ENVIRONMENTAL WATER REQUIREMENTS: A DEMAND MANAGEMENT PERSPECTIVE

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ABSTRACT

This paper examines water management within the environment. It argues that discussion of, and decision-making governing, the allocation of water for the environment should be expanded to consider the application of demand management to the environment. The paper examines the technical feasibility of this and goes on to propose some principles that purposively address parity across water use sectors in terms of their water rights, responsibilities and performance objectives. It concludes that a more equitable policy framework encourages better resource analysis and promotes better-informed trade-offs and management concerning water allocation, particularly in times of low water availability.

Key words

Environmental water needs, demand management, water policy, wise use of water.

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INTRODUCTION

Demand management is at the forefront of water management for almost all water use sectors. Demand management argues that the benefits or values of water use are obtained or safeguarded for lesser amounts of water, hence a reduction in demand. This cross-sector allocation of water occurs by means of a number of mechanisms which are well-known(1). This paper asks whether such tools exist for saving water within the environmental/ecological sector.

The reason why water use for environment is questioned stems from the implications of the EU Habitats Directive on UK irrigators during drought (2). Interpretation of the Directive allows the environment to be prioritised during dry periods, requiring other sectors (e.g. agriculture) to share the remainder. As a drought intensifies this remainder becomes a disproportionally lesser amount of the total supply. UK irrigators appreciate the need for environmental water but understandably detect the unfairness of a law that says they should save water but the environment should not.

ENVIRONMENTAL WATER PRODUCTIVITY AND DEMAND MANAGEMENT

The literature reveals an interesting slant on environmental water management. The general view is that the environment's water problems emanate from elsewhere and that if the negative effects of other sectors were ring-fenced, or if environmental water needs were secured, this would solve those problems. Moreover, the phrase, 'the wise use of wetlands' concerns the wider planning of catchments and floodplains to protect wetlands (3), or their use, in ways compatible with their natural properties (4) rather than extending to the analysis of rate of environmental water use. Although some authors have sought to question the link between over-abstraction and environmental degradation (5, 6), few suggest that the environment itself should be included in the analysis of water efficiency and productivity. While the environment may be seen as a dumping ground for the profligacy of water use in (or effluent from) other sectors, this common reality masks the point that water use in the environment should also be held to account.

PRIORITY AND PROPORTIONAL WATER USE

An example of this non-accountability can be seen in the way that the Habitats Directive has protected environmental water. Interpretation of the legislation allows the environment in some catchments (under certain drought conditions) to have a priority water share. In the UK and other countries, rights were sometimes issued without due consideration of a) other users and b) a change in the balance between supply and demand. These tended to be fixed rights allowing the user to abstract water despite reduced sufficiency. The Habitats Directive provides water to the environment below a threshold of supply so that its water needs are safeguarded. Other sectors then move rapidly towards deficit and drought orders. This priority division contrasts with a proportional approach which shares supply more equitably between users in agreed proportions (7), in which reducing water needs are shared between sectors securing significant marginal benefits at these low levels of use. These proportions may be set (e.g. 50:50) or conditional (e.g. a change from 50:50 to 80:20 at a given point). Fixed rights are suitable for water-abundant or simple mono-sectoral use situations but are discordant when demand commonly exceeds supply and both alter in complex and dynamic ways.

ENVIRONMENTAL WATER MANAGEMENT AND DYNAMICS

A number of observations can be made which precede the discussion on environmental demand management. Human and geological history states that dry spells are a natural part of climatic variation causing wetlands to shrink and expand. These changes result in ecological and hydrological dynamics in which flora and fauna compete, multiply and change. Drying cycles are associated with wetlands; by drying out, the environment undergoes natural, climate-imposed demand management.

The Habitats Directive uses the precautionary principle in safeguarding water for the environment. This might be genuinely required in some locations and useful in the short-term as a stopgap, but it appears to preclude the fact that short-term dryness is a desirable or acceptable feature of the environment. There are on going debates about the degree to which environments are resilient to, and formed by, short-term change. The real problem is consistent year-on-year drought leading to irreversible loss. If wetlands and riverine areas do recover from drought (and can do so with vigour), this dynamic factor might partly constitute environmental water demand. Therefore optimal flows, river flow objectives and a flow duration approach are important because they acknowledge that natural perturbations exist and form important criteria in assessing environmental needs(6, 8). With precautionary protocols it is difficult to entertain the tradeoffs of marginal costs and benefits of an extra 'lifeline' dose of irrigation set against a short-term abstraction from the environment, and to study whether switching is feasible and productive.

It is necessary to ask whether within a managed environment, water demand for wetlands can be managed so that the benefits and functions of wetlands are cost-effectively retained at lower rates of water use. If the answer is 'yes', this implies what irrigators know already - that money has to be spent to save money and that water, valued properly, requires investment to save water. It is tendentious to suggest that water should be valued properly so that only non-environmental sectors invest in water-saving technology without applying that rule to the environment. This leads to other questions: (a) should the environment be held accountable (and by whom), (b) should water be saved where possible, (c) do the technical solutions exist to reduce water demand, and (d) do incentives exist to make the requisite investments? By raising these questions, this paper endorses views held by Gardiner [3], Williams [9] and Hollis [10] that the hydrological science of wetlands management is, by comparison to ecological studies, under-developed. The notion of environmental demand management raises the imperative for eco-productivity assessment, hydro-management and impact monitoring. Yet, an over-reliance on precautionary methodologies to determine water needs might obviate a more detailed and ultimately robust productivity-defined assessment of that need. This argument is not attempting to halt or reduce environmental restoration and reclamation; instead, it is proposing that methods to do so must take an efficient route in economic, ecological and hydrological terms. In other words, there may be insufficient water for water to be used inefficiently within the environment when it could be better managed to increase environmental benefits and/or provide for other sectors.

There is certain theory and evidence that argues that managed aquatic environments do not function in the same ways as natural systems [3]. The complex nature of effect and counter-effect within ecological systems means that interference alters subtle chemical and physical processes [11]. This too is not denied. Nonetheless, in water-short situations, trade-offs are necessary and there might be scope to secure natural environmental functions and release water for other sectors. In the future, it can be envisaged that managed wetlands are less distinguishable from natural wetlands than they are today.

TECHNICAL SOLUTIONS TO ENVIRONMENTAL DEMAND MANAGEMENT

Observations of man-made, natural and managed wetlands indicate that a variety of technical options exist to reduce water need (Table 1). They relate to water quantity (either directly or indirectly) by manipulating quantities through water levels, water quality, storage and water loss from a given area. For example, area is a major determinant behind water use via evaporation and seepage. Water demand is implicitly established during wetland area planning and zoning - particularly for man-made wetlands. Area volume depth relations can be managed to spread water or hold back and store water, and there is literature examines the use of structures or operations in controlling water levels [10, 12]). There are tradeoffs in deeper levels, flow velocities, water residence times and water quality, together with design and site management [5, 6] considerations, which maximise ecological functioning for a given area or length of water use; the move towards naturalised channels is an example of this aspect [13]. Furthermore, there are many examples of seepage, leakage control and the use of pipes to deliver water to distant locations[12]. Less well known are water timing, placement and scheduling decisions that extend water benefits over a larger area [14, 15]. In addition, water quality can be managed in ways that make best use of freshwater such as the use of treated water [17], dredging and artificial aeration of eutrophic sediments.

While the technical provisions above help determine how much water is saved, moving towards these objectives requires an incentive framework that encourages all sectors - not just irrigators.

SUPPLY SOLUTIONS

The role of the environment in obtaining greater or more secure supplies for itself, or for other sectors it then takes water from, is also important. Accepting the fact that definitions and examples of supply and demand management do exist, the distinction between supply and demand is often unclear; supply solutions cannot therefore be disregarded.

Supply management for the environment already occurs, for example, when the often small amounts of water (so called Q95) associated with environmental protection are obtained by pumping water from one groundwater or reservoir source and delivering it to another location [11, 21]. Also, the history of UK canal building during the last three centuries reveals much flow augmentation via water reservoir and transfer engineering. Whilst this commenced as a transport issue, canals now have important amenity and environmental functions. In addition, it is generally acknowledged that wider catchment management (e.g. use of land drainage) can affect water availability for environmental needs [5]. These kinds of mixed storage and transfer solutions demonstrate the flexibility and wider thinking that can be applied to environmental water needs.

PRINCIPLES OF A MORE EQUITABLE WATER POLICY

Underlying the equitable application of demand management to all sectors is a more equitable policy process. This is outlined below, presented as principles of water policy.

The first principle is that EU Directives and Water Framework should be allowed to evolve over time and be flexible in interpretation between catchments. A less flexible approach, albeit complex and considered, is often inappropriate at the sub-catchment scale when different sectors and resource endowments mix to create wholly new situations. This flexibility also applies to the science behind resource assessment; an over-reliance on the precautionary principle in safeguarding flows for the environment needs to be avoided. The EU Habitats Directive has the hallmarks of being too biased in principle, making its implementation likely to over-supply the environment in situations where that may not be necessary. This principle recognises that the UK can bring considerable forces to bear on water management, ranging from borrowing money within financial markets, to physical infrastructure, to legislative and financial control, to changing cultural and educational norms regarding the use of water and services received. In the UK, it is not necessary to rely on a relatively narrow suite of ideas, such as demand management or community participation if they do not serve case-specific problems.

The second principle stems from the fact that demand management necessitates accurate calculations of environmental water productivity or use. The increasing number of studies of in-stream and environmental needs form the basis of such calculations but perhaps do not go far enough. The derivation of measures of environmental water productivity that express benefits as a ratio of water used should also be encouraged.

TABLE 1. Environmental water demand management - technical options

Method	Explanation and examples
A. Wetland size	
Wetland size management	The sizing and zoning of wetlands is an important step in the establishment of the size of the water demand through evaporation and seepage.
B. Adjusting area, volume, depth, velocity relations	
Weirs, culverts and gates	Weirs and gates in rivers and ditches can hold water within the environment [10]. Peat dams, wood, metal dams and U-shaped culverts have also been tested [10]. Trade-offs in aeration and flow velocity may occur.
Channel and wetland substrates and morphology	The shape, material, construction and maintenance of waterways alter the balance of water flows, connectivity, levels and losses and related ecological gain. Topsoil can enhance the ecology of man-made wetlands [14]. Natural beds rather than concrete training walls provide benefits [13].
Drainage density/design	Drainage ditches are added or filled in or blanked off to manage water levels and the status of soil and land moisture [12].
Pumping regime	Drainage pumps control levels of water (e.g. Somerset levels [16].)
C. Seepage and leak control	
Surface leak control	Wetland perimeters can be tended to reduce surface spills & leaks that serve a lesser or no environmental purpose.
Lateral seepage control	Sunken cofferdams or impervious sheeting reduce lateral seepage (e.g. Wicken Fen, UK). Options cover bentonite, steel and plastic piling. Membrane lining of drains on wetland side [12] has seen success.
Vertical seepage control	Lining materials reduce vertical seepage and are employed in man-made wetlands and waterway restoration [18, 14].
D. Water delivery control	
Piped supply	Pipes supply water with minimal losses to satellite wetlands and allow adjustment of ratio of wetland storage to throughflow for downstream rivers.
Artificial mist and spray application	Certain flora/fauna species require damp conditions that might best be delivered via misters and sprays. This was being considered in Tanzania [19] to provide mist for a rare type of frog living close to a waterfall.
Navigation aids	Fish ladders at dams are an example of improved aquatic-life navigation.
E. Water use and allocation	
Wetland zoning	Wetlands zoned into hydro-ecological areas with different water regimes. Protected core wetlands provide a nucleus to re-colonise wetlands.
Water scheduling	Water is cycled between aquatic areas in a manner not too dissimilar to the irrigation scheduling of fields [14, 15] to maintain moist conditions.
Water recycling/re-use	Water can be recaptured and recycled within waterways, examples of this are found on the Grand Union Canal, Central England.
Low flow targeting - defining 'optimal flows'	Purposively reducing river flows below normally-accepted flows to accept or force ecological change while managing a trade-off in water re-allocation.
Evaporation and micro-climate control	Surrounding vegetation and landscaping alters micro-climate, humidity and drying. (E.g. Ecologists [12] noted that scrub cover raises evaporation).
F. Water quality management	
Dilution management	Wastewater treated at source necessitates smaller environmental flows to require dilution [6] or cleaned sufficiently to replace potable supplies [17].
Flushing/throughflow control	Environmental freshwater flows required to flush seawater reduced by employing tidal barriers. (The proposed Yare Barrier, UK was an example).
In-situ water, sediment and bed management	Dredging/aerating rivers, lakes and broads with nutrient-rich sediments can enhance water quality and aquatic life [20].
Saltwater replacement	Theoretically, the balance of seawater over freshwater reduces the need for the latter. Applications exist in tidal, mangrove and coastal areas.

The third principle is that the wise use of water should extend to the environment, using options outlined in Table 1. It is understood they will not be applicable or desirable in all situations. However, they show that improved hydro-environmental productivity is attainable. A critical look at the efficacy of wetland management, as implied by these suggestions, is not new [22].

The fourth principle is that supply management is given greater priority in cross-sectoral studies of water management, and that environmental decision-makers be drawn into this aspect. It is partisan to suggest that the sector gaining greatest economic benefit (examined as an opportunity cost) during droughts can opt out of investments which are designed to boost water availability during the same period.

The fifth principle is that the framework of water rights should be more equitable across sectors so that time-limited rights and the rights application process apply to all sectors, not just agriculture. There is a need to incorporate production-orientated values in rights assessment such that water is being used to good environmental purpose. In addition, a system of proportional rights could be considered so that fluctuating supply is more explicitly shared between users.

The sixth principle is that economic instruments to save water should be considered for the environment. In other words, there should be an economic rationale or trade-off in the allocation decision. Even if gains for the environment are not shown to be equal to the losses in other sectors, the analysis should be in the public domain and fully factored.

The seventh principle is that, where possible, community decision-making and public perceptions should be incorporated when establishing environmental water needs. The subject of public expectations of environmental benefits is not without debate; for example, some argue that providing public access to wetlands is just as important as achieving scientific ecological desirables [23].

The eighth principle argues that natural environments do not always require the distribution of water by natural means. Britain's nature is strongly underpinned by a highly managed 'built' system. Therefore, using man-made interventions in strategic locations can generate widespread natural gains enhancing otherwise naturally functioning systems [8]. This principle states that a trade-off in approach is required as well as a trade-off in objectives.

CONCLUSIONS

1. Demand management of environmental water is the maintenance or enhancement of hydro-environmental values and functions while saving water. The paper outlines a number of technical means to effect those savings.
2. The examination of environmental water reveals the need to consider a number of cross-sectoral principles of water policy.
3. It is suggested that an environmental demand management perspective might extend and deepen hydro-benefits for the environment.
4. The marginal benefits of a balance in policy outweigh the costs associated with the perceived unfairness of the Habitats Directive. Even if a small fraction of water is re-transferred from the environment to agriculture in a drought situation because of a more balanced policy, that water may carry with it a disproportionate sense of fair play.
5. Without sufficient emphasis on the wise use of water being applied to the environment, there may be a tendency to rely on supply solutions such as controlling irrigation abstraction.
6. An environmental emphasis, combined with water-policy parity might encourage better analyses of cross-sector hydrological management, which is a widely recognised weak spot.
7. Demand management applied to all sectors releases, cumulatively, more headroom so that functional and productive performance can be maintained across different ranges of hydrological supply, cost and operation.

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