

1

Water, Policy and Procedure

There is a certain relief in change, even though it be from bad to worse; as I have found in traveling in a stagecoach, that it often a comfort to shift one's position and be bruised in a new place.

Tales of a Traveller, *Washington Irving* (1824)

1.1 Pressing Needs for Conservation and Protection?

Among the nations, the three constituent countries of Great Britain (England, Wales and Scotland) were early to industrialise and have been that way for around two and a half centuries. While this observation sets the scene for an account of the water resources of Britain, the last 30 or more years have seen dramatic changes away from the heavy industrial sector. Yet problems persist, particularly where 'technical fixes' have not provided solutions. Once it was assumed that regulatory measures, and especially 'end of pipe' pollution problems are solved (in theory) through consenting and licencing, yet diffuse pollution of waters persists from a range of contaminants and from a range of industrial and other activities. These result largely from the ways by which we conduct our economy and new solutions are sought. Not only is Britain definitively to manage its water resources on a catchment (or river basin) basis, but new political imperatives are emerging that require water management in part to become an extension of 'civil society;' this eclipses older ideas about 'technocratic management'.

This chapter outlines the present issues for sustainability and sustainable development in water resources, and it also scopes out the challenges. This is a tall order, for there is no agreed definition of sustainability or for any prescription of sustainable development. Such received wisdom on the subject is, however, helpful to a point for there is general agreement that three spheres of 'social' 'economic' and 'environmental' sustainability are involved. Figure 1.1 shows a common variant of the famous Venn diagram used in many accounts. Other commentators choose to re-name or expand this into other spheres, including the cultural and political. Certainly the latter is of great interest here, for changes in water governance are driven by political agenda and the political dimension can be seen as the driver for the others. While implicit in the social, to delve into the murky depths of cultural activities is also implied.

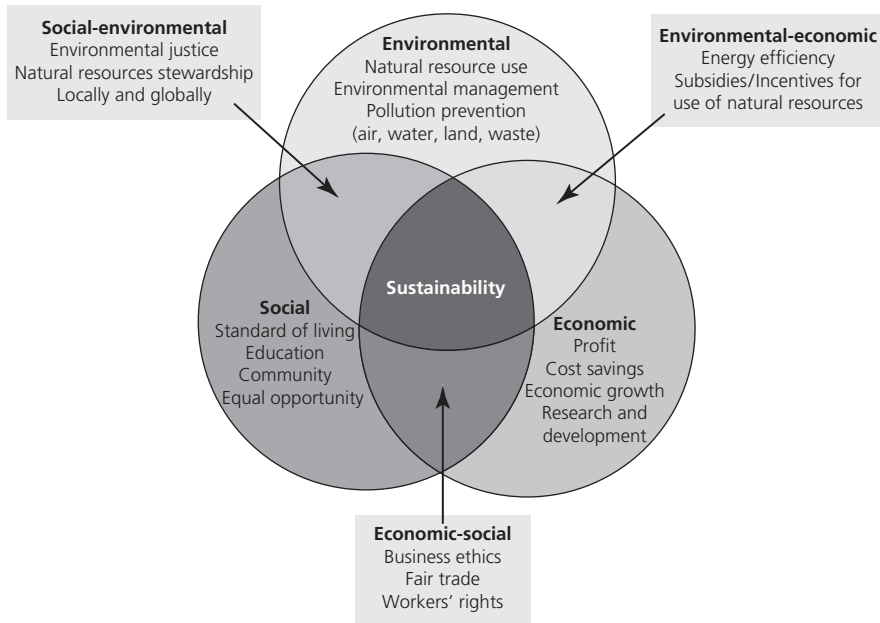


Figure 1.1 Spheres of 'sustainability' Rodriguez et al 2002.

Actually the Brundtland Report 'Our common Future' of 1987 (World Bank, n.d.) sought to define the notion of sustainable development, to use the oft-quoted definition:

'development that meets the needs of the present without compromising the ability of future generations to meet their own needs.'

This is a good stage-setter, but it gives an objective without ways and means. No doubt feeling a bit cynical, in some ways it has become that 'it is simply a new manifestation of an old, tired discourse.' Various accused of being too western, too anthropocentric, even hiding the fact that the economic framework itself cannot hope to accommodate environmental considerations, perhaps a critique of the neo-liberal worldview that the answer lies within small adjustments to the market system, especially where the underlying presumption of economic growth remains. Is it, on account of being such a broad concept that it is open to wrong action, be that through good or poor motives? It can be therefore more catchphrase than a revolution in our thinking. We are sent back to thinking about equity, environmental justice and how the means of production are organised (Hove, 2004).

This book is about water in Britain, and it brings in a few comparisons from North America' from 'continental' Europe and from elsewhere. This constrains it to mature, developed economies. Furthermore, a volume that goes into the details of development theory is not its purpose. Mercifully, in water resource science and policy, there are boundaries that may be defined socially and politically (as stakeholder groups), as well as in a geological and topographic sense (Cook *et al.*, 2012). Even more helpful, if traditional aspects of standard setting and notions of 'carrying capacity' are included, presuming the

calculations of these variables reflect real water quality and ecosystem issues, some of this work is done for us. For the World Conservation Union has described the idea of carrying capacity as 'improving the quality of human life while living within the carrying capacity of supporting ecosystems' (Gardiner, 1994).

Yet the real revolution in water management has been in the socio-economic-political sphere. Progress in water resource management as affects Britain seemed to falter from about 1990 onwards, and one manifestation was the UK research councils' Rural Economy and Land Use Programme (RELU) between 2004 and 2013 (RELU, 2015). Its objective was to take a long, sidewise look at UK land use issues by all interested parties, so that teams of social and natural scientists, policy makers and engineers, practitioners, theorists and all shades in between were involved. One illustration is the persistent issue of *diffuse pollution*, that is pollution (in this case of waters) that is not about attributing blame to an individual site or enterprise, *but to the way we do things*. Classic examples are nutrient pollution and pesticides from farming systems, loading of sediment to river systems from various land uses, phosphates and pathogens from sewage treatment and various hydrocarbons, salt and even heavy metal contamination in runoff from roads. In some way, we are all responsible and to go to the individual farmer or industrial concern is patently not only alienating, but it is difficult and expensive to enforce and would seem to contradict notions of 'natural justice.'

Mainland Great Britain is a small and overcrowded island and it has been stated that England, Wales and Scotland were early to industrialise. However, since around 1980 there has been a serious move away from the heavy industrial sector. Setting aside the momentous social changes of this, the often bitter legacy of neo-liberal 'Thatcherism,' that changed communities often for the worse and made unemployment endemic in the economy, Britain was to suffer in the long-term for transition towards a service based economy. Industry continued, but in a muted form and with new products replacing some steel, coal products, ships and so on. Car production did continue, but it is under foreign ownership and operating under different constraints.

In parallel with industrialisation, an intensive agriculture has developed which largely concentrated in lowland areas. Official statistics for 2011 for the entire UK suggest that around 76% is in agricultural production (Defra, n.d.), this includes roads, yards, derelict land and associated buildings. Of the remainder, some 10% (and rising) is under forest and woodland and 14% under 'other,' mainly urban and industrial, but also semi-natural vegetation and recreational land use. Rivers, lakes, streams and canals cover some 2,580 km² and there is an unquantifiable volume of water beneath our feet as groundwater.

At the planetary level, the 'hydrosphere' is the arena in which hydrological processes occur and it is intimately related to geological, geochemical and biological planetary systems. As the above statistics suggest, for the land-based part of the hydrological cycle, to regard the hydrological cycle as wholly a 'natural' process belonging to some Arcadian, 'deep green' paradise world with little human intervention is of no use. Britain is certainly no exception.

With a population (2011 census) of around 61.3 million (53.0 million in England, 3.1 million in Wales and 5.2 million in Scotland), England and Wales had a population density of 371 persons per km² with several well-known large centres of population making it unevenly distributed and the figure is far lower for Scotland at 67 persons

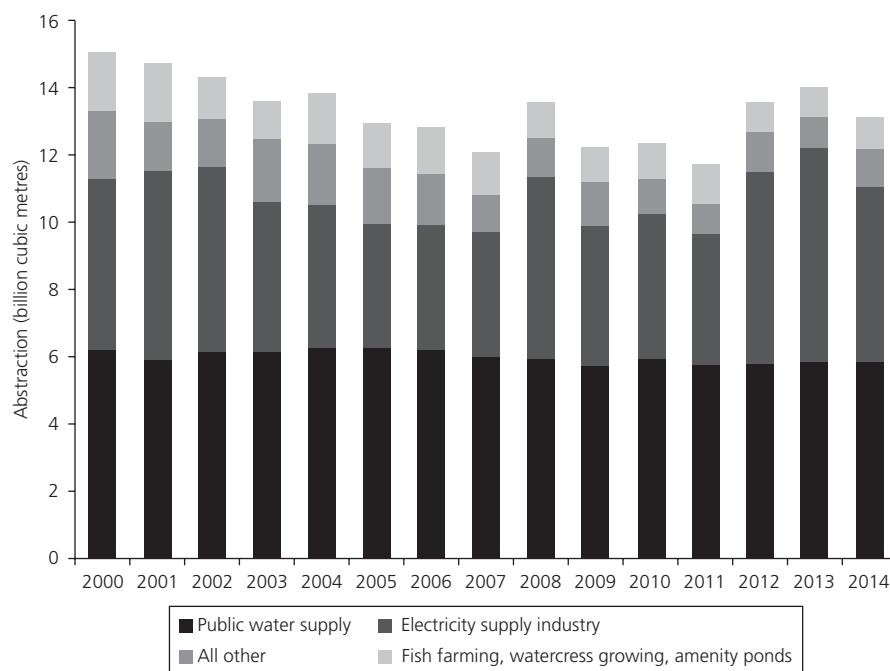


Figure 1.2 Estimated abstractions from non-tidal surface water and groundwater in England and Wales, 2000 to 2014 (Defra, 2016a) (Source: Environment Agency and Natural Resources Wales).

per km² with most living in just two large cities. Overall, England and Wales combined is among the most densely populated countries in the world. Pressures on water, as on other resources such as land and energy, are therefore considerable and potentially problematic.

Estimated water abstraction volume from non-tidal surface water and groundwater in England and Wales between 2000 and 2014 is shown in Figure 1.2 and fell steadily from an estimated 15 billion cubic metres in 2000 to 11.4 billion cubic metres in 2011, after which it increased again.

Overall categories continue to fall except spray irrigation, included in 'other' in Figure 1.2 (Defra, 2013a; 2016a).

The changes in abstraction levels between years include factors attributed to:

- Weather conditions, for example drier years could result in an increase in abstraction for agriculture and spray irrigation.
- Changes in the level of activity in different sectors.
- Improvements being made in the efficiency of water usage.
- Changes to abstraction licences.

The main reason for the overall decrease in abstraction between 2013 and 2014 is the fall in the level of abstractions used for electricity generation. Levels of abstraction for electricity generation fell by 16% from 6.4 billion cubic metres in 2013 to 5.3 billion cubic metres in 2014. The abstractions for public water supply decreased slightly between 2013 and 2014 by 2% to 5.8 billion cubic metres in 2014.

For Scotland, the overall figure for abstraction is smaller, for 2012 it being about 737.7 million cubic metres from an overall far wetter climate (Scottish Government, n.d.a) and showing a strong downward trend of 13% between 2002/3 and 2009/10. Between 2010/11-2011/12, the volume of raw water abstracted also decreased but the figure is calculated using a different methodology. There was a 16% reduction in treated water produced between 2002/03 and 2009/10. Between 2002/03 and 2011/12, domestic water consumption increased by 7%, whilst non domestic consumption reduced by 18%. Of this around one third is for domestic supply. Leakage in the delivery system in Scotland in 2012 was around 27% of the total extracted with a long-term downward trend. Overall, however, water resources in Britain remain tight and continue to present problems for continuity of supply as well as water quality, something that will be dealt with later.

Perhaps to become too embroiled in statistics is to fail to set the scene properly. The curious reader can always visit many websites, be they governmental, regulatory, industrial, or linked to supra-national organisations such as the European Commission or United Nations organisations. The fascination many of us have for water is not only its barometer on how ‘sustainable’ our development may be, but more importantly how might this precious resource be allocated with equity, and how might appropriate governance structures be put into place.

Drivers of change have long been not so much domestic legislation, but EU directives, culminating in arguably the most dramatic and far-reaching Water Framework Directive or WFD (2000) of the European Union (EU). This bold step forward in integrating socio-economic and technical measures is correctly called the “Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy” (EC, 2014a,b). WFD calls for ‘integrated river basin management for Europe’ and incorporates notions of ‘good status’ for waterbodies (ecological, chemical and quantitative), achieving a ‘good status’ for all waters by a set date(s), base water management on river basins, streamlining legislation, finding “combined approach” of emission limit values and quality standards, getting the prices right and getting the citizen involved more closely.

In the author’s experience, it was heralded by a warm welcome, even excitement by a whole range of water professionals. Only at the time of writing are notes of caution being sounded. However, it remains the yardstick and as far as water institutions are concerned, there has been a focus (or range of foci) that has caused a degree of re-orientation. No bad thing, some would say.

Perhaps as far as Britain is concerned, there are two key points. One is that before 2000, the EU set no regulation on quantity of water abstracted. Now it was a matter of supra-national legislation. The other being that the ‘great British public’ was to be involved in the decision making. How and why this development remained somewhat obscure is unknown, but it certainly sharpened up and advanced the political dimension in the watery debate. Meanwhile, other issues may have been regarded as being in hand. Getting the price right was part of an objective of water industry privatisation after 1989, itself a part of a ‘neo-liberal’ economic revolution that remains highly controversial to the present; the aim was to remove much of the cost of investment and regulation from the public purse. The concept of ‘Good Status’ is complicated and will be dealt with later, but would parallel moves towards environmental conservation and away from the dominance of ‘hard-engineering’ solutions.

Suffice to say, to anyone who grew up with notions of publically owned Regional Water Authorities between 1974 and 1989 as being stable institutions operating ‘in the public good’, remains bemused and intrigued by the changes in succeeding decades. Anything described as ‘new’ becomes suspect, for it too may soon become a curiosity of environmental governance history! We remain deeply concerned with changing regulatory environments.

1.2 A Conceptual Framework for Water Regulation

Water supply and usage is a matter of appropriating water from the land surface, sea and underground for some purpose while minimising the knock-on effects to both the resource and the wider environment including flooding (Defra (2014a)). To summarise:

- *Water resources* are to do with resource balance within defined hydrographic units (such as a river basin or groundwater unit) and with sustaining bulk supply. In England and Wales, abstractions are controlled by licence controls and a parallel system has recently been developed for Scotland.
- *Water uses* include fisheries, recreation, conservation and navigation and they have to be identified as separate from instrumental abstraction for public or industrial supply. These uses will impact issues of both water resources and water quality.
- *Water quality* considerations should equally apply to chemical quality, (in terms of both direct toxicity as to other impacts of human activity including nutrient loading from agriculture or sewage effluent) as to biological, aesthetic and physical conditions that influence it. Water quality objectives are set within the envelope of absolute limits, now set by the EU that replaced governmentally set standards. They will also affect the uses to which water is put.
- *Flood defence* hitherto has involved public bodies taking charge in order to improve or maintain waterways, or to plan for flood management. There have been major re-evaluations since the flooding of 2000/1 across southern England and later serious occurrences further north.
- *Floodplain and wet habitat restoration* increasingly includes the relaxation of defences to save public money and to allow for the re-wilding of river corridors and coastal areas to create or renew floodplain functions and wetland habitats. Originally led by Scottish public policy, this is now a major consideration across Britain.
- *Internalising costs*, starting with regulation the idea of funding of water resource management has been prevalent in England and Wales since the 1980s. While grant-in-aid for flood defence will always involve public expenditure, investment in the water industry *per se* is a matter of private investment.
- *Getting the citizen involved* is perhaps the single greatest development in water resource planning in 20 years or more. Moving beyond mere public consultation in planning to a point where communities have a say in water management involves public participation is revolutionary given the ‘technocratic’ past of the water industry. Here is a new need for total ‘stakeholder’ engagement.
- *The rise of new institutions* is needed to take public engagement forward. While there are always rumours of new statutory bodies, the *zeitgeist* of the present day demands the growth of voluntary sector body involvement, including the rise of Rivers Trusts as new actors in river basin management and governance.

- *Planning of water resources and allocation of functions* is implicit in all the above; however, a competent authority that delivers ‘regulation’ is central for forward planning. This includes all of strategic planning of bulk supply options at a national scale (including bulk regional transfers) to water resource planning and related development within a catchment. Regulatory bodies are involved in the statutory planning system when, for example, urban development is involved. Integrated Water Resource Management manifest in River Basin Management Plans (formally ‘Catchment Management Planning’) should allow for the holistic appraisals of options and issues defined within river basins.

Britain had moved forward greatly with the adoption of Catchment Management Planning from 1990 onwards. The laudable aim was indeed to move water into the statutory planning process, something that had been evolving since at least the famous Town and Country Planning Act of 1947. Now the EU is underpinning this, and expanding its functions into new and democratic realms. The full history of this is covered in Chapter 3, however, here it is worth noting the various policies that have been put in place to deal with pollution, and are a part of the need to consolidate (or streamline) legislation.

Water quality has persistently continued to present problems for water managers and planners in Britain. While it is not so serious north of the border, it persists in England and Wales and predictably is worst in areas that are densely populated, or intensively farmed. One commonly heard distinction is between point pollution and diffuse pollution. Point pollution at least in theory is controlled by ‘end of pipe measures’ and can be licenced as ‘consents to discharge’ by a regulatory body, because the location, type of contaminant and potential perpetrator of pollution incidents is generally known – or knowable. There may be legal constraints on ordinary discharges, means of prosecuting for illegal discharges and the possibility of land-use controls in urban areas. Aside from criminal discharges that potentially lead to prosecution, point pollution can arise from operational errors and plant malfunctions. Unfortunately, the water industry itself is not exempt from this!

Diffuse (sometimes non-point) pollution remains highly problematic. Unlike urban areas, there are no real controls over rural land use. It is incentivisation through ‘agri-environmental schemes’ that are, and have been for some 30 years or more, the way forward. For example, Higher Level Stewardship (Defra, 2014b) incentivises farmers to manage heritage landscapes, that is ‘to deliver significant environmental benefits in priority areas’. Arguably, benefits by way of reducing diffuse pollution to waters is a by-product, although reducing the farmed area under the plough, or in intensive live-stock production, can only help reduce sediment, nitrogen and phosphorous loading. A more ‘pollutant targeted’ approach has been tried with controlling nitrogen inputs to land, since 1990. Now manifest as ‘Nitrate Vulnerable Zones’ (EA & Defra, 2014) these are compulsory (that is not incentivised) for: ‘If your farm is in an NVZ, you must comply with the NVZ rules.’ Driven by EU legislation, the Nitrates Directive (91/676/EEC) NVZs cover some 62% of the area of England, 3% in Wales and 14% in of Scotland (Scottish Environment Link, 2015). In a sense, this is a control on rural land use, although it is really management of land that is the objective.

Implicit in the above description is a question: What is politically and economically the best way to engage with communities and/or industries who might be potential polluters? The cost of ‘regulation’ may be met by a polluting industry as part of its

profits, and in economic terms a means of 'externalising internalities' (Chapter 10). That said, pragmatic considerations are both political and economic. To do nothing until there is an 'incident', then issue first a fierce warning followed by a fine for non-compliance with a licence or regulation regarding water contamination does not easily engage the 'offending' stakeholders, nor is it especially cost-effective. The regulatory authorities are forever chasing (chemically or otherwise) potential miscreants and that costs technician and equipment time, to say nothing of ensuing legal costs.

Carrots (rather than sticks) are proving more than ever to be effective in terms of the politics of engagement and cost of regulation. This is the revolution in water governance. Farmers never were out to pollute for its own sake, far from it, but poor communications and isolation lead to misunderstandings; those misunderstandings lead to economic inefficiencies in terms of fertiliser use, animal welfare and so on. Rivers Trusts and others are proving new arenas, not only for the resolution of conflicts, but also acting long-term as Non-Governmental Organisation (NGO) intermediaries, sometimes termed 'honest broker' agencies for 'good stewardship' of land and water, and hence themselves providing leadership. Water companies, once vilified by creating poor ecological conditions by discharging poorly treated sewage, are in the business of payment for ecological services provided by land managers of one sort or another, and in doing so are protecting their own assets: the water environment itself. Before moving on, we can contemplate replacing the famed 'Polluter Pays Principle' by the 'Beneficiary Pays Principle.' Controversial in terms of blame allocation, but for the river basin manager or water consumer the real question is 'Does it work?'

1.3 The Historical Perspective

There is an agenda for 'green history' (Sheail, 2002), and water naturally plays a major part in that. In short, alongside social and natural sciences, there is a great need for historical enquiry in environmental studies, for *inter alia* it informs the sustainable development debate (Cook, 1999a). Furthermore, the breadth of historical enquiry (documentary, palaeo-environmental, archaeological etc.) is of itself integrative, making a parallel with the required 'holism' of the entire sustainable development debate in general and with catchment management in particular. In short, we must learn from past mistakes.

Human societies intervene in the hydrological cycle in order to exploit water resources. The usual ways are by constructing reservoirs to regulate river flow, by diverting surface flows and by sinking wells (later boreholes) into aquifers (rock formations that store water in economically useful amounts) to tap groundwater. Excess water is removed by improvements to drainage, often by the digging of ditches and by engineering works that widen and straighten channels. The objective has always been to meet local needs by smoothing out irregularities in the supply, on a seasonal basis.

The human dimension is further realised through legal systems. All major legal systems through time have adopted the principle that there can be no private ownership of flowing water (Kinnersley, 1988). The early 'hydraulic' civilisations of the Middle East and elsewhere show that water management in agriculture may go back millennia, typically in situations when canals were dug to divert water to fields growing crops.

The very survival of such civilisations depended upon water management at all scales. In Britain specifically, 'civilisation' came later in history, however the temperate climate enabled the 'Neolithic Revolution' that included the development of agriculture from about 6,000 years ago. Water management if only in the form of ditches dug to drain waterlogged soils date from prehistory (Cook, 1994). The following account traces the development of water resource exploitation from the perspective of surface waters (rivers, dams and flood alleviation), agriculture, groundwater, industry and urbanisation. Legislation is covered in Chapter 3.

1.3.1 River and Spring Diversion, Dams and Flood Alleviation

The development of water management is the starting point for appreciating the evolution of the water industry as it is today, a major player in Britain. Larger scale 'engineering' works date from the Roman occupation. Much was learned from the imperial city itself, for Rome was supplied via over 300 km of aqueducts (Binnie, 1995). Urbanisation brought piped water to Roman cities, and an aqueduct discovered in 1900 brought water to *Durnovaria*, Roman Dorchester from the river Frome in the late first century AD (Engineering Timelines n.d). Sheail (1988) traces the beginnings of direct river modification to the first century AD, the prime aims being improved land drainage, prevention of flooding and transportation. Modified areas included the Somerset levels and Fenland, where the Car Dyke in Lincolnshire may date from the time of the Roman occupation (Purseglove, 1988 p. 40). Also, during the Roman occupation, the first dams were constructed across small streams in connection with the fortifications on Hadrian's Wall and associate with mineral workings (Newson, 1992a). Advanced engineering skills were probably largely lost following the collapse of Roman administration in 410 AD and recovered in the medieval period. Water mills, likely introduced to Britain by the Romans, are known later from the Anglo-Saxon period (Stanier, 2000) and fish ponds, fish weirs, mill races and leats were recorded in the Domesday Book (1086).

After the Norman Conquest, there are well-reported water supply arrangements for the former Benedictine Christchurch Priory at Canterbury (the modern Cathedral), where from about 1160 AD, water was drawn from springs in the lower tertiary deposits outside the city through an aqueduct system of pipes to a water tower that survives today. The canons of St Gregory's were allowed to divert some of this water for their priory *en route* in exchange for a basket of apples each September (Hayes, 1977). Medieval pipes were typically made of elm (which was durable), although in 1236 the Corporation of London provided six-inch lead pipes to convey water from the River Tyburn to a conduit head at Westcheap. Cast-iron pipes were introduced in Edinburgh in 1755 but leaks prevented widespread use before the start of the nineteenth century (Binnie, 1995).

The historical dimension should also consider the development of what in the modern sense would be regarded as scientific ideas. Early ideas concerning the hydrological cycle could be intriguing, but somewhat off-track (Cook, 1999a). By the late seventeenth century, both English and French thinkers were approaching modern understandings of hydrology. Significant insights were provided by Rene Descartes, whereas Pierre Perrault developed the concept of the hydrological cycle, accounting for the disposition of rainfall by evaporation, transpiration, groundwater recharge and runoff (Nace, 1974).

Edme Mariotte established that precipitation was sufficient to account for river flow and Edmund Halley established that the water on land could be accounted for by precipitation alone and that oceanic evaporation could account for precipitation worldwide (Smith, 1972). Hydrological measurement thereby became a part of the empirical method, and during the eighteenth century, rain gauges were employed to establish the amount and distribution of rainfall in England. Indeed, hydraulics became a favourite subject of papers delivered to the Royal Society since its foundation in 1661 (Hall, 1989).

Pressure gradients enable water to flow, and where the topography is not suitable, water has to be pressurised either for direct supply, or more usually to fill a service reservoir (such as a 'water tower'). In 1581 an undershot paddle wheel system was installed beneath an arch under London Bridge, and this was used to pump river water into a tower and through a distribution system in the City (Hall, 1989, p. 14; Binnie, 1995). It was used to supply the lower part of the City, and was operational until 1822. However, higher ground continued to require new gravity-fed arrangements. The eighteenth century saw more developments in pumping technology; lifting was first achieved via a windmill, then horse-driven pumps and finally a steam engine in 1768. By the end of the century, water supply developments were going hand-in-hand with canal technology, enabling a steam-pump and reservoir dominated industry to emerge in Victorian times.

Dam construction became widespread during the eighteenth century associated with water supply, to provide compensation water (a guaranteed supply of water released to keep a mill turning) and as canal reservoirs. By 1900, the era of large dam building had begun (Sheail, 1988). It was the growth of large centres of population, in response to industrialisation, which led to the widespread construction of domestic supply dams. Dam and reservoir construction accompanied by appropriate distribution systems is a means not only of smoothing supply by regulating the transfer of water from the upper to lower regions of catchments, but also of delivering water at the right place. An Act of Parliament in 1609 had enabled the construction of the 'New River', completed in 1613, to supply London. Water was brought from springs at Chadwell and Amwell in Hertfordshire, via a channel 1.2 m deep and 3 m wide with a typical fall of only 4 cm per kilometre, to the Round Pound at Clarkenwell, London, and thence to a cistern for distribution (Hall, 1989, p. 13). A century later, in 1709, the New River Company caused water to be raised to another small reservoir in Pentonville so that houses on higher ground could be supplied.

Reservoir construction on a significant scale meant the danger of river flows ceasing altogether during dry periods, and the major spur to construction was the canal system which itself had to be maintained with sufficient water. In order to maintain water in higher-level canals, while preventing rivers drying up altogether, inflow could be divided into two streams, one for reservoir inflow, the other encircling the new reservoir to the original channel. Sheail (1988) notes how much time was spent by Parliamentary Committees considering these 'compensation flows' compared with other aspects of reservoir construction, at a time when hydrological principles were poorly appreciated. In modern times, compensation flow remains an important design constraint, with flow discharged through a valve in the base of a dam. An organised system of river management emerged during the nineteenth century, and by 1900, both large dam building and inter-basin transfers of 'raw' waters had begun.

Victorian dam construction was common in order to supply growing urban areas and included Lake Vyrnwy in North Wales to supply Liverpool. Masonry dams were

possible provided impermeable rock foundations were available, and Vyrnwy is an example. Of around 3000 dams in Britain today, almost half belong to the Victorian era, and most of these were of the 'embankment type', with a puddle-clay core. In this pre-soil mechanics era, experience dictated a slope of 1:3 on the water side, and 1:2 on the outside, irrespective of soil (Binnie, 1995). An example is the Upper Bardon Dam in Yorkshire. Such engineering knowledge was reached through experience, including dam failure and loss of life. Dam construction reached its zenith in the immediate post-Second-World-War period, but slackened off after 1960. Reservoir construction is no panacea for future water supply problems. Spin-offs such as water recreation have long been overshadowed by considerations of land-take from agriculture loss of natural habitats and loss of community where settlements are flooded.

The great age of dam construction can and never will be repeated. However, the dramatic alteration to landscape and environmental impact, as well as economic feasibility is often questioned in association with new proposal for impoundment. Proposals in water-stressed lowland southern England for lowland pumped storage reservoir construction at Broad Oak in Kent keeps re-emerging decade upon decade (CPRE, n.d.) being presently proposed by the water supply company South East Water. At the time of writing a second proposal, in southwest Oxfordshire by Thames Water (Oxfordshire County Council, 2013) is likewise proving controversial.

1.3.2 Agriculture

From the Neolithic period onwards, soil-water management systems have been employed in pursuit of food production. These enhance surface water drainage, control flooding, manipulate watertable levels, constrain livestock by 'wet fences' and possibly control soil erosion on steeper slopes (Cook, 1994; Cook and Williamson, 1999). Later developments allowed for the irrigation of pastures as watermeadows and catchmeadows. Modern soil-water management includes elements of these, although irrigation in production agriculture has overwhelmingly shifted to arable land.

Artificial features relating to water management, including features likely to be wells, are evident in the archaeological record (Cook, 1999a); other early examples of domestic water supply include clay-lined ponds from the Middle Bronze Age (Bradley, 1978, p. 50). These features permitted settlement and agriculture in areas with little or no surface water. Management of water evolved in an *ad hoc* manner to suit local environmental conditions, the needs of farming systems, early industry, settlements and navigation, in accordance with the social order and economic requirements of the time. Eventually safer and reliable methods of delivery of domestic and industrial supplies became possible.

Piecemeal land reclamation of wetlands continued after the Roman occupation of Fenland throughout the Medieval period. The presence of Norwich, once England's second city, would have provided an impetus for economic development, including drainage improvements in Broadland (Sylvester, 1999). Parallel developments in the Romney Marsh area of Kent and on the Somerset Levels and Moors and Fenlands meant that, in addition to land drainage for agricultural development, regional drainage was improved. Monasteries had the resources to effect large-scale drainage improvements in the Middle Ages, and it was largely due to their involvement that such regions experienced substantial reclamation for agriculture. Additionally, on Romney Marsh

the Rhee Canal was constructed in the thirteenth century to enable access to several ports and keep the port of New Romney from silting up (Brooks, 1988). It is in the post-medieval period that drainage at a regional scale really reached its zenith, typified by but by no means uniquely represented in Fenland and spectacularly (from an engineering point of view) by the canalisation in the seventeenth century of the 'Bedford rivers' (Taylor, 1999) under the guidance of Sir Conelius Vermuyden, a Dutch land drainage expert brought in by Charles I, originally for drainage works at Hatfield Chase. Other areas impacted at this time included the Isle of Axeholm, wide areas of Lincolnshire, the Somerset Levels, along the Thames, and the Norfolk and Suffolk coasts, and coastal areas of Hampshire and Sussex experienced drainage works.

Early methods of underdrainage used such materials as brushwood or stones. In the nineteenth century these were replaced by tile drainage (Harvey, 1980, p. 71), to be replaced in the nineteenth century by earthenware pipes and tiles (Williamson, 1999). Since the 1930s and especially in the post-Second-World-War period there was a dramatic increase in the progress of underdrainage (Stearne and Cook, 2015), which became grant-aided by government, although this is no longer the case. In more recent decades, government grant-aid has been progressively replaced by payments to reinstate wetland environments in targeted areas under agri-environmental schemes such as the contemporary Higher Level Stewardship. This may be viewed as a historical irony to parallel the well-known payments to replace hedges that were once removed under subsidy!

Viewed overall, improvements to regional drainage were both large scale and effective, and included the deepening, straightening and widening of watercourses, and more efficient pumping, particularly common after 1945. Where gravity drainage was insufficient to rid an area of excess water, mechanical help was employed to provide a further spur to field drainage. Windmill technology, introduced into England in the twelfth century, was later to permit the mechanical lifting of water in the seventeenth and eighteenth centuries using scoopwheels (in effect a waterwheel operating in reverse to lift water), and later true pumps (Cook, 1999b). Where the land to be reclaimed was too low, or commonly where peat wastage and shrinkage occurred after reclamation, windmills attached to scoopwheels were employed to lift water up to arterial watercourses. Wind power could be assisted first by more efficient steam power in the nineteenth century and in the following century diesel and electric pumps became widespread in all areas requiring drainage.

Protection from flooding through improved flood defences, both from freshwaters and saline waters in coastal regions are also essential components of effective, regional-scale water management which today permits agricultural intensification. Policy documents such as 'Making Space for Water' (Defra, 2005) enjoin us to utilise inland and coastal management that potentially realise floodplain and coastal marsh functionality, although no detail is really given in respect of the operation (and hence social and environmental utility) of historic water management systems (e.g., Cook, 2010b).

Before the twentieth century, irrigation of arable and horticultural crops would be rare, excepting the 'sub-irrigation' practiced by maintaining relatively high ditch levels between fields in areas of wetland reclaimed for agriculture such as the Fens of eastern England. However, meadow irrigation was widely practised in England. It would have been particularly effective during the 'Little Ice Age' because it raised soil temperatures, protected the sward from frost, controlled weeds and flushed the soil with nutrients (Cook, 2007). Irrigations could bring about early grass growth in the late winter/early spring (the 'early

bite' for animals) and boost hay production by re-wetting the topsoil later in the season. Topographically, 'floated watermeadows' could occupy either valley sides or alluvial floodplains.

Irrigation to reduce the soil water deficit is overwhelmingly a twentieth and twenty-first century practice, and largely undertaken since the 1960s on arable land. Post-Second-World-War irrigation has become a major draught on surface and groundwaters in certain regions of the UK. Overall, in England and Wales spray irrigation usually accounts for around one percent of non-tidal abstractions annually (EA, 2008; Defra 2015c), although regionally it is in East Anglia followed by the Midlands that together take the lion's share with the amount depending upon the year and locally the figure can be appreciably more. Water is also used in agriculture for other purposes such as washing livestock yards and in produce processing.

1.3.3 Groundwater Development

Groundwater development also has its history, and the occurrence of wells and clay-lined ponds is known from British pre-history. Inevitably, wells continued as a source of supply throughout history in both rural and urban locations with relatively shallow watertables, and where surface water sources were either remote or scarce. The availability of the resource prior to systematic exploitation in the nineteenth century would, nonetheless, be dependent on natural rates of discharge and recharge (Cook, 1999a,b). It is also probable that human interventions, through land-use changes and drainage improvements, affected groundwater availability from early times. For example, these may have caused a lowering of watertables in the chalk of southern England, requiring that wells had to be dug deeper in the fourth century (Sheail, 1988).

The quality of groundwater has generally been higher than surface waters on account of filtering of particulate materials and degradation of organic pollutants during transit underground, although solutes will travel freely through underground strata with the water. In modern times, groundwater sources require considerably less treatment than surface sources. In England, the chalk sources frequently only required chlorination.

During the nineteenth century, the advent of steam technology permitted the pumping of groundwater from larger wells and later from boreholes. Wells constructed at this time are typically 1-3 m wide and relatively shallow, although some reached to 125 m (Hall, 1989, p. 34). Such wells often were lined, and in suitable geology (typically chalk) had adits radiating at the bottom to facilitate the abstraction of water. Boreholes are sunk by drilling, or are percussion drilled. Evidently bores as deep as 300 m were achieved in the late nineteenth century (Whitaker, 1908, p. 4), and modern examples may be as deep as 500 m (Wilson, 1983, p. 87); generally, boreholes are less than a metre in diameter.

Groundwater abstracted in this way comes to supplement surface abstractions, and today, it is a resource in need of the most careful management in southern and eastern England. Sadly, groundwater has suffered from the 'out of sight, out of mind' problem, and, in 1922, in his presidential address to the Institution of Water Engineers, W.J.E. Binnie stated that:

'there is nothing to prevent a private individual sinking a well immediately adjacent [to a public source] by means of which the community may be deprived of its water supply.'

He continued to call for a licensing system to be introduced, a situation not realised until 1963 (Binnie, 1995). Nowadays, in England, around 30% of public supply comes from groundwater in Wales the figure is more like 3%. This source is especially important in the drier east of England (EA, n.d.a). For Scotland, around 5% of Scotland's public water supply comes from groundwater and sub-surface water largely is of good quality drawn from 96 boreholes and springs supplying around a third of a million people. Needless to say, it is invaluable in the production of whisky (Scotland's Environment, n.d), although pressure arises from agricultural pollution, water abstraction, causing water-table levels to drop, pollution from historic mining activities and from historic industrial activities. Nitrate Vulnerable Zone (NVZ) designations are for Moray/Aberdeenshire/Banff and Buchan, Strathmore/Fife, Lothian and Borders, and Lower Nithsdale, all in the east of the country (Scottish Government, 2015).

Pressures on the resource are serious and will be described later in some detail. To summarise, there are four key points to remember:

- Groundwater can be over-abtracted (reducing the resource availability over time).
- Groundwater can be polluted (contaminating supplies) because it is hidden and receives a range of contaminants with industrial and agricultural sources.
- Groundwater has an intimate relationship to surface waters, both flowing in rivers and streams, and standing as in wetlands. Over-abstraction has dire environmental consequences where it causes surface water to diminish or dry up.
- Aquifers may themselves be damaged or destroyed by engineering works and mineral abstraction (hence destroying the resource once and for all time).

1.3.4 Industry

Industry is a major user of water, and the changing patterns of water use in this sector are described in Chapter 9. From the eighteenth century onwards, industrial development occurred on a large scale, and all sectors used water in increasing volumes. For example, 'primary' industries used water at sites of mineral extraction or minewaters pumped from mines are frequently sources of contamination, including acidification. 'Secondary' industries consumed it during manufacturing that could involve polluting industries such as leather tanneries, dying and varnishing (Cook, 2008a) and also coking plants. Indirect effects caused by low pH precipitation has acidified some British waters since the mid-nineteenth century, culprits include the combustion of sulphurous coals and later the internal combustion engine. Transportation required water for the canal system and keeping certain (especially high-level canals) supplied could be a problem; and that water could be polluted through accidental spillage. One landmark piece of legislation was the the 'Rivers Pollution Prevention Act, 1876' prohibited the pollution of rivers by the discharge of sewage and other waste.

Problems therefore arise in respect of both quantity and quality of supply. We may identify three key and potentially negative aspects to water use at a location:

- Water is abstracted and returned to a water body with only physical changes.
- Water may be polluted in some way upon its return.
- Water may be abstracted and lost to the immediate environs.

Historically, watermills (known from the Roman period but probably only common in England since Anglo-Saxon times) 'return' water to a river with only a loss of kinetic

energy caused by the drop required to drive the wheel; however, this did not prevent corn millers coming into conflict over use of low river flows (Newson, 1992a, p. 14) nor a requirement for nineteenth century millers to adopt steam technology for use at times of low flow (Cook, 2008a).

Today, water used for cooling in power stations returns river (or estuary) water with increased temperature. Although bulk supply is hardly affected, increased temperatures can damage fish stocks and reduce oxygenation of waters. Furthermore, antifouling chemicals used to prevent slime build-up may introduce toxic pollution, and drainage from coal stockyards may be acid. 'Heavy industrial' plants have a high potential for environmental contamination. The main offenders have been coal and bulk mineral extraction, power generation (including sulphurous emissions and gas-plant effluent), the products of blast furnace 'wet scrubbing' and steel and chemical manufacture including petrochemicals. Many cause a range of contamination such as pH reduction, suspended sediment or metalliferous contamination, deoxygenation and contamination from a variety of organic compounds including solvents and hydrocarbons. Waste from chemical or pharmaceutical production potentially contains a wide range of chemical substances. Light industry also has the potential for polluting waters, with products from the food processing industry, detergents, paper mills and dyestuffs often included amongst effluents (NRA, 1994a).

Then there is 'fracking' that is hydraulic fracturing of rocks to extract gas from hydrocarbon-rich rocks (sometimes referred to as 'shale gas'). Unlike, for example, drilling for water, oil or gas in a conventional manner, fracking has proven extremely controversial, as it involves pumping into wells under high pressure, a mix of sand, water and (unspecified) chemicals to extract the gas that can then be used in the 'dash for gas'. This revival in interest in gas for energy is hoped to provide less carbon dioxide emission per unit of energy extracted. It is hoped it will bridge the gap between large-scale fossil fuel usage worldwide and the adoption of non-carbon emitting nuclear power and renewable sources of energy. Alternatively, it is a dangerous geological process that involves investment that delays widespread adoption of such 'clean energy technologies' while posing geological problems including the generation of seismic activity, triggering local earthquakes, as well as groundwater pollution (BBC, 2015).

Contamination in rivers can be cleansed relatively rapidly due to low residence times in the channel. However, there is great concern in Britain over groundwaters at risk many of which have long residence times and can be contaminated from industrial effluent. An interesting twist to the problem of groundwater quality is the persistent problem of rising groundwaters, since the demise of many heavy industrial plants, and controls on licensing of abstractions in the second half of the twentieth century (Wilkinson and Brassington, 1991). Apart from problems of the flooding of underground tunnels and cellars and risk to foundations in such cities as Liverpool, Birmingham and London, there is the risk of a spread of underground contaminants. In former industrial areas, the intersection of watertables and contaminated land (seldom well documented) presents serious hazards to groundwater quality. Today, as a result of supra-national legislative provision from the EU, there are instruments including the Groundwater Directive 80/68/EEC and subsequent Water Framework Directive EEC 2000/60/EC aimed to protect first specific aspects of the water cycle, now calling for 'integrated river basin management' in Europe, to protect all aspects of waters and provide cleaner rivers and lakes, groundwater and coastal beaches.

1.3.5 Urbanisation and Supply: The Rise of an Industry

The rapid growth of industrialisation in the eighteenth and nineteenth centuries led to urbanisation, and a growing demand for continuous, potable water presented problems. The supply in London was intermittent until the late 1880s; in poorer districts supply was often from standpipes which operated typically three days per week limited to periods as short as one hour per day (Binnie, 1995). The eighteenth century saw the origins of certain water supply companies, mainly in London. By 1801, some 6% of the largest towns were supplied by statutory joint stock companies, a figure which rose to over half by 1851 (Hall, 1989, p. 18). In Brighton, a public water supply company dates from around 1825 (Headworth and Fox, 1986), when a small water company provided reliable, piped supplies in the Brighton area from a well sunk to the north of the town. A pumped supply was provided from a new well in 1834. Similarly, public supplies were provided elsewhere in Sussex for Worthing (1857), Chichester (1874), Bognor Regis (1877), Littlehampton (1888) and Sleaford (1896). In the nineteenth century, less leak-prone iron pipes began to replace the bored timber pipes used since Roman times (Courtney, 1994).

By 1901, most large towns had municipal waterworks on account of the inability of the private sector to keep up with demand, particularly in supplying large industrial centres with water services for poor populations. Examples include Bradford (Briggs, 1968, p. 156), where the Corporation took over the Bradford Waterworks Company in 1854. In 1872, an Act of Parliament transferred responsibilities from a number of small water undertakings in the Brighton and Hove areas to the Brighton Corporation, a process of takeovers which continued until 1918 (Headworth and Fox, 1986).

Serious human health problems only really arose in the context of the 'dirty end' of the emergent water industry, for innovations in water supply (reservoir construction and borehole construction) found easy, if costly, engineering solutions. Many statutory supply companies today trace their origins back to the second half of the nineteenth century. The Waterworks Clauses Act 1847 gave a standardised framework to water undertakings, where before individual Acts of Parliament had given rights over catchment and supply areas, and powers to install pipes and conduits and charge for water. Clearly, an industry emerged in parallel with others in manufacturing, agriculture and energy supply. The Victorians raised vast sums of capital by voluntary and municipal effort. This affected not only waterworks at the 'clean end', but also sewerage and sewage disposal.

Glasgow had utilised treatment through settling tanks and sand filters since 1808, yet filtration was only slowly added to the London supply after 1852 and abstraction was subsequently taken from the non-tidal waters above Teddington Weir (Binnie, 1995). The need for improved sewerage was highlighted in the 'Great Stink' of 1858, when London sewers became anaerobic. Furthermore, intake pipes in the Thames tapped polluted surface waters, and there is plenty of evidence of the poor condition of surface waters in industrial towns outside London (Briggs, 1968, p. 146). Subsequent modification of the main drains caused interception of major waterways to discharge downstream at Barking and Crossness (Binnie, 1995). By the end of the century settlement tanks and percolating filters were common in sewage treatment.

During the last quarter of the nineteenth century, some local authorities provided sewerage farms as well as waterworks (Briggs, 1968, p. 25), and until 1974 local authorities had the responsibility for sewage disposal. In reality, there were many problems

here, including a sewage crisis manifest in the mid-nineteenth century when the struggle was on for effective means of treatment (Cook, 2008a). So problematic was this that Goddard (1996) can find a misplaced optimism in later nineteenth century, relating to sewage management. Waterborne disease, in the UK, sadly continued well into the twentieth century.

Sewage can contain human waste and other organic waste including animal carcasses, fats and oils. Organic wastes are likely to produce odours (especially under anaerobic conditions), have a high biochemical oxygen demand (BOD) (resulting in low dissolved oxygen in receiving waters), and have high ammonia contents. They are also likely to contain pathogens (both bacteria and viruses) where not adequately treated. Furthermore, industrial processes can discharge to sewers. Cesspits frequently contaminated domestic wells, and when main sewers were first introduced in the nineteenth century, main watercourses became cesspools. Consequently, municipal sewerage schemes, often ambitious, were constructed, as in Birmingham where high mortality rates in some areas were linked to poor sanitation (Briggs, 1968, p. 223).

Nineteenth-century concern over waterborne diseases such as typhoid and cholera (of which there were epidemics in 1831/32 and 1848/49 killing almost 90 000 people) was linked to the rapidly urbanising population countrywide. One cluster of cholera cases was traced to a pump at Broadstreet in Soho, London, and led to the case for improved supply being accepted after 1853 (Binnie, 1995). Improvements in the distribution networks replaced *ad hoc* arrangements in supply, and most notably the adoption of low leakage pipes led to more sanitary arrangements for domestic supply.

Municipal water resource management schemes emerged alongside small private water companies, especially following the Waterworks Clauses Act of 1847 (Hall, 1989, pp. 17-18). The Act sought to standardise waterworks practice in terms of supply, pressure and quality, replacing the need for individual private Acts of Parliament for rights over catchment and supply areas, and powers to install pipes and conduits. The Act consolidated various preceding Acts passed with the objective of providing individual towns with private supply companies, declaring that the piped supply should be both pure and sufficient for domestic consumption. Bathing, washing and depositing rubbish into the undertaker's waters were forbidden (Elworthy, 1994, p. 47).

1.4 The Political Dimension

The Compact Oxford Dictionary (1996) defines policy as: 'course or principle of action adopted or proposed by a government, party, business etc.' otherwise the adjective 'prudent' and 'sagacious' may be furthermore involved! It is left to the reader to decide whether this is universally applicable to the UK and beyond.

'Policy' is something that is implicit for all kinds of institutions and hence affects, or is affected by, many stakeholder groups, actors and economic sectors. We may now talk of 'governance' implying a far more complicated picture than 'top-down' or 'command and control' and implying centralised decision-making (although this can occur at many levels). For modern political scientists to effect a revolution in our thinking around environmental management is in every way as dramatic as the legislation of the past two centuries or the achievements of Victorian water engineers, or the municipal pioneers and the scientists and technologists who came to vastly improve the water delivered to

our taps. It will be demonstrated how power and decision making in water matters is being devolved to communities and to river basin groups, typified by the Rivers Trust movement, but for historical purposes we should start at the top.

EU Directives translated into UK law and policy formulations provide a basis for wider countryside planning and urban and industrial development including mining, quarrying and landfill. In short, water resource protection will be the single most important factor in shaping land use into the twenty-first century. Recently, this is particularly borne out because the call for Water Protection Zones in the uplands has the potential to cover vast tracts of land supplying upwards of 70% of drinking water for the UK from around 40% of its land areas (RSPB, n.d.), and as an 'ecosystem service provider' conservation of water supply at source goes hand-in-hand with many ecological and heritage objectives. Before the new millennium, it was disappointing to realise that water in the UK had been such a neglected resource, when compared with other areas of public policy. The literature abounds with examples from areas such as industry, agriculture, urban development and finance, making water policy look a poor relation, at least in historical terms. Arguably, it has only been since the Water Act 1989, and the sweeping changes subsequently introduced, that water emerged on the political agenda in a significant way. We hope that is changing and rapidly, not the least because of the Water Framework Directive (WFD).

Once waterborne diseases (such as cholera) were controlled by improving water supply during the nineteenth century, perceptions of hydrological 'problems' have been slow to emerge. This may be because hydrologists were slow to make their knowledge known to policy makers, or because the knowledge itself, or the political will to solve problems, lagged behind industrial, agricultural and urban developments. In Britain, land-use policy has been achieved only via market intervention, and hence land-use planning is rare outside urban areas (Newson, 1992a, ch. 8).

An example of historical slow response is the impact on upland afforestation. This severe land-use change was first identified as reducing water yield to reservoirs in the 1950s (Law, 1956), being followed by decades of research to consolidate these findings (Calder, 1990). Research in Scotland followed somewhat later. Issues of water quality (other than those associated with trade effluent and organic waste management) are even more recent. Concerns over nitrates in water were first aired in the early 1970s, and pesticides in surface waters later became an identifiable problem (Gomme *et al.*, 1991), subsequently these were detected in groundwater.

Water protection policy must therefore move on from urban (mainly point-pollution) controls within catchments to embrace rural (and predominantly diffuse) pollution. It must also consider differing timescales. Hydrological timescales normally operate over hours or days (longer when considering groundwater balances), increasing sediment loading to a drainage basin through urbanisation or arable farming switches to the 'geomorphological' timescale measured in years and centuries.

Policy making is, by its nature, interdisciplinary, incorporating not only hydrology and water resources but also hydraulic engineering, waste management, soil science, geomorphology, ecology and agricultural sciences and there is an increasing need for landscape/environmental history and archaeology. The social science compliment has to include not only economic considerations, but also politics and sociology considerations. One tangible requirement is in modern agri-environmental policy, when Higher Level

Stewardship (HLS) pays farmers and landowners to protect 'heritage' or ecological valuable landscapes (Defra, 2014b), for:

'HLS is being targeted in 110 areas across England. These target areas are where Natural England are seeking the most environmental benefits from HLS agreements for wildlife, landscape, the historic environment and resource protection. Outside these areas, we will consider all other applications depending upon the current national priorities and features present on the particular holding.'

Any regulatory body, if it is to reflect the modern ethos of integrated catchment management, has to reflect diversity in its institutional structure. The operation of the National Rivers Authority (1989-1996) was in exactly this position in England and Wales, and the EA even more so (Chapter 4) because it brings the additional 'media' of land and air to considerations of the water environment.

Before commencing a description of contemporary river basin governance it is useful to rehearse the needs for regulation in modern water institutions that arise for the following reasons:

- There is the need to balance the 'stakeholder' interests in water management. Waters are not only consumed by agriculture, industry and for domestic purposes, but are involved in conservation, landscape and recreation interests.
- As a 'temporary use resource', water availability can be finite within a specified time-frame. It may not automatically meet demand during dry periods, so the adverse results of mismatch are seen in environmental, supply and (potentially) health terms.
- Volume of supply does not always ensure that potential pollutants will be attenuated or diluted to a level where they apparently present no problem. This may be termed the 'carrying capacity' of the water environment. Policy and legal solutions, as well as 'technical fixes', are sought to ameliorate resulting problems.
- There are the ancient concerns of flood defence and land drainage, matters for the regulator on account of both the coordination effort required and capital costs involved in meeting the 'common good'. The latter are generally considerable.
- Although the banking crisis may suggest otherwise, there remains the politically (i.e., 'neo-liberal') motivated shift from state ownership of utilities (and indeed other industries) towards *state regulation of privatised undertakings*.
- This change therefore pulls away from a clear focus on water supply for human welfare that maintains sustainable abstraction and water quality towards the *profit motive*. This danger would seem to pertain in England but not in the remainder of UK.

While the notion of 'science into policy' is helpful because it stresses the scientific knowledge required for informed decision making, in practice it implies a one-way flow of ideas. A pluralistic approach is essential in solving water management problems. Policy, arising at the top from EU or UK legislation gives direction to a regulator, whereas the regulator also formulates policy, interprets legislation and (ideally) resolves conflicts. Being at the 'sharp end' the regulator operates in a preventative manner, and furthermore should be able to anticipate problems. Even this is an insufficient descriptor of development since the year 2000.

Water regulation in Britain has passed from 'technocratic' leadership to consultation-based management. This allows room for a democratic component whereby stakeholders' views are sought in the planning procedure. The needs of all 'users' of the water

environment are ideally considered, including conservation and human and animal health interests. From this process, objectives for management are set. The question remains for whom are they set, how really are decisions made, and finally how is environmental and behavioural change effected on the ground?

It should also be noted that EU environmental policy based upon 'command and control' style legislation, typical of environmental quality legislation, has its critics, and this arises primarily due to the requirement for enforcement. The Union's Fifth Action Programme incorporated aspects of sustainable development, preventative and precautionary action and shared responsibility (Hillary, 1994) in an effort to move away from the (expensive) command approach. Water supply is not listed within the Programme (although industry and agriculture are), but Chapter 10 will demonstrate the preoccupation of the EU with water quality issues. Since then, WFD article 14 actively requires public participation.

Prior to 1989 the Regional Water Authorities (RWAs) had self-regulation under the principle of integrated catchment management. A well-known syndrome in environmental governance called 'poacher and gamekeeper' existed, with roles played by a single authority in resource regulation and operation of the utility sides. Regulation instantly became external to the utility side, and a new and stronger legal framework is in place. Because free markets in water supply are difficult to make work because of fixed infrastructure and the need for supply monopoly, neo-liberal ideology required a substitute for 'market forces' that, in theory would drive unit costs down and work to optimise economic efficiency. The state retreats, leaving only a regulatory framework and somehow market forces take over water supply and treatment, and solve all ills. If that cannot work we are in what is a 'market-failure' position where for example, if pollution is viewed as arising from the 'self-interest' of individuals involved in transactions, there arises a societal cost in its abolition for the welfare of individuals and the environment is in peril (Bannock *et al.* 2003). Water pollution (in this example) represents a societal cost or an 'externality' that is not internalised as a true cost of delivering water of sufficiently good quality (actually determined through regulation via EU Directives). Intervention comes via policy development and the debate about 'who pays', polluter, consumer or society at large will continue to rage (Benson *et al.*, 2013b). Even to get to the point of attributing blame (included in 'policing') requires a technical infrastructure, so that the cost of policing water quality and quantity issues incurs considerable cost.

The resulting shift in economic policy formulation after 1980 moved away from planning (often for state-owned industries or employing interventionist policies such as agricultural price support) towards a free-market approach which (in theory) prefers market mechanisms to decide how prices are set, and where investment is made. However, the protection of both public (consumer) and environmental interests is unavoidable, and hence is the *raison d'être* for water policy development. In Chapter 3 it will be shown how regulation for both economic and environmental purposes has, in fact, led to an explosion of policy formulation affecting the operation of water utilities; merely to privatise the former RWAs as they stood might have been a disaster—on account of the poacher and gamekeeper principle.

Books dealing with policy theory *per se* (rather than practical application) have come from the social rather than natural environmental sciences, and have tended to concentrate upon policy analysis. That has been extremely useful but now there is a growing literature of what, for present purposes, we may refer to as 'applied political science'.

Such analyses makes suggestions for how communities, professionals and other interest groups not only engage with, but participate in problem solving commencing with engagement at the 'issue definition stage'.

Policy analysis is a process which considers both how policies are actually made (description) and how policies should be made (prescription). A consideration of policy theory is merited here because practically orientated water resource planners are then able to view the process in abstract. It is also helpful to reiterate the imperatives of public policy formulation following decades of 'neo-liberalism'.

In practice, natural monopoly regulation on private water and sewage undertakings is tight, and we will see how policies reflected in 'command and control' types of legislation could prove to be expensive and unpopular. Kinnersley (1994, p. 9) rightly identifies a need for new forms of coordination between water agencies, water users and government. He identifies causes as inertia among water undertakers and a realisation that good quality water supply is proving problematic.

A long-standing framework for policy formulation, based upon Hogwood and Gunn (1984, p. 2), is listed below:

- 1) Deciding to decide (issue search and agenda setting).
- 2) Deciding how to decide (issue filtration).
- 3) Issue definition.
- 4) Forecasting.
- 5) Setting objectives and priorities.
- 6) Options analysis.
- 7) Policy implementation, monitoring and control.
- 8) Evaluation and review.
- 9) Policy maintenance, succession, or termination.

An example of policy implementation in water quality is provided by the groundwater nitrate issue, discussed at length. Raised concentrations of nitrate in water have been perceived to be a problem to both human health (when ingested) and to natural ecosystems, although scientists and clinicians still argue over the extent of both. The greatest problem arises within unconfined aquifers over which there is intensive arable farming, although intensively managed pasture and the ploughing of grass also contribute. Furthermore, the reader is invited to compare that above with the more contemporary 'adaptive management cycle for catchment planning and process implementation' based in United States Environmental Protection Agency (USEPA) practice (Chapter 11).

The need for a pluralist approach is illustrated by the two kinds of explanation regarding how nitrate of agricultural origin comes to be in ground and surface waters in concentrations which are causing concern: one is scientific (based in soil and agricultural sciences), and the second lies in the need for food security and involves agricultural price support. This is policy-based and arguably provides the basis for the cessation of damaging land-use practices.

The North Atlantic blockade of the Second World War prevented the import of food into Britain. During the 1930s the British countryside had a high proportion of grassland, arguably a response to domestic agricultural depression. The ploughing of grassland over aquifers after 1940 released mineralised nitrate, and the subsequent use of nitrogenous fertiliser 'topped-up' the supply. Once it was thought that most of the nitrate in waters leached directly from inorganic sources; now it seems most is taken up

by the crop, and it is the degradation of the increased plant biomass which releases mineralised nitrogen.

Agricultural price support was maintained after the war in order to maintain food security in Britain. On the Continent, the Common Market had gone down the same route and Britain became subject to the Common Agricultural Policy after her accession in 1973. By the mid-1980s, agricultural support policy linked to increasing use of fertiliser led to 'food mountains' and a nitrate problem in aquifers and rivers of the arable areas within parts of Europe. Lowland areas of Britain proved especially vulnerable.

By the late 1980s, the nitrate debate had reached fever pitch, and in 1990 some 192 sources exceeded the EC limit of 50 mg l^{-1} for nitrate (11.3 mg l^{-1} for $\text{NO}_3\text{-N}$) in drinking water. Farmers complained that they were victims of their own success, and criticism was the prize for doing what society asked of them. Fertiliser manufacturers were ready to blame the ploughing of grassland, or even felt exonerated due to the realisation that the effect of applying fertilisers was indirect (DoE, 1986). The RWAs were blamed for delivering polluted water to the consumer, while the environmental lobby blamed all three. It was the beginning of enforcement of the EU Drinking Water Directive of 1980 (80/778/EEC) which was to make the difference.

We may ask how the nitrate issue fits into the classic framework for policy making and implementation? An attempt to investigate this is given in Box 1.1. Hogwood and Gunn (1984, p. 10) admit their framework is not always followed in sequence, and there is much 'looping' and 'overlap' between stages. Although idealistic, this sequence helps

Box 1.1 The nitrate issue in terms of a framework for policy making and implementation

In terms of 'agenda setting' (1), the issue was identified as a potential problem once water analyses detected raised concentrations from the early 1970s. 'Issue filtration' (2) revolves around whether the existing institutions and procedures were sufficient to deal with the matter. The years before 1989 really represented a research stage, when the issue was explored (e.g., Foster *et al.*, 1986); the pre-privatisation water industry may have considered means of dealing with the problem (MAFF/STW/DoE, 1988), but little was actually done in connection with bulk water supplies, beyond source blending, to reduce concentrations.

'Issue definition' (3) involved objective analysis and the identification of probable causes, and, through various empirical and modelling exercises, quantification of the problem. Intensive farming practices were identified as the major cause, and therein was a probable cure. Predictions have been made as to likely future groundwater concentrations, and estimates made of likely affected acreage (Cook, 1991), these meeting the requirements of point (4), 'forecasting'. Setting objectives and priorities (5) involved meeting the EU limit of 50 mg l^{-1} NO_3 in drinking waters, and establishing that a programme of monitoring was desirable once the selected option was under way. However, the possible means of achieving these aims had meanwhile to be considered as 'options analysis' (6). These would seem to be treatment or blending of waters (MAFF/STW/DoE, 1988), or the prevention of pollution at source, the selected option in this case.

Policy implementation, monitoring and control (7) could then follow. Considering points 5, 6 and 7, the establishment of protection zones to avoid land management

practices deemed inappropriate was selected. The establishment and operation of Nitrate Sensitive Areas (NSAs) over selected vulnerable groundwater areas and through which farmers were compensated for presumed loss on productivity, and Nitrate Vulnerable Zones (NVZs) aimed to protect all waters resulted, in the latter farmers are not compensated and protection measures as mandatory (Chapter 9). Evaluation in terms of farmer uptake of the NSA scheme and pollution monitoring and review (both 8) of the policy has been continual (Archer and Lord, 1993). This has led to policy maintenance (point 9) in the existing 10 areas, and the announcement in 1993 of new candidate NSAs. Since then, there are no more NSAs, but at the time of writing uncompensated NVZs comprise some 58% of England, having been reduced. Evidently, using an EU Directive, UK governmental thinking was to move towards compulsory restrictions as compensation payments over so much of the country would be economically unsustainable.

us to marshal thoughts of policy analysts around a specific problem. Policy and procedure (designation, establishment and evaluation) have to progress together to be successful and cost effective.

Britain has been (and is) engaged in a struggle with policy development to protect both waters and the wider environment. Synthesis of ideas of regulation and management is on the way, and we are able to learn from experience elsewhere in the world, especially other European countries and North America. These are explored in Chapter 10 and 11 of this book. However, the evolution of a policy to protect waters from nitrate pollution invokes top-down measures from central government in response to EU supra-national Directives, compulsion of a perceived ‘polluter’ and there is an implicit debate about compensation, violating the ‘polluter pays principle’ for the compensation is given for a loss of profit, a by-product of which is nitrate contamination of groundwater.

On the other hand, widespread NVZ measures protect both surface and groundwater from nitrates of agricultural origin and this requires compliance. This costs (public) money. Is there another way that is more participatory and smacks less of compulsion?

River basin groups in Britain, typified by the Rivers Trust movement, are becoming self-organising (Cook *et al.*, 2012). Hence there is a counter-action that has every potential to keep statutory authorities effective but at arms length from stakeholders as new institutions that are manifestations of ‘civil society’ take a lead in protecting water catchments used in public supply, in fishery protection, and more (Cook and Inman, 2012). Complicated new governance arrangements this may seem, but participatory democracy ought to be easier to sustain, be more efficacious (e.g., in sustaining in-stream ecology of rivers) and seek win-win solutions that improve compliance with statutory authorities, improve farm holding bottom lines and deliver environmental goods.

1.5 Summary

Early intervention in the hydrological cycle emerges as practices concerned with prehistoric water supply and field-scale soil-water management, probably in the Neolithic period. From Roman times, the beginnings of urban water supply, navigation and flood defences may be identified, and it is probable that some concept of legal

regulation existed at the time. Early forms of industrialisation, a developing agriculture, and the need to provide both smaller settlements and towns with clean, abundant water led to pressure on the resource which may be charted *inter alia* by legal developments of both case law and statute law in England. As technology advances, we see the improvements in land drainage, flood defences and supply. These are linked to improved pumping technology and developments in hydraulic engineering such as efficient pipes for water delivery under a fairly constant pressure.

What emerges is a strong managerial theme, and the details of how this came about depended upon the political climate of the times. The Victorians saw water and sewerage services as a public good because of contemporary pressing issues of public health, and progress in legislation passed at this time is outlined in Chapter 3. With characteristic civic pride they either caused water services to be created through municipalities, or in many cases brought existing private supply companies into public ownership. The need for tight regulation became very clear in the 1960s, and in 1974, all-embracing RWAs were created within the public sector. RWAs embraced the principle of integrated catchment management, (WFD talks of Integrated Water Resource Management) which can mean all things to all people, but basically involves the total management of the hydrological cycle within a drainage basin (including wastewater management and flood control). As such, the need for all-embracing water management institutions became self-evident, and the RWAs dealt with issues of resource regulation, monitoring, pollution control and planning. Against this was the often-made point that the RWAs were both ‘poacher and gamekeeper’. Self-regulation did not work in many instances (albeit the cause may have been as much public sector under-investment as institutional inefficiency) and this was witnessed by periodic assessments of water bodies and problems with drinking water supply.

By the 1980s, with political fashion strongly against public ownership, the water industry was, to the surprise of even many right-wingers, privatised through the 1989 Water Act. The remaining private water supply companies (only dealing with the ‘clean’ end, and not sewage disposal) had provided a link with a partially private sector past. In order to regulate the resource side (as opposed to the consumer interest side), the National Rivers Authority (NRA) and then the Environment Agency (EA) in England and Wales were created. In Wales in the latter case replaced by Cyfoeth Naturiol Cymru—or Natural Resources Wales (NRW)—in 2013. Parallel, though not identical, developments in regulation occurred in Scotland, although the utilities were never privatised.

Controversy over privatisation of utilities south of the Border has gone from raging indignation to a gentle simmer among environmental activists and political commentators of whatever stripe. Yet the industry functions well and meets demand; especially it can raise investment at will from private means in a way an effectively nationalised industry could not. However, jobs were lost, legislation had to be introduced to protect the vulnerable and private sector efficiency did not bring about even a stabilisation of water and sewerage service charges, let alone a reduction. Ironically, the Thames Tideway Tunnel project, promoted by Thames Water plc, is designed to end the release of untreated effluent into the River Thames and is underwritten by central government as it is too ambitious to fail (Pinsent Masons, 2012). From 2013, central government provided a £50 subsidy in domestic consumer bills aimed at addressing higher bills in

the region compared with elsewhere (South West Water, 2012). Some might say these are significant examples of market failure post-privatisation of the water industry.

While geographic reference in terms of water services largely pertains (an inhabitant of Salisbury is served by 'Wessex Water', but energy services may be purchased by Scottish Power!), ownership of water companies is forever changing and, as observed at privatisation, there is no guarantee this if UK based, raising a small spectre of 'water security' to parallel that energy security. However, the sources remain British. There are chinks in the armour of a private water industry and controversy continues, especially questioning the profit motive (Tinson and Kenway, n.d.). Not only may professionals caught off guard still use words like 'public' and 'service' but Yorkshire Water was almost mutualised in 2000, Hyder (including the former Welsh Water) broke up with its water division becoming under the management of Glas Cymru (Welsh Water, 2013), a private company limited by guarantee (essentially not-for-profit) achieved this. The notion of an efficient but not-for-profit industry remains a possibility, something not imagined by the Thatcher government of the day. Remaining in public hands, the Scottish government passed legislation in 2005 allowing for competition in the water industry whereby business customers can potentially choose their water supplier, although Scottish Water continues to deliver water and remove wastewater (Central Market Agency Scotland, 2016).

Economists and politicians of left, right and centre will no doubt continue to debate the rights and wrongs of particular ownerships for the water industry, once seen as a public good operated through a public service. The most interesting political (with a small 'p' in this case) development of the present decade is the rise of NGO type river basin organisations, largely in the Rivers Trust movement. This parallels ideas from across the conventional political spectrum and seems acceptable to all. There have been a few years during which to assess the operation and cost-effectiveness of this 'democratisation' away from direct water environmental regulation and is explored further in Chapter 4.

