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Chapter 7

England and Wales: countering 'unsustainable abstraction' with the catchment based approach

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ABSTRACT

England and Wales have a long-established abstraction licensing regime for determining water allocations amongst economic sectors, particularly agriculture. This regime is implemented by the Environment Agency (EA) and Natural Resources Wales (NRW), primarily through Catchment Abstraction Management Strategies (CAMS) and attendant Abstraction Licensing Strategies (ALS), to support policy requirements for environmental sustainability. Over time, water licensing has been increasingly linked to water availability in catchments while licence trading now provides greater flexibility in allocations. Ongoing reforms will further seek to integrate resource sustainability and the catchment based approach (CaBA) to management into this evolving regime. Yet a critical question concerns whether such policy commitments to countering 'unsustainable abstraction' have been achieved, particularly by the agricultural sector. Here, we define sustainability in terms of the environmental, social and economic outcomes of governance.

Keywords: Abstraction licensing, England and Wales, environmental sustainability, water allocation

7.1 INTRODUCTION

England and Wales face significant threats to water resources (Cook, 2017) (Figure 7.1). Ground and surface waters are subject to growing abstraction pressures from industrialisation, population growth and agricultural production. Up to 20% of surface waters experience over-abstraction (HM Government, 2018). Around 19.7% of total abstraction is from groundwater (Defra, 2019a), particularly in drier eastern regions where spray irrigation is practised. Climate change is predicted to increase such pressures, with a 15% fall in river flows anticipated by 2050 (Houses of Parliament, 2017). Countering 'unsustainable abstraction' is therefore a central guiding principle of national water abstraction policy alongside a progressive shift to catchment based approaches (CaBA) in water management (Defra and Welsh Government, 2013). However, the degree to which this institutional framework is securing sustainable water supply to sectors such as agriculture is an important concern.

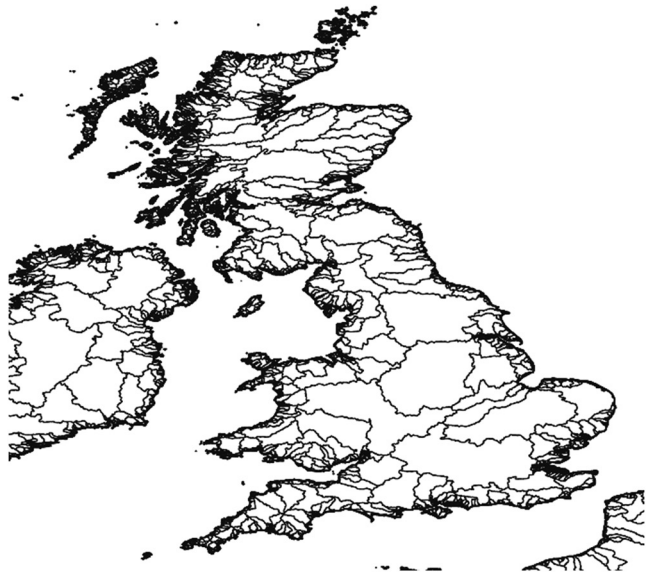

Figure 7.1 Hydrological boundaries of river basins in England and Wales.

By first setting out the main institutional framework for water allocation in England and Wales, this chapter will then provide an overview of related law and policy, management targets, volumetric caps, formal allocation and re-allocation rules, monitoring and compliance mechanisms and related policy instruments. Analysis of environmental effectiveness, economic efficiency, social equity, and resilience suggests that water abstraction by the agricultural sector is sustainable, yet significant risks remain. Evidence is drawn from national-scale trends and catchment-scale data.

7.2 THE OVERARCHING INSTITUTIONAL FRAMEWORK

7.2.1 The nature of water rights

The abstraction regime evolved from common law rights initially developed in the late medieval period (Cook, 2017). Under English common law, riparian rights to abstract surface water relate to ownership of land over which water flows. Holders of riparian rights are entitled to 'ordinary' proprietary use of waters flowing on their land for domestic or agricultural needs (McGillivray, 2013). However, as there has 'never been absolute ownership' of surface water flows or riparian rights to percolating water, securing judicial remedy for disruption to such flows has consequently proved difficult for riparian owners under the common law system[1] (Cook, 2017). Problematically, there is an absence of a 'common law right to receive any particular flow of surface water and, in the case of groundwaters… no right to receive even a reasonable flow' (McGillivray, 2013).

Over-abstraction emanating from this common law system became increasingly apparent in the 19th century, leading to the creation of water conservation institutions such as the Thames Conservancy Board in 1857 (Cook, 1999). Demands for national controls then emerged in the early

[1]In *Chasemore* v. *Richards* (1859), the riparian owner sought legal redress through the courts to stop Croydon Board of Health abstracting groundwater for public supply, as it reduced river flows to his mill. The action and subsequent appeal to the House of Lords failed since it was ruled that there was no common law right to percolating water.

20th century. A serious drought in 1921 prompted the government Ministry of Health's Advisory Committee on Water to recommend controls on groundwater abstraction, subsequently adopted in the 1945 Water Act (Cook, 1999). Limited central government licensing for groundwater abstraction in vulnerable zones was introduced, thereby initiating a gradual expansion of administrative regulation through water law. Regulation has however not removed common law rights entirely. What has emerged incrementally is a 'stewardship' system that limits 'private rights in a water law context in order to advance important public interests' such as environmental protection through licensing abstraction (McGillivray, 2013).

7.2.2 Current legal and policy context

The current water abstraction licensing system effectively dates from the Water Resources Act 1963 (Downing, 1993). Key institutional innovations introduced were firstly a Water Resources Board to steer national water resource development, plus 29 regional river authorities to undertake the water management functions of pre-existing local river boards, including abstraction licensing and control. Licensing functions were then transferred to 10 multi-function Regional Water Authorities after the Water Act 1973. Responsibility for abstraction management subsequently passed to the Environment Agency (EA) in 1995, after the Water Resources Act 1991. The EA's equivalent, Natural Resources Wales (NRW) was created in 2013. The Water Act 2003 then introduced three abstraction licence categories (see below), a simplified licensing application process and an abstraction limit of 20 cubic metres per day below which licenses were not required. Further reforms were adopted following the government white paper *Water for Life* in 2011 (HM Government, 2011) and were formalised in the Water Act 2014.

These legal innovations are implemented through Defra (Department for Environment, Food and Rural Affairs) and EA strategy, plans and programmes. A strategic steer is set by broader government environment policy; currently Defra's 25 Year Environment Plan (HM Government, 2018)[2]. The key implementing measure is Catchment Abstraction Management Strategies (CAMS). Introduced in 2001, CAMS assess water availability in each catchment and identify where demand affects the water balance. Each CAMS relates to a specific hydrological unit: for example, the Stour (Environment Agency, 2003). Abstraction Licensing Strategies (ALS) are produced for each catchment based on CAMS assessments. They in turn determine abstraction licensing within the catchment boundaries. Both strategies also integrate with River Basin Management Planning objectives, originally introduced under the EU Water Framework Directive (WFD).

Reflecting the Directive's environmental protection emphasis, a critical driving principle of national policy has been avoidance of 'unsustainable abstraction', deemed to occur where (Defra and Welsh Government, 2013):

> *… abstraction can alter the natural flow regime either directly changing surface water flows or indirectly by lowering groundwater levels and consequently affecting flows to springs, wetlands, lakes and rivers.*

Where abstraction was considered unsustainable, the EA implemented the Restoring Sustainable Abstraction (RSA) programme (2008 to 2018). The programme allowed the Agency to investigate, amend and revoke abstraction licenses where they were considered environmentally damaging. These powers were significantly enhanced by the removal of pre-existing compensation measures for revoking and amending water company licences in the Water Act 2014. A programme was also adopted in 2017 whereby the EA can revoke unused or underused licences, plus review time-limited licence renewals.

[2]Chapter 2 of the 25 Year Plan identifies maintaining 'sustainable supplies of water for future generations' as a central aim (HM Government, 2018).

Water companies[3] additionally have statutory requirements relating to water abstraction through production of Water Resources Management Plans (WRMPs) and drought plans. The Water Act 2003 made completion of WRMPs every five years a statutory requirement. To ensure sustainable abstraction, company plans must show how future abstraction demand will be met alongside environmental protection through supporting River Basin Management Plan objectives. The annual Water Industry National Environment Programme (WINEP) also sets out industry requirements for meeting statutory environmental obligations, thereby steering company investment plans (United Utilities, 2020). The Programme is supported by WISER (Water Industry Strategic Environmental Requirements), constituting water company actions requested by government agencies for meeting environmental obligations. Water companies are legally required to produce plans detailing drought response actions.

This system is currently under reform to enhance sustainability and the catchment based approach. After consultation with the UK and Welsh Governments, Defra published its Water Abstraction Plan for sectoral reform in 2017 (Defra, 2017a, 2019b). A key Plan goal is 'to end damaging abstraction of water from rivers and groundwater whenever it is cost beneficial to do so', to increase the number of 'sustainably abstracted water bodies from 82% to 90% for surface water and from 72% to 77% for groundwater by 2021' (Defra, 2017a). Actions to achieve this goal include: using WINEP to ensure sustainable abstraction by water companies; reviewing 50% of time-limited licences by 2021 to address their environmental impacts; adjusting permanent licences to prevent environmental damage; and completing the Restoring Sustainable Abstraction Programme by revoking unused licences, removing under-used licences and regulating previously exempt abstraction (ibid.). To achieve these actions, the Plan refers to updating abstraction licensing strategies to better protect the environment in conjunction with a 'stronger catchment focus' that involves 'engagement in catchments facing particular environmental pressures from abstraction' (ibid.). Subsequently 10 priority catchments were designated by the Environment Agency 'for developing and testing innovative solutions to achieve greater access to water and address unsustainable abstraction' through catchment based approaches involving multiple stakeholders (Environment Agency, 2019a). The first four priority catchments were introduced in 2018, with another six announced in 2019[4].

Additional reforms have since been undertaken. Firstly, the abstraction licensing service is being modernised by digitising licence information. A 'Manage your water abstraction and impoundment licence' service allows users to submit abstraction records online, access their licence details and share licence management with the EA (GOV.UK, 2018). By early 2019, 3000 licence holders had registered for this service (Defra, 2019b). Secondly, a future reform will shift the current abstraction licensing system into the EA's wider Environmental Permitting Regime[5], to ensure consistency with industrial permitting. Finally, water trading is being expanded through revisions of Abstraction Licensing Strategies (see below).

7.2.3 Controlling access to water: a catchment based approach

Access to water for abstraction is determined by CAMS and their associated Abstraction Licensing Strategies. Catchment Abstraction Management Strategies involve a technical assessment of water resources available for abstraction using data collected within defined CAMS boundaries. This assessment determines Abstraction Licensing Strategies within each catchment – 82 in England

[3]The water industry was privatised under the Water Act 1989, creating 33 companies to provide drinking water supply and sewerage.

[4]The 10 priority catchments are the Till and Tweed, Idle and Torne, South Forty Foot (Witham catchment), Cam and Ely Ouse, East Suffolk, Arun and Western Streams, Alt and Crossens, Wye, Brue and Otter.

[5]The Environmental Permitting Regulations (EPR) combined pre-existing Waste Management Licensing (WML) and Pollution Prevention and Control (PPC) regulations, becoming operational in 2008. Permits are required for activities including waste management and discharging pollutants to water bodies.

and 14 in Wales. These documents specify how the EA and NRW will manage licensing within each catchment. Each strategy contains information on water resources available for abstraction, the conditions for applying for new licences and conditions attached to existing licences (Environment Agency, 2016). In issuing licences, the Environment Agency states that it will examine 'the local impacts of the proposed abstraction or impoundment and ensure that we protect the rights of existing water users in addition to protecting the environment' (ibid.), reflecting the 'stewardship' notion by balancing private riparian rights for water abstraction with public interests in environmental protection.

7.2.4 Permitting requirements

Part IV, 23 (1) of the Water Resources Act 1963 originally required that any person abstracting water from a supply source had to apply for a licence from the requisite river authority, with charges for licenses specified in the legislation. Exceptions included abstractions below one thousand gallons (4.5 m^3), plus water for domestic and agricultural use, apart from spray irrigation because of its higher water demands. Reflecting common law, only landowners or those they permitted to access the land were entitled to apply.

Under the Water Act 2003, the pre-existing single abstraction licence system was changed to encompass three categories (Environment Agency, 2014a). A *full licence* is required to abstract over 20 m^3 per day, a *transfer licence* is required to transfer over 20 m^3 per day between sources. A *temporary licence* is needed for abstracting over 20 m^3 per day for less than 28 days. An additional licence may be needed for impounding water. Separate consent is required to abstract groundwater from a borehole. New licences must also be granted as time limited (Ofwat, 2015). An application charge is payable to the Environment Agency or NRW, in addition to the annual licence charge (Environment Agency, 2020a). If granted, licence fees are calculated according to volume of water abstracted annually multiplied by factors including the source type, season, the degree of loss to the water source and whether the source is tidal (ibid.). Trading of licences is also permitted, as discussed below. Further amendments to the licensing system are likely as it becomes incorporated into the Environmental Permitting System (Defra, 2019b).

7.2.5 Collaborative programmes and decision-making

Catchment-scale collaboration of actors is encouraged under current government water policy. Although the Water Resources Act 1963 first created catchment based river authorities, until recently water management agencies were characterised by technocratic decision-making with limited input from user groups (Benson *et al.*, 2014). As such, CaBA was established by Defra in 2013 to promote collaborative partnership working. To date, over 100 catchment based partnerships have come under CaBA coordination (CaBA, 2021). Links are also being created with the Catchment Sensitive Farming partnership between Defra, Natural England and the Environment Agency which integrates on-farm advice and training around sustainable abstraction to enable farmers to protect water resources (Defra, 2019b).

A collaborative approach was also promoted in the 2017 Water Abstraction Plan through its 10 Water Resources Priority Catchments (WRPC). For example, the CamEO Partnership encompasses the Rivers Cam, Lark, Little Ouse and Thet, Wissey and South Level within the Cam & Ely Ouse WRPC in East Anglia (CamEO, 2021). The Partnership is co-hosted by Anglian Water and the Rivers Trust, partnering with the National Farmers Union, local councils and wildlife protection non-governmental organisations (NGOs). CamEO has undertaken several initiatives to support sustainable abstraction in collaboration with industry actors.

Another collaborative partnership model is Water Abstractor Groups (WAGs), comprised of farmers in eastern England (Holman & Trawick, 2011). These groups represent agricultural and horticultural members in protecting their water rights through working collaboratively with government agencies. For example, the Broadland Agricultural Water Abstractors Group (BAWAG), is an association of 170

members, formed in 1997, based within the Broadland and North Norfolk CAMS areas (BAWAG, 2021). Key aims include lobbying on behalf of their members regarding water licenses and promoting best practice in sustainable agricultural water management.

Finally, water companies are engaged in parallel regional-scale partnership processes. Water Resources East (WRE), a not-for-profit company established by Anglian Water in 2014, engages water companies, energy companies, internal drainage boards, public bodies, NGOs, universities, civil society and farmers groups in collaboratively managing regional water resources (WRE, 2021). Other regional bodies are Water Resources North (WReN), Water Resources West and Water Resources South East.

7.3 DEFINING THE AVAILABLE RESOURCE POOL

7.3.1 Setting and meeting the volumetric cap in catchments

The volumetric cap is set on a catchment basis by the Abstraction Licensing Strategy. For each sub-catchment, surface and groundwater interactions may be investigated using numerical modelling techniques enabling limits to be placed for individual sources. The EA or NRW estimates the amount of water available for abstraction throughout the year, calculated at four different flow parameters: 'Q95 (the flow of a river which is exceeded on average for 95% of the time i.e., low flow), Q70, Q50, and Q30 (higher flow)' (Environment Agency, 2020b). These are used to assess water availability but defining full Environmental/Ecological Flow Regimes remains difficult (Cook, 2017). While it is desirable to modulate flow with human and natural requirements, in many situations and particularly in chalk streams, variables such as in-stream ecology and abstraction support cause complexity (Klaar *et al.*, 2014).

Such data are mapped across catchments for each parameter, with colours indicating potential water abstraction availability: green for water available, yellow for restricted water available, and red for water not available. The same system is used for groundwater availability. Licences are set according to the water available in a sub-catchment, with new licences considered by the EA in 'green' areas depending on the impacts on downstream flows and protected areas. In 'yellow' areas, where Environmental Flow Indicators (EFIs – see below) show environmental impacts, no new licences are issued and existing licences may be subject to volumetric reduction. In 'red' zones, licences are not issued as flows cannot ensure 'good ecological status'. However, licenses can still be traded within this overall cap, under certain conditions (see below).

7.4 DEFINING ALLOCATION AND RE-ALLOCATION RULES

Water allocations are subject to EA or NRW licensing, but various exemptions have applied. The 1963 Act had permitted holders of abstraction licences to pass them on after their death through succession of land ownership, that is in perpetuity. The historical exemption for 'grandfathering' abstraction rights was then changed, through 2017 amendments to the Water Resources Act 1991[6]. Existing licences may also be split or transferred if land is sold or leased, subject to EA agreement, meaning the licensing is not now tied to absolute land ownership and trading is also possible within the same catchment or groundwater unit (Environment Agency, 2014b). Water suppliers also received government compensation for revocation and variation of licences, but this was ended by the 2014 Water Act. Other historical exemptions removed by legal amendments in 2017 included the rights of irrigators and The Crown to take unlimited amounts of water, and authorities to transfer water between inland sources (Defra, 2017b). 'Low risk' abstraction activities are still exempted from

[6]Four pieces of legislation amend the 1991 Act: The Water Abstraction (Transitional Provision) Regulations 2017; The Water Abstraction and Impounding (Exemptions) Regulations 2017; The Water Abstraction (Revocations etc.) (England) Order 2017; The Water Abstraction (Specific Enactments) Regulations 2017.

licensing, for example dredging (ibid.). Agriculture has no priority licensing exemption over other sectors, with applications assessed on their individual merit.

7.5 MONITORING AND COMPLIANCE

7.5.1 Hydrological monitoring

Government agencies conduct continuous resource assessment through monitoring networks. Surface water is monitored at Assessment Points (APs), covering river basins. In the Hampshire Avon catchment there are 18 APs, situated mainly along the Avon and Wylye rivers (Environment Agency, 2020b). Water situation reports are published monthly, while river flow and rainfall reports are issued weekly. Situation reports provide data on rainfall, soil moisture deficit, river flows and groundwater levels plus projections on future water availability.

Environmental impacts of abstraction are measured through modelling Environmental Flow Indicators (EFIs) (Defra, 2020). Both the EA and NRW use these indicators to estimate the water required to sustain ecological health of rivers. Here, the EA defines 'surface water bodies with flow greater than the EFI as supporting Good Ecological Status under the Water Framework Directive' (ibid.). Groundwater abstraction is monitored using quantitative tests for groundwater levels, surface water flow protection, water quality and spring discharge (ibid.). In meeting these tests, agencies determine whether groundwater complies with WFD 'good' status for groundwater bodies. Where water levels drop to unsustainable levels, a 'hands off flow' condition can be imposed on licensing. According to Defra (2016) a 'hands off flow (HoF) or level (HoL) condition allows the Regulator to reduce or stop abstraction when flows at a gauging station, or levels in a borehole, pass a specified threshold'.

7.5.2 Enforcement and ensuring compliance

Infringements to licences can result in enforcement action (Environment Agency, 2019b). Here, an 'outcome-focused enforcement' approach is pursued (ibid.). Enforcement intervention options start with (i) advice and guidance to suspected transgressors aimed at behaviour modification, followed by (ii) warnings, (iii) enforcement notices, (iv) civil sanctions and finally (v) commencement of criminal proceedings. Here, the EA can issue compliance notices, restoration notices, stop notices, enforcement cost recovery notices and non-compliance penalty notices. For minor infringements, a fixed monetary penalty can be issued. More serious offending can elicit a variable monetary penalty. Significant infringements can involve criminal proceedings, which could result in fines or even imprisonment. Although no data exist on numbers of criminal actions undertaken relating to water abstraction, the EA recently stated that illegal activity was increasing in the West Country through drilling of unlicensed boreholes (Environment Agency, 2019c). Compliance can be enforced through other areas of government policy, for example through cross-compliance conditions for government funding, described below.

7.6 THE BROADER POLICY INSTRUMENT MIX

7.6.1 Drought policy

Water abstraction policy links to national drought policy (Environment Agency, 2017). In terms of environmental, agricultural and domestic water supply, UK Government policy classifies droughts as civil emergencies involving a multi-actor response. Droughts are managed centrally by a National Drought Group in Defra, comprising the EA, government ministries and key stakeholders. The EA has also adopted drought management plans for its 14 operational areas, identifying actions for drought events that are reviewed annually. Under drought management conditions, the Environment Agency can change licence conditions for agricultural irrigators (Defra, 2015a). Under a Section 57 Restriction, spray irrigators within a specific catchment can have their water allocations reduced or even stopped.

7.6.2 Other regulatory instruments

Water abstraction in England and Wales is dominated by industrial concerns. The principal abstraction sector is the privatised water industry, thereby necessitating interrelated national policy for integrating abstraction objectives into water company policy through statutory obligations to produce Water Resources Management Plans and drought plans. However, agricultural abstraction is more significant in specific regions, particularly where spray irrigation is used by farmers, and is covered by parallel rules. For example, farmers receiving financial support from agri-environment agreements and the Basic Payment Scheme, Countryside Stewardship (CS) and other grants must also comply with cross-compliance conditions for water abstraction related to meeting licensing conditions (GOV.UK, 2020; NFU, 2021a). These rules are comprised of Statutory Management Requirements (SMRs) and Good Agricultural and Environmental Conditions (GAECs) (Defra, 2015b). A set of conditions, GAEC2, are established for water abstraction.

Other areas of policy important for agricultural water abstraction are regulations for nature protection. Under the EU Habitats and Birds Directives, the Environment Agency and Natural Resources Wales have been legally compelled to intervene where abstractions impact on protected areas; particularly Natura 2000 sites, including Special Areas of Conservation and Special Protection Areas (Defra, 2013; JNCC, 2020a). Applications for water abstraction licences are also assessed for any impacts on Sites of Special Scientific Interest (SSSIs), designated by Natural England under powers in the Wildlife and Countryside Act 1981. The Act forbids landowners to undertake water abstraction that could damage an SSSI without first obtaining consent.

7.6.3 Economic instruments

The licensing system also permits the trading of abstraction rights for surface waters, which has proved popular in agricultural areas. Parties can secure a licence by securing agreement with an existing licence holder for all or part of their rights, subject to EA permission. Water trading applications are considered according to guidance criteria for preventing water body deterioration. In East Anglia they relate to location, season, quantity, rate, purpose and catchment (Environment Agency, 2020c). Both the donor and recipient should 'abstract within the same surface watercourse and have comparable effects on other surface water features' (ibid.). A preference for trading water abstractions from downstream sources is maintained by the EA, since it potentially results in lower environmental impacts. Trading should also occur for abstraction in the same season: shifting licenses from winter to summer could result in greater environmental pressures. Where water is also determined unavailable for abstraction by the ALS, water trading is unlikely to be permitted. Trades should also occur for the same purpose, with the 'consumptiveness' of abstraction comparable (ibid.).

7.7 ASSESSING PERFORMANCE

7.7.1 Environmental effectiveness

Environmental effectiveness can be gauged by examining national and catchment level evidence on water abstraction levels. In assessing the ongoing reform process, Defra (2019b) reflected back on natural flow level targets in its Water Abstraction Plan 2017. Some progress was discernible: while 82% of surface waters met the required flow standards in 2017 (using 2016 data), by 2019 this figure had marginally increased to 84% (Defra, 2019b). Surface water bodies classified as 'potentially unsustainably abstracted' identified in 2017 was 10% but by 2019 it had declined to 7% (ibid.). The number of unsustainably abstracted water bodies, however, increased from 8 to 9 during this period (ibid.). In addition, the report predicts that reductions in groundwater abstractions in wetland areas should allow an increase in groundwater bodies classified as sustainable, from 72% recorded in 2019 to 77% in 2021 (ibid.). In attributing reasons for these positive environmental trends, Defra refers to implementation of the Restoring Sustainable Abstraction programme: by 2019, 282 licences had been either amended or revoked, making up to 40 billion (10^9) litres of water available for the environment (ibid.).

Data from individual priority catchments support the broader national environmental trends. For example, the Cam and Ely Ouse catchment was defined as a 'priority catchment' in the Defra Water Abstraction Plan 2017. While intensively farmed, with 60.5% of its land under arable cultivation, the catchment also encompasses 167 designated protected areas, including Special Areas of Conservation, Special Protected Areas, SSSIs and Ramsar sites (Environment Agency, 2020d). Actions to reduce water abstraction under the Restoring Sustainable Abstraction programme resulted in savings of 18 443 006 m^3/year, in addition to a further 333 957 m^3/year from revoking unused and underused licences (ibid.). Another factor for improvements in environmental flows may be the nascent partnership approach, for example CamEO.

Given this evidence, to what extent does the sector exhibit environmental unsustainability, that is restricted flows? National levels of actual abstraction of groundwater and non-tidal surface water in England had fallen between 2001 and 2011, from 11.6 billion m^3 to 8.2 billion m^3, but started to rise up to 2017 when it reached 10.4 billion m^3 (Defra, 2019a). No data are published for the period since, making reform impacts difficult to assess. However, the WFD river basin management planning assessment shows that surface water bodies meeting high or good ecological status has not improved since 2000: 36% or 3322 UK surface water bodies were classified as being high or good status in 2019 but in England this figure fell to only 16%; down from 25% in 2009 (JNCC, 2020b). The picture in individual catchments is also concerning. Priority catchments are still experiencing unsustainable flows despite licence modifications or revocations, according to recent revisions of Abstraction Licensing Strategies. For example, the Cam and Ely Ouse – already under high abstraction pressures from agriculture – shows no water availability at Q70 flows and above; even at Q50 water availability is restricted or unavailable (Environment Agency, 2020d).

7.7.2 Economic efficiency

The economic efficiency of water abstraction has arguably increased under the reform process for some sectors, particularly through digital transformation and water trading. By 2019, 3000 licence holders were registered on the EA's digital licence system. Registered licence holders can access their licences online and submit abstraction data; representing a significant increase in efficiency over the previous paper-based system (Defra, 2019b). For the EA, the digital service also involves efficiencies in managing licence applications and implementation. Licences containing hands off flow or hands off level conditions can be actioned online during low river flows, thereby freeing up time for Agency staff.

Water rights trading is also creating economic efficiencies in agricultural sector allocations. Barriers to water trading were eased by the Water Act 2003 but uptake was low, with only 51 trades before 2011 (Lumbroso *et al.*, 2014). Despite initial concerns over potential challenges (see Houses of Parliament, 2017), trialling of the new trading system amongst farmers, coordinated online by the EA, has been positively received. Initial assessment shows that 84% of users were satisfied with the system, with Defra (2019b) quoting positive feedback from farmers. Similarly, a joint National Farmers' Union (NFU) and Cranfield University report (Rey *et al.*, 2018) identifies strengths and weaknesses in water trading, as expressed by farmers. Respondents highlighted the opportunities offered by better water allocations in catchments, greater water efficiencies and the potential to generate money. But concerns included the potential for water companies and industry to buy up agricultural allocations and the erosion of historic rights to water (ibid.). The NFU also highlights examples of successful trading such as the Wheatley Watersource pilot project, jointly developed by Anglian Water and Essex & Suffolk Water (NFU, 2021b). Success of this online trading platform has led to the inclusion of abstractors in the Cam and Ely Ouse and adjacent catchments (ibid.). While some ongoing concerns over the system remain amongst farmers, the NFU has demonstrated its support by establishing an online Water Bank to fast-track short-term licence trades (NFU, 2021c). Donors of licences can register online with their local Environment Agency offices and be matched with recipients within their catchment.

7.7.3 Social equity

Another important aspect of sustainability is its social dimension. Social equity could be measured through conditions for setting licences and priorities given for different sectoral allocations, although these – as described previously – are assessed against individual applications on merit and could be considered procedurally fair between social actors. However, we could also consider the shift towards collaboration in water abstraction as another indicator of equity. As Wondolleck and Yaffee (2000) argue '[i]n successful collaborative efforts, considerable effort is made to craft decision-making processes that are fair and outcomes that are judged equitable'. When applied to catchment partnerships this principle of procedural justice or fairness is considered critical to ensure the sustainability of institutional arrangements and improvement actions (Smith *et al.*, 2015).

National-level data show that social equity is apparent in catchment partnerships. Although less than 10% of CaBA catchment coordinators stated in 2017 that the approach was effective in addressing water resources issues, primarily because of the difficulties in engaging abstractors, the government has sought to counter this problem through promoting collaboration around abstraction in the Water Resources Plan (Defra, 2019b). Here, the CaBA abstraction working group is co-chaired by the Rivers Trust and the Environment Agency, to provide a steer on the integration of abstraction objectives into catchment planning and programmes.

Social equity is also being increased through the EA's priority catchments. According to Defra (2019b), within the four initial catchments, based in agricultural areas, 'abstractors and stakeholders… are keen to work together' to better share water. It further states that the Environment Agency has 'made significant progress on engagement and is moving towards co-development of solutions' (ibid.). The approach in the South Forty Foot catchment has been to 'Ask the people who farm the land' through workshops designed to inform options (ibid.). Ideas generated included: 'artificial recharge schemes, and improved sharing of surface water resources by better communication amongst abstraction sectors' (ibid.). Collaborative initiatives adopted in the Cam and Ely Ouse include a trial Water Abstraction Alert system, involving the NFU and internal drainage boards in information sharing, and the Water Resource Advisory Farm Visits scheme that provides outreach advice for farmers from the NFU, Norfolk Rivers Trust and Natural England (Environment Agency, 2020d).

7.7.4 Climate resilience

An evident risk to water allocation is climate change, particularly for the agricultural sector. In England, only one per cent of abstracted water is used by agriculture and most comes via mains supply as well as direct abstraction from rivers and boreholes. In the agricultural sector, the largest user is dairy production particularly in the South West (Defra, 2017c), although in the east of England and the Midlands spray irrigation use is considerable (Defra, 2011). Drought incidences are predicted to increase significantly over coming decades (Water UK, 2016). Attendant restrictions on abstraction licensing may then occur, with the Environment Agency predicting an average reduction of 15% in river flows by 2050 (Houses of Parliament, 2017). Groundwater recharge in Southern England may also experience a 40% decline by 2080 under a 'worst case' climate change scenario (ibid.). Significant impacts are predicted for the agricultural sector (Defra, 2018).

National policy has consequently promoted resilience in determining water allocations. Defra has signalled to water companies that Water Resource Management Plans should reflect increasing challenges from climate change (Defra, 2019b). Regional scale collaborations such as Water Resources East should allow greater strategic responses. A National Framework for Water Resources, adopted in 2020, prioritises future regional water planning in conjunction with industry stakeholders (Environment Agency, 2020e). The UK National Adaptation Programme (Defra, 2018) also identifies risks to water supply for agriculture from climate change, also citing the licensing reforms as integral to enhancing sector resilience:

Agriculture is a key consumer of water, most notably during what tend to be drier months, when there is an increased public demand for water. We are [therefore] working with farmers and other abstractors to ensure that abstraction licences are sustainable… and that the agriculture sector has access to water and uses it efficiently.

Irrigators are at particular risk, leading to the UK government designating this sector in terms of 'essential water need' in planned future reforms of water abstraction (see Knox *et al.*, 2020). Future water scarcity may have a disproportionate effect on high-value irrigated vegetable production. Potato growing for example accounts for 25% of irrigated farming but is primarily located in already-water-stressed regions such as East Anglia (Watts *et al.*, 2015). A smaller allocation goes to meadow irrigation, which may be similarly impacted. This historical use of surface and (occasionally) spring water dates back typically some 400 years and represents both management of historical landscapes on valley floors and hillsides as well as supporting habitats and biodiversity (Cook & Williamson, 2007). Here, the 2003 legislation requires a transfer licence because water abstracted from a river is returned to the river system locally. This is the case for the Harnham Water Meadows in Salisbury, Hampshire where a licence has been granted (Wiltshire Times, 2020).

That said, implementation of sustainable abstraction in catchments is variable, particularly in intensively farmed areas. Examination of recently revised Abstraction Licensing Strategies shows that climate change is not generally a determining factor in allocations. One briefly pledges to review climate impacts in licensing (Environment Agency, 2020f). Another identifies likely climate impacts for the catchment but no related management measures (Environment Agency, 2020d). Meanwhile, some agricultural catchments continue to face water stress. East Anglian farmers faced challenging conditions in August 2020 due to low rainfall and higher than average temperatures, with low river flows, farm reservoirs depleted and additional abstraction pressure placed upon irrigators (NFU, 2020).

7.8 CONCLUSIONS

Water abstraction policy is undergoing significant reform in England and Wales to ensure greater sustainability. Reforms aim at better linking water availability to allocations in catchments through licensing, alongside the promotion of catchment based partnership working and instrumental innovations such as water trading and licensing system digitisation. The Water Act 2003 permits the revocation or variation of a licence in order to prevent 'serious damage' to the water environment and hence remains a mechanism for limiting abstraction at source. On the one hand, reforms are realising positive environmental impacts through reductions in water abstraction which restore river flows, enhance economic efficiency through online licence application management and water trading, and increase water available to agricultural users. Increased social equity is achieved through the inclusion of actor groups, such as farmers, in catchment decision-making. Benefits for future climate resilience are also discernible. On the other hand, such reforms have yet to reduce albeit historical levels of over-abstraction in many catchments, particularly those subject to intensive agricultural abstraction pressures. They are however a positive step, as such changes – particularly collaborative partnership working – can take time to produce long-term sustainability benefits (Smith *et al.*, 2015).

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