service to interdisciplinary work, it is really happening now," says Rosenzweig. She leads the Metropolitan East Coast Region for the US National Assessment, which involves teams of researchers and stakeholders from such coastal zone sectors as infrastructure, water resources, human health and institutional decision-making. The National Assessment programme will study the region's vulnerability to climate change. The Metropolitan East Coast is crucial to the assessment, says Rosenzweig, because "we are focusing on the role and response of large cities such as New York".

Rosenzweig also heads an interdisciplinary science team involved in predicting the effect of El Niño on agricultural and marine systems as they relate to food supply. On the private side, she works with a consortium of four major agri-businesses, led by Pioneer Hy-Bred International, to evaluate how regions of interest around the world will be affected by climate change. □

Water and welfare: hydrology options

Potter Wickware

Water supply and quality issues worldwide give hydrologists a broad range of problems and opportunities to occupy them in the years ahead. Ismail Serageldin, vice-president for special programmes at the World Bank and chairman of the World Commission on Water for the 21st Century, says that existing technology can be applied for immediate benefit in developed and developing countries, for example in the reuse of minimally treated water, harvesting rainwater and preventing leaks. At the same time, researchers can work towards economic desalinization methods, discovery of deep aquifers by remote sensing, engineered crops for maximum water utilization in arid regions, and other advanced technologies.

Some areas of need are going completely unaddressed, he says. For example, more needs to be done to mitigate the effects of monsoon flooding and the associated problems of wastewater flushing and water quality. But little research is taking place anywhere in the world in this important area. Basic science is also needed to generate adequate baseline data to make accurate predictions and decisions. "Most environmental statistics at present are unreliable or incomplete, and projections are also bedevilled by the difficulty of modelling interactions among sectors," he says.

Indeed, "why must we rely on water as the means of sanitation, where water and human waste are dumped together, creating major problems and requiring treatments which most developing countries cannot afford?" Serageldin asks. "Scientists should explore how to cut the link between water and sanitation, and thereby dramatically reduce water demand."

Hydrologists' knowledge also plays an increasingly important role in land use decisions, says William K. Michener, at the Joseph W. Jones Ecological Research Center in Newton, Georgia. In the United States, a trend in favour of managed flooding and restoration of wetlands can be seen in the Clinton administration's proposed Clean Water Initiative, which aims for a net increase of 100,000 wetland acres per year. This will be paid for with $2.3 billion in new water-related funding over five years.

The great Midwestern floods of 1993 and 1995–96 taught the lesson that managed flooding is a more sensible strategy than the flood suppression attempts of the past, says Michener. He points out that the licences of many older flood control dams are coming up for renewal by the US Department of Energy. Each licence review provides an opportunity to establish minimum water flow levels and create flow regimes that more closely mimic natural ones. In some cases dams are dismantled altogether, leading to large-scale habitat restoration, as with the 161-year-old Edwards Dam on Maine's Kennebec River and similar proposals for stretches of Idaho's Snake River. In 1993, 160 licences affecting 262 dams on 105 rivers expired; half of these relicensing actions are still under way. Some 550 more dams are due for relicensing in the next 15 years.

Finally, hydrologists' expertise is called on for policy recommendations as efforts gain momentum to strengthen the Clean Water Act, reorganize the activities of the US Army Corps of Engineers, and reframe the federal flood insurance programme.

The after-effects of mining present a quite different sort of problem and opportunity for hydrologists. Kirk Nordstrom, a hydrologist with the US Geological Survey in Boulder, Colorado, describes the Iron Mountain Superfund site, where groundwater percolates through faults, saturating metal-sulphide formations and generating copious acid drainage. The lack of buffering potential in the surrounding matrix and the vigorous sulphide- and metal-oxidizing activity of acid-adapted soil bacteria produce a witches' brew of concentrated heavy metals in a negative pH solution upstream of fisheries, population centres and agricultural land in California's upper Sacramento Valley. Although the US Environmental Protection Agency has the situation in hand for the time being, a permanently engineered solution based on sound geological and hydrological knowledge has yet to be proposed.

Water supply and quality problems afflict many parts of the world, but the same sets of multidisciplinary technical, social and political skills are needed everywhere to effectively manage them. D. M. Smith, an environmental plant physiologist with the Institute of Hydrology in Oxford, England, collaborates with scientists in Kenya to examine below groundwater interactions between trees and crops. Chiefly motivated by the problem of land degradation and desertification, Smith says he tries to develop systems of land use that balance exploitation of resources, including water, with conservation. This reduces to a problem of engineering combinations of trees and crops that fit a particular locality. But, after factoring in the social, cultural and economic issues, climate change and high rates of population growth, the problems become complex. "As a consequence," he says, "hydrologists working in this field will be most effective when they work together with, for example, agronomists, economists and anthropologists."

He also stresses that the work must be participatory, with farmers and scientists working together. When he worked in Niger, West Africa, Smith says he would sit under a shady tree with groups of farmers to decide on experiments that could be done in their fields. "The advantages of collaboration over prescription are plain," he says. "When something works, the farmers will have been instrumental in making it happen, will have assessed the risks inherent in changing their practices and will therefore be more likely to adopt the measure permanently."

Smith adds the qualification that, although the community-based approach is effective for adaptive research, it is less straightforward for process-oriented research. For example, the investigation of micrometeorological control of soil evaporation is difficult with participatory methods. This makes it harder to obtain funding for this type of research in developing countries.

Funding, of course, is critical to getting the job done at all. Just as water is maldistributed in the world, so is money for water-related research. The United Kingdom can support research by a couple of hundred scientists at its Institute of Hydrology. But a country such as Niger has scanty financial resources, although it has the scientists, trained locally and overseas. The solution, in Smith's view, is to "twin" research institutes in the north and south. Scientists in developing countries would be provided with funding, training and access to state-of-the-art techniques and instruments.

"I believe there is scope for twinning research institutes, rather as towns are twinned across Europe — between England and Romania, for example. Such a scheme would be particularly apt for environmental science, because scientists from the north and south face similar issues. Ideally, twinning would come with a long-term source of funding for training and reciprocal visits to promote collaboration, perhaps funded by the United Nations or World Bank," he says. □