ADAPTATION

Wells of wisdom

Managing climate risks to fresh waters has so far been approached by designing action plans. Now adaptation protocols are integrating knowledge of water-system vulnerabilities into more flexible strategies to keep taps running and ecosystems healthy.

Robert L. Wilby

Managing freshwater resources involves grappling with variations on three types of problem: an area can be furnished with too much water, with too little or the available water may be too dirty to meet human needs[1]. Historically, a central premise of planning has been that natural variability in the hydrological cycle does not shift over time. However, this assumption is being challenged in light of climate change[2]. The question now is how to adapt existing decision-making protocols so that they accommodate more dynamic situations. Writing in *Journal of the American Water Resource Association*, Casey Brown and colleagues[3] propose a flexible framework for combining information from climate models with the best features of 'bottom-up' (or vulnerability-led) approaches to water management.

Over the past 20 years, water-resource plans have typically been designed around a series of plausible futures. These scenarios have been considered without attaching probabilities to them. Some analyses have included the outputs of climate models, which are translated into higher-resolution projections of river-basin impacts for the purpose of evaluating sets of adaptation options[4].

This has brought about a clash of instincts. Water resource managers tend to prefer to plan for a discrete set of futures, whereas climate change scientists bring a greater *a priori* acceptance of uncertainty. Thus managers' scenario-led strategies suppose that climate model projections are sufficiently reliable to make informed investment and planning decisions, placing emphasis on issues of scale and on climate processes that are poorly described in models. This can generate very wide predictions of river flows and lake and groundwater levels, of which the usefulness has been questioned, prompting appeals for greater investment in super-computing and climate modelling[5].

Brown and colleagues began from a different starting point. They developed an approach for the long-term management of Lake Superior in the United States and Canada. The lake's management is important not only because of its size, but because it influences the water levels of many other lakes (Fig. 1). The board of the International Upper Great Lakes Study (the body responsible for planning the lake's management) had already rejected a strategy of selecting an optimal plan based on what seemed to be the most likely future scenario. Instead, therefore, Brown and his team developed a management process that could evolve with changing circumstances.

Their first task was to integrate information about regional climate change with stakeholders' perceptions of vulnerabilities. For this they organized a series of technical meetings in which stakeholder groups from commercial shipping, coastal systems, hydropower, tourism and so on, met to define 'coping zones' in terms of the lake levels that they considered acceptable, survivable and intolerable. These lake levels then served as a common metric against which projections of climate change could be evaluated.

The next step was to work out what regional climate states could tip the system into the less desirable coping zones, allowing the authors to home-in on the climate risk information that is most critical to designing the regulation of water releases into the lake. With reference to the most vulnerable features of the plans, tailored questions could then be asked of climate models about which of these states is more probable than others.

The plans for Lake Superior that result from their work will take the form of a portfolio of adaptation options that are appropriate for a range of conditions. They will be published in March 2012. As conditions change, different plans may be implemented. Non-climatic drivers of the water balance, such as population growth, economic development, shifting societal priorities or changes in land cover could later alter stakeholders' definitions of the coping zones, as well as the extent to which the lake levels fluctuate between them. But with an adaptive management process such changes can be incorporated and the regulation plans for the lake

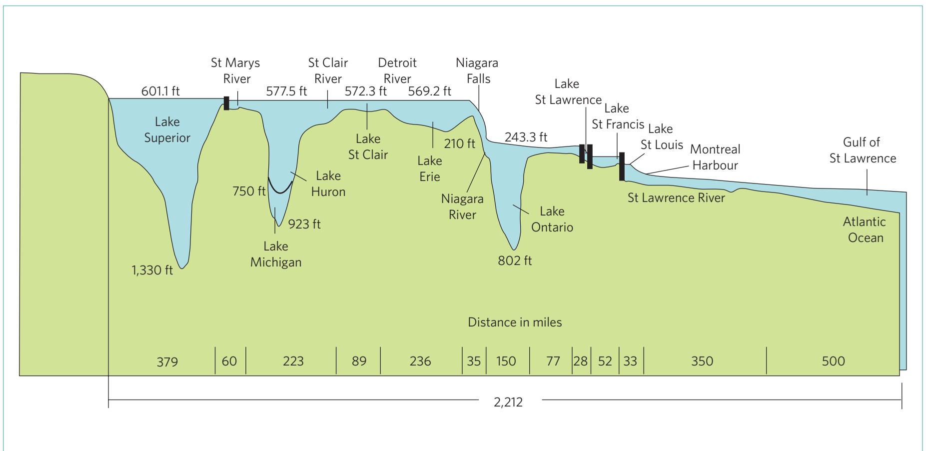

Figure 1 | System profile of the Great Lakes of North America. Due to its relative elevation, the management of Lake Superior's water level has implications for the other lakes in the Great Lakes region. The figure shows typical water surface elevations and comparative lake depths of the Great Lakes. Casey Brown and colleagues[3] developed an approach for the long-term management of Lake Superior that allows an adaptive response to climate change, as well as to non-climatic drivers such as population growth and economic development.

adjusted. Monitoring data will keep the plan in line with evolving conditions. Overall, this strategy should avoid 'lock-in', whereby future options are limited by earlier decisions[6].

But will Brown and colleagues' proposal really work in practice, and can it be applied elsewhere? Some experts contest that climate models were not originally conceived to solve adaptation problems[7] and that palaeohydrological evidence could do a better job of testing system performance under extreme conditions that have actually occurred. Others assert that water management is already in crisis in large parts of the developing world, and that the imperative is not uncertainty about the future, but the certainty of present scarcity.

These arguments apart, the suggested framework is only feasible if other support systems are in place. Adaptive management depends on well-designed, well-maintained and continuously funded monitoring networks. But the long-term business case for such networks can be hard to make compared with less comprehensive early warning systems, particularly during economic downturns.

Staff must also have the technical skills and resources to enable the integration of adaptation practices as part of (rather than in addition to) their day jobs. Professional bodies such as the Water Research Foundation are working hard to improve access to the latest climate risk information and to develop adaptation guidance for practitioners. Yet this is set against widespread de-skilling and downsizing within the water industry.

Furthermore, adaptive water management protocols work best if they are implemented by institutions with strong governance that are themselves flexible enough to adjust their rules according to changing circumstances. This is necessary for securing investment, resolving conflicts and maximizing the benefits of cooperation between evolving organizations.

The work of Brown and colleagues[3] provides an example of how relatively simple adjustments to the way water managers set about making decisions and gathering information could improve resilience to climate change. Crucially, their method is appropriate for the type of information that climate scientists currently provide. Although the work raises important questions about the wider preparedness of society to monitor and manage emerging climate risks, it will hopefully guide others seeking to meet the future water needs of both society and the environment. ❐

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