

5. ACTION

The far-reaching effects of lakes thus far created by man, and the prospect that many more will be proposed for construction in the years immediately ahead, make it important to initiate certain action at the national and international levels for the enhancement of human capacity to act sensitively and intelligently when undertaking major environmental modifications.

Since man-made lakes are major elements in both enlarging human production and in disturbing natural systems, part of the needed action involves policies of governmental and intergovernmental agencies and part involves the design and promotion of research. These steps are recommended not only because they promise improvement in dealing with man-made lakes, but because the experience with such a finite system has implications for action on the broader front of overall environmental management and economic development.

In suggesting desirable public action we are acutely aware that the scientist and the public decision-maker may have different perspectives. The scientist is interested in obtaining the maximum amount of relevant data and in refining analysis: he is concerned with the discovery of scientific regularities and the modelling of processes. The public decision-maker, in contrast, needs to have the optimum amount of data required to make timely decisions that have an acceptable probability of capturing the greatest part of the potential benefit available. He would like to know the full effects, but he never will have that mastery of the world, and must always settle for something less.

When we speak of increasing accurate techniques of modelling the complex ecosystem that is a man-made lake we are interested primarily in identifying whatever small number of critical variables must be clearly identified and wherever possible quantified to make the decision-making process ever more effective. This, in turn, is a constructive step for the planning of research; it helps the attempt to get the right questions investigated at the right time and at the right scale.

The immense number of investigations from which the findings in this report are abstracted may be assembled in a variety of ways, and the Knoxville Symposium brings them together in the most comprehensive fashion yet attempted. It may be taken as background reading for this report. For reasons noted in Chapter 1, such efforts lack the synthesis necessary to make them fully useful in guiding policy. Characteristically, studies of man-made lakes are pursued either as exercises in a particular scientific discipline or as routines of a government bureau. Sometimes they are the object of special study teams. The most comprehensive efforts in many parts of the world, ironically, have been salvage operations. The result is an unevenness in treatment, fragmentation of information on any one project or subject, and almost invariably, a failure to provide a holistic focus on the total impact of a reservoir in a general geographic context. In this report we have pointed out numerous places where more incisive assessment could change the impacts in the ecosystem. Thereby, we have indicated the social significance of the decisions and the scientific grounds on which they are made.

The following recommendations are aimed at policy makers and scientific

administrators who have the power to apply the lessons thus far learned and to promote research activity, communication, and cooperation to generate understanding needed for decision.

Essentials of Public Policy

On the basis of available knowledge about these new ecosystems three aspects of public policy may be recognized as essential to the consideration of further construction.

1. *Assessment of Alternatives.* Any decision to build a man-made lake should be based upon a comparison of its likely effects with those which would result from alternative technical and social actions to serve the same public aims. This requires at least preliminary assessment of relationships outlined in this report. To carry out such an assessment is an extremely difficult task, and the government agency must decide how much uncertainty as to the results it is willing to bear.

2. *Canvass of Impacts.* It is transparently evident that unless care is taken to anticipate the full consequences of building a new lake, including the impacts on the socio-cultural system, the responsible public agency courts serious damages and expensive salvage or corrective operations. A policy of going ahead with the development of a man-made lake will not do without systematic canvass of those relationships and without willingness to take measures to cope with the most difficult ones before they arise. A policy of neglect does not pay in either the long or the short run. There already are enough cases in which the costs of only one unanticipated side effect have increased the economic burden of the undertaking by 50 to 100 percent above that used in the feasibility finding.

If a thoroughgoing canvass of the full consequences of a new dam is made it may lead to one or more responses:

- a. The proposal may be encouraged with the understanding that certain precautions will be taken in unit design, construction, filling and operation phases of the project, or that design will provide for greater flexibility of eventual operation.
- b. The proposal may be delayed until further investigations are made of questions that appear to be serious, unanswered, and suited to study.
- c. Investigations of critical problems involved in operation of the dam may be launched so as to proceed parallel with the preparation of final construction plans.
- d. The proposed project may be deferred in recognition of the social costs attaching to it.

3. *Consultation with the People Affected.* A necessary provision of public policy if unfortunate consequences are to be avoided is in arranging for the involvement of the people directly affected by displacement or associated actions in the future lake basin system. As has been shown, the people whose lives are disrupted often are taken into the confidence of the builders only after a final decision has been taken. Then it may be possible to prevent some of the human injury but too late

to avoid or remedy such distress in the planning. The people touched by the environmental transformation caused by a man-made lake are to be treated as a potentially dominant part of the ecosystem in transition. In the choices which must be made as to who will be disturbed and what assistance they are given, their voices should be heard. Some distress is inevitable, and bearable stress must be weighed against future advantage.

It should be clear that in the face of inability to predict many of the possible results and of the futility of halting all action until we learn how to predict, it behooves us to develop flexible administrative machinery. With man-made lakes as with environmental management in general, the human race's scientific and engineering capacity has run far ahead of its ability to single out objectives and implement them effectively. Any realistic analysis of effects needs to be framed with regard for the structure and capacity of the governmental system to carry out the program. This comprises their ability to generate needed information, to pass some of it along to people affected (providing opportunity for the people's response to be heard in setting aims and selecting alternatives), to evaluate extra-market factors, to use external help, and to gauge the distribution of effects among different social classes and geographic areas. An important aspect is the government's willingness to bear uncertainty while pushing for the achievement necessary to its survival. All of this is a part of examining the full effects and of consulting the people concerned.

The policies suggested will apply during the period of lake management as well as preceding construction. In the latter the administrative organization may be entirely different, and sometimes suffers from being more attuned to building than to operation.

These policies are simple, and fundamental to the thoughtful creation and management of a new lake. To execute them is troublesome for planners unaccustomed to thinking in these terms, and several measures would expedite their acceptance.

Intergovernmental Support

4. *Criteria and Impact Statements.* The response of governmental and intergovernmental agencies to proposals for new man-made lakes would be enhanced by use of a somewhat uniform set of criteria for appraising proposals for study of financing of new lakes. The major outlines for criteria may be deduced from this report and are given in general form in the FAO publication on *Man-made Lakes* (Lagler, 1969). They will be stated as questions in the section on that topic in the forthcoming Economic Commission for Africa publication on water resource planning in Africa. They include appraisal of the chains of reactions in the hydrologic, atmospheric, biological, and social systems that have been noted.

Such criteria should become the point of departure for whatever revised or extended statement may be prepared by cooperation among the chief study and financing agencies for guiding the appraisal of environmental aspects of economic development projects. Several of the national bilateral aid agencies are already concerned. The principal intergovernmental agencies involved with work in developing countries are the United Nations Development Programme, the Interna-

tional Bank for Reconstruction and Development, Inter-American Development Bank, and Asian Development Bank. The same criteria should apply in higher income countries. The agreed criteria might well be published in a form intended to reach engineers, biologists, economists and others concerned with lake design.

One of the frequent recommendations for improvement of economic development planning is that environmental impact statements be required as a part of any new financing proposals. These statements are expected to specify what is known about environmental consequences. If the criteria which are suggested by our efforts were to be put into practice by operating agencies, such statements would be a normal part of any feasibility report, but they would be impact statements in a broader sense than have prevailed heretofore. They would attempt to touch upon the whole range of impacts in the ecosystem of which man is a part. They would use benefit-cost analysis wherever appropriate but not be tied to it.

The criteria could not reasonably be drawn so that those using them would expect all of the questions to be answered; they could assure that the right questions are asked and that candid replies are given to responsible officials and to the people directly affected. In a strict sense, effective adoption of criteria would eliminate the need for the special requirement of impact statements. However, that time is far distant for several reasons.

The fundamental consideration in moving toward the application of criteria is that the methods of examining the whole set of impacts as outlined in this report are so poorly developed that the best-intentioned planning group is sorely pressed when attempting to produce an appraisal dealing with the subject as adequately as scientific knowledge permits. In addition, there are no exemplary demonstrations of the kind of analysis required, no thorough-going examination of accrued experience, and only a little training of scientific competence to carry out such activities. The remainder of the recommendations indicate practical action which should be taken to assure that desirable criteria are applied in the field.

Three general observations should be made about the preparation of feasibility reports and social impact statements. The first is that rigorous appraisal concentrating upon only one set of effects and largely ignoring others, as when fisheries are omitted from a sophisticated feasibility study of a power project, may be more dangerous than no appraisal at all. It conveys a false sense of confidence, and discourages attention to factors that are less susceptible to quantitative measurement than engineering works or the benefits which are long term. The second is that no feasibility report or social impact statement is adequate if it is viewed as a solitary exercise never to be repeated or checked. They should be viewed as only a step in a continuing process of system change and manipulation. A third observation is that the sheer size and complexity of these great enterprises demands that no effort should be spared to bring the best brains to bear on their appraisal and planning.

5. *Early Warning System.* The present informal « early warning system » operated by the United Nations Development Programme should be extended to include all the intergovernmental agencies, but with one agency continuing with the primary responsibility. The present system provides for notification of inter-

ested agencies when there are commitments to study new reservoir projects. Spreading the word is helpful but it needs to be supplemented by arrangements to provide, upon request, any interested national or regional agency contemplating a new lake with advice as to practical steps which might be taken to anticipate and deal with the full consequences of construction. This might be expected to be most used by developing countries. However, a number of developed countries have also shown they could benefit from early identification of likely problems. Such advice probably could come best through teams of consultants made available by intergovernmental agencies. As a minimum such a team would include persons with breadth of administrative view and with scientific experience in biological, hydrological, and social aspects of man-made lakes and in interdisciplinary assessments.

In time the need for the early warning service and the supporting teams would be eliminated by the building of suitable competence among the planning agencies. However, that will be slow in coming, and meanwhile the limited scientific experience needs to be marshalled in a fashion which will avoid the cumbersome and competitive procedures of the intergovernmental agencies. At present it is impossible to assemble at the international level the kind of team suggested here without formal negotiation with UN, IBRD, FAO, WHO, UNESCO, and WMO. As a result, almost never has a genuinely integrated team been sent into the field.

The precise administrative responsibility for such a service may need to be determined in the light of whatever new agencies, if any, may be created as a result of the Stockholm Conference. Some agency, whether a new one or an old one with enlarged authority, should be empowered to operate the service and to draw proficient scientific personnel on a standby consulting basis without being subject to the customary agency restrictions as to appointment and tenure.

6. *World Register, Classification, and Global Evaluation.* We support the proposal by Keller at the Knoxville Symposium to establish an international register for providing a central source of accurate information on all reservoirs completed or authorized for construction with a surface area of more than 100 km². It should be maintained by an agency having ready access to national planning activities and to the catalogue established by the International Commission on Large Dams. Wherever they are, reservoirs have certain common features and considerable similarity in the problems they pose. As a minimum, for discussion purposes, it is suggested that the register include the following information:

Identification of reservoir by:

Name

Geographical coordinates of dam

Maximum height of water at dam

Elevation of water height above sea level

Estimated maximum surface area

Estimated maximum volume of storage

Estimated maximum shoreline length

Expected annual and long-term fluctuations in reservoir level

Mean annual discharge of streams flowing into reservoir

Drainage area above dam

Mean annual precipitation on the lake and in the drainage area

Mean annual air temperature in January and July

Principal purposes

Population relocated:

Number

Government expenditure per capita

Livelihood

If possible: map showing extent of water surface and bottom topography.

Positive and negative experience with existing reservoirs can be an important source of new planning methods. One of the difficulties in the way of drawing upon this experience is in the variety of local conditions. Another is in the trouble involved in gaining access to results elsewhere. The world register would be a simple, first step, extending the few present and out-of-date compendia, and should be coordinated with the Project Aqua list of aquatic sites proposed for conservation.

It should be supplemented by a problem oriented classification based on combinations of major factors affecting the quantity and quality processes that are known. This would include lake size and geometry, water balance and conductivity, and climate, soil vegetation in the basin and at the lake site, and human population and livelihood. The ICSU Committee on Water Research should be requested to advise on the Register and to develop the basis for such a classification.

The World Register could serve as a basis for making a preliminary assessment of the trends and magnitude of the effects of the earth's man-made lakes on the global environment. To be assessed would be changes in radiation and heat balance, the relation of evaporation to both land and atmospheric phases of the water cycle, the relation of new lakes to primary production, and the direct human impacts. An assessment of this sort would be an appropriate activity for SCOPE.

7. Clearing House Service. The early warning service and register would find a useful supplement in a clearing house service on current scientific investigations on man-made lakes. The service would gather and disseminate minimum information such as the following for each problem under investigation:

Sponsoring organization,

Principal scientific investigator and address,

Location of work,

Statement of problem being studied,

Duration of investigation.

The format and problem descriptions would require careful selection in order to expedite use of automated equipment. An information service of that type should be viewed as part of the massive problem of exchanging scientific information, and whatever device is found would have to struggle with ways of reaching the large number of disciplines affected. The only reason that an activity of this sort is seen as a practicable action at this stage is that the actual number of projects, in contrast to studies, is relatively small, that the overwhelming pro-

portion of research on them is supported by a few government funds, and that a closer linkage of the intergovernmental agencies and research institutions in a few countries — principally France, India, and Netherlands, the U.S.A., and U.S.S.R. — would cover the major part of current activities. ICSU should seek funds to carry out this activity, perhaps advantageously as a part of the UNESCO Program on Man and the Biosphere. An alternative would be to make full use of existing mechanisms and facilities in this field, especially of the Data Centre and the integrated Scientific Information System on Aquatic Sciences, maintained in the Resource Division of FAO's Department of Fisheries.

8. *Training.* As a short-term but timely operation, intensive training courses based on national needs should be provided for national and international personnel who are seeking to further interdisciplinary work on man-made lakes. These are needed at three levels: administrators, middle-level technicians, and scientists. Knowledge can be translated into effective policy and design only with the help of scientists who have been exposed to integrated approaches. The courses might well be arranged to permit field observations in specified regional conditions. They should be organized by SCOPE in collaboration with the interested international scientific unions and UN, the regional economic commissions, FAO, UNESCO, WMO, IBRD, and WHO. There are numerous training programs for engineers to design new dams and a few in economic analysis, but almost none for those who must deal with other aspects of ecosystem modification.

Scientific Cooperation

In the long run the influence of these efforts to obtain more careful and balanced examination of man-made lakes will only be as strong as the scientific activity necessary to deepen the knowledge of relationships.

9. In addition to the activities already recommended, major thrusts need to be encouraged by a variety of scientific organizations in the following directions:

- a. *A comprehensive, sustained effort to construct models of the processes involved in the evolution of reservoir ecosystems.* Refined models are urgently needed, but will require improved methods of measuring and relating the many parameters involved. Prediction of inflows and discharges from a physical model system is a relatively well-developed science. Practical predictions of the physical and chemical dynamics within reservoirs are not yet completely feasible even though these dynamics are dominated by the singularities of inflow, outflow, morphometry, climate, retention time, surface area to volume ratio — values for all of which are often readily obtainable. The need remains for model studies over a more representative range of conditions including parameters of biological production and water quality management. Without more experience in particular situations it is doubtful that a satisfactory general model of reservoir structure can be developed. Models involving social and economic elements are even less well developed and should be vigorously encouraged.
- b. *A thorough application of benefit-cost analysis to the impacts and planning*

of sample projects. The emphasis here would be on refinement of methodology to deal with intangibles, with different spatial patterns of distributions, and with the effects of value assumptions.

- c. *A pilot demonstration of the instrumentation, data processing, analysis and automated monitoring of a major man-made lake, with special care for the measurement and significance of each parameter.*
- d. *Preparation by a study group of at least two exemplary social and ecological impact statements for a man-made lake proposal.* This should include the complete set of factors discussed in this report. It would assess the role and cost of baseline studies and the risks of decision-making without adequate data.
- e. *Design and supervision of pilot communities to demonstrate new production systems for relocatees and other lake basin inhabitants.* Training and extension would be incorporated, and continuing evaluation would be essential.
- f. *Special international review of interdisciplinary problems of high importance in predicting transformations in man-made lakes.* Those having particular urgency are: the effect of water balance, watershed management, and flow conditions on water quality, mud-soil ecology in the drawdown zone, and biological production; the effect of aquatic vegetation on physical, chemical, biological, and human use aspects of man-made lakes; the conditions in which new technology, social organization and livelihood are diffused among lake basin populations.

Certain of the foregoing (a-f) may well be incorporated in symposia or seminars now being planned. Thus, IASH is planning a field seminar on the Great Lakes in 1972 (IFYGL), and a symposium on lakes is to be held in Finland in 1973. One practical way to stimulate more intensive work in these fields would be for SCOPE, in cooperation with concerned intergovernmental agencies, to convene for each an international study group of not more than two dozen members to review the field and to identify the most promising new lines of research.

The actions proposed here would be mutually supportive and are not in any sense exclusive of other needs or opportunities. The essential policies of development agencies and government cannot be carried out effectively unless improved analytical methods and comparative data are available. The underlying research and training will not be undertaken unless governments are disposed to canvass the whole range of impacts of a man-made lake and to call upon personnel capable of anticipating and dealing with them. The underlying requirement is an integrated view of man as a dominant in the new ecosystem. In this regard, man-made lakes may point the way to constructive modes of action wherever human society considers a massive change in the environment.