18,726	↓ (-5%)

Notes: Total water demand includes leakage and freshwater for electricity generation. Change is characterised as an increase (red arrow up) or decrease (green arrow down). The extent of change is characterised as weak (one arrow), moderate (2 arrows) or strong (3 arrows).
Source: Environment Agency and Natural Resources Wales (2013)

Table 6.3 Innovation: estimated change in land use and water demand from current values and water demand in 2050 for household, industrial/commercial, agriculture, electricity generation and leakage

	Land use change	Demand (million litres per day)	Change from baseline on water demand
Household	↑↑	8,038	↓ (-7%)
Industrial and commercial		8,696	↑↑ (21%)
Agriculture (irrigated crops)	←→	492	↑↑↑ (157%)
Electricity generation (freshwater only)	Not applicable	559	↓-4%
Leakage	Not applicable	940	↓↓↓ (-70%)

Notes: Change is characterised as an increase (red arrow up) or decrease (green arrow down). The extent of change is characterised as weak (one arrow), moderate (2 arrows) or strong (3 arrows).
Source: Environment Agency and Natural Resources Wales (2013), Knox et al. (2013)

6.5 Pressures on water management issues

6.5.1 Water supplies and wastewater services

Water and wastewater services remain privatised and are provided by several competing multinational companies that exploit the individual elements of the business processes that have been split out (for example, abstraction, treatment, distribution network and billing). Consumer demand for good water quality and the tightening of drinking water standards experienced over the past 40 years has driven tighter environmental standards. Water and wastewater treatment has advanced so much that, in many areas, wastewater and water treatment have merged into one plant and wastewater is not discharged to the environment as it is being used as a source of potable water. Customers choose the greenest and most efficient companies driving further innovation across the industry.

Water infrastructure is improved and enhanced, resulting in reduced levels of leakage by 70% and in the augmentation of supplies from new reservoirs, inter-basin transfers and artificial groundwater recharge (for example, using sustainable drainage systems). Water companies also invest in monitoring systems and comply with water abstraction regulations, allocating sufficient water to the environment allowing for healthy aquatic ecosystems. The areas where supplies are scarce benefit from technological advances in desalination technology, which is now less energy demanding.

Significant investment in sustainable drainage systems, coupled with a reform of the existing sewerage infrastructure, improves the water quality of the receiving water bodies. Sewerage systems are increasingly separate systems and technology permits disinfection of storm overflows; sewer overflows are no longer a problem, even considering an aggravation of winter rainfall and rainfall intensity due to climate change. Improved planning and qualified personnel reduce the number of incidents associated with misconnection of domestic appliances to the sewage network. Investment in R&D brings about effective techniques and processes for treating

wastewater, removing the majority of pollutants from the effluents. There is therefore compliance with tightened discharge consents for sewage treatment works.

6.5.2 Sustainable intensification of agriculture

The intensification of agriculture is sustainable and production targets are associated with efficient use of resources (for example, land, water and fertiliser) and not just yield. Closed loop systems create market opportunities for business ventures that focus on the recovery of nutrients and chemicals from the environment (for example, mining for phosphorus reduces fertiliser costs). There is a greater enforcement of compliance with the Nitrates Directive and cheaper fertilisers do not discourage farmers from following guidelines such as the Standards of Good Agricultural and Environmental Condition (Defra 2012b) or Code of Good Agricultural Practice (Defra 2011b). There is a reduction in nutrient application and the impacts of fertiliser applications are significantly reduced. As targets are consistently met, there is a progressive tightening of environmental regulations on the use of chemical fertilisers for continuous improvement. However, the use of manure/slurry or sewage sludge is more difficult to regulate because of their more variable nutrient content.

Precision technology makes best use of inputs and multiple crops are grown under improved polytunnels using special sunlight reactors and ground source heat pumps. Farming machinery moves to smaller sized and lighter autonomous units, allowing for greater fuel efficiency, and reduced soil compaction and robotics cause rural population decline. There is an emphasis on closed loop agricultural systems such as high technology aquaponics and on genetically modified crops, mainly for livestock feed, reducing the need for fertilisers and pesticides, which are mostly used for cereals and root crops. New chemical compounds for pesticides and herbicides, which are less toxic to the environment, are introduced into the market as a result of investment in R&D. However, the risk-based framework adopted by the EU for accelerating licencing of new products leads to occasional environmental disasters.

Nationally meat consumption increases and is associated with a growing population as per capita consumption reduces. There has been a move away from grass-fed livestock farming in the uplands to intensive production on less productive soils in lowlands and synthetic meat in urban and industrial areas. The manure and slurry are used in anaerobic digestion plants to provide energy to run livestock installations and farm vehicles. The digestate produced following anaerobic digestion is used on the fields, completing the closed loop cycle. Thus, pollution is reduced and more land is available for improved biodiversity, wildlife corridors and leisure or horticultural cropping if necessary.

Carbon forestry projects are promoted as a cost-effective measure of carbon sequestration and forests expand beyond the current objective of 12% largely in wetter and upland areas. Expansion of woodlands also produces construction materials. Fast growing and more water-intensive species are selected.

6.5.3 Energy, industry and services

Energy demand increases by 65% with population growth and increased per capita consumption mainly due to the electrification of transport and heating. There is a move away from coal and a decrease in gas. England and Wales explore solar generation and invest in an international grid. There is no expansion of hydroelectrics associated with the upgrade and augmentation of the water infrastructure. Ceasing production at coal power plants reduces the byproducts of combustion and allows decommissioning of the remaining coalmines. Because water is no longer abstracted for cooling towers, (where typically one-third of the water used for cooling is lost on evaporation), river

flows increase and there is an end to thermal pollution issues and fish kills when water is drawn into the coal power plant.

Regulation is tighter and the consents applied to the industry are stringent. Incentives for developing closed loop systems result in industry investing in manufacturing processes for recovering waste and byproducts into raw materials. This cost-saving opportunity reduces the impact of industrial effluents on the receiving water bodies, despite increasing electricity demand. Increased industrial abstractions are associated with increasing water demand.

A variety of novel chemicals with reduced environmental impacts are available and quickly adopted by the manufacturing and services industries. However, innovation is not always positive and, on occasions, the drive for improvement has collateral or unforeseen environmental impacts. New types of pollution are a concern; for instance, the evolution of nanotechnologies and synthetics for the textile, pharmaceutical, beauty and energy industries. Regulations are gradually updated to control new pollutants.

There is a small increase in water demand by the services sector. People have more leisure time and the demand for technological services increases substantially. The associated water demand is partially offset by the regulation controlling water use. Moreover, with virtual experiences on the rise, demand for water is not as big as it could be (for example, there is no need for 'real' water in virtual swimming pools).

6.5.4 Flooding policy and practice

There is a co-ordinated effort to enhance flood protection at a national level. Levels of run-off generation are reduced, urban development takes up sustainable drainage systems, permeable paving and porous road surfaces are common, and farming practices avoid soil compaction. An increase in woodland area allows for flow stabilisation to a limited extent.

With technology at its heart, flood protection is based on river modification and has little consideration for the natural mechanisms of water regulation. The most common flood and erosion control measures include raised banks and shoreline reinforcements.

6.5.5 Tightening of environmental standards

A long-term strategy to protect the environment as a resource for food, water and energy leads to a push from the government, with help from industry and farming sectors, to tighten regulation and set higher standards of environmental protection. A process of self-regulation develops through a system of certification where the government plays an auditing role.

Priorities are given to those environmental regulations that have a direct benefit to the economy such as those that protect the availability and quality of water intended for human consumption, for example, ensuring sustainable levels of abstraction and preserving the water quality through:

- good practices in fertiliser and manure application such as those set in the Standards of Good Agricultural and Environmental Condition and the codes of good agricultural practice
- stricter levels of pollutants specified in discharge consents

Moreover, areas in which water requires special protection because they contain economically significant species are also further protected. Examples include commercial aquatic species such as shellfish (covered by EU directives) and watercress, but also commercial inland fishing and sport fishing for leisure.

The full ecosystem services are not accounted for in optimising the economic benefits, and so any environmental resources that do not provide a direct benefit to the economy are not protected. Consequently, there is little change in the standards for protection and compliance in Special Areas of Conservation designated under the EU Habitats Directive. Invasive non-native species proliferate in certain areas reducing compliance with the Water Framework Directive.

7 Scenario 3: Sustainable behaviour

This scenario describes England and Wales in a world where political and public interests are focused on economic, social and environmental sustainability with equal importance.

7.1 Scenario overview

The political agenda is driven by a desire for economic stability represented by steady and moderate growth. Personal and national attitudes are aligned to long-term environmental sustainability and greater financial equity. The majority of the population lives on middle incomes. The environment has high priority alongside health and welfare, and these are viewed as rights for all citizens; society has more ownership of water and ecosystem problems. Environmental regulation is a tool for ensuring environmental outcomes are achieved, leading to tighter regulation and higher standards. The role of the public as a watchdog helps to ensure compliance with environmental regulation.

7.2 Drivers and activities

The drivers and activities for water resources and the water environment for the sustainable behaviour scenario are presented in Table 7.1.

Table 7.1 Sustainable behaviour: important drivers and activities for water and the water environment

Key factors	Drivers and activities for water and the water environment
Political attitudes	International, national and regional alignment of political powers for a better environment delivers efficient regulation and environmental policies that drive sustainability.
Governing priorities	The political agenda drives environmental protection for the benefit of the economy and society. Ecosystem services provide a guide for decision-makers and protection of the water environment is high on the agenda.
Economy	The overriding goal for government is to maintain economic stability with constant moderate growth, and low and stable inflation. There is equity and all individuals can afford to pay for their basic needs.
Price of resources	The government introduces whole life costs using environmental and social costs in a whole life analysis allowing a true comparison of the options available to the customer. Products with higher total costs are heavily taxed while the remainder continue to be affordable.
Demographics	The population in England and Wales increases slightly to 66 million in 2050. There is greater social integration of national and immigrant communities.

Key factors	Drivers and activities for water and the water environment
Attitudes and behaviour	Consumers are altruistic, sharing the benefits and dis-benefits resulting from sustainable governance and business strategies. The public acts as a 'watchdog' for industrial and agricultural malpractice, protecting the environment.
Technology approaches	Technology is embraced to optimise production and minimise its impacts on the environment. New technologies are adopted given the proven reliability, cost-efficiency and low risk of unexpected impacts. Older technology is often retrofitted or maintained when this is more economical and/or sustainable than replacing it.
Green technology	There is a significant investment in green technology to assist sustainable development. This results in considerable adoption of water-saving and low carbon technologies.
UK legislation	Under national co-ordination, centralised initiatives allow regions to adapt regulations to their needs. Thus tailored environmental regulation delivers different levels of environmental sustainability across the country.
EU legislation	The EU retains its regulatory role, maintaining coherence across all Member States in terms of environmental standards and regulations. International agreements hold EU countries responsible for transboundary water issues.
Climate change	Climate change mitigation measures are taken seriously, with increased evidence of climate change impacts. To reduce carbon emissions, there is a focus on both low carbon technologies and green energies. Climate change adaptation measures focus on soft management options working with the natural processes rather than on hard engineering solutions.
Land use changes	Expansion of arable land is necessary to make up for the less productive sustainable agriculture. Crops that can thrive in less productive land are adopted. Both urban and agricultural areas are managed to provide environmental opportunities as habitats.

7.3 Progression from the present to 2050

7.3.1 Present to 2030

During the period of slow growth in the 2010s, the English and Welsh governments focused on social support networks to guard against discord and discontent from the population. These networks protected people from a drop in their living standards (for example, with subsidies and charitable initiatives), which improved social cohesion.

There was greater scientific evidence that the increasing number of extreme events experienced in the 2020s had been caused by climate change. Media coverage swayed public opinion, not only raising awareness of the importance of our environment, but also creating an understanding that long-term sustainability is a common goal that requires individual effort.

Heavily prescribed legislation from the EU and international agreements set targets for environmental performance and strict global emission targets. With media and public support, the government created overarching political and regulatory reforms to

improve the environment. Economic stability was favoured over an economy with potentially high growth but also frequent recessions and variable inflation. Cost–benefit analyses gradually incorporating environmental and social costs were used in the 2020s as a powerful tool to compare options and make decisions. Remediation measures were generally more costly than preventive measures. Companies became responsible for disclosing the resources and environmental impacts of their products, thus allowing the public to make informed decisions. Those products not complying with the expected level of environmental commitment attracted higher taxes. 'Green actions' were seen as a symbol of status and took precedence over behaviours demonstrating economic wealth. With moderate growth the emergence and uptake of technologies were initially slow. There was a general trend to repair and reuse.

England and Wales played a small role in the global food market with an emphasis on fresh vegetables and meat, a niche market, being supplied to nearby areas in Europe. England and Wales participated in the global market as a sustainable producer.

7.3.2 2030 to 2050

In the 2030s, England and Wales transferred the political powers from national decision-making bodies to regional governance through the Regional Devolution Initiative. While environmental legislation was produced at EU and national levels, regional governments were free to choose the processes to meet the standards. As a result of differing legal frameworks at a regional level, together with different pressures, some catchments achieve higher environmental standards than others, but all comply with minimal environmental standards.

The water environment has benefited from governance strategies in the past 4 decades. During the 2020s, legislation focused on minimising the impacts of a growing population on environmental resources. During the 2030s and 2040s, legislation concentrates on improving environmental quality and implementing the necessary mechanisms for ensuring that the population maintains behaviours that consider the environment in a long-term perspective. Technology is now embraced, optimising production and minimising environmental impacts.

During the 2040s, there is a shift towards increasing personal accountability, which ensures the population remains sustainable in their practices and consumer choices. Mechanisms to achieve this include personal carbon credits which drive reduced water use. Domestic water recycling in homes is the norm and there are tight controls over housing development, business permissions, and public energy and water infrastructure. Goods are more expensive as the price of externalities, such as virtual water, are passed on to the consumer. A slow but strong shift in the economy occurred with carbon- and water-intensive products being almost entirely priced out of the market. Those products with low environmental and social costs remain affordable to the majority of society on middle class incomes.

7.4 Influence of important drivers and activities on water management and land use in 2050

The English and Welsh population grows by 19%, but demonstrates sustainable attitudes and behaviours towards the environment. There is an expansion of irrigated land being brought into production for agriculture, but the rate at which land is allocated for urbanisation and industrial development remains below that of population growth.

Water demand reduces by 28% from the baseline (Table 7.2), with a reduction in household and industrial/commercial demand, leakage losses and use in electricity

generation despite an increase in water used for agriculture (Table 7.3). Reduction in domestic water demand is achieved through behavioural change backed up by a low degree of technological innovation (for example, use of rainwater or greywater for outdoor purposes). Population growth is offset by a reduction of per capita consumption by 41% that is based on the goodwill of consumers with a raised environmental awareness (for example, on the impacts of water over-abstraction on aquatic ecosystems and the energy required to treat and transport potable water).

The goal of industry and agricultural sectors is to produce goods with small environmental footprints. The consumer and government regulation drive sustainable practices. Consumers buy ethically, selecting environmentally friendly products. The price of water increases as it becomes a valued resource, thus stimulating investment in water-saving technologies. The government imposes high taxes for products with high environmental and social costs in the whole life of the product.

Table 7.2 Sustainable behaviour: population size for England and Wales and total water demand for 2050 considering changes from baseline values

	Baseline	2050	Change from baseline
Population (in thousands)	55,250	66,000	↑↑ (19%)
Household per capita demand (litres per day)	156	92	↓↓ (-41%)
Total demand (million litres per day)	19,699	14,112	↓↓ (-28%)

Notes: Total water demand includes leakage and freshwater for electricity generation. Change is characterised as an increase (red arrow up) or decrease (green arrow down). The extent of change is characterised as weak (one arrow), moderate (2 arrows) or strong (3 arrows).
Source: Environment Agency and Natural Resources Wales (2013)

Table 7.3 Sustainable behaviour: estimated change in land use and water demand from current values and water demand in 2050 for household, industrial/commercial, agriculture, electricity generation and leakage

	Land use change	Demand (million litres per day)	Change from baseline on water demand
Household	↑	6,101	↓↓ (-29%)
Industrial and commercial		5,682	↓↓ (-21%)
Agriculture (irrigated crops)	↑↑	272	↑↑ (42%)
Electricity generation (freshwater only)	Not applicable	176	↓↓ (-70%)
Leakage	Not applicable	1,881	↓↓ (-40%)

Notes: Change is characterised as an increase (red arrow up) or decrease (green arrow down). The extent of change is characterised as weak (one arrow), moderate (2 arrows) or strong (3 arrows).
Source: Environment Agency and Natural Resources Wales (2013), Knox et al. (2013)

Extensive sustainable agriculture that integrates environmental sustainability into the production system becomes the norm and an increased number of floodplains are used for agriculture (for example, to graze cattle). The application of chemicals is reduced

and soil is nurtured. Nevertheless, there is an expansion of irrigated arable and horticultural land as a result of raised temperatures and an increase in the production of vegetable crops that require irrigation. Water for irrigation is used more efficiently than under current conditions. There is a relaxation of aesthetic expectations of produce (for example, knobbly carrots and marked apples are accepted by consumers), allowing farmers to sell 'substandard' produce. Farmers focus irrigation on increasing yields rather than improving quality of produce.

7.5 Pressures on water management issues

7.5.1 Water supply and wastewater services

The provision of water and wastewater services is managed at a local level and the water industry has undergone mutualisation. Customers elect the executives and members of the public manage the utility on a rotation basis. Members also have the right to vote on important decisions that influence how the company complies with the regionalised legal requirements.

Water is affordable to all despite its price being high. Water companies invest in maintaining the infrastructure and monitoring systems, and in reducing leakage losses. Water resources are carefully protected for future generations and sustainable abstraction guarantees reduced impacts during low flow periods and on sensitive water bodies and habitats. In water-stressed areas, interruptions such as hosepipe bans are common and accepted by the population as necessary measures to cope with climate change. Local water is used to supply the local population when possible and water trading within regions becomes the norm. Water transfers across regions are considered a low priority measure and are only considered in areas with a high water deficit.

European agreements for very low carbon emission targets as a result of the climatic disasters experienced since the 2010s mean that wastewater treatment is less efficient. Low energy intensive wastewater treatment processes are used, such as tertiary treatment in reed beds. These processes are generally not as efficient, even though the flow entering the sewage system has decreased due to a reduction in per capita domestic water consumption and is accompanied by a decrease in food waste, sanitary and hygiene products reflecting sustainable behaviours. Locally led regulation has relaxed discharge consents, particularly into coastal water environments, ensuring high compliance with the relaxed environmental water quality standards. Discharge consents for sewage treatment works have been relaxed compared with those currently set by the Urban Waste Water Treatment Directive. Despite increased urban density, sewer blockages and sewer overflows incidents are less common.

Mutualisation of the water industry implies a significant temporal and spatial change (depending on who is in charge) in the impacts of discharges on the receiving water bodies and on public health scares. However, investment in water quality monitoring has been locally led to ensure compliance with water quality standards, for instance in catchment sensitive areas and in bathing waters. Moreover, in wealthier regions, low energy technology is available to perform wastewater treatment processes at higher standards, albeit at a higher cost.

Rural and more isolated areas become more populated and the number of small wastewater treatment plants using very simple treatment processes increases, some of which are private plants. This poses an increased risk of pollution.

7.5.2 Extensive sustainable agriculture

There is higher demand for locally grown and seasonal produce grown sustainably. There is a move towards extensive agriculture with integrated farming systems that combine chemical (for example, fertilisers and pesticides) and biological methods while seeking to maximise agricultural production. Biological methods include biological processes and cycles for controlling pests, crop rotation, and legume crops for increasing nitrogen fixation and application of slurry/manure. Integrated farming systems are beneficial for the environment as these practices require fewer chemical inputs and minimise the risk of land and water pollution. Moreover, these agricultural practices avoid land lying fallow or being abandoned, intensive tillage and land degradation by soil erosion (for example, buffer zones and wetlands prevent nutrients and solid substances running off into the water bodies).

There is a significant decline in diffuse pollution as a result from more sustainable agricultural practices. This is further enhanced by legislation banning the use of certain pesticides and biocides that exceed given thresholds of environmental damage. Where pollution may still occur, community regulation often leads to measures being taken.

Extensive agricultural practices utilise more surface area for most types of production. Land for producing cereals, legumes, potatoes and vegetables is obtained by converting grasslands or other areas used for livestock production for which demand has reduced. Agriculture is also practised in floodplains (for example, to graze cattle), where farmers accept higher risks.

There are also increased pockets of organic farming that further preserve or maintain the natural resource base by nurturing the soil, enhancing biodiversity and balancing the ecosystem while producing crops. Domestic agriculture is also widespread with people planting in their gardens and allotments. This is driven by a cultural movement to be closer to the land and is rarely practised out of necessity. Keeping practices within environmental limits is a sign of success and neighbours maintain close vigilance of their peers.

There is a reduction in livestock production, particularly in lowlands but also in uplands, as society eats a more vegetarian diet and the cost of meat rises. The price of ruminant based meat increases due to externalities such as methane emissions. Livestock and storage of slurry and manure are managed effectively, reducing the impacts on the water environment.

7.5.3 Energy, industry and services

EU regulation demands lower carbon emissions leading to a scenario where the renewables dominate through the use of wind as main source of energy and with investment in carbon capture and storage to reduce carbon dioxide emissions. There is an increased electrification of heating and transport. There are fewer cars, shorter commutes and increased use of public transport associated with reduced urban pollution. Biofuel is mainly manufactured from residues of food crops or biomass imported because there is a lack of land available to grow energy crops given the lower productivity of agricultural systems. Reduced dependency on fossil fuels reduces the release of the byproducts of combustion into the environment and allows the decommissioning of the remaining coalmines.

There is a focus on pollution prevention as opposed to end-of-pipe solutions. Consumers are informed about the impacts of a product in its whole life cycle and vote with their money for sustainable products, driving continuous improvement towards water use efficiency and reduced environmental impacts across industry. This is complemented by product legislation that bans substances responsible for

environmental impacts and health hazards (for example, general chemicals and pharmaceuticals).

There is a reduction in water demand by the services sector. A less consumerist society is complemented with sustainable service design (for example, improved operation and maintenance of swimming pools and gyms to use water more efficiently). Service businesses also rapidly improve the water efficiency of offices.

7.5.4 Flooding policy and practice

Catchment flood planning is developed locally and the level of flood protection differs across the country. There is an emphasis on natural processes for controlling run-off and river flows. River modification and investment in engineering projects is minimised and associated with areas that have been historically developed and where it is unpractical or unlikely to relocate the population. Floodplain areas are clearly demarcated and no development is allowed. Modified river reaches are restored, mainly in regions with wealthier communities, contributing to increased natural storage capacity of flows and reduction in flood risk as well as improving the opportunities for recreation, biodiversity and attractiveness of the landscape. River restoration includes remeandering, creating natural river banks where previously banks were encased in concrete and fish passages that enable the migration of fish past sluices and other obstacles. Some floodplains are used for agriculture (for example, grazing cattle) and farmers are aware of the risk associated with crop losses which is gradually increasing as a result of climate change.

Combined sewage systems are common, but there is improved surface water management (for example, sustainable drainage systems and targeted removal of surface water connections) to ensure the infrastructure operates efficiently. Urban run-off has reduced as surface water management schemes became compulsory in new developments, offsetting the increased run-off resulting from climate change. In established urban areas, run-off is also being reduced to a limited extent as rainwater harvesting is very popular among individuals and paved areas are substituted by green spaces. Urban run-off entering water bodies is not only reduced, but also less polluted as less ‘traditional’ cars and more ‘green’ cars are used. Road run-off is often captured and filtrated by the ‘blue-green infrastructure’, that is, a network that provides a solution to urban and climatic challenges by building with nature.

7.5.5 Tightening of regionalised environmental standards

England and Wales develop a governing framework that integrates the environment with social aspects and the economy. The regulatory reform is associated with a change in social values – the individual has the ability to make informed decisions on products based on its social and environmental wider implications – often providing an alternative to developing tougher regulations. Compliance is achieved through relevant regulatory reform, self and community regulation, and consumer awareness ensuring compliance with expected environmental protection.

European legislation drives the national agenda to prioritise a reduction in greenhouse gas emissions and improve environmental performance. EU and national legislation are adapted at the local level and environmental standards vary across the country. Some regions have healthier ecosystems than others, but generally there is compliance with high environmental standards. The exception is when higher water quality objectives contradict the carbon agenda; water quality is marginally reduced where improvement of water quality requires energy intensive processes.

Use of chemicals, biologically active substances, pesticides, biocides and pharmaceuticals is subject to tighter control and regulation. This involves an enhanced system of product registration, which provides users with a greater knowledge of the impacts of products (that is, embedded energy and water). It is difficult to obtain approval for a new chemical unless a comprehensive breakdown of its environmental impacts and costs is available. Similarly, mechanisms are put in place to ban substances exceeding set thresholds of environmental contamination (for example, eliminating phosphates from all laundry products by 2020, thus reducing phosphate in water).

There is commitment to ensure the long-term viability of habitats and ecosystems, particularly through river and coastal restoration works. Maintaining and improving conditions for biodiversity means there is an increase in the government's ability to meet the Habitats and Birds Directives and the Water Framework Directive objectives, despite relaxation of discharge consents implying reduced compliance with the Water Framework Directive in some areas. Invasive non-native species are a minor concern in achieving the objectives of the Water Framework Directive.

8 Scenario 4: Local resilience

This scenario presents an image of England and Wales influenced by localism, where political agendas are shaped by the short-term interests of communities in pursuit of self-sufficiency.

8.1 Scenario overview

The political agenda is shaped by goals for self-sufficiency taking account of poor economic conditions. Local priorities drive political agendas with influence over environmental regulation, spending and operating systems on water and wastewater services, energy and flood protection. Poor economic conditions (that is, low gross domestic product) mean the majority of the population struggle to meet their basic needs. Individuals adopt a subsistence-type lifestyle and a 'make-do and mend' culture, where close relationships within communities provide security. Short-term management and protection of environmental resources are conducted locally and not at a catchment scale, disregarding the longer term environmental interests and the interests of downstream communities.

8.2 Drivers and activities

The drivers and activities for water and the water environment for the local resilience scenario are presented in Table 8.1.

Table 8.1 Local resilience: important drivers and activities for water and the water environment

Key factors	Drivers and activities for water and the water environment
Political attitudes	Controls are regionalised with a focus on self-sufficiency due to a lack of international cooperation. There is pressure to protect environmental resources at a regional scale.
Governing priorities	Government priorities are set to ensure long-term subsistence. However the short-term needs of the local population often take precedence. Water quantity and quality is protected for public health reasons, rather than for the environment or to support biodiversity and with little regard for the impacts on downstream communities.
Economy	The state of the economy is poor with little international interaction. This impacts the funding available for agricultural subsidies, environmental initiatives, and investment in R&D and infrastructure.
Price of resources	The cost of resources varies significantly yearly and seasonally. Technology is rarely used as it increases prices. Energy becomes generally very expensive.
Demographics	The population reaches 65 million in 2050 in England and Wales. Economic pressures drive a move towards shared housing and increased household density. The affluent of society move to areas with abundant resources.

Key factors	Drivers and activities for water and the water environment
Attitudes and behaviour	Society reduces consumption of food, water and energy. Individual communities are more concerned with their own well-being than that of neighbouring communities.
Technology approaches	Water, wastewater and energy infrastructure is obsolete as a result of poor investment. There is little investment in R&D and environmental initiatives. The population is risk averse to new technological approaches remaining faithful to traditional agricultural and industrial practices.
Green technology	Individuals aim to reduce waste produced and water consumed in order to minimise costs, leading to widespread use of small household appliances such as composting bins and rainwater harvesting.
UK legislation	Environmental legislation is flexible and allows regions to set their own standards. Short-term goals often lead to regulatory relaxation to ensure compliance (for example, land planning, discharge consents and water abstraction).
EU legislation	International and EU agreements and legislation have a very limited influence in the UK. Regionalisation leads to incoherent practices across the country regarding implementation and enforcement of policies.
Climate change	There is very limited governmental investment in mitigation and adaptation measures due to poor economic conditions. In many instances individuals and communities implement their measures such as building on-farm reservoirs for irrigation and raising earth embankments for flood protection.
Land use changes	Regionalisation leads to disputes within and between communities over the control of resources such as water (for example, issues trading water licences) and land. The need to satisfy the local food demand leads to a move towards subsistence agriculture based on small-scale family farms. Urban areas see an increase in density but do not expand in area.

8.3 Progression from the present to 2050

8.3.1 Present to 2030

During the 2010s the world's economy collapsed, led by US and European economic decline. The collapse was followed by alternating periods of growth and recession in those countries dependant on US and European markets, such as England and Wales. Countries focused on survival, which led to an era of extreme protectionism and to the collapse of global international markets, although international trade continued through the few remaining bilateral agreements.

Centralised institutions are perceived by society to have mismanaged the economy, having consistently benefited the affluent, which causes mistrust and a general disengagement with central governance. Local communities have turned inwards to the people they know and kept relationships with other regions to a minimum. A modest life

became the norm, with a certain level of community initiative helping to source goods cheaply.

During the 2020s, local communities focused on improving their social well-being and welfare. This included improved management of local environmental resources that have a direct impact on human health, such as protecting the water quality of their local water bodies. Selfish community behaviour is evident with little regard to the downstream impacts. Environmental protection was assisted by regulatory standards defined at local levels as legislation – in line with the Devolution Act 2010 – provided a legal framework empowering communities. There is a move towards subsistence agriculture. Farmers choose crops suitable to the water availability in their area minimising the need for irrigation.

8.3.2 2030 to 2050

Each community of England and Wales focuses on their own subsistence. The population has little monetary resources and is proactive in minimising consumption of resources. Houses have been adapted to become more efficient, significantly reducing water consumption and maximising the use of rainwater and greywater; often individuals retrofit their own homes making use of their DIY skills. In addition, increased household occupancy also means higher resource efficiency.

Economic progress is slow and there is an expansion of parallel economies with local currency schemes reaching 25 million members in the UK. This exacerbates national budget problems, reducing the government's ability to intervene on behalf of communities. Communities struggle to obtain access to resources and the pace of population growth slows down. Meeting short-term needs takes prevalence over longer term thinking and the environment is only protected for public health reasons, with total disregard for the wider benefits to the environment and society. Subsistence agriculture becomes more widespread across rural and urban areas; family food is produced in allotments and gardens. Intensive farms still exist and local produce is sold locally, associated with high price fluctuations. Reduced investment in R&D means that available technology is essentially unchanged from the 2010s and 2020s, and agricultural practices (for example, fertilisers and pesticides) cause environmental harm.

Investment in water and wastewater infrastructure is generally kept to a minimum and water treatment and distribution networks are getting to the end of their useful life being old and unreliable; interrupted water supplies and high leakage losses are common. Regions with strong local leadership and available funds have maintained their own infrastructure, improving standards and reliability of service. Water abstraction is determined by local needs and in periods of stress, water is abstracted beyond sustainable levels. Standards for effluent and environmental water quality are set by local authorities and are less stringent (with exceptions) than earlier in the century. Energy shortages and rationing have become a way of life, but wealthier regions explore additional sources for more reliable energy (for example, reinstating old mill sites).

8.4 Influence of important drivers and activities on water management and land use in 2050

The population of England and Wales grows by 18%, with a marginal increase in land used for household, industrial and commercial purposes (Table 8.2). Household occupancy increases with multiple generations living under the same roof. This results in little growth in urbanised land, which occurs mainly in the margins of large urban

areas. Equally, there is little change in the land allocated for industrial developments. There is, however, a significant expansion of agricultural land with irrigated crops.

Total water demand increases by 6% despite an increase in population of 18%. Greater savings and efficiencies are sought by society so as to reduce costs, but this is compromised by lack of investment in infrastructure, technology and knowledge. Water demand for agriculture increases by 40% and household demand increases by 7%, being accompanied by 20% increased leakage losses (Table 8.3). During periods of water stress, water is abstracted beyond sustainable levels impacting the water environment.

Industry and agriculture aim to use locally sourced raw materials and to minimise the cost of production. The magnitude of the environmental impacts considered acceptable by the local community depends on the services and products in question; a greater environmental footprint is accepted for producing goods and services that are core to the community's subsistence. The price of water rises, but there is inertia in investment in water-saving technologies which are perceived as costly, with the exception of greywater reuse to a certain extent. Industry and agriculture face the challenge of producing affordable goods for the population with resources that become increasingly expensive.

There is an increase in food produced locally, especially in the regions struggling most to meet the demands of their population. This is associated with a diversification of agricultural sectors at a regional scale (that is, arable, potatoes, horticulture, biofuel and livestock production). Although intensive farms still exist, subsistence agriculture becomes more widespread across rural and urban areas (for example, in allotments and gardens) and is often practised by first generation unskilled farmers.

Table 8.2 Local resilience: population size for England and Wales and total water demand for 2050 considering changes from baseline values

	Baseline	2050	Change from baseline
Population (in thousands)	55,250	64,930	↑↑ (18%)
Household per capita demand (litres per day)	156	142	↓ (-9%)
Total demand (million litres per day)	19,699	20,783	↑ (6%)

Notes: Total water demand includes leakage and freshwater for electricity generation. Change is characterised as an increase (red arrow up) or decrease (green arrow down). The extent of change is characterised as weak (one arrow), moderate (2 arrows) or strong (3 arrows).
Source: Environment Agency and Natural Resources Wales (2013)

Table 8.3 Local resilience: estimated change in land use and water demand from current values and water demand in 2050 for household, industrial/commercial, agriculture, electricity generation and leakage

	Land use change	Demand (million litres per day)	Change from baseline on water demand
Household	↑	9,201	↑ (7%)
Industrial and commercial		7,197	↑ (1%)
Agriculture (irrigated crops)	↑↑↑	269	↑↑ (40%)
Electricity generation (freshwater only)	Not applicable	355	↓↓-39%
Leakage	Not applicable	3,762	↑↑ (20%)

Notes: Change is characterised as an increase (red arrow up) or decrease (green arrow down). The extent of change is characterised as weak (one arrow), moderate (2 arrows) or strong (3 arrows).
Source: Environment Agency and Natural Resources Wales (2013), Knox et al. (2013)

8.5 Pressures on water management issues

8.5.1 Water supply and wastewater services

The process of devolution transferred the responsibility of managing water resources to local authorities. Local authorities are allowed to adjust environmental regulations to fit the requirements of the local population. These have immediate detrimental impacts on equity between communities and on the water environment, as catchments are being managed at a local authority scale with a lack of co-ordination between different local authorities in those catchments. Although there is greater control of water abstraction licences and usage at a local level, the impacts on local authority areas downstream are disregarded. There is a lack of environmental monitoring as poor investment results in the deterioration of hydrological and hydrogeological monitoring systems and so only visible pollution events are detected. The severity of the impacts varies across regions.

Local measures to augment supplies such as small water reservoirs and boreholes are developed in order to cope with periods of water stress. Local authorities facilitate these developments benefiting households, farmers and the industry, albeit at a cost to the water environment.

Regional water and wastewater companies have been replaced by smaller local companies, often at a catchment scale. Tight budgets mean that investment to maintain and upgrade infrastructure has been minimal and infrastructure is getting to the end of its useful life in many cases (for example, leakage losses are high). Where local water demand is high or local water availability is low, water prices are high, supplies are unreliable and water is over-abstracted, affecting the environment.

There is a great variation across regions in terms of water quality. Wastewater services are equally unreliable and sewage incidents become more frequent (for example, sewage overflows in periods of heavy rainfall; raw sewage builds up and spills into the environment during outages of the national electricity grid). Local communities do not

feel responsible for downstream impacts and there is a trend for relaxation of discharge consents for sewage treatment works, except where effluent discharge occurs upstream of fisheries or an abstraction point for the same community. When regulation and management systems fail to protect the local resources, efforts to control (visible) pollution events tend to be driven by community anger. As communities are unable to control upstream discharges, they have to treat the water they abstract to a higher level. Public health scares associated with a contaminated water environment (for example, microorganisms, heavy metals and chemicals) are more frequent, although the severity is low.

8.5.2 Move towards subsistence agriculture

The massive return of small-scale family farms is complemented by a significant rise in urban and rural allotments, gardens and school plots being used to produce family food.

There is competition for local water among water consumers, so farmers use this resource carefully and which is reflected in the crop they select. Farmers' groups are established to enable them to tackle their challenges collectively (for example, building on-farm water storage). Water demand for agriculture increases by 40% in the 2050s, with investment in cereals and drought-resistant horticultural crops, as potatoes are deemed too water intensive to fully meet carbohydrate demand (Knox et al. 2013). Agricultural production is more vulnerable to extreme weather events as a result of climate change. Urban farmers collect and use rainwater, but many commercial farmers have to accept frequent production losses. Also, where sewer overflows are frequent, farmers prefer to irrigate their crops with groundwater and avoid using contaminated water from their winter storage reservoirs. Communities invest in arable crops (wheat, corn) which can be stored, providing more reliable supplies to deal with fluctuating levels of production.

The available technology for agriculture is more than 2 decades old and practised by first generation farmers who have less skills and experience. This has resulted in increased diffuse pollution. Common practices include the abundant application of sewage sludge and manure, both provided locally, as the price of inorganic fertiliser increases. There has been a transition to mixed farming to enable the use of slurry and manure. Fertiliser application practices vary regionally, but to optimise yields, environmental regulations are often relaxed. This contributes to the saturation of arable soil with nutrients, the build-up of heavy metals and the pollution of receiving water bodies with sediments and nutrients. The pesticides and herbicides used are now old and many pests are resistant to them. Farmers either apply higher quantities of pesticides and herbicides or utilise substances previously banned by the EU. Occasionally, cheap biological controls are put in place. Farmers accept greater production losses as a result of pests.

Overall, meat consumption remains the same; decreased consumption per capita is offset by the increasing population. Livestock production is concentrated on less productive soils. Relaxed regulations means livestock density increases, optimising production per unit of land but with additional environmental impacts. A steady reduction in investment leads to deterioration in slurry, manure and silage storage on livestock farms, resulting in the release of contaminated effluent into the environment. Livestock production also contributes to the erosion of river banks, particularly where cattle are allowed to graze near riparian areas. Furthermore, there is increased use of veterinary products to ensure animal growth and to control parasites. There is increased domestic husbandry of small animals such as chickens, pigs and sheep in urban areas causing local issues concerning nutrient, microbes and chemicals running into water.

8.5.3 Energy, industry and services

Energy companies become local monopolies. Due to high energy prices, electricity demand reduces by 28%. Energy generation is regionalised, being sourced from wind and gas from waste and landfill sites. There is an increased number of coal-fired power stations with locally mined coal. The re-activation of coal mines offers local employment. Land pressures for food production have greatly reduced the land available for production of energy crops. The energy infrastructure is old and failing, and energy security is an issue. Many communities invest in small renewable energy generation units. New sources include wind farms limited to small-scale plants as communities have little funds available. These renewable sources are backed up by small-scale generators powered by fossil fuels. As communities reduce the frequency and distance of commuting and travelling, there is a reduction of released combustion products into the environment.

Nationally led legislation for industry is weak and non-prescriptive. However, close control by the surrounding community and local authorities ensures accountability for environmental impacts, especially observable ones, and prevents industrial development to some extent. There are exceptions for industrial operations deemed of vital importance to the community and those with impacts that are not directly observable (for example, contamination of groundwater). Industry invests in greywater reuse systems, but maintains the existing wastewater treatment technologies, even if dated and non-efficient, as long as there is no risk of being fined or shut down.

A decline in the services industry and the quantity of services provided is associated with a reduction in water consumption. Services are only affordable to the affluent of society and the vast majority of society undertakes DIY as a necessary hobby. With more people working from home, water demand shifts from the service sector to the domestic setting.

8.5.4 Flooding policies and practice

There is little co-ordination across communities in terms of flooding policies and practice. This results in a patchwork along river lengths composed of a mixture of engineering solutions (with different levels of sophistication) and areas where natural mechanisms are used (for example, floodplains). Wealthier communities are better protected, but a greater number of areas are more vulnerable to flooding with farmland being particularly at risk.

Wastewater infrastructure that is obsolete and lacking maintenance is subject to additional pressures from increased household occupancy and increased intense rainfall events due to climate change. Thus, incidents such as combined sewer overflows and overload of sewage treatment works occur more frequently with greater impacts on the water environment. Communities are increasingly resilient at dealing with sewer flooding and more dwellings are being adapted to minimise the impact.

A significant quantity of urban run-off from new and old developments enters combined sewers and rivers directly. Where there is a financial benefit, local councils have installed surface water management schemes in new developments. Pollution from urban run-off is also aggravated by a lack of vehicle maintenance, even though this is offset by a significant reduction in the number of vehicles due to the high costs associated with running a car.

There is investment in wood as a cheap source of energy and construction material, resulting in an expansion in woodland areas where it does not directly compete with food production. This may provide some marginal benefits in river flow regulation.

8.5.5 Local communities dictate water quality standards

The political outlook empowers local councils to decide which standards have to be complied with in the region under their control. Some national and European legislation is in place, including best practice guidance directives, but water quality standards are often relaxed. Communities look inwards at their own well-being, disregarding their impacts on neighbours and areas further downstream. There is an increase in regulation at the local level as communities police environmental water quality to ensure it is good enough to meet their needs. Water resources are managed to prevent health hazards, but this fails to acknowledge and address water's aesthetic and ecological values.

Reduced investment in monitoring means that enforcement regulation is often ineffective as it is limited to visible impacts. Communities fail to develop co-operative relationships outside their region for managing shared resources, leading to the failure of initiatives such as programmes for sustainable abstraction that attempt to manage beyond individual catchments or the adjacent environment. This has significant implications for water resources and the water environment.

There is decreased compliance with Habitats Directive objectives for listed fish species (principally salmon, shads and lampreys) and for farmland fauna and flora as agricultural land expands and removes buffer strips. Lack of co-ordination between communities along full river lengths means that in-river obstacles to fish migration are not removed (for example, obstacles to dam rivers for irrigation) and that fish passages are not maintained or installed, which limits fisheries. This also hinders the government in meeting the objectives of the Water Framework Directive and EU Eel Regulation. Similarly communities fail to pursue compliance with the statutory fisheries duty to protect migratory and freshwater fish under the Marine and Coastal Access Act, which extended this duty to additional migratory fish species. However, there are some exceptions, such as those communities where the fishing industry is central to the local economy. Invasive non-native species become widespread, further downgrading the status of the water bodies under the Water Framework Directive.

9 Scenario 5: Reference

This scenario describes how England and Wales might look considering the progression of the current political drive, economic conditions and the dynamics of international trade. Economic growth is combined with environmental sustainability, but short-term goals often constrain environmental improvement.

9.1 Scenario overview

The political agenda is driven by the desire for economic growth () and the aspiration for sustainable development (for example, carbon agenda, Natural Environment White Paper and Water Framework Directive). Society shows a level of environmental concern, but attitudes and behaviours are mainly focused on self-interest and personal income. Society is dominated by the middle class and there is increasing disparity between the affluent and the poor minorities. The government values the environment for the wider services it provides, but short political cycles cause most long-term initiatives to fall short of their original goals. The EU maintains a significant role in dictating standards and codes of good practice. Environmental regulation alternates between periods of tightening and relaxing of standards associated with economic conditions and particular issues that come in and out of public concern.

9.2 Drivers and activities

The drivers and activities for water resources and the water environment for the sustainable behaviour scenario are presented in Table 9.1.

Table 9.1 Reference: important drivers and activities for water and the water environment

Key factors	Drivers and activities for water and the water environment
Political attitudes	There is political awareness of the need to protect the environment and to mitigate climate change. However, short-term economic goals are a priority and advances in environmental protection are limited to times when it receives greater public attention. Other measures of national success (other than gross domestic product) are adopted which reflect social and natural capital, but only economic measures are taken seriously in influencing policy.
Governing priorities	Water security is high on the agenda, but disjointed political goals resulting from international, national and regional political strategies pose difficulties to implementing a practical framework.
Economy	In a global economy, English and Welsh economic growth is slow. There is a move towards tightening environmental regulations protecting the water resources and the water environment when relevant for the economy and society.
Price of resources	Land prices rise as a result of an expansion of urban areas and arable land to house and feed an increasing population. England and Wales are still partially dependent on fossil fuels whose prices increase as existing reserves get near depletion. Water is an expensive commodity.

Key factors	Drivers and activities for water and the water environment
Demographics	The population grows to just over 70 million in England and Wales. There is high immigration of skilled and unskilled workers. The majority of the population has left the coastal areas due to the impacts of sea level rise and flooding, and moved to inland urban centres.
Attitudes and behaviour	Water users are willing to make minor lifestyle sacrifices to reduce consumption of resources in order to minimise costs. Domestic users prefer water- and energy-efficient household appliances.
Technology approaches	The funding for R&D in England and Wales is progressively reduced and prioritised to develop technologies that permit carbon and energy savings as well as water savings. Investment in agricultural technology is associated with improving short-term gains rather than long-term sustainability. New technology is embraced if it is reliable and provides short- to medium-term economic gains.
Green technology	There are initiatives to improve water saving and water infrastructure, but decisions with a short-term focus reduce their potential efficiency. Low energy technology for wastewater treatment is available.
UK legislation	Regulation favours production practices that optimise the utilisation of resources without compromising the environment. Environmental protection, associated with tighter environmental regulation during growth periods, is relaxed during less favourable economic conditions. Water resources are highly regulated and protected.
EU legislation	The EU has a role in defining the environmental regulations and standards which value water, ecosystems and the environment. There is greater flexibility for Member States to adapt targets according to their local circumstances.
Climate change	Weather extremes such as flooding and droughts attract public attention, but investment in adaptation measures is limited and has to be prioritised. Climate change drives a trend towards sustainable development, but this is not matched by public actions or the political agenda.
Land use changes	The global dynamics of food production create pressure on national agriculture. A balance is established between increasing food productivity, water security and environmental protection. Arable land expands for intensive agriculture, where market driven decisions lead to a change in crop selection and increased yields. The environmental impact of agricultural practices is generally higher.

9.3 Progression from the present to 2050

9.3.1 Present to 2030

England and Wales, as members of the European Union, have been part of an international market in which the World Trade Organization has become an increasingly powerful player. The overall governance approach was top-down, from European to national and regional levels. Using this strategy, the government aimed at maintaining a strong economy ensuring competitive advantage in international markets. International trade, combined with national production, was envisaged as the solution to feed a growing population with limited resources. However, a competitive role in international markets was not achieved successfully, and through the 2010s and 2020s the economy went through cycles of increased prosperity intercalated with periods of recession.

During the 2010s, the public and some political classes demonstrated a willingness for improving the environment, but corporations and lobbyists had significant influence over the political agenda, interfering with regulatory reforms and the definition of standards (for example, negotiations on Common Agricultural Policy reform and extension of the Kyoto protocol). The low economic growth of the 2010s and early 2020s resulted in government budgets focusing on the short term and further reducing budget allocation for environmental protection. Initiatives with long-term perspectives, mainly driven by the EU, were followed although the objectives have been redefined and lowered (for example, energy strategy and Water Framework Directive). Some improvements in efficiency for water, transport and energy infrastructure resulted from these initiatives.

Society's priority was to cover its basic needs and environmental protection was not seen to be essential. Consumption was affected by the unfavourable economic conditions and the disparity between the affluent and the poor increased. During the 2020s, the low and middle classes were struggling financially. The media emphasised the importance of the economic recovery, especially during periods of recession, and adaptation to climate change impacts. Environmental protection was perceived to deter economic growth. The regulatory efforts for environmental protection (for example, Water Framework Directive and Standards of Good Agricultural and Environmental Condition) that had been supported during times of increased growth were frequently reviewed, resulting in a relaxation of regulation and lowering of standards. During the 2010s and 2020s, little action was taken to enhance or protect the environment. The few exceptions were driven by the EU and included banning substances toxic to humans, animals and the environment.

9.3.2 2030 to 2050

The impassive political nature of the previous 2 decades resulted in a slow degradation of the existing infrastructure (for example, water and energy), which had not been updated, but maintained sometimes beyond its life expectancy. During the 2030s, the pressures resulting from a growing population exposed the inadequacies of this ageing infrastructure. This was further exacerbated by the impacts of more frequent extreme weather events, for which the existing short-term solutions were no longer suitable. This led to the realisation that the political strategy of the past 2 decades was not effective.

The economic indecision of the 2020s and the 2030s created a call for action. In the face of a tight budget, the government aimed to combine economic growth with environmental protection. Public pressure was a driver for long-term thinking, but

lobbyists and conflicting opinions did occasionally stifle political agendas. Nevertheless, in the 2040s there was progress towards environmental protection, particularly on environmental issues with direct relevance to the economy (for example, loss of pollinators, degradation of water resources and biodiversity loss) and those backed by strong interest groups such as birds being protected by the RSPB. The EU maintained strong regulation of chemical substances, with a risk-based approach making it difficult to approve new products.

The high price of fossil fuels provided an incentive to renew the commitment to renewable energy and to update the energy infrastructure. Biofuels were increasingly used to fuel transport which in turn increased the competition for land to grow food crops.

Public pressure influenced investments to improve the existing infrastructure and to mitigate and adapt to climate change. The budget was tight and measures were prioritised. Flood defence mechanisms were implemented in areas of high population density or where industrial and agricultural activities generated high income. The EU, supported by its members, removed agricultural subsidies forcing farmers to optimise their practices to reduce inefficiencies and maximise gross margin.

9.4 Influence of drivers and activities on water management and land use in 2050

English and Welsh populations grow by 28% (Table 9.2) and more land is brought into production for agriculture and biofuel crops; new developments for industrial and housing purposes also increase competition for land (Table 9.3). There is little change to overall levels of water consumption (Table 9.2). Water demand increases for agriculture by 100%. Domestic use reduces by 10%, with a 14% reduction in per capita consumption. There is a 5% reduction in both water consumption from the industrial and manufacturing sectors and leakage losses (Table 9.3). An increase in water prices is the main driver for reducing water consumption. The government has regulations and initiatives in place to manage water resources and the water environment.

The goal of industry and agricultural sectors is to produce goods at the lowest cost while complying with environmental regulation. Consumer brand reputation is important, with many producers investing in certification procedures with benefits for the environment. Raised water prices lead to investment in R&D and implementation of water-saving technologies that provide medium- and short-term economic benefits.

Table 9.2 Reference scenario: population size for England and Wales and total water demand for 2050 considering changes from baseline values

	Baseline	2050	Change from baseline
Population (in thousands)	55,250	78,340	↑↑ (42%)
Household per capita demand (litres per day)	156	151	↓ (-3%)
Total demand (million litres per day)	19,699	29,347	↑↑ (49%)

Notes: Total water demand includes leakage and freshwater for electricity generation. Change is characterised as an increase (red arrow up) or decrease (green arrow down). The extent of change is characterised as weak (one arrow), moderate (2 arrows) or strong (3 arrows).
Source: Environment Agency and Natural Resources Wales (2013)

Table 9.3 Reference scenario: estimated change in land use and water demand from current values and water demand in 2050 for household, industrial/commercial, agriculture, electricity generation and leakage

	Land use change	Demand (million litres per day)	Change from baseline on water demand
Household	↑↑	9,490	↑↑ (10%)
Industrial and commercial		6,800	↓ (-5%)
Agriculture (irrigated crops)	↑↑	384	↑↑↑ (100%)
Electricity generation (freshwater only)	Not applicable	2,980	↓ (-5%)
Leakage	↑↑	9,490	↑↑ (10%)

Notes: Values for electricity generation are not available in literature.
Change is characterised as an increase (red arrow up) or decrease (green arrow down). The extent of change is characterised as weak (one arrow), moderate (2 arrows) or strong (3 arrows).
Source: Environment Agency and Natural Resources Wales (2013), Knox et al. (2013)

9.5 Pressures on water management issues

9.5.1 Water and wastewater services

The water industry operates under the instruction of shareholders to maximise profits. Their operations are restricted by environmental regulations preventing over-abstraction and pollution of the receiving water bodies. Networks of hydrological and hydrogeological monitoring systems allow enforcement of existing environmental legislation.

The costs to manage water resources and the water infrastructure increase as a result of climate change and a growing population. These costs are transferred to the consumer and the price of water increases. During periods of economic growth, Periodic Reviews set high water price increases allowing companies to improve existing water infrastructure and its resilience to climate change, and to reduce leakage losses.

Water companies are permitted to over-abstract during periods of drought which are increasingly frequent as a result of climate change. The security of public water supplies has a higher priority than the protection of the aquatic environment. Furthermore, water treatment of abstracted surface water is usually required in those periods when low dilution capacity from the rivers means that water is often contaminated (for example, with heavy metals and chemicals).

Regulation of wastewater released into the environment is tight and the level of compliance high, especially for catchment sensitive areas and from agglomerations with more than 10,000 population equivalents. In rural areas, where the number of houses increases, water quality can deteriorate as a result of septic tanks with poor quality drainage and illegal direct connections to surface water systems.

Expansion of urbanisation has intensified pressure on existing infrastructure, which has not been developing to meet the expanded need. It is a legal requirement that all new

urban developments must install sustainable drainage systems. In older urban areas, however, the sewage infrastructure has not been updated and is still vulnerable to increased winter rainfall and periods of intense rainfall due to climate change. Overall, there is a reduction in the number of sewage incidents such as combined sewer overflows and overload of sewage treatment works.

9.5.2 Intensification of agriculture

Intensification of agriculture and expansion of irrigated areas occur in response to increasing global demand for food. England and Wales are integrated in the world market and national production is specialised to local conditions such as soil types, water resource availability and the sensitivity of the receiving water environment. Farmers select crops that generate higher profits and require fewer resources (for example, there is a shift from irrigated to rain-fed crops).

There is increasing pressure on agricultural land, specifically due to the competition for land to grow food crops and energy crops. Prime arable land has increased in value. Furthermore, agricultural subsidies have been progressively removed and the price of phosphorous and water has increased. Thus, agricultural produce becomes more costly for the consumer despite farmers optimising the use of resources such as water and fertiliser (using sludge or manure when available instead of chemical fertilisers). Large farms and big corporate farmers benefit from economies of scale while smaller enterprises struggle.

A progressive reduction in the funding allocated for agricultural research means the techniques available for intensification of agriculture are still based on traditional soil management practices and the use of chemicals and inefficient irrigation. There are a greater number of irrigated crops due to pressures for higher yields and raised temperatures as a result of climate change. Some areas traditionally associated with agriculture, such as East Anglia, find management of water resources very challenging with warmer summers and less reliable rain patterns to replenish groundwater sources. Reduced security of abstraction (for example, more frequent abstraction cessation orders) has associated impacts on yields and profits.

The impact of agriculture on the water environment is generally greater mainly due to soil compaction and erosion issues. The funds available for investing in agro-environmental measures are reduced. Gains in the arable area associated with the removal of buffer strips are taken, exacerbating soil erosion and sediment delivery to water bodies and leading to a loss of habitat for farmland birds. Farmers are required to follow environmental guidelines defining fertiliser and slurry/manure application limits, and spreading windows. However, non-compliance by some farmers has contributed to the saturation of arable soil with nutrients, the build-up of heavy metals and the pollution of the receiving water bodies with sediments and nutrients (for example, soluble nitrogen leaching into groundwater).

Subsistence agriculture is associated mainly with plots in urban areas, with agricultural practices varying immensely between those that protect the environment and those that use chemicals indiscriminately (fertilisers, pesticides and herbicides).

Livestock production remains virtually unchanged. There is a per capita reduction in the consumption of red meat. However, this is offset by the increasing population and export to foreign markets. Guidelines for cattle production limit over-intensification (cattle head per area) and prevent pollution. Biodigesters are used widely to obtain energy from manure.

9.5.3 Energy, industry and services

England and Wales, led by the EU, have adopted an energy strategy with a low carbon footprint. The UK invests significantly to increase the share of renewable energy in its range of energy sources, particularly from less costly sources of renewable energy such as wind farms and geothermal plants. Biofuels are central to the UK's energy strategy, specifically for transportation. The dependency on fossil fuels progressively reduces which, alongside regulation and international agreements, means there is no re-activation of coal mines. There is an increase in energy prices, which drives energy efficiency.

Pollution by hazardous substances and priority hazardous substances is less of a concern as the EU has banned the use of chemicals with high environmental impacts and has a risk-based approach for the approval of new chemicals. In the manufacturing sector, there has been an improvement in compliance levels alongside marginally higher standards, resulting in low concentrations of chemicals in industrial effluents. The most advanced manufacturers reuse materials if this provides short-term economic advantages, but industrial treatment technologies are slow to advance.

There is an increasing service- and knowledge-based economy, leading to an increase in water demand in the services sector. Greater efficiencies are achieved as existing offices and commercial premises are improved in terms of water and energy efficiency and new 'smart' buildings constructed. The growing virtual world, using virtual water instead of 'real' water (for example, virtual white water rafting and virtual fishing), offsets part of this increased water demand.

9.5.4 Flooding policy and practice

There is significant media attention given to flooding events and their impacts, prompting upgrades to flood defences built in the 2010s. Flood defences are built between 2030 and 2050 to deal with the level of climate change experienced in that period. There is no political will or government funding to implement adaptation measures to cope with the uncertain increased severity and frequency of flood events projected for the future. Catchment flood management planning prioritises vulnerable areas with greater impacts such as areas with high population density or premium agricultural land (Grades 1 and 2). Common flood and erosion control measures include raised banks and shoreline reinforcements. Flood risk therefore increases in the other areas, which are gradually abandoned by farmers and householders. These abandoned areas become important for their flood attenuation properties.

Schemes for improving the management of surface waters are implemented in new developments as legally required. New developments occur only in areas not vulnerable to flooding, where it is possible to insure the properties. In existing urban areas, there is inertia to retrofitting sustainable drainage systems which, coupled with the impacts of climate change, causes urban run-off that often enters sewerage systems and water bodies directly. In rural areas, soil compaction due to increased agricultural intensification (for example, soil management practices) and heavy machinery leads to enhanced quantities of run-off.

9.5.5 Alternating tightening and relaxation of environmental standards

Geopolitical instability led to disjointed efforts in maintaining international environmental standards. The existing regulatory environment results from cycles of tight regulation, intercalated with periods of deregulation. It drives the development of short-term based impact regulation as opposed to risk-based environmental protection. The long-term

initiatives, mainly led by the EU, usually fail to deliver their original objectives. A lack of co-ordination and inefficient long-term planning causes ineffective spending and increases the cost of environmental protection.

There is an overall reduction in the level of regulatory protection provided to the environment with a relaxation of the objectives currently set out in the Habitats and Nitrates Directive, the Water Framework Directive and the Marine and Coastal Access Act, among others. There is a variation in the level of compliance, which is aligned with economic cycles resulting in periods of greater environmental degradation. An exception to this reduced level of environmental protection is in regard to the security of water supplies and the long-term sustainability of water resources, which has been driven by political pressures arising from the impacts of climate change experienced. Sustainable abstraction plans based on defining abstraction limits that respond to catchment conditions were developed, as well as compensation schemes to control unsustainable abstraction. Similarly, discharge consents were revised. In periods of slower economic growth or increased water stress, however, there is a tendency to relax those standards. Local councils are allowed to redefine compliance levels, resulting in short periods of environmental degradation.

References

ALCAMO, J., 2008. *Environmental futures: The practice of environmental scenario analysis*. Amsterdam: Elsevier.

BOWMAN, G., MACKAY, R., MASRANI, S. AND MCKIERNAN, P., 2012. Storytelling and the scenario process: understanding success and failure. *Technological Forecasting and Social Change*, 80 (4), 735-748.

BRADFIELD, R., WRIGHT, G., BURT, G., CAIRNS, G. AND VAN DER HEIJDEN, K., 2005. The origins and evolution of scenario techniques in long range business planning. *Futures*, 37 (8), 795-812.

CHAPAGAIN, A. AND ORR, S., 2008. *UK water footprint: the impact of the UK's food and fibre consumption on global water resources*. Godalming, Surrey: WWF-UK.

DEFRA, 2008. *Future Water. The government's water strategy for England*. CM7319. Norwich: HMSO.

DEFRA, 2010. *Fertiliser Manual (RB209),* 8th edition. London: Department for Environment, Food and Rural Affairs.

DEFRA, 2011a. *Biodiversity 2020: A strategy for England's wildlife and ecosystem services*. London: Department for Environment, Food and Rural Affairs.

DEFRA, 2011b. *Protecting our water, soil and air: a code of good agricultural practice for farmers, growers and land managers*. London: Department for Environment, Food and Rural Affairs.

DEFRA, 2012a. *Water use by industry* [online]. London: Department for Environment, Food and Rural Affairs. Available from: http://webarchive.nationalarchives.gov.uk/20130123162956/http:/www.defra.gov.uk/statistics/environment/green-economy/scptb10-wateruse/ [Accessed 11 May 2017].

DEFRA, 2012b. *Standards of Good Agricultural and Environmental Condition* [online]. London: Department for Environment, Food and Rural Affairs. Available from: https://www.gov.uk/standards-of-good-agricultural-and-environmental-condition [Accessed 11 May 2017].

ENVIRONMENT AGENCY, 2006. *Environment Agency scenarios 2030*. Science Report SC050002/SR1. Bristol: Environment Agency.

ENVIRONMENT AGENCY, 2011a. *Water: Planning ahead for an uncertain future. Water in the 2050s*. Briefing note. Bristol: Environment Agency. Available from: https://data.gov.uk/data/contracts-finder-archive/download/815282/b5bb574c-3fae-4942-ba2e-a169200af3b6 [Accessed 11 May 2017].

ENVIRONMENT AGENCY, 2013. *England's waters: Challenges and choices*. *Summary of significant water management issues.* Consultation paper. Bristol: Environment Agency.

ENVIRONMENT AGENCY AND NATURAL RESOURCES WALES, 2013. *Current and future water availability – addendum. A refresh of the Case for Change analysis*. Briefing note. Bristol: Environment Agency.

EUROPEAN COMMISSION, 2012a. *A blueprint to safeguard Europe's water resources*. COM(2012) 673 final. Brussels: European Commission.

HM GOVERNMENT, 2011a. *Water for life*. White Paper CM8230. London: TSO.

HM GOVERNMENT, 2011b. *The Natural Choice: Securing the value of nature*. White Paper CM8082. London: TSO.

KNOX, J., DACCACHE, A., WEATHERHEAD, K., GROVES, S. AND HULIN, A., 2013. *Assessing climate and land use impacts on water demand for agriculture and opportunities for adaptation*. R&D Technical Report FFG1129/TR. London: Department for Environment, Food and Rural Affairs. Available from: http://randd.defra.gov.uk/Document.aspx?Document=11705_DefraFFG1129_Cranfield_PhaseIFinal_05.12.13.pdf [Accessed 11 May 2017].

KOWALSKI, M., WAYLEN, C., CLIST, S., WILCOX, S., LYNN, S. AND GARROW, D., 2011. *Freshwater availability and use in the United Kingdom. A review of freshwater availability and non-household (consumptive) use in the UK.* RSC014-001 for WRAP. Banbury: Waste and Resources Action Programme.

MAACK, J., 2001. Scenario analysis: a tool for task managers. In *Social Analysis: Selected Tools and Techniques*, Social Development Papers No. 36, pp. 62-87. Washington DC: The World Bank. Available from: http://siteresources.worldbank.org/INTCDD/Resources/SAtools.pdf [Accessed 10 May 2017].

ONS, 2012. Annual mid-year population estimates for England and Wales, Mid 2011. London: Office for National Statistics. Available from: http://www.ons.gov.uk/ons/dcp171778_277794.pdf [Accessed 11 May 2017].

PILLKAHN, U., 2008. *Using Trends and Scenarios as Tools for Strategy Development.* Erlangen, Germany: Publicis Corporate Publishing.

RSPB, 2013. *State of Nature 2013.* Sandy, Bedfordshire: RSPB.

TAPPER, R., HADJIKAKOU, M., NOBLE, R. AND JENKINSON, J., 2011. *The impact of the tourism industry on freshwater resources in countries in the Caribbean, Mediterranean, North Africa and other regions*. Research project for the Travel Foundation, UK.

THE FUTURES COMPANY, 2012. *Socio-economic scenarios for water to 2050.* Unpublished report prepared for the Environment Agency.

UK NATIONAL ECOSYSTEM ASSESSMENT, 2011. The UK National Ecosystem Assessment: Synthesis of the Key Findings. Cambridge: UNEP-WCMC. Available from: http://uknea.unep-wcmc.org/Resources/tabid/82/Default.aspx [Accessed 11 May 2017].

WRIGHT, G., VAN DER HEIJDEN, K., BURT, G., BRADFIELD, R. AND CAIRNS, G., 2008. Scenario planning interventions in organizations: an analysis of the causes of success and failure. *Futures*, 40 (3), 218-236.

Bibliography

ALLEGRA STRATEGIES, 2012. *Taste of the Future. A look to the future of foodservice 2012–2015.* Foodservice Consultants Society International UK & Ireland (FCSI).

BÖJESON, L., MATTIAS, H., KARL-HENRIK, D., EKVALL, T. AND GÖRAN, F., 2005. *Towards a user's guide to scenarios – a report on scenario types and scenario techniques*. Stockholm: Royal Institute of Technology.

BRAUNGART, M., MCDONOUGH, W. AND BOLLINGER, A., 2007. Cradle-to-cradle design: creating healthy emissions – a strategy for eco-effective product and system design. *Journal of Cleaner Production*, 15 (13-14), 1337-1348.

CHARRON, D.F., THOMAS, M.K., WALTNER-TOEWS, D., ARAMINI, J.J., EDGE, T., KENT, R.A., MAAROUF, A.R. AND WILSON, J., 2004. Vulnerability of waterborne diseases to climate change in Canada: a review. *Journal of Toxicology and Environmental Health, Part A: Current Issues*, 67 (20-22), 1667-1677.

CHAVE, P., 2001. *The EU Water Framework Directive: An Introduction*. London: IWA Publishing.

CHINABUT, S., 2006. Problems associated with shellfish farming. *Revue Scientific et Technique (International Office of Epizootics)*, 25 (2), 627-635.

COOPER, J., LOMBARDI, R., BOARDMAN, D. AND CARLIELL-MARQUET, C., 2011. The future distribution and production of global phosphate rock reserves resources. *Conservation and Recycling*, 57: 78-86.

CORDELL, D., DRANGERT, J. AND WHITE, S., 2009. The story of phosphorus: Global food security and food for thought. *Global Environmental Change*, 19 (2), 292-305.

DEFRA, 2006. *Rural Development Programme for England 2007–2013: Consultation*. London: Department for Environment, Food and Rural Affairs.

DEFRA, 2012c. *Waste water treatment in the United Kingdom – 2012. Implementation of the European Union Urban Waste Water Treatment Directive – 91/271/EEC*. PB13811. London: Department for Environment, Food and Rural Affairs. Available from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69592/pb13811-waste-water-2012.pdf [Accessed 11 May 2017].

ENVIRONMENT AGENCY, 2008. *Continuous estimation of river flows*. Science Report SC030240. Bristol: Environment Agency.

ENVIRONMENT AGENCY, 2009a. *Response to Defra consultation on new regulatory order to address the passage of fish (for Water Framework Directive and EU Eel Regulation).* Bristol: Environment Agency. Available from: http://webarchive.nationalarchives.gov.uk/20140328084622/http://www.environment-agency.gov.uk/research/library/consultations/106537.aspx [Accessed 11 May 2017].

ENVIRONMENT AGENCY, 2009b. *Water resources strategy for England and Wales*. Bristol: Environment Agency. Available from: http://webarchive.nationalarchives.gov.uk/20140328084622/http:/www.environment-agency.gov.uk/research/library/publications/40731.aspx [Accessed 10 May 2017].

ENVIRONMENT AGENCY, 2011b. *The case for change – current and future water availability*. Report – GEHO1111BVEP-E-E. Bristol: Environment Agency. Available

from: http://webarchive.nationalarchives.gov.uk/20140328084622/http://cdn.environment-agency.gov.uk/geho1111bvep-e-e.pdf [Accessed 11 May 2017].

ENVIRONMENT AGENCY, 2011c. *Catchment Flood Management Plans: Annual Report 2011*. Bristol: Environment Agency.

EUROPEAN COMMISSION, 2007. *Positive and negative effects of nanotechnology on the environment.* DG Environment News Alert Service, 26 July 2007. Brussels: European Commission.

EUROPEAN COMMISSION, 2012b. *River Basin Management Plans: Report on the Implementation of the Water Framework Directive (2000/60/EC).* COM(2012) 670 final. Brussels: European Commission. Available from: http://ec.europa.eu/environment/water/water-framework/impl_reports.htm#third [Accessed 11 May 2017].

EUROPEAN COMMISSION, 2012c. *The UWWT Directive lays down four main principle obligations* [online]. Brussels: European Commission. Available from: http://ec.europa.eu/environment/water/water-urbanwaste/directiveprinciples/index_en.htm#regulation [Accessed 11 May 2017].

EEA, 1999. *Environmental indicators: Typology and overview.* Technical Report No 25. Copenhagen: European Environment Agency.

EEA, 2009. *Water resources across Europe – confronting water scarcity and drought.* Copenhagen: European Environment Agency.

GARNETT, T. AND GODFRAY, C., 2012. *Sustainable intensification in agriculture. Navigating a course through competing food system priorities*. Oxford: Food Climate Research Network and the Oxford Martin Programme on the Future of Food, University of Oxford.

GORDON, A., 2008. *Analytical vs. judgement foresight.* Presentation to Futures Analyst Meeting, 20 May, London.

GRAHAM, A., DAY, J., BRAY, B. AND MACKENZIE, S., 2012. *Sustainable drainage systems. Maximising the potential for people and wildlife. A guide for local authorities.* Sandy, Bedfordshire: RSPB; Slimbridge, Gloucestershire: Wildfowl & Wetlands Trust.

HODGE, I. AND RENWICK, A., 2006. *Business as usual projections of agricultural activities for the Water Framework Directive: Phase 2*. Report prepared for Defra project WT03035. Cambridge: Rural Business Unit, University of Cambridge; Edinburgh: Land Economy Group, Scottish Agricultural College.

HOODA, P.S., EDWARDS, A.C. AND MILLER, A., 2000. A review of water quality concerns in livestock farming areas. *Science of the Total Environment*, 250 (1-3), 143-167.

HOWARD, D.C., WADSWORTH, R.A., WHITAKER, J.A., HUGHES, N. AND BUNCE, R.G.H., 2009. The impact of sustainable energy production on land use in Britain through to 2050. *Land Use Policy*, 26 (Suppl. 1), S284-S292.

HUMAN RIGHTS WATCH, 2012. *'Waiting here for death': forced displacement and 'villagization' in Ethiopia's Gambella Region* [online]. New York: Human Rights Watch. Available from: https://www.hrw.org/report/2012/01/16/waiting-here-death/forced-displacement-and-villagization-ethiopias-gambella-region [Accessed 11 May 2017].

INMAN, A., 2006. *Soil erosion in England and Wales: causes, consequences and policy options for dealing with the problem*. Discussion paper prepared for WWF. Godalming, Surrey: WWF-UK.

IPCC, 2007. *Climate Change 2007: Synthesis Report*. Geneva: Intergovernmental Panel on Climate Change. Available from: http://www.ipcc.ch/publications_and_data/ar4/syr/en/spms3.html [Accessed 11 may 2017].

NATIONAL GRID, 2011. *UK Future Energy Scenarios. UK gas and electricity transmission*. Warwick: National Grid. Available from: http://www.nationalgrid.com/NR/rdonlyres/86C815F5-0EAD-46B5-A580-A0A516562B3E/50819/10312_1_NG_Futureenergyscenarios_WEB1.pdf [Accessed 11 May 2017].

THE FUTURES COMPANY, 2013. *Building electricity generation scenarios to identify water demand impacts.* Unpublished report prepared for the Environment Agency.

UKTAG, 2003. *Guidance on morphological alterations and the pressures and impacts analyses. Final working paper*. TAG2003WP7c (01). Edinburgh: SNIFF. Available from: http://www.wfduk.org/resources%20/morphological-alterations-and-pressures-and-impacts-analyses [Accessed 11 May 2017].

US EIA, 2012. *Annual energy outlook 2012 with projections to 2035.* DOE/EIA-0383(2012). Washington DC: US Energy Information Administration.

VISIT BRITAIN, 2012. *Foresight Issue 100*. London: VisitBritain. Available from: https://www.visitbritain.org/sites/default/files/vb-corporate/Documents-Library/documents/2012-2%20Inbound%20Tourism%20Growth%20Potential.pdf [Accessed 11 May 2017].

WWF, 2006. *Illegal water use in Spain. Causes, effects and solutions.* Madrid: WWF-Spain. Available from: http://wwf.panda.org/what_we_do/how_we_work/policy/wwf_europe_environment/news/index.cfm?68900/Spain-sucked-dry-by-illegal-water-use [Accessed 11 May 2017].

Appendix A: Process adopted to analyse the scenarios

A.1 Elaborating the scenarios

The Environment Agency's original socioeconomic (Environment Agency 2006) and recently updated (The Futures Company 2012) scenarios consist of 4 plausible futures based on the 'axes of uncertainty' method. The original scenario environments are identified as the extremities of governing priorities and consumption patterns (see Figure 4.1).

This project used the same 4 quadrants as a thematic basis for each scenario, but they were elaborated further by clustering a series of prioritised drivers into the distinct themes. The scenarios and the narratives produced are defined by the extremities of each quadrant where, for example, sustainable behaviour is a measure of dematerialised consumption, long-term resilience and sustainability (Figure 4.1).

A new set of drivers, with a focus on impacts and consequences to water users and the water environment, were developed through participatory methods as outlined below. It is the key factors (or drivers of change) that establish the context for the scenarios, which means those included in this report are not entirely consistent with previous versions (Environment Agency 2006, The Futures Company 2012). However, this allowed the addition of a fifth scenario (the reference scenario) as means of comparing change in the other scenarios described in this report. The reference scenario builds on current trends and measures of change, reflecting a trajectory of the current system as it exists today with no extremities or unpredictable events and relatively consistent development of the system.

A.2 Scenario construction

A.2.1 Key factor analysis

Developing the key factors involved an assessment of what would drive and shape the future of catchment management in the UK. A 'key factors' workshop was held on 18 June 2012 in Bristol and a second, duplicate workshop with a different audience on 3 July 2012 in London to identify a variety of key factors derived from a 360° environmental scanning process based on a PESTLE analysis. The PESTLE framework, which covers a range of political, economic, social, technological, legislative and environmental factors, allowed an analysis of the external macro environment (big picture) that affects catchments. The purpose was to detect and understand the broad, long-term issues that influence catchment management.

Workshop outputs served as the foundation for identifying the most important activities that influence the management of water and the water environment. The main output from the workshops was a list of the key driving factors identified (Table A.1). Experts from CERF (now called CIRF) and the Environment Agency augmented the workshop with a comprehensive desk study, using a number of reports related to the topic, and discussion around the factors that influence English and Welsh catchments. A list of 12 key factors was presented to the Environment Agency for approval. These key factors then formed the basis for elaborating the scenarios.

Table A.1 List of final key factors for catchment management

PESTLE area	Key factors
Political	• Political attitudes
	• Governing priorities
Economy	• Economy
	• Price of resources
Society	• Demographics
	• Attitudes and behaviour
Technology	• Technology approaches
	• Green technology
Legal	• UK legislation
	• EU legislation
Environmental	• Climate change
	• Land use change

A.2.2 Development of key factor projections

With the list of key factors identified and approved, the next phase involved describing possible projections for each one. Projections represent alternative, plausible developments for a particular key factor. Information collected during the key factor workshops and the narratives available in the existing scenario documents (socioeconomic and future water scenarios) were integrated to develop a set of projections for each key factor that were consistent with expert input and the predefined context of the scenarios.

From the information gathered as part of the key factors analysis, a brief outline of each key factor was produced in a draft report, sketching out information relating to catchment management in England and Wales for 2050.

The draft set of key factors was then presented at a workshop held on 8 October 2012 in Bristol, with the experts from CERF (now called CIRF) and the Environment Agency, along with representatives from the CERF Futures Partnership (Appendix B). During the course of the workshop, working groups discussed, revised and enhanced the proposed key factor projections, ensuring these were consistent with the predefined context for each scenario.

Following the workshop, telephone interviews and comprehensive desk-based research were carried out, various data evaluated and trends analysed to supplement the data. Feedback from experts within the Environment Agency guided the development of a final key factors report.

A.2.3 Scenarios and impacts on the water environment

The scenarios paint an integrated picture of the future and include illustrative roadmaps (that is, progressions showing future development of the system) from current time to 2030 and 2050.

The implications of the scenarios were explored, focusing on impacts on water and the wider environment. Expert interviews, conducted by telephone, provided the majority of information on scenario implications; analysis identified the most important source pressures, exposure pressures and the environmental impacts associated with the conditions in the scenarios.

The description of environmental impacts was complemented with an indication of the direction and magnitude of change for 9 environmental indicators identified in the Environment Agency's significant water management issues evidence-gathering project for the Water Framework Directive. Further analysis included an assessment of impacts to 4 types of catchment showing different topography, climate, land uses and water resources across England and Wales (that is, uplands, lowlands grassland, lowlands arable and lowlands urban). This phase was carried out using expert elicitation methods (workshop discussion, interviews and input from the Environment Agency's stakeholders). While it is acknowledged that the impacts on some of the identified fields might be ambiguous, a rigorous 'sense-checking' approach was applied to the analysis to reduce the uncertainty inherent in aggregating disparate opinions from experts.

A case study analysis explored the implications of scenarios on a number of sectors that have a dependence on water and the water environment. Through a desk study, the analysis was two-fold:

- an assessment of impacts of environmental change on the sector
- an assessment of the impacts of the sector on the environment

This was not intended to be a comprehensive assessment of all sectors of society, but illustrative of some of future state and impact on important sectors including:

- general public
- manufacturing industries
- leisure industries
- utility companies (water and energy)
- farming and fisheries

Appendix B: Contributing experts

Project Steering Group

Carter, Vince	Forestry Commission, England
Cathcart, Robert	Natural England
Doran, Helen	Natural England
Forrow, David	Environment Agency
Johnston, Eilidth	SEPA
McGonigle, Daniel	Defra
Monk, Kathryn	Natural Resources Wales
Rodgers, Andy	Environment Agency
Tinsley, Derek	Environment Agency
Viegas, Bruno	Defra

Expert input through workshops, interviews and review of draft documents

Bardsley, Sarah	Environment Agency
Bailey Jeremy	Environment Agency
Barraclough, Declan	Environment Agency
Blacklidge, Clare	Environment Agency
Bolton, Lucy	Environment Agency
Bryson, Paul	Environment Agency
Burton, Lucy	Environment Agency
Cariss, Helen	Natural Resources Wales (formerly Forestry Commission Wales)
Carter Vince	Forestry Commission, England
Cathcart, Rob	Natural England
Chatterton, Julia	Cranfield University
Davey, Ian	Environment Agency
Delgado, João	Cranfield University
Diamond, Mark	Environment Agency
Doran, Helen	Natural England
Favenger, Becky	Natural Resources Wales
Forrow, David	Environment Agency
Green, Hannah	Environment Agency

Harriet, Orr	Environment Agency
Harris, Robert	Defra
Jenkins, Lyn	Environment Agency
Johnston, Eilidth	SEPA
Jones, Ruth	Environment Agency
Joyce, Ellen	Environment Agency
Knight, Caroline	Environment Agency
Leaf, Simon	Environment Agency
Letts, Jamie	Environment Agency
Leveson-Gower, Henry	Defra
Lickorish, Fiona	Cranfield University
Logan, Paul	Environment Agency
Lorentzon, Anna	Environment Agency
Maas, Glenn	Environment Agency
Monk, Kathryn	Natural Resources Wales
Neale, Simon	Natural Resources Wales
Nowosielski, Andrzej	Environment Agency
Rathe, Anna	Cranfield University
Riley, Kate	Environment Agency
Scott, Mark	Environment Agency
Tidridge, Chris	Environment Agency
Turner, Amanda	Environment Agency
Weber, Geraint	Environment Agency
Willows, Robert	Environment Agency
Wright, Julian	Environment Agency

Expert input from Cranfield University

Cartmell, Elise	Cranfield Water Science Institute
Chatterton, Julia	Centre for Environmental Risks and Futures (now Cranfield Institute for Resilient Futures (CIRF))
Delgado, João	Centre for Environmental Risks and Futures (now CIRF)
Garnett, Kenisha	Centre for Environmental Risks and Futures (now CIRF)

Prpich, George	Centre for Environmental Risks and Futures (now CIRF)
Henriques, Catarina	Cranfield Water Science Institute
Holman, Ian	Cranfield Water Science Institute
Janes, Martin	River Restoration Centre
Lickorish, Fiona	Centre for Environmental Risks and Futures (now CIRF)
Mant, Jenny	River Restoration Centre
Pollard, Simon	Centre for Environmental Risks and Futures (now CIRF)
Rathe, Anna	Centre for Environmental Risks and Futures (now CIRF)
Shaw, Hayley	Centre for Environmental Risks and Futures (now CIRF)

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