Implementing environmentally sound management of inland waters

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While it is now widely accepted that the harnessing of water resources can make a major contribution to economic progress in various parts of the world, there is also increasing concern about the adverse environmental effects that such development may produce. Reviewing experiences in several countries, however, it seems that it may be possible to reconcile the management of water resources and the maintenance of environmental integrity. The paper assesses the likelihood of a reconciliation taking place in the light of a number of trends in contemporary water management. While many of these trends are in the direction of harmonious development, the pace of accommodation has typically been slow and erratic. The authors offer some suggestions as to how this might be overcome through modifications in legislation, policies, procedures and administrative structures.

Keywords: Water resources; Environment; Water management

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The provision of a safe water supply and satisfactory sanitation facilities for the world's population is now widely accepted as a highly desirable and urgent goal. So also is the reduction of damages from droughts and floods that collectively result in the loss of tens of thousands of lives and billions of dollars of property damage and income across the world each year. It is also agreed that a firm attack must be made on the mounting pollution of water, the atmosphere and the land. Stimulated in large part by the resolutions of the United Nations Conference on the Human Environment (Stockholm, 1972), Human Settlement (Vancouver, 1976), Water (Mar del Plata, 1977) and Desertification (Nairobi, 1977), a wide variety of programmes have been initiated by individual nations and by international bodies, including the United Nations, the World Bank and Regional Development Banks.

Some success can be justly claimed from these efforts.[1] From data produced by the World Health Organization (WHO) from surveys undertaken in 1976, 1980 and 1983, it is evident that far more people had access to clean water in 1980 than in 1970.[2] Important progress has also been made in the provision of sanitation facilities and the reduction of losses from droughts and floods.[3] All the same, the gap between what is desired and what has been attained remains large. Progress has been much greater in urban areas than in rural ones. It has also been more profound in South-east Asia and East Asia than in Latin America, the Caribbean region and Africa.

Several factors have been responsible for the relatively slow rate of progress. One is that the costs of providing the needed facilities is enormous and far beyond the abilities of the regions that need them most to pay for. Even with a massive infusion of international aid it would be impossible to meet the targets that have been set. Current estimates for providing safe water supplies and adequate sanitation facilities for the world's population range upwards from $365 billion. Experience over the past few years and various deficiencies in the coverage of surveys of the situation suggest that this figure is far too low.[4] Ultimately, it may be more in the region of $500 billion. Even

more money will be required for programmes dealing with other water problems.

A second reason for the gap between targets and achievements has been rapidly escalating costs, including interest rates. In many countries inflation rates have exceeded 10% in the past decade. A third factor has been continued population growth. In many of the Third World countries, especially where the needs for water supply and sanitation facilities are greatest, population is growing at rates in excess of 3% per annum, thus exacerbating the problem of closing the gap. A fourth difficulty stems from the fact that many of the world's major water bodies are shared by several nations, thus increasing the importance of cooperation and coordination in water management. Unfortunately, the tendency is to seek independent alternatives first, thus raising the possibilities of conflicts on the one hand and avoiding the potential for cost reductions from jointly developed programmes on the other.[5]

Fifthly, there has been a growing concern about the environmental and social impacts of water development. Projects that have been intended to stimulate economic growth or provide more food have sometimes had adverse effects on agricultural lands, forests or fisheries and on native communities. The Aswan Dam is often cited as one example. The Peace River project in British Columbia is another.[6] Others in Africa and elsewhere have also been cited.[7] Questions have inevitably been raised as to whether the goals that are being sought in water development programmes can be achieved without serious disruption of the environment or severe social impacts.

The matter of environment and development became an issue of increasing international concern in the mid-1960s. At that time the prevailing view seemed to be that environmental disruption was an inevitable price to be paid for economic progress. Since then, however, this position has been increasingly challenged in fora organized by various United Nations bodies, in the scholarly literature and elsewhere. There is growing consensus today that, given certain preconditions, *both* economic development and environmental management can be pursued simultaneously.[8] Arguments supporting this shift in viewpoint have focused predominantly on the water resources scene. It is here perhaps that the apparent conflict has been particularly sharp but also where the attempts to find an accommodation have been most sustained.

This paper is intended as an initial attempt to address the issue of the manner in which the philosophy underlying environmentally sound water management can be encouraged and facilitated on an even wider scale. It takes the view that the key to reconciling the apparent conflict between development and environment lies in the incorporation of three critical elements in planning and policy making:

1. recognition of the concepts of sustainable development and resilience;
2. the adoption of a comprehensive viewpoint; and
3. the pursuit of higher levels of efficiency.

What is environmentally sound water management?

Any attempt to develop water resources results in some modification of the environment. Sometimes the impact is expressed mainly in the river region, aquifer or lake itself, as in an alteration in the normal flow or the

[1]For a review of international developments during the past decade, see Asit K. Biswas, *Overview Paper*, Interregional Symposium on Improved Efficiency in the Management of Water Resources, United Nations, New York, NY, 5–9 January 1987; and Asit K. Biswas, *Freshwater Strategies, Problems and Prospects,* Working paper, Oxford, October 1981.

[2]*Ibid.*

[3]Peter G. Bourne, ed, *Water and Sanitation: Economic and Sociological Perspectives*, Academic Press, New York, 1984.

[4]Asit K. Biswas, 'Water for the Third World', *Foreign Affairs,* Autumn, 1981, pp 148–166.

[5]Biswas, *op cit*, Ref 1.

[6]Peace-Athabasca Delta Project Group, *The Peace-Athabasca Delta: A Canadian Resource,* Information Canada, Ottawa, 1972.

[7]United Nations Development Programme, *River Basin Development: Policies and Planning,* United Nations, New York, NY, 1976 and W.M. Warren and N. Rubin, eds. *Dams in Africa: An Inter-Disciplinary Study of Man-Made Lakes in Africa,* Frank Cass, London, 1968.

[8]M.K. Tolba, *Development Without Destruction,* Tycooly International, Dublin, 1982.

quality of the water body. In other instances the effects are much more widespread and may result in considerable alterations in land resources, forests or fisheries. Beyond this, water development may have major impacts on human settlements and economic activities. The seriousness of these impacts depends upon the ability of the various physical, natural and human systems to absorb them, as well as human perceptions about them.[9]

To some degree the environmental impacts of water management are beneficial, particularly when they open up new avenues for economic development or social improvement without serious impairment of the resource base or the ecological system. The creation of a reservoir, for example, may provide additional habitat for the raising of fish or new opportunities for water-based recreation. Often, however, environmental consequences are adverse, varying in the degree of their intensity and social acceptability.

Broadly, three types of environmental effects of water development are recognized.[10] The first is physical and generally results from the alteration of river and ecosystem regimes as a consequence of the construction of control works, such as dams or levees.[11] There are numerous examples: siltation is one. Reference is frequently made to reservoirs that were created for the generation of hydroelectric power, but where the rate of accumulation of sediments was so rapid that a major reduction of generating capacity occurred within a few years of the construction of the associated dam. The Sanmen Dam on the Huang He (Yellow River) in China provides an especially dramatic illustration. The damming of the river began in 1960. By 1984 the generating capacity had been reduced by more than 75% of that available 24 years earlier. The Sanmen case is perhaps an extreme one, but there are other dramatic examples. The useful life of the Ambukloo Dam in the Philippines has been reduced from 60 years to 32 years because of increasing sedimentation resulting from deforestation in the upper region of its watershed. Similar difficulties have been experienced with other projects in various parts of Asia and Africa.[12]

Other problems also result from alteration in siltation patterns, as has been dramatically illustrated in the case of the Aswan Dam in Egypt. Not only is the reduced flow contributing to severe erosion downstream, but it has been responsible for the reduction of plankton and organic carbon below the dam and hence the destruction of a formerly thriving sardine fishery.

Dam construction in certain regions may also occasion severe salinization. In some cases the impact may be so adverse that it eliminates the productive capacity of agricultural land. Over 50% of the irrigated land in the Euphrates valley in Syria and the lower Rafadain plain in Iraq suffer from salinity and waterlogging. In Iran such problems affect 15% of the total area of the country. In Pakistan more than 27 million acres out of 31 million irrigated acres are severely affected.[13]

Another physical problem that results from dam construction in certain regions of the world is that of the accumulation of aquatic weeds. Serious difficulties have been encountered as a result of weed growth in the reservoirs at Swan, Kamba, Pa Mong and Brokopondo. In the latter instance the water hyacinth spread so rapidly that within two years it had covered over 50% of the surface of the Brokopondo reservoir. Elsewhere various types of aquatic weeds cover more than 80% of the

[9]Asit K. Biswas, 'Environmental consequences of water resources development', Keynote address for 4th Congress, Asian and Pacific Regional Division, International Association for Hydraulic Research, Chiang Mai, Thailand, 11–13 September 1984.

[10]Asit K. Biswas, 'Water: a perspective on global issues and policies', *The Journal of The Water Resources and Planning Division,* Proceedings of the American Society of Civil Engineers, Vol 105, No WR2, 1979, pp 205–222.

[11]Asit K. Biswas, 'Impacts of hydro-electric development on the environment', *Energy Policy*, December 1982, pp 349–354.

[12]Biswas, *op cit*, Ref 9, and see also Asit K. Biswas, 'Irrigation in Africa', *Land Use Policy,* Vol 3, No 4, October 1986, pp 269–285.

[13]M. El-Gabaly, 'Problems and effects of irrigation in the Near East region', in E.B. Worthington, ed, *Arid Land Irrigation in Developing Countries,* Pergamon, Oxford, 1977, pp 239–249.

water-courses in Egypt and vast areas in the Congo basin. The accumulation of weeds has a variety of impacts, but the most notable are losses through evapotranspiration. Costs of weed clearing may be in the order of millions of dollars and sometimes the effects of the remedy may be even more destructive or hazardous that the weeds themselves. The use of herbicides is an example.

A second type of environmental effect associated with water development in some parts of the world is the creation of favourable habitats for the parasitic and water-borne diseases such as schistosomiasis, liver fluke infections, filariasis and malaria. This has been particularly true of certain irrigation projects in tropical and subtropical regions. In Egypt, the replacement of simple primitive irrigation with perennial irrigation has led to a considerable increase in the incidence of schistosomiasis in that country with perhaps as many as half of the inhabitants of some parts of the newly irrigated acres now suffering from the disease. A similar story can be told about the infiltration of the blood fluke in the Sudan as a result of the development of the Gizera irrigation scheme. In some countries in the Far East irrigation development has led not only to rapid spread of schistosomiasis but also liver fluke infections, eosinophilic meningitis and bancroft filariasis.[14]

A third type of environmental disruption may also occur as a result of water resource development. This is the disruption of human settlements and human activities. The construction of the Kariba Dam on the Zambesi required the resettlement of some 75 000 Tonga tribesmen and the creation of the Lake Nasser reservoir behind the Aswan High Dam necessitated the removal of more than 100 000 people. At least 80 000 had to move when the Volta Dam was built in Ghana. Considerable problems were encountered in each instance not merely in finding new sites for settlement but also in furnishing food for those who had to move and in controlling the spread of certain diseases such as sleeping sickness.

It is clear from the above that environment has a wide variety of meanings and that environmental disruption can take many forms. In some instances water projects may even result in the destruction of the resource on which they depend. It is also apparent that severe damage may be sustained by other resources or by activities in addition to those directly related to water development. At the same time experience across the world indicates that many of the problems of reconciling development and environment result from a failure to consider them simultaneously. Thus in many cases there are ministries of industry and development which work in isolation from ministries of the environment. Often, too, the latter may be isolated from ministries dealing with various resources. Such separation clearly militates against the adoption of a holistic view. In addition, there is typically little attention given to possibilities for improving efficiency in the use of capital on the one hand and the use of water on the other. An overemphasis on construction alternatives has deflected attention from such options as demand management, which would not only reduce capital requirements but also be environmentally less disruptive. Various commissions and authors have observed that there is enormous waste in water supply systems, notably those involved in urban water supply and irrigation. They have also drawn attention to advantages of pricing mechanisms which reflect the true costs of supply and the value of water in use.[15]

Recognition of these disadvantages and deficiencies has led to

[14]Biswas, *op cit*, Ref 10 and Asit K. Biswas, 'Health, environment and water development: an understanding of interrelationships', *The Environmental Professional*, Vol 7, 1985, pp 128–134.

[15]US National Water Commission, *Water Policies for the Future*, US Government Printing Office, Washington, DC, 1973; Jack Hirschleifer *et al*, *Water Supply: Economics, Technology and Policy*, University of Chicago Press, Chicago, 1960 and P.H. Pearse, F. Bertrand and J.W. MacLaren, *Currents of Change*, Final Report of the Inquiry on Federal Water Policy, Environment Canada, Ottawa, September 1985.

increasing pressure for the specific inclusion of environmental effects as a consideration in water resources planning and policy making. It was given considerable impetus as a result of the proposal for a World Conservation Strategy by IUCN and UNEP in 1980 in which the key concept was 'sustainable utilization of species and ecosystems'.[16]

Environmentally sound water management implies that:

1. development be controlled in such a way as to ensure that the resource itself is maintained and that adverse effects on other resources are considered and where possible ameliorated;
2. options for future development are not foreclosed; and
3. efficiency in water use and in the use of capital are key criteria in strategy selection.

Recognizing these ideas is one thing; translating them into action is another. What needs to be done beyond the preparation of handbooks, staging of training programmes and conducting of planning experiments? More specifically, what is required to foster the adoption of the three elements noted above in planning and policy making, namely the recognition of concepts of sustainable development and resilience, the incorporation of a more comprehensive perspective and the pursuit of higher levels of efficiency?

None of the elements is entirely new. All have been introduced in varying degrees across the world. We turn now to an examination of a number of themes of contemporary water management which incorporate one or more of the three elements.

Themes of contemporary water management

There have been some important changes in the approach to water management in various parts of the world during the past 30 years or so. Seven sets of concepts or themes may be identified, as follows:

1. the adoption of a comprehensive viewpoint;
2. the promotion of a search for the widest possible range of choice;
3. the recognition of water as an economic good;
4. the use of the river basin as a unit of area in various phases of water management;
5. the involvement of the public in planning and policy making;
6. the consideration of environmental impacts; and
7. the assessment of social effects.

Comprehensive viewpoint

The adoption of a comprehensive viewpoint implies the recognition of several important concepts in water management.[17] One is that there are numerous potential uses of a given resource and that each has some effect on all the others. Occasionally, the pursuit of one may preclude several others, as in the use of a stream for the disposal of toxic wastes. Optimal use of the stream can only be attained if all the potential uses are considered simultaneously and a combination is chosen that conforms to a selected criterion, such as the maximum net economic return or the preservation of a particular ecological web.

A second concept is that use can sometimes be enhanced if several purposes are pursued simultaneously, that is, in a multiple purpose project.[18] There are numerous possibilities, such as in hydroelectric

[16]International Union for the Conservation of Nature and Natural Resources (IUCN), *World Conservation Strategy: Living Resource Conservation for Sustainable Development,* Gland, Switzerland, 1980.
[17]Gilbert F. White, *Strategies of American Water Management,* University of Michigan Press, Ann Arbor, MI, 1969.
[18]Gilbert F. White, 'A perspective on river basin planning', *Law and Contemporary Problems,* Vol 22, No 2, 1957, pp 157–187.

power generation, flood control and irrigation development, as illustrated by the Columbia River scheme or in the development of the Tennessee Valley in the USA.

A third idea is that of the interrelationship of water development to the development of other resources. Water schemes often have effects upon land resources, as in erosion or the flooding of agricultural land. Similarly, land use practices can influence both run-off and water quality. Removal of vegetation or the introduction of irrigation are illustrations. Obviously the pursuit of particular goals in water development may impair the attainment of objectives in the management of other resources and vice versa. It makes sense, therefore, to identify such interrelationships and seek accommodation of effects in water planning.

Fourthly, a comprehensive viewpoint may imply the integration of water planning with overall economic and social planning. This is especially important when water is scarce and is vital to an economy, as in Israel or Jordan, or when water development is costly and may account for a large proportion of capital investment in a country. This is particularly true in Third World countries; but it has become increasingly so in a number of industrially advanced ones as well, notably the UK.[19]

Finally, the adoption of a comprehensive viewpoint has implied a recognition that water resources management requires inputs from a wide range of disciplines. Today the engineering profession is joined increasingly by specialists from such disciplines as economics, law, geography, sociology, biology and even psychology. A measure of the sophistication that water planning has reached may well be the number of disciplines that have been called upon to make concrete contributions to it.

The adoption of a more comprehensive viewpoint has been accomplished through a variety of modifications to existing institutions. These include the integration of *purposes* of management (such as provision of water supply, improvement of water quality, flood control, water-based recreation, etc). Initially each purpose is undertaken independently, usually with separate legislation and administrative agencies. Eventually conflicts appear and economies of integration also become apparent. Larger, more comprehensive water agencies are then established. Increasingly today, the tendency is to link water development with other resource development, and, even more, to environmental management. The omnibus ministry of natural resources or ministry of the environment has become a widespread feature in North America, Western Europe and several other parts of the world.

A similar process of integration may be envisioned with respect to specific *functions* of water management, such as data collection, research, regulation and development. As depicted in Figure 1, there is a gradual increase in the scale and sophistication of functions. With respect to data, for example, the initial focus is upon the supply side; but it slowly expands to embrace the demand side and various economic, social and environmental considerations as well. It may be noticed that as the scale of management grows there is a growing tendency for government involvement to increase, reflecting in large measure the need to reconcile conflicts, provide public goods and to link water management to overall economic and social development.

[19]Dennis J. Parker and E.C. Penning-Rowsell, *Water Planning in Britain*, George Allen and Unwin, London, 1980.

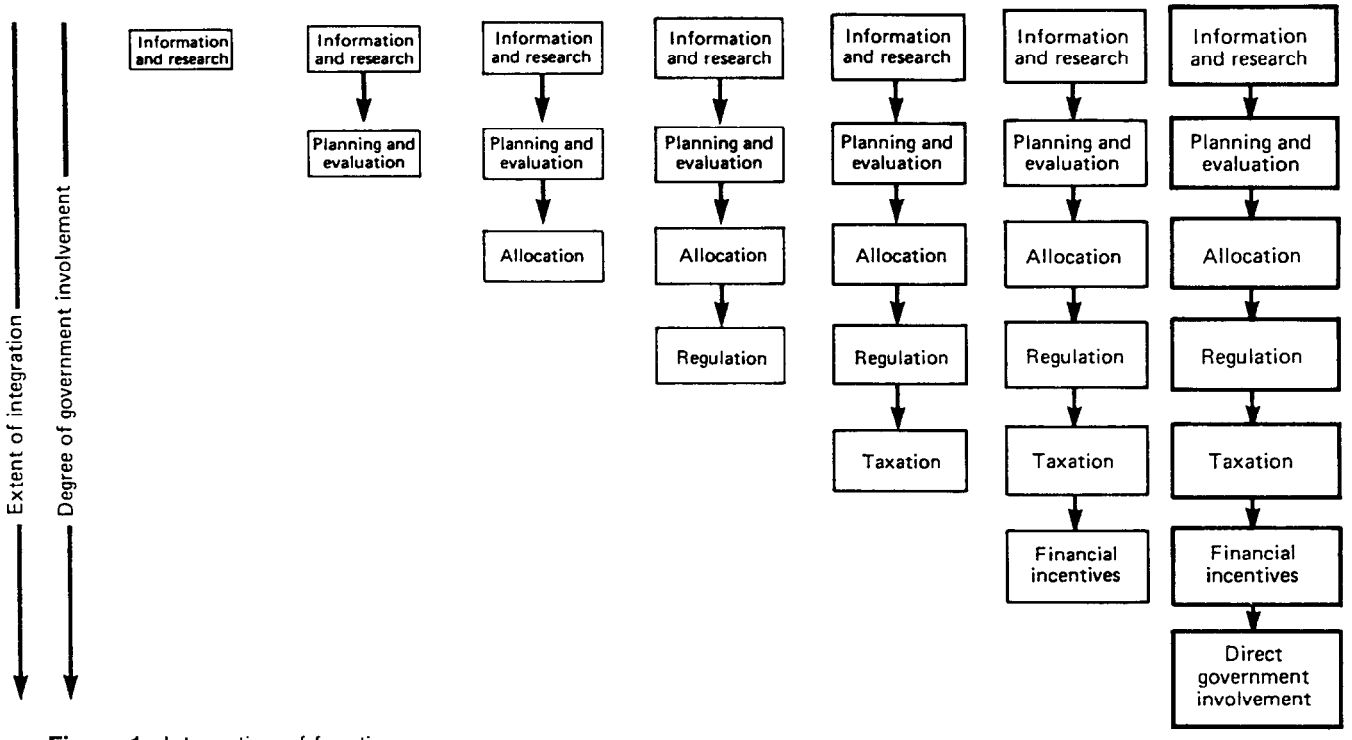


Figure 1. Integration of functions.

[20]Gilbert F. White, *Choice of Adjustment to Floods,* University of Chicago Department of Geography Research Series, No 93, Chicago, 1964 and D.I. Smith and J.W. Handmer, 'Urban flooding in Australia: policy development and implementation', *Disasters*, Vol 8, No 2, 1984, pp 105–117.

Range of choice

Theoretically there are several possible ways in which a given water problem might be dealt with or a water-related service provided. White and Smith and Handmer[20] have shown, for example, that there may be as many as a dozen different strategies for reducing flood losses (Table 1). An impending water shortage in at

Table 1. Classification of flood adjustments: structural/non-structural, mode of implementation and the theoretical effect on losses.

	Governmental[a] Engineering[b]	Institutional[c]	Individual	Effect on losses
Structural	dams levees diversions and channel improvements retarding basins			Prevent losses
Non-structural		acquisition	house raising	
		non-regulatory measures: fiscal and financial incentives, infrastructure provisions	small levees other flood proofing local warning systems	Modify losses
		regulations: zoning, subdivision and building regulations	response to warning salvage	
		information and education		
		forecasts, warning systems, emergency plans		
		salvage		
		state and national emergency services		Redistribute loss
		insurance		
		relief		
Do nothing				Accept loss

[a]Governmental measures are those requiring a central authority to make and enforce regulations, to administer financial incentives/disincentives and to finance, construct and maintain major works. In the last case involvement may be through an agency regulating private enterprise; [b]Engineering refers to the construction of major public works; institutional measures are those requiring the direct involvement of government authorities through, for example, land use regulations, or their indirect involvement as guardians of the public interest, for instance by controlling the insurance industry.

Source: Smith and Handmer, *op cit*, Ref 20.

Table 2. Alternatives for meeting increasing demands.

Goals	Approaches	Techniques
Bear shortage or pollution		
Use available supply	Storage	Reservoirs Storm catchment
	Transport	Aqueducts Ground pumpage Motive transport
Increase overall supply	Precipitation inducement	Cloud seeding
	Increase and capture snow and ice-melt	
Improve water quality	Treat influent	Fresh water purification Desalination
	Treat effluent	Advanced waste treatment
Change water use	Reduce use or alter demands	Price curbs/metering Use restrictions Recycling
	Curb waste	Evapotranspiration reduction Seepage reduction
	Alter distribution	Dual supply lines Directed pipelines Bottled water

Source: James F. Johnson, *Renovated Waste Water*, University of Chicago, Department of Geography, Research Paper No 135, Chicago, 1971.

least nine alternative ways (Table 2). Experience in North America, Europe and elsewhere has shown, however, that only a limited range of such options is typically considered by water managers[21] and that this may lead to suboptimal choices, as reflected in higher economic costs, significant social losses or major environmental damages.

In several countries there is now a conscious attempt to canvass as wide a range of options as possible and to review the implications of adopting each of them. In the case of flood losses, for example, land use regulation and structural adjustments are considered side by side with various construction alternatives. Where water quality is at issue, incentives as well as penalties are now taken into account. Moreover, there are attempts to deal with the causes as well as the symptoms of pollution problems (Table 3).

Water as an economic good

There has been mounting pressure from economists and others in recent years for water to be treated like any other natural resource, such as forests, fisheries or minerals: that is, to regard it as an economic good which can be traded in the market. Fees, it is argued, should be charged by the owner (generally the government) for its use and the price of services provided by its development should satisfactorily reflect the

[21]W.R. Derrick Sewell, 'The New York crisis: an opportunity for more effective management of urban water supplies', *Journal of Geography*, November 1966, pp 384–389. Also, by the same author, 'Environmental perceptions and attitudes of engineers and public health officials', *Environment And Behaviour*, Vol 3, No 1, March 1971, pp 23–59. See also White, *op cit*, Ref 20.

Table 3. Opportunities for applying institutional instruments for water pollution control.

Production–consumption stage	Policy instruments
Input mix	Use charges, taxes, pricing, raw material specification, subsidies/grants
Production	Land use zoning, taxes, subsidies/grants, process specification
Product output	Product specification, taxes
Product use	Taxes, pricing, subsidies/grants
Pollutant discharge	Collective treatment, (user charges) emission standards, subsidies/grants, dilution rights/transferable discharge permits, withhold discharge during periods of low flow
Environment (ambient water)	Ambient standards, mixing zones specification

Source: L. Grima, 'Institutional instruments for water pollution control', *Geo Journal*, Vol 5, No 5, 1981.

cost of supplying them. Marginal costs rather than average costs should be used as the basis for pricing such services. Economists also argue that water should be allocated among competing users or uses on the basis of the economic value derived, that is, the value in use. The higher the value, then the more the user will be willing to pay. Finally, they suggest, the scope and scale of water projects should be determined through a comparison of benefits and costs. Such an evaluation would weigh the gains and losses of various scales of development and various combinations of uses. Optimum scales and combinations would be those which produced the largest net benefits.

Recognition of such concepts has taken a variety of forms in water resources planning. Cost–benefit analysis, and more sophisticated derivations of it, is now used by water agencies all over the world. There is an extensive literature describing its conceptual underpinnings and its potential applications. There are several handbooks that show how to use the technique.

In addition to introducing and refining cost–benefit analysis, economists have helped to improve water demand forecasting. At one time estimates of future demands were based on little more than straightline extrapolations of recent water use. No account was taken of such factors as the elasticity of demand or changes in technology or product mix. Research on such matters has materially helped improve forecasting techniques.[22]

The river basin as a unit of area

The river basin has become increasingly accepted as a unit for water resources management.[23] The rationale stems from the concept of a river as an organic entity, so that interference with or modification of any part of it will be felt elsewhere in the system. Engineers and geographers in particular have expoused the idea.[24] Economists too have recognized it, since it is an attractive way of 'internalizing externalities'.[25]

The extent to which the river basin has been adopted as a unit, however, has varied considerably. In England and Wales, France and Jordan it is now used as the unit for all phases of water management in the country as a whole. In some countries it is employed for the management of water in specific regions, such as in the Tennessee Valley in the USA or in the Conservation Authorities in Ontario in Canada. Its most extensive use has been as a basis for the collection of data on water quantity and quality. Increasingly, however, it is being employed as the unit for water resources planning. Worldwide, examples can be found, as also manuals describing principles and setting out data requirements and procedures.

Public involvement

Thirty years ago there was little attempt in most countries to consult the public on goals and strategies in water planning. The same was true in many of them even a decade ago. Generally, it was believed that planners and politicians could accurately gauge what the public wanted and how it would react to what was provided.[26] Where public consultation did take place it was almost always at the end of the planning process. Mounting pressure, on grounds both of ethics and pragmatism, however, has resulted in a major shift towards a more direct role for the public in shaping options and in making decisions.[27]

[22]W.R. Derrick Sewell and Blair T. Bower, eds, *Forecasting and Demands for Water*, Queen's Printer, Ottawa, 1969 and J. Kindler and C.S. Russell, eds, *Modeling Water Demands*, Academic Press, New York, 1984.

[23]White, *op cit*, Ref 18 and Ludwik A. Teclaff, *The River Basin in History and Law*, Martinus Nijhoff, The Hague, 1967.

[24]Bruce Mitchell and James S. Gardner, eds, *River Basin Management: Canadian Experiences*, Department of Geography Publications Series, University of Waterloo, Waterloo, Ontario, 1983.

[25]Allen V. Kneese and Blair T. Bower, *Managing Water Quality, Economics, Technology, Institutions*, Johns Hopkins University Press, Baltimore, MD, 1968.

[26]Albert E. Utton, W.R. Derrick Sewell and Timothy O'Riordan, eds, *Natural Resources for a Democratic Society: Public Participation in Decision-Making*, Westview Press, Boulder, CO, 1976.

[27]John C. Pierce and Harvey R. Doerksen, *Water Politics and Public Involvement*, Ann Arbor Science, Ann Arbor, MI, 1976.

Table 4. Strategies for public involvement.

1. Public opinion polls and other surveys
2. Referenda
3. The ballot box
4. Letters to editors or public officials
5. Public hearings or inquiries
6. Advocacy planning
7. Representations of pressure groups
8. Public meetings
9. Workshops or seminars
10. Protests and demonstrations
11. Court actions
12. Task forces

Increasing time, commitment and value of feedback ↓

Public involvement, of course, can take a wide variety of forms (Table 4). In some cases it amounts to little more than tokenism, with plans submitted for public approval, sometimes through the ballot box or in the public hearing at the end of the process. Sometimes there is no dialogue at all. Increasingly, however, a more productive role has been created in which a wider range of perspectives and talents can be called upon. The task force and the workshop are illustrative. Particular progress in this respect has been made in Canada, New Zealand and the USA.[28] Attempts are now being made in several developing countries, especially in Asia, to involve water users directly in water management processes. In Pakistan it has now become a legal requirement.[29]

Environmental impacts

The assessment of the impacts of water development projects on the environment has come to be recognized as an integral part of planning. Until about 15 years ago there was little or no public concern about such matters and professionals in the water industry saw no reason to be worried about anything other than the manner in which environmental modification would affect the efficient operation of facilities. Today, however, water management agencies almost everywhere are highly conscious of the need to identify and evaluate the impact of projects on physical phenomena and on ecological systems. In some countries environmental impact assessment is now an elaborate process, often involving research and considerable interaction with various interest groups within the public.[30] In some cases guidelines are provided as to what should be taken into account and how various impacts should be measured. Properly done, impact assessment involves a wide range of disciplines and a wide spectrum of interests.[31,32]

Social impacts

Over the past 30 years attention in the evaluation of water resources plans has gradually shifted from technical considerations to economic and environmental factors. More recently it has begun to embrace social impacts as well. Questions are being posed, for example, as to how far given schemes will disrupt traditional lifestyles, create ghost towns once construction is completed or set in motion a train of native land claims or a movement for a new political structure. Such questions have particular relevance in northern North America where clashes between quite different sets of cultural values are inevitable. Similar concerns have begun to arise in other areas too, notably in New Zealand where Maoris' lands and other rights might be involved and in Australia where there is growing pressure for the recognition of aboriginal rights.

Several responses have been made. One has been to highlight social effects in environmental impact assessments relating to water development projects. Another has been to foster the preparation of broadly based strategic plans for regions which are presently sparsely inhabited but which may come under considerable pressure for development in the future. In Canada the lead for such planning to date has come mainly from proposals for offshore hydrocarbon development, as in the Beaufort Sea or Lancaster Sound. But some of it will have relevance to water resources as well. Possible developments in the Mackenzie River basin are a case in point.[33]

Each of the themes has resulted in a variety of institutional responses. Sometimes this has been expressed in wholesale restructuring of water

[28]W.R. Derrick Sewell, 'The future of public participation in water resources planning and policy-making', in Barry Sadler, ed, *Water Policy for Western Canada: The Issues of the Eighties*, University of Calgary Press, Calgary, Alberta, 1983, pp 77–85; also B. Sadler, ed, *Involvement and Environment*, Environmental Council of Alberta, Edmonton, Alberta, 1978; also Barry Sadler, ed, *Public Participation and Decision-making; Strategies for Change*, Environmental Council of Alberta, Edmonton, Alberta, 1980.

[29]Asit K. Biswas, 'Public participation in water resources planning and policy making', Keynote address, International Symposium on Decision Making in Water Resources Planning, Oslo, Norway, 5–7 May 1986.

[30]Timothy O'Riordan and W.R. Derrick Sewell, eds, *Project Appraisal and Policy Review*, John Wiley, Chichester, 1981.

[31]W.R. Derrick Sewell and B.R. Little, 'Specialists, laymen and the process of environmental appraisal', *Regional Studies*, June 1973, pp 161–171.

[32]Asit K. Biswas and Qu Geping, Environmental Impact Assessment for Developing Countries, Tycooly International, Oxford, 1986.

[33]Barry Sadler, ed, *Water Policy for Western Canada: The Issues of the Eighties*, University of Calgary, Calgary, Alberta, 1983.

management legislation, policies and administrative apparatus, as occurred in England and Wales in 1963[34] and in France in 1964.[35] More often it has fostered institutional changes with respect to a particular water use or a particular water management purpose, such as reduction of damages from floods or droughts, as was the case in the USA,[36] or Canada.[37] A brief indication of some of the responses is provided in Table 5.

Experience in the adoption of the various concepts has varied considerably from one country to another. This has reflected the fact that problems vary both in their nature and severity from place to place. It has also reflected differences in political culture. In some countries there is an almost built-in penchant for change; in others there is an overpowering respect for the traditional way of doing things. Besides this, some countries are spurred into innovation by necessity while others can afford the luxury of biding their time.

It is possible to discern, therefore, a spectrum of adoption. Some countries have introduced several of the ideas with great enthusiasm. In

[34]W.R. Derrick Sewell and Lorna Barr, 'Evolution in the British institutional framework for water management', *Natural Resources Journal,* Vol 17, 1977, pp 395–413.
[35]Jean-Loic Nicolazo-Crach and Claude Le Frou, *Les Agences Financières de Bassin,* Pierre Johanet, Paris, 1977.
[36]Gilbert F. White, 'Optimal flood damage management: retrospect and prospect', in Allen V. Kneese and Stephen C. Smith, eds, *Water Research,* Johns Hopkins Press, Baltimore, MD, 1966, pp 251–270.
[37]R.B. Macklock and G.A. Page, 'Cutting our flood losses', in W.R. Derrick Sewell and Mary L. Barker, eds, *Water Problems and Policies,* Department of Geography, University of Victoria, Victoria, BC, Canada, Cornett Series, No 1, 1980, pp 7–121.

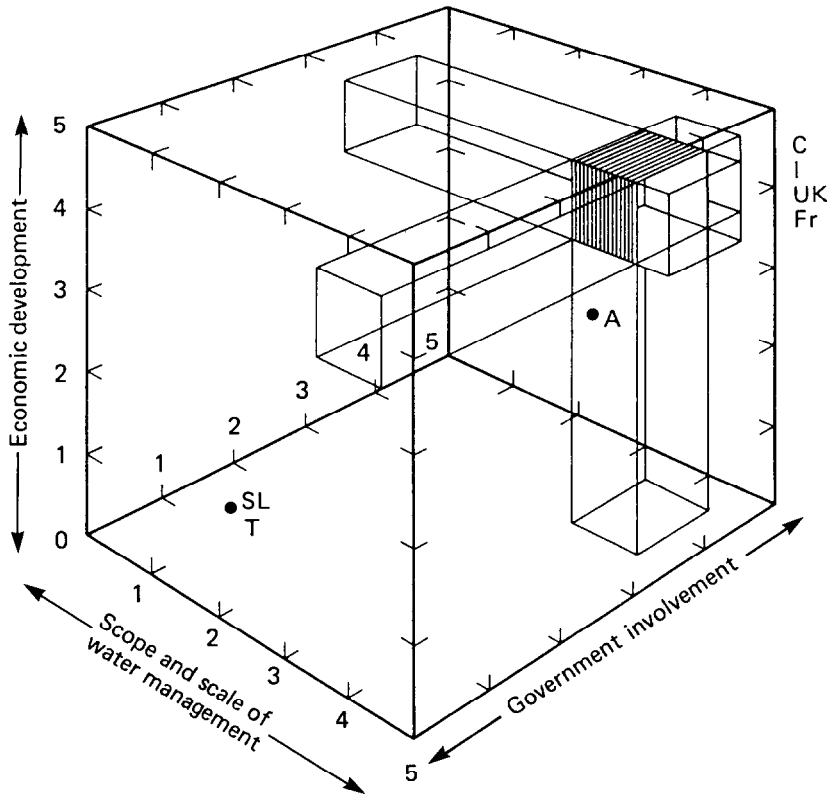
Table 5. Contemporary concepts in water management and associated institutional responses.

Concepts	Institutional responses	Illustrations
1. Broadening perspective		
a) Coordinated water management	Omnibus national water agencies	India, Jordan, Israel, Hungary, Egypt, Sudan, Zambia, Zimbabwe
b) Links with environmental management	Ministries of environment with water resources branches	Canada, UK, France
c) Links with economic and social policy	Planning commissions or coordinating bodies	Israel, Hungary, France, India
d) Broadening range of professions	Professionals from disciplines beyond engineering, including law, economics, biology, geography	Canada, USA, UK
2. Expanding the range of choice	Policies to improve water use efficiency, such as recycling, wastewater renovation, planting of drought resistant crops	USA, UK, Israel, India, Egypt, Jordan
	Policies to supplement construction options such as flood insurance, land use control, flood plain mapping	USA, Canada, UK
3. Water as an economic good	Charges for resource use: water withdrawal charges, prices to reflect real costs,	UK, France, Canada New South Wales, South Australia, Zimbabwe Israel
	Allocations to reflect values in use, metering	Fylde, UK; Denver, USA; Nairobi, Kenya
4. The river basin as a unit for management	River basin planning	USA, Canada, UK, France, India Hungary
	River basin management	TVA (USA), RWA's (UK), ABF's (France), DVC (India), Gennossenschaften (FR Germany)
5. Public involvement	*Ad hoc*, usually at end of process, narrow range of methods	Most countries
	Continuous, often required by law, using wide range of methods	USA, Canada, UK, France
6. Environmental protection as key element in water management	Specific legislation or clauses in water legislation	USA, Canada, UK, India
	Environmental impact assessment	USA, Canada, France, UK, New Zealand, FR Germany, India
7. Protection of minority rights and redress of social losses	Social impact assessment	Canada, New Zealand, USA, UK
	Settlement of native land claims	Canada, USA, New Zealand
	Institution of compensation measures	Canada, USA, New Zealand

contrast, there are a number where management today is just about the same as it was 30 years ago – or even longer. This is not necessarily bad. It may well be that the style adopted is appropriate to the physical, economic and cultural circumstances. Approaches tend to reflect stages of institutional evolution, as is suggested in Figure 2. One might expect, for example, that a country that has reached a high level of economic development, such as the USA, France or the UK, would tend to place high pressure on its water resources and would develop fairly sophisticated laws, policies and administrative arrangements to deal with the problems that have emerged. In many instances this would be likely to result in an increasing degree of government involvement. Such a situation might contrast vividly with that in certain Third World countries, such as Sierra Leone or Tanzania, where legal codes are simple, policies cover fewer issues and administrative arrangements tend to deal with single issues rather than a broad spectrum of problems in a coordinated manner. What is said about water institutions may also characterize institutions dealing with environmental management.

Moving towards a wider adoption of principles of environmentally sound water management

It is evident from the foregoing discussion that most, if not all, of the themes of contemporary water management are compatible with principles of environmentally sound water management. Generally,



C Canada
I Israel
UK United Kingdom
Fr France

A Australia
SL Sierra Leone
T Tanzania

Figure 2. Evolution of water institutions.

they aim to reduce resource conflicts, minimize environmental and social impacts and improve water use efficiency. They endeavour to foster a reduction in capital requirements and long run operating and maintenance costs. Thus far, however, progress in adopting such concepts has been relatively slow. Moreover, where these ideas have found their way into legislation, policies and administrative frameworks, it has seldom been for reasons of environmental protection alone. Even so, while institutional inertia continues to characterize the water industry in most parts of the world, the need to deal with the environmental question is rapidly gaining recognition. In part this has resulted from a number of crisis events, such as the failure of a given project to realize the benefits claimed for it in the planning stage, perhaps because of damage to the resource base (such as increasing salinity or waterlogging, or the growth of water weeds) or impacts on human health.

It is not the purpose of this paper to provide a precise blueprint for action to foster the adoption of environmentally sound water management. Rather it is the intention to stimulate thinking about a number of measures that could be tried with this in mind. The suggestions which follow are derived in large part from the successful introduction of themes associated with contemporary water management described earlier.

Existing legislation should be reviewed to determine the extent to which its underlying principles could accommodate the notion of environmentally sound water management and, where modifications would be needed towards this end, what implications this would have for established rights and present activities.

Water resources policies should be examined in terms of the extent to which they foster or impair the adoption of environmentally sound water management. Specific attention might be drawn to policies which fail to encourage efficiency or which reduce resilience. The relative

Table 6. Old and new experts in planning.

Old expert	New expert
Solution-oriented (defines a problem in terms of a solution)	Problem-oriented (explores a situation to define the problem)
Bounded	Unbounded
Emphasis on primary effects	Secondary and tertiary effects
Simplifying	Complexifying
Assumption-accepting	Assumption-challenging
Question answering expertise	Question asking expertise
Professional	Extra-professional
Error-denying	Error-embracing
Surprise-free	Surprise-embracing
System-closing	System-opening
Elitist	Democratic
Technocratic	Public
Comforting	Threatening
Conflict-masking	Conflict-exposing
Product-oriented	Process-oriented
Organization captive	Boundary spanning
Protected	Exposed
Hired Gun	Free-floating
Institutional	Personal
Client-oriented	Issue-opportunistic
Politically explicit	Politically ambiguous
Late in political process	Early in political process
Choice related	Issue-formulating
Well defined expectations	Uncertain expectations

Source: Donald J. Michael, *On Learning to Plan and Planning to Learn*, Jossy Bass, San Francisco, 1973.

merits and disadvantages of megaprojects and microprojects, for example, should be objectively reviewed in this connection.[38]

Administrative structures should be examined in a similar light. Experience clearly indicates that where environmental considerations are dealt with as matters outside the responsibilities of resource management agencies, they are often treated as peripheral rather than central. Moreover, when there is no link between resource and environmental management agencies, the latter are often treated as peripheral rather than central. When there is no link between environmental management agencies and central planning bodies, environmental issues are generally given little or no consideration.

Consideration should also be given to the kinds of professional expertise that will be needed to implement the concept of environmentally sound water management. Are the backgrounds and the experience of existing professionals likely to foster the acceptance of this idea? There are some real doubts about this, given the persuasions and the commitments of many of those currently involved in water management. Donald Michael[39] offers us a major challenge in his characterization of present and future planners (Table 6). Wholehearted acceptance of the concept of environmentally sound water management doubtless is a move from the 'old experts' to the 'new'.

[38]W.R. Derrick Sewell and Harold D. Foster, *Towards Crisis Avoidance: Canadian Water, A Case Study,* Report prepared for the Royal Commission on the Economic Union and Development Prospects for Canada, 15 August 1984 and 'Dam construction and the case against superdams', *The Ecologist,* Vol 14, No 516, 1984.

[39]Donald J. Michael, *On Learning to Plan and Planning to Learn*, Jossy Bass, San Francisco, 1973.