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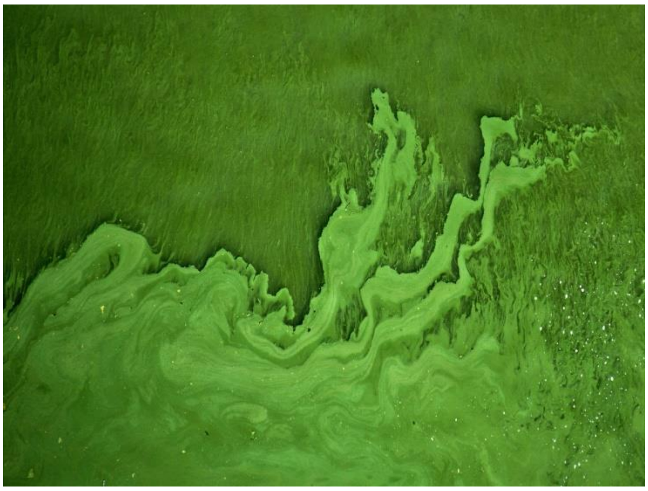
Reducing agricultural pressures on freshwater ecosystems



Freshwater ecosystems in the UK face a myriad of pressures, with agricultural activities a leading source of impacts. Defra's Agricultural Transition Plan proposes a "systems" approach to mitigate environmental pressures. This POSTnote first describes the components of UK freshwater catchments, then summarises opportunities for developing a more integrated approach to addressing the pressures that agricultural practices place on freshwaters.

Overview

- Fragmented policy approaches have failed to reverse the impairment of England's freshwater ecosystems: just 14% of rivers are classified as in a good ecological state.
- Livestock and soil management, including manure and fertiliser use, are the leading agricultural activities affecting freshwater ecosystems.
- Previous water monitoring has focussed on large water bodies, with significant evidence gaps for headwater streams and smaller freshwater bodies.
- Defra are funding habitat restoration on farmland under recently announced initiatives. In appropriate locations this could restore water quality and provide other environmental benefits.
- Addressing these pressures will require clear targets, further actions, better communication and knowledge sharing and co-ordinated payments to farmers.

Background

Freshwater environments, and the benefits that they provide, such as clean and plentiful water,[1–3] are being impacted by human activity.[1] Agriculture and sewage effluent are the leading causes of English rivers not meeting good ecological status.[2] Agricultural issues include use of high levels of nutrients (nitrogen and phosphorus) applied to land as fertilisers and manures. This disturbs the cycles through which these nutrients move among atmospheric, land, freshwater and marine environments.[4–8] In freshwater environments, nutrient excess leads to a degradation of water quality and oxygen levels, affecting aquatic life (PN-478).[9] Agriculture is a diverse activity and gives rise to other pressures on freshwater environments including eroded soil and pesticides, herbicides and fungicides entering watercourses.[1–3]

Farming in England occupies over 70% of land area.[10] The Government funds agri-environment schemes to reduce the impact of agricultural activities on freshwaters to deliver environmental benefits.[11–14] The natural starting point for addressing freshwater quality is the water catchment (the drainage area), taking into account all the land and water use within them, as well as the benefits they provide. [15–17] Each catchment is unique and subject to different pressures and land management and hence they vary in their vulnerabilities.[18] For instance, chalk streams and rivers may have lower flows in summer where excess nutrients have greater impact (PB-40). However, a catchment approach can be used to address the local challenges in different areas (PB-40, PB-42).

The Government has set out its environmental ambitions with the 25 Year Environment Plan (25 YEP),[19] and the Agricultural Transition Plan (ATP).[20] The ATP includes changes to farming regulation and enforcement, as well as replacing the current subsidy payment system for farmers. This will move beyond the fragmentary policy of the past to a 'systems' approach (similar to an 'ecosystems' approach[21]).[20] This aims to address the multiple pressures faced by ecosystems through the delivery of the Environmental Land Management scheme (ELM). The 25 YEP states a need for more effective application of the 'polluter pays' principle whereby those who pollute are responsible for the resulting costs. For example, the new Farming Rules for Water (FRfW) regulation restricts the use of manures and fertilisers.[22] Farmers have called for support to comply,[23] whereas conservation groups have demanded more enforcement.[24,25] In addition farmers will be paid to deliver 'public goods' (PB-42), such as "clean and plentiful water",[26] through ELM scheme agreements. Measures to reduce pressures on freshwater ecosystems will need to be integrated with delivery of other environmental objectives in a systems approach. Both Defra and the Environment Agency (EA) recently announced systems approaches to manage interactions between human and environmental systems, with the EA framework highlighting their value.[27–29]

Catchment systems

The UK has different types of catchment which contain diverse freshwater habitats that contribute a diversity of benefits, from carbon sequestration and clean water provision to the unique biodiversity they support.[30] Despite the inter-connectedness of freshwater ecosystems, monitoring has focussed on large rivers and lakes, historically ignoring smaller freshwater bodies that drain into or connect them.[31,32] As part of a systems approach, all components of a catchment need to be included in the evidence base.[31,32] Defra has recently established an expert working group on small water bodies to bring together research, policy and stakeholder organisations.[33]

Estuaries and transitional waters

UK estuaries, or the tidal river mouths, suffer from eutrophication, largely from agriculture and sewage effluent.[34] This is when excess nutrients accelerate plant growth which then depletes oxygen in the water, negatively impacting all aquatic life (PN-478). Relationships between the management of coastal fisheries, floods and estuaries are not well understood and research suggests that enhanced flooding runoff declines water quality and near-shore cod fisheries.[21]

Rivers

The previous EU monitoring required under the Water Framework Directive (WFD), has provided a good understanding of large rivers and waterbodies in the UK (PB-40). However, just 14% of English rivers assessed under the WFD achieve good ecological status and 0% of rivers are at good chemical status (for priority chemicals such as pesticides[35]). Agriculture affects more than 60% of these failing rivers, with sewage effluent affecting over half. The urban and transport sectors affect a small number of rivers.[2,36]

Lakes

Lake ecosystems have been widely affected by human activities, including nutrients from agriculture building up in the sediments.[37,38] Excessive water level fluctuations also trigger ecosystem destabilisation, although the true extent of these impacts from floods or droughts are not fully understood.[39,40] Recent research highlights that to ensure the long-term provision of benefits from these ecosystems, lakes need to be maintained in a good ecological state as once they are degraded their restoration is challenging.[41]

Small water bodies

Small water bodies such as ponds, small or shallow lakes (including meres), springs and headwater streams are the most numerous freshwater environments.[31,32] Headwater streams, defined as the length of stream 2.5km from the source, are estimated to make up 80% of global and European rivers,[42,43] yet have been excluded from the direct WFD assessment due to their small catchment sizes (<10km^2).[32] There are major evidence gaps on the state of their ecology,[44,45] but what evidence exists shows negative trends.[46] For example, twelve meres in Shropshire and Staffordshire were investigated in 2010, all Sites of Special Scientific Interest and important wetland habitats.[47] They were all in 'unfavourable' condition from excess nutrients mainly originating from agriculture, entering the meres via atmospheric deposition, groundwater (PB-40), surface water runoff and eroded soil.

Wetlands, field drains and ditch systems

Protected UK wetlands are in poor condition with many suffering from eutrophication, largely from field drains and the ditch systems which drain into wetlands from farmland.[48,49] As well as runoff, the sediments in drains and ditches accumulate high levels of nutrients over time, with their relative contribution to eutrophication of downstream open water bodies not well understood.[48] However, strategically placed small field wetlands (making up <0.1% of the catchment) combined with new clean water ponds are effective at trapping sediment and preventing runoff into catchments, with benefits for water quality and biodiversity if appropriately managed.[50,51] It was previously thought that only large wetlands (2% of the catchment area) could prevent runoff.[52]

Groundwater

Groundwater is the water that is present within the fractures and pore spaces of rocks (PB-40). It is a pathway for water between different ecosystems, which can take up to 90 years for water to pass through.[53,54] This suggests a more realistic monitoring timeframe of over 50 years for realising water quality improvements is needed.[55,56] Groundwaters are not well researched, but studies suggest they can support biodiversity in ecosystems over 70m below the watertable.[57,58]

Applying an effective systems approach

A systems approach requires consideration of the range of ecosystems across a catchment, their processes and the benefits they provide as well as mitigating the multiple pressures facing them.[21,31] Policy options to take account of catchment governance are outlined below.

Establishing a regulatory baseline

Pollution from multiple diffuse agricultural sources (often tens of thousands of individual fields) is difficult to trace and attribute.[50,59] Unlike other sectors, >95% of serious pollution events in 2015 were from farming activities that do not require permits.[60] The existing regulatory baseline is the 2018 FRfW regulation with a recently released regulatory position statement clarifying the interpretation of the legislation,[61] with subsequent prosecutions.[62] Previously, serious pollution incidents took place across the UK that did not result in prosecutions, such as the River Llynfi in Wales where over 45,000 fish died in a single pollution incident.[63]

The 25 YEP considers what is potentially achievable for a given freshwater habitat site,[19] and targets encapsulated in regulations need to reflect this.[64] Full restoration of small water bodies to a historic pristine state, or 'rewilding', is only likely to be an option in areas where environmental change has been limited. This suggests a focus on improving their resilience in impacted agricultural and urban catchments, and reducing human-generated pressures.[31] Advice, backed up by regulation and supported by financial incentives can be an effective driver of improvement,[65,66] but the dividing line between regulation and incentive for good practice is blurred. For example, in the River Axe in 2019, every £1 spent by the EA in regulatory visits led to £33 invested in infrastructure improvements.[67]

An effective monitoring programme

An effective monitoring programme of both farms and the wider environment provides a baseline to measure compliance against environmental regulations (PN-627).[60] The EA are now combining earth observation data with monitoring and modelling data to target farm inspections.[68] However, both commentators[69] and the EA itself[70,71] have highlighted that the EA's water quality budget is too low for effective enforcement, although there are options to address the funding shortfall (Box 1). Commentators also suggest the EA's monitoring system is not currently sufficient to assess progress against delivery of the Government's objectives.[60,72–76] For example, monitoring has omitted smaller water bodies,[32] such as headwater streams, and the timeframe for water to move through a catchment.[53] Monitoring the wider catchment area would start with the primary upland streams and continue to the lakes and estuaries at the river mouth.[31,77] Defra is funding research on monitoring all natural assets across the wider catchment area.[78]

A widely cited example for the value of strategic long-term monitoring in both setting and measuring progress against targets is that of Lake Erie. Daily monitoring was used to diagnose unexpected and unintended causes of recurrent eutrophication in the western Lake Erie basin.[79] This has informed planning to meet the new nutrient reduction target set by the US and Canadian Governments,[80] and highlighted the need for tailored responses based on a region's geographical features and monitoring data[81] in combination with appropriately targeted mitigation measures.[82]

Payments for freshwater ecosystem benefits

Under the ELMs, farmers will be paid to provide public goods by Defra.[83] The private sector will also provide payments through market-based schemes,[84] and in some contexts farmers may receive both (blended finance, PN-636).[11]

Defra-funded payments for freshwater benefits

Defra is considering how to value the provision of benefits from freshwater ecosystems. This is straightforward for some benefits, such as the provision of food,[85] but not for others, such as climate regulation, which benefit society but are outside of traditional financial transactions.[86] 'Reverse auctions' are one approach, where farmers propose their delivery cost for each

Box 1: The value of protected freshwaters

To enable better decision making to address the deterioration of freshwater ecosystems, a recent Rivers Trust report has valued fisheries from England's freshwaters at £1.7 billion, on top of wider health and biodiversity benefits.[87] While the EA has stated its budget is too low to tackle pollution from agriculture,[70] there are options to raise funding by alternate means. WWF highlights the cost savings associated with better advice and more enforcement combined with reforming farming subsidies and reversing soil degradation.[88] In addition, the EA could raise further charges from those it regulates to: cover its litigation; rectify the damage caused by pollution incidents; and fund future regulatory enforcement.[89–91] The Clean Air Strategy commits to introducing environmental permits to generate revenue and control livestock numbers for beef and dairy farms.[92]

ecosystem benefit, and the funding is awarded to the best value for money bid.[93] A reverse auction will be used to offer seven interventions in Poole Harbour, Dorset in 2022.[93]

Market-based payments for freshwater benefits

Alternatively, private market-based payments (not reliant upon Government funding) can incentivise the provision of freshwater ecosystem benefits.[94] There are a number of successful ecosystem benefit marketplaces: EnTrade, set up by Wessex Water, provides a mechanism for reverse auctions whereby farmers bid for and agree their contracts and payments via an online trading platform;[95] and South West Water and its "Upstream Thinking" Partners have used NatureBid, another auction trading platform.[96] New developments include the North Devon Biosphere "Natural Capital Marketplace"[97] and the NFU's Wessex area Nutrient Management Trading Scheme, which is a 'cap and trade' scheme allowing farmers meeting their nutrient management targets to sell credits to those who are not.[98] Commentators have suggested that while these are individually successful, it is a complex market place with multiple sites offering similar services, and one centrally coordinated "Natural Capital Outcomes" trading platform would offer clarity for regulation.[99] They highlight that nutrient trading programs can use appropriate incentives and penalties, bringing public and private stakeholders together to reduce waste and pollution.[24]

Another option is the Landscape Enterprise Networks (LENs).[100] These create markets for shared commercial interests for public and private stakeholders on the ecosystem benefits demand side, which farmers deliver through nature-based solutions on the supply side.[101] A LENs project surveying farmersfound higher farmer interest when the scheme was presented as flexible, light on administration and when it offered a 'flat price' mechanism over a "reverse auction".[102]

Nutrient balances

The nutrients phosphorus and nitrogen are a major cause of eutrophication.[9,60] A circular approach that recovers and recycles nutrients from waste (e.g. sewage and animal manures) would reduce the need for imports and minimise losses to the environment (PN-477).[103] Livestock slurries and manures could be recycled and converted to provide phosphorus and nitrogen fertilisers.[69,104,105] While the transport of manures in their natural state is uneconomic and impractical due to their high water content, transport is possible for products that have been processed.[60,106] In Denmark, the near total use of available organic manure has reduced demand for inorganic fertiliser by 50%.[107] The EU has replaced 30% of its phosphorus in fertiliser with that recovered from sewage sludge, meat and biodegradable waste.[108]

The Environmental Audit Committee has recommended that the UK Government undertake research into the feasibility of livestock manure as a biofertiliser, which can be transported to arable farms to reduce dependency upon artificial fertilisers.[60,109] This would reduce overapplication of phosphorus to land in areas of phosphorus surplus by removing it from high supply areas thus reducing the amounts entering freshwater ecosystems. Other options to reduce nutrient surpluses in areas of intensive livestock production include reducing livestock numbers,[110] reducing the nutrient content of animal feed[111] and removing nutrient-enriched sediments from drains and ditches.[50] However, these options all have practical limitations.

Knowledge exchange and peer-to-peer learning

Farmers undertaking new management measures may address water quality pressures.[112] However, evidence shows that poor understanding of existing regulation contributes to low compliance with policy interventions.[65,113,114] The values and culture of farmers has been informed by agricultural policies' focus on increasing production and reducing costs.[115,116] The adoption of widespread land-use changes to make a substantial difference to freshwater quality would be facilitated by taking account of these identities and framing messages accordingly, with proactive and sustained farmer engagement.[114,117] This may equip farmers with the confidence and ability to shift behaviours to address these pressures (PB-42).[114,118]

Peer-to-peer learning could include the use of extension workers, or local facilitators, to engage farmers with localised case studies and demonstration sites for innovative farms. Evidence on the effectiveness of extension workers includes examples of universities or Government agencies, that have established trusted relationships with farming communities.[119–121] In the UK, this type of advisory approach has achieved some desired outcomes,[114] and include Catchment Sensitive Farming programmes[66] and Defra's Demonstration Test Catchments.[122] The EFRA Committee have called for the Government to both fund and enable knowledge exchange and peer-to-peer learning to enhance farmer confidence and the delivery of public goods through the agricultural transition.[123] The Committee's report emphasises the importance of high-quality, local knowledge appropriate to individual farms.

Land zoning

The existing range of voluntary, incentivised and regulatory controls on agriculture are insufficient to restore freshwater ecosystems (PN-478), which will require a wider systems approach.[124,125] For example, the implementation of nitrate vulnerable zones frequently siloed the management of issues (such as biodiversity, water and soil quality) without a joined-up approach between different governance structures, such as planning of developments (PB-42). The National Food Strategy (NFS) has recommended a "Three Compartment Model".[126] This would lower yields for some farms that move to nature-friendly farming (such as restoring small water bodies); remove yields completely for others with full nature restoration; with high-yield farms producing enough food from others for the UK to remain food-secure.[127,128] In these cases land-use could be prioritised to optimise: the sustainability of agriculture; the ability to deliver benefits to freshwater ecosystems (due to climate, soil types, drainage or other reasons);[128,129] or benefits to local communities.[130]

There are examples of environmental restoration of former agricultural sites in the UK that highlight the complexities involved, such as heathland with a legacy of excess nutrient enrichment with fertilisers[131–133] or the recovery of complex natural ecosystems (PB-34). However, tools such as SCIMAP (which identifies high-risk areas for land cover)[134] and FARMSCOPER (which models diffuse pollution mitigation measures)[135] help target conversions appropriately to give positive results. The restoration of a wetland habitat from intensively farmed arable land in Cambridgeshire in 2014 was successful, with the researchers calculating a net gain to society.[136] Following stakeholder conflicts,[137] researchers developed a tool to calculate the benefits to society from both the agricultural and freshwater ecosystem land-uses. For five benefits (climatic regulation, nature-based recreation, grazing, flood protection, and arable productivity) the conversion to wetland habitat created a net benefit of nearly £62,000 per year (or £129 per hectare per year).[136] This included the costs for food production and rural livelihoods, but not the value of enhanced biodiversity nor improved water quality.

Catchment-based governance

The HM Treasury Dasgupta Review on The Economics of Biodiversity highlighted a disconnect in existing UK water policy between the needs of the users and its governance.[17] Catchments do not recognise governance boundaries with different users governed by different institutions, which makes integrated management difficult. The Dasgupta Review recommended polycentric governance, where information is shared in all directions (neither a top-down nor bottom-up approach).[17,138,139] This approach can improve dialogue between stakeholders to develop more inclusive decision-making frameworks (PB-40), with retail stakeholders such as Sainsbury's recognising the need for this integrated governance approach.[140]

Set up by Defra, the Catchment Based Approach (CaBA) is an existing collaborative approach between stakeholders such as farmers, conservation bodies and local authorities.[16,141,142] CaBA deliver integrated water management using a polycentric-style of governance across every catchment in England.[143] This includes establishing support networks for farmers,[144] as well as the OFWAT-funded Catchment Monitoring Cooperative, a citizen science approach to growing local ownership and community engagement that can be combined with statutory monitoring.[145] However, the NFU queries the extent of CaBA engagement with farmers.[146] CaBA includes local authority planning teams in nearly half of their partnerships, which can address regulatory difficulties such as developing on-farm water infrastructure.[143] CaBA believe that with long-term funding and regulatory support, they can assist the delivery of sustainable water management in accordance with the 25 YEP.[143]

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