

nature of the new management practice and its duration; altitude and slope; and soil depth and characteristics depending on the approach adopted¹⁸. As well as the ecological determinants of carbon sequestration, the barriers to transitions in management must be identified to develop effective incentives and governance, based on understanding of the local cultures and practice¹⁹. The monitoring programme could be financed by the Green Climate Fund of the United Nations Framework Convention on Climate Change, which is just taking its first steps, and managed by the Food and Agriculture Organization of the United Nations.

Realization of the full potential for synergy between adaptation and mitigation requires social innovation on the global scale to reconcile conflicting views through joint learning²⁰, not least between the north and the south. What is needed is a beyond-nation-state cross-scale, multi-actor and inter-knowledge institutional architecture for carbon exchange, inclusive in its decision-making through new constituency models²¹. To be effective, the exchange scheme must be inclusive also in action, a priori rewarding any verified practice by citizens and private and public actors — on a voluntary, market-driven or regulatory basis. Extensive carbon rewards from industrial countries to African smallholder

communities through as small a number of intermediaries as possible, giving the land and carbon rights to local communities, and a voice also to the poorest, could foster physical, human and social capacities, and ensure food security improvements^{4,11}. Even small carbon rewards could act as a trigger for low-income communities to transition to carbon-sequestering agriculture when low-cost, reliable verification enables upfront payments^{2,4}.

The Green Climate Fund can be designed as a role model for social learning²⁰ on governance to underpin a just and resilient global community. Carbon rewards to African smallholder communities represents an excellent case, as it also offers opportunities to trigger food security. Quantification of carbon sequestration in smallholder agriculture represents the primary knowledge gap to be bridged and the use of farmers' fields for obtaining this information is a powerful solution that seems to be readily at hand. □

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COMMENTARY:

Water stewardship in the twenty-first century

Peter Simpson

The impacts of extreme weather are being felt by us all and scientific research points to a likely worsening of weather patterns in the next decades. Therefore, it is imperative to think carefully about how we build the infrastructure of the future to increase the resilience of our societies.

Over the past three years the UK has experienced some of the most varied and extreme weather events and seasonal trends ever recorded. We may not be able to link these directly to climate change, but since 2011 we have seen examples of precisely the type of extreme conditions that climate projections suggest are likely to be the norm in the future.

Are we preparing well to cope with these changes? Will our water infrastructure meet the changing pressures and demands? Will our landscape be resilient and able to buffer extreme weather? As communities, are we willing to adapt our behaviour to a changing climate? These are questions that we all need to urgently consider.

As a water company, we at Anglian Water need to understand what role we play in the water cycle and, more widely, in a society tackling these challenges. In the UK, water companies are privately owned and provide either only water services to their customers or, in addition, treat used water before returning it to the environment. Water companies prioritize improving



Figure 1 | Water-level extremes in the UK. **a**, Pitsford reservoir, Northamptonshire, UK, during the 2012 drought. **b**, Cromer pier during an east coast storm surge last winter, Cromer, UK.

customer service, maintaining assets and infrastructure, improving drinking water quality and the quality of water returned to the environment, and managing the balance between supply and demand.

To put this into perspective, in the region where Anglian Water operates — East Anglia and the east midlands — we are investing £2.3 billion over the period 2010–2015 to achieve those objectives¹ for the benefit of the 6 million domestic customers and 110,000 businesses who rely on us every day to maintain their quality of life and sustain their operations respectively. At 137 local water treatment works, Anglian Water abstracted, treated and supplied 1.1 billion litres of high-quality drinking water through 38,000 km of water mains every day last year. Over 900 million litres of used water were taken back, through 76,000 km of sewers, and treated in 1,124 water recycling centres before being returned to the environment. Looking to the future, water availability should not limit society's ability to support a growing, thriving and healthy population. Water companies are required to provide services for new developments (domestic or industrial) wherever they emerge, but are not statutory consultees in the planning process. To raise the water issue up the agenda, we have worked with the Environment Agency and local authorities to provide information on pinch points using documents called water-cycle studies. However, when a decision is made, we are sometimes left with the challenging task of dealing with the water-related impacts.

Our region is fast growing, has a long coastline and much of the land is low lying; that is why we have focused on managing the impacts of housing growth and climate change in our business planning. We have developed a sustainable road map for our business — 'Love every drop' — to ensure we deliver the long-term outcomes we have identified when planning for the period 2015–2020. Ten outcomes were agreed during a consultation process that saw tens of thousands of our customers give their views on our future direction as part of our regulatory business planning process for the period to 2020 (<http://go.nature.com/eFmOZH>).

The water challenges

The UK's 2012 Climate Change Risk Assessment stated that "by the 2080s, reductions in summer river flows may be significant across the UK, with the largest decreases in southern and eastern England. By the 2080s almost the whole UK population may be living in areas affected by a supply–demand deficit unless significant action is taken both to reduce the demand for water and to increase supplies"². In other words, in a number of instances, we will have to cope with 'too little' water (Fig. 1a). However, too much water brings other challenges; the report also states that the area of land used for high-quality horticultural and arable production, which is liable to flood at least once in every 3 years, could rise from the present level of 30,000 ha to 75,000 ha by 2050 and to 130,000 ha by 2080. The area of the UK's agricultural land at risk from flooding is projected

to increase by 150% by 2080³. If these predictions were not enough to gain widespread attention, then the extreme weather that we have experienced in the UK since the release of the risk assessment report should have provided enough of a dramatic illustration (Fig. 1b).

At the beginning of 2012, several counties in the midlands had seen their driest year on record — a situation that got gradually worse in the spring. By April, agricultural and domestic water use restrictions were in place with impacts on crops, habitats and wildlife, as well as customers and businesses, who had to adapt to the first restrictions in 20 years on using the water they paid for (for example, hose pipe bans).

Then the drought broke and the period between April and June 2012 was the wettest on record. Between April and September 2012 the Anglian area received 153% of the long-term average rainfall. Over 4,500 properties were flooded in England and Wales and the impact on agriculture was large, with an estimated £600 million worth of crops lost⁴. Agriculture is an extremely important sector for the East of England, with a contribution of £1,308 million to the economy in 2012⁵.

Was this weather pattern in 2012 a one-off, an anomaly, an outlier that we can discard from our risk management and decision making processes? Probably not, if we consider the flooding that occurred this past winter — the magnitude of the associated financial and societal impacts is yet to be fully calculated.

Is there any silver lining to be found in these dark clouds? Well yes, if we choose to look for it. The human race has an unquestionable ability to change, adapt to pressures and overcome challenges. Adapting to the variability of our weather can be done, but it will need a twenty-first century approach. It means that we need to innovate and collaborate to transform the way we deal with these problems.

The need for collaboration

From a water resource perspective, the scale of the challenge is outlined in Anglian Water's latest 25-year Water Resource Management Plan. By 2040, based on middle-range assumptions on climate change, housing growth and sustainability reductions, we predict the need to secure 254 megalitres per day (Ml d⁻¹) of water from a combination of new supplies and demand reductions. In the worst case scenario, water needs rise to 540 Ml d⁻¹, including a deficit of approximately 150 Ml d⁻¹ from climatic changes — around 12% of dry-year annual average demand⁶. Demand reductions are a must throughout the year, but it is also clear that new resources will also be required. Climate change projections suggest drier summers but also greater opportunities for winter rainfall — capturing that rainfall must form part of our considerations. But what should a twenty-first century reservoir do, what is its function, how integrated could a supply system be for all potential beneficiaries: communities, the environment and agriculture?

We only manage a portion of the water used in our region and for some time we have believed that there needs to be a greater ownership of the challenges we face if we are to achieve a favourable outcome. The Anglian and Midland regions together account, on average, for over 75% of reported abstractions for spray irrigation each year⁷.

That is why we have worked with the Cambridge Institute for Sustainability Leadership (CISL) over the past five years to develop a collaborative approach to water stewardship. In the latest stage of this work, we have been investigating the opportunities for the development of multi-sector water resource management plans and an integrated approach to new water resource infrastructure.

There are financial, environmental and social opportunities from a collective approach to the management of water in catchments. An integrated system would provide additional resources to be treated for public and industrial use, and non-treated water to supply

strategically positioned agricultural storage facilities and buffer important wetland environments. The question is whether such an integrated system is physically achievable and economically feasible, and what financial and regulatory barriers to implement it might exist. Only by working openly with financial institutions, academics, land managers, regulators, farmers and major food producers and retailers we will be able to answer those questions.

A twenty-first century approach

The collaborative work facilitated by CISL, in particular through the 'Sink or Swim' project on understanding the role and responsibility of each sector as related to water, has provided the thought-space to discuss the possible finance streams that would support a new multi-use approach to water resources. Rather than a system providing the resources for exclusive use by the water company to meet domestic and industrial needs, we could design a more integrated system with the capacity to meet multiple needs. A practical example would be a reservoir that meets the predicted customer demand with 75% of its capacity and supports agriculture and the environment with the remaining 25%. The system should also provide an additional network for untreated water to support strategic agricultural supply reservoirs. A successful system would generate financial economies of scale, allow efficient management of licences and permits, support protection of agricultural production and maintain environmental quality. We could achieve a true collaboration if the agricultural community would invest in such a new water resource (and take it a step further, to sub-surface trickle irrigation at the farm level), if the food manufacturing, produce and retail sectors would pay growers a premium for guaranteed quality and length of season.

This integrated approach may also deliver other ecosystem services and societal benefits including lower levels of soil compaction, a greater ability of the landscape to deal with excesses of rainfall when they occur and a greater connection of customers to their role in the water cycle. All very desirable adaptations to climate change. With CISL members under the 'Sink or Swim' project, we have debated the viability of a number of different models for investing in, and owning and operating an integrated system. The models move away from the typical one — with ownership and operation dominated by the water company — to a model based

on social collectives coming together to invest at the catchment scale. Examples of such a multi-sector approach in practice are not yet available, but we have analysed possible implementation issues at the level of specific catchments. For example, in the Wissey catchment, Norfolk, we have been working to understand the water resource requirements for domestic and industrial growth, the changing demands for agricultural use and the ongoing environmental needs. At this very local level we can test the potential availability of water, the cost of the infrastructure, the practicalities of integration and the cost-benefit relationship of implementation. It is early stages but the findings are looking promising. The scale of the challenge brought an unlikely range of organizations together: land managers, academics, financial institutions, food producers, retailers, engineers, water companies, regulators, government departments and agencies. It is the opportunity for adaptation solutions to a changing climate, common to us all, that is keeping these organizations at the table and might make the twenty-first century integrated water resource system a reality.

So I would ask you, is water vital to the success of your business? If it is, ask yourself, do you know where it comes from? Do you know how vulnerable it is to climate change and what other services — social, industrial or ecological — rely on it and how their needs are changing? Do you understand the risk to your business of having too little water? Do you understand the risk of being flooded by too much? It is important that we all consider these questions and seek the answers and solutions together, to put water at the heart of a whole new way of living and secure a sustainable future. □

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