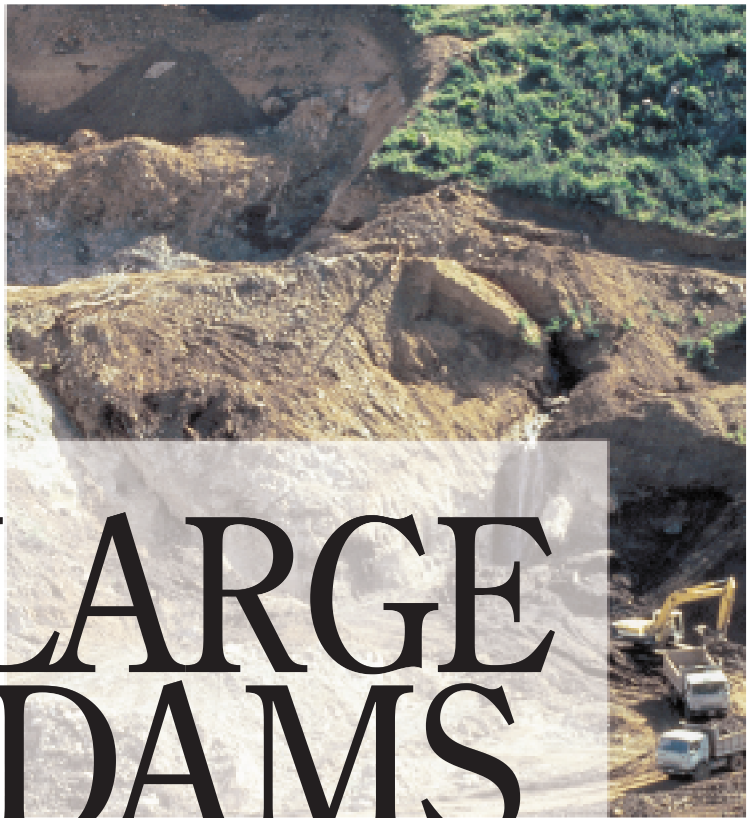


LARGE DAMS

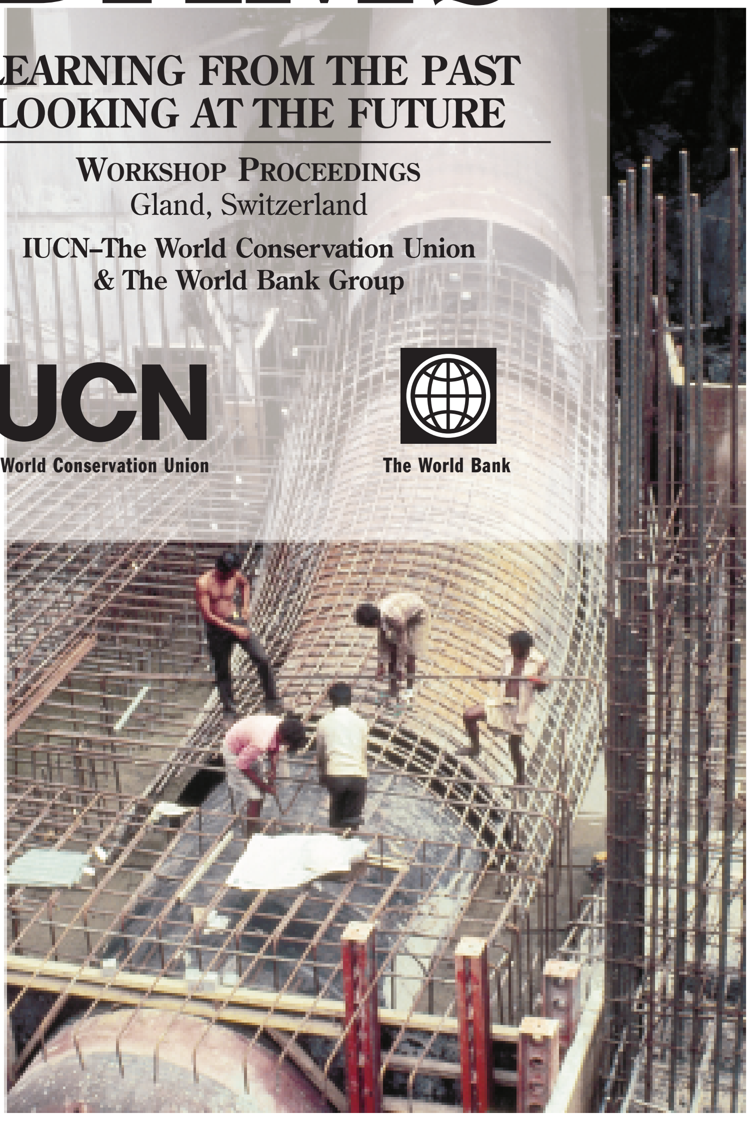
LEARNING FROM THE PAST LOOKING AT THE FUTURE

WORKSHOP PROCEEDINGS
Gland, Switzerland

IUCN–The World Conservation Union
& The World Bank Group

IUCN The World Conservation Union

The World Bank



IUCN - THE WORLD CONSERVATION UNION

Founded in 1948, IUCN-The World Conservation Union brings together States, government agencies, and a diverse range of non-governmental organizations (NGOs) in a unique membership: 895 members in all, spread across 138 countries. As a Union, IUCN seeks to influence, encourage and assist societies throughout the world to conserve the integrity and diversity of nature and to ensure that any use of natural resources is equitable and ecologically sustainable. A global secretariat and 35 regional and country offices coordinate the IUCN Programme and serve the Union membership, representing their views on the world stage and providing them with the strategies, services, scientific knowledge and technical support they need to achieve their goals. Through its six Commissions, IUCN draws together over 6,000 expert volunteers in project teams and action groups, focusing in particular on biodiversity conservation and the management of habitats and natural resources. The World Conservation Union builds on the strength of its members, networks and partners to enhance their capacity and to promote global alliances in support of conservation at the local, regional, and global levels.

THE WORLD BANK GROUP

The World Bank Group is a family of multilateral development institutions owned by and accountable to member governments. These governments exercise their ownership function through Boards of Governors on which each member country is represented individually. The World Bank today includes five international organizations: The International Bank for Reconstruction and Development (IBRD) is the largest source of market-based loans to developing countries and is a major catalyst of similar financing from other sources. It lends to governments or to public or private entities with government guarantees. The International Finance Corporation (IFC) supports private enterprise in the developing world through the provision and mobilization of loan and equity financing and through advisory services. The International Development Association (IDA) provides finance on concessional terms to low-income countries. The International Centre for Settlement of Investment Disputes (ICSID) provides conciliation and arbitration services for disputes between foreign investors and host governments. The Multilateral Investment Guarantee Agency (MIGA) provides noncommercial investment risk insurance and technical services to help promote investment flows.

LARGE DAMS

LEARNING FROM THE PAST
LOOKING AT THE FUTURE

WORKSHOP PROCEEDINGS
Gland, Switzerland

April 11-12, 1997

Editor: Tony Dorcey

Co-Editors: Achim Steiner
Michael Acreman
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IUCN
The World Conservation Union

The World Bank

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PREFACE

Working in partnership towards sustainable development is an often-cited objective. The workshop on large dams jointly organized by IUCN - the World Conservation Union and the World Bank Group has been acknowledged by all involved as a promising example of learning and cooperation.

Together we decided to tackle one of the "big debates" in sustainable development. For far too long conflict and controversy have prevented constructive dialogue and objective assessments. Given the many differing perspectives on large dams, a great challenge remains in interpreting their development effectiveness and applying the lessons learned to future decisions on whether dams have a major role to play in land, water and energy development and how particular dams should be selected, constructed and operated. This challenge reflects the complex judgments involved in meeting development needs, maintaining the viability of ecosystems and protecting the livelihoods and cultures of people affected by such major infrastructure developments.

The workshop in Gland has created an important opportunity for addressing these questions in an open, transparent and rigorous process. It is our hope that the proposed independent commission to be established by November 1997 will enable all stakeholders to make substantive contributions to the review of large dams and the development of new standards, criteria and guidelines to inform future decision-making.

We would like to thank the participants of the workshop for the time and effort they invested in making this dialogue a success. Their continued commitment to the follow-up process of establishing the commission has been remarkable. The support of the Swiss Agency for Development and Cooperation (SDC) in contributing to this large dams dialogue was critical and their role in supporting this partnership is appreciated by all involved. We also owe a special vote of thanks to the authors of the overview papers — Robert Goodland, Engelbertus Oud, Terence Muir, Thayer Scudder and Anthony Churchill — who provided an important starting point for our discussions.

Tony Dorcey, who facilitated the workshop, proved indispensable in creating the right atmosphere and the right process for an open and constructive debate. Together with Mike Acreman, workshop rapporteur, he prepared the workshop summary report. Andres Liebenthal (OED/World Bank) and Achim Steiner (IUCN) formed the team that prepared and coordinated much of the process that led up to Gland. The support provided by the IUCN staff in Washington and Gland in organizing the workshop and producing these proceedings was critical. To all those who made the Gland workshop a reality, we owe a debt of gratitude.

This publication is an invitation to work with us in building on the success of the Gland initiative. As you will see from the letters included in Appendix B3, both of our institutions have fully committed themselves to realizing the mandate given to us in Gland, Switzerland.

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IUCN–The World
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Robert Picciotto

Director General
Operations Evalution,
The World Bank Group

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* Invited but were unable to attend.

PART I

SUMMARY REPORT OF THE WORKSHOP

LARGE DAMS: LEARNING FROM THE PAST LOOKING AT THE FUTURE
Summary Report of the Workshop

Group photograph of the workshop participants.

Summary Contents

INTRODUCTION

Something different and most promising happened in Gland, Switzerland, in early April 1997. For two days, 37 stakeholders, representing diverse interests from around the world, explored whether they could work together in seeking resolution of the highly controversial issues associated with large dams. Given more than two decades of increasingly acrimonious exchanges about the development effectiveness of large dams, most participants were not optimistic about the outcome. But by the time they left Gland, all had been surprised and excited by the breadth of the consensus on how to move forward and the issues to be addressed. Most notably, agreement was reached on the next step: A World Commission should be established to assess experience with large dams and to propose if and how they can contribute to sustainable development. All those present in Gland committed to making the commission a reality within six months and to seeking a mandate for it to report within two years.

In Part I, this monograph summarizes what happened in advance of the workshop, during the two days of discussions and immediately following the workshop's conclusion. In drafting the proceedings, we have attempted to capture what was new and different about the Gland workshop and to identify the implications for how to build on the initial consensus and sustain its momentum. Part II contains the full text of three overview papers that were commissioned and two others that were reproduced to inform the discussions.

1.0 THE WORKSHOP: ORIGINS, PLANNING AND PROCEEDINGS

1.1 GROWTH OF CONTROVERSY

Dams have played a key role in development since at least the third millennium B.C., when the first great civilizations evolved on major rivers, such as the Nile, Tigres-Euphrates and Indus. From these early times, dams were built to supply water, control floods, irrigate agriculture and provide for navigation. More recently, since the onset of the industrial revolution in the 18th century, they have also been built to produce motive power and electricity. In the 20th century, new technologies have made possible the construction of increasingly large dams to meet various mixes of these purposes; the 221-meter-high Hoover Dam, inaugurated in the United States in 1935, ushered in a new era of big dams. In the last half of this century, construction around the world accelerated, with some 35,000 large dams being built between 1950 and the late 1980s (International Commission on Large Dams, 1988), the largest of which, Nurek in Tajikistan, reached 300 meters high (International Water Power and Dam Construction Handbook, 1995).

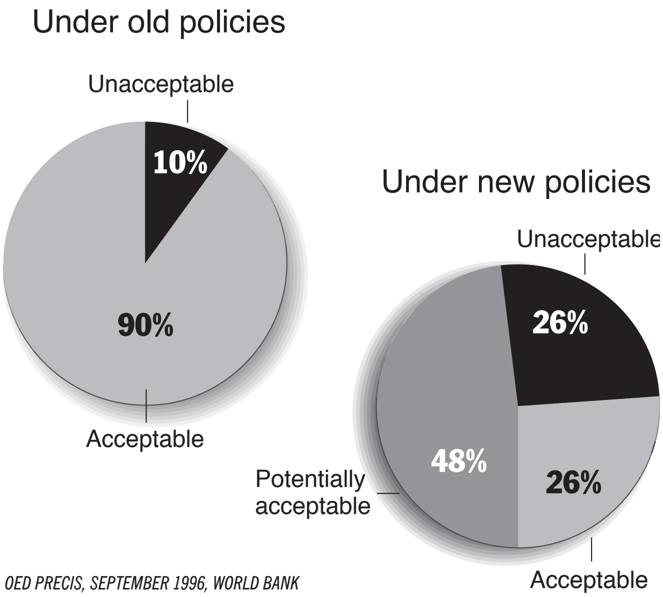
However, there has been mounting controversy, particularly over the last two decades, about the role of large dams in development (Goldsmith and Hildyard, 1984; McCully, 1996). As development priorities changed and experience accumulated with the construction and operation of large dams around the world, various groups argued that expected economic benefits were not being produced and that major environmental, economic and social costs were not being taken into account. In the 1980s proposals for large dams began to be fundamentally questioned by locally affected interests and global coalitions of environmental and human rights groups (for example, Sardar Sarovar). In the 1990s this has resulted in a succession of calls for a moratorium on World Bank funding and reparations for those affected by construction of large dams (for example, the 1994 Manibeli and 1997 Curitiba Declarations).

1.2 WORLD BANK REVIEW

When he was appointed president of the World Bank in 1995, James Wolfensohn announced his intention to undertake a review of its development effectiveness. Although it had been involved in the financing of a relatively small proportion of the large dams, the World Bank Group had become a major focus of criticism because of the number of problematic projects, including some of the biggest and most controversial, in which it was involved. It was in this context that the independent Operations Evaluation Department (OED) of the World Bank began a review of large dam projects. The first phase was designed to be an internal desk study of 50 large dams assisted by the Bank and was completed by OED in September 1996. The second phase was planned to be a broader study, involving the collection of new data and participation by other stakeholders, to evaluate the development effectiveness of large dams in terms of technical, economic, social and environmental implications for future financing by the World Bank Group, as well as other sources.

Using available data for projects completed between 1960 and 1995, the dams were classified according to their economic justification and whether they satisfied the impact mitigation and management policies existing at the time of their approval, or could have been planned so as to satisfy policies that the Bank had introduced over the intervening years (Liebenthal et al., 1996). OED concluded that while 90 percent of the dams reviewed met the standards applicable at the time of approvals, only about one-quarter were implemented so as to comply with the World Bank's current, more demanding policies. The review also concluded that mitigation of the adverse social and environmental consequences of large dams would have been both feasible and economically justified in 74 percent of the cases. The main conclusion was OED's conditional support for the construction of large dams, provided that they strictly comply with Bank guidelines and fully incorporate the lessons of experience. The analysis, conclusions and recommendations were summarized and made public in an OED Précis (1996).

The impact of large dam projects



OED PRECIS, SEPTEMBER 1996, WORLD BANK

1.3 WORLD BANK PARTNERSHIP WITH IUCN-THE WORLD CONSERVATION UNION

One of the initiatives of the director-general of IUCN, David McDowell, upon his appointment in 1994, was to seek strategic partnerships with key international agencies so that they might work together to resolve controversial issues and meet joint interests. An agreement negotiated with the World Bank and signed in 1994 was one of the early partnerships to be established. It was under this agreement that the Bank approached IUCN in 1996 with the idea that they might jointly host a workshop to discuss the findings of the OED desk review (Phase I) and their implications for the design, methodology and process of a proposed in-depth study (Phase II) on large dams to be undertaken in 1997-98. In agreeing to proceed, both organizations recognized that this workshop would address one of the most controversial issues in the field of environment and development policy today and that a successful outcome was by no means assured.

Special funding to support the workshop was provided by the World Bank through the Swiss Agency for Development and Cooperation (SDC), which had decided that one of the priorities in allocating the SDC/OED trust fund should be to seek a resolution to the conflicts surrounding large dams.

1.4 PREPARATIONS FOR THE WORKSHOP

Robert Picciotto, director general for Operations Evaluation Department of the World Bank, and George Greene, assistant director general of IUCN, were given overall responsibility for the workshop. Reporting to them, Achim Steiner, who was IUCN's liaison officer to the World Bank, and Andres Liebenthal, who had led OED's desk review, were asked to organize the workshop, focusing on five key preparatory tasks: agreement on the specific objectives, development of background information, selection of participants, facilitation of the sessions and design of the agenda.

Objectives of workshop

Four specific objectives were developed through discussions among some of the key stakeholders associated with IUCN and the World Bank:

- Review the OED desk study of large dams in

Box 1: Summary of Oud and Muir Paper on Engineering and Economic Aspects

Engelbertus Oud, the head of Water, Power and Land Development for Lahmeyer International, a German engineering firm, and Terence Muir, also of Lahmeyer International, summarize the main engineering and economic aspects of the planning and design for large dam projects. One important trend in large dam projects is the increased role of private-sector financing. This has led to an emphasis on the part of private developers to cut project costs, shorten the duration of design and construction, and offload as much risk as possible onto other parties, particularly the host government. There are also a number of technological developments that make the planning, construction and operation of large dam projects more efficient. Another very important trend is increasing public interest in large dam projects. This leads, in turn, to changes in how dams are planned, designed and operated. The review of project Environmental Impact Assessments (EIAs) and project design, as well as regular inspection of construction and operation of dams, particularly as they grow older, by a group of independent experts, is seen as key to providing suitable assurance to the public, dam owners, lenders and governments. It is also acknowledged that increasing public scrutiny of environmental and social impacts will make the trade-offs between the benefits and costs of dam construction more explicit.

Box 2: Summary of Scudder Paper on Social Impacts

Thayer Scudder, a professor in the Institute of Development Anthropology at the California Institute of Technology, asserts that the adverse social impacts of dam construction, whether short-term or cumulative, have been seriously underestimated. Large-scale water resource development projects have unnecessarily lowered the living standards of millions of local people. According to the World Bank's senior environmental advisor, "Involuntary resettlement is arguably the most serious issue of hydro projects nowadays. Scudder argues that the goal of resettlement must be for those removed and the host population among whom they are resettled to become project beneficiaries. The income and standard of living of the large majority must improve to the greatest extent possible. Besides resettlers and hosts, other people affected by dam construction include rural dwellers residing downstream from a dam. They are often neglected in project assessments because it is assumed that they will benefit from the project; however, there are frequently significant negative downstream impacts. While the World Bank has attempted to improve its performance, it continues to underestimate adverse resettlement outcomes and downstream impacts. Although more detailed research is needed, Scudder suggests a number of ways in which all project affected peoples can become better off. These include increasing local participation, improving the design and implementation of irrigation schemes, training and technical assistance to utilize the reservoir fisheries, and strategic flood releases that can benefit downstream users and habitats. Multilateral donors are essential to ensure that more local people become project beneficiaries.

terms of its data, assumptions, approach, analysis and conclusions and compare the results to documented experience from other sources, including experience of industrialized countries;

■ Develop a methodological framework for the Phase II study that would consider the critical issues that need to be addressed in determining the future development of a large dam—including evaluation of alternatives and social, resettlement, environmental, economic, technical and other relevant policy criteria;

■ Propose a rigorous professional and transparent process for defining the scope, objectives, organization and financing of follow-up work, including a Phase II study incorporating basic guidelines for involvement by governments, the private sector and non-governmental organizations (NGOs) as well as public participation, information disclosure and subsequent dissemination of results; and

■ Identify follow-up actions necessary for the development of generally accepted standards for assessment, planning, building, operation and financing of large dams that would adequately reflect lessons learned from past experience.

Background information

In addition to providing the invited participants with a copy of the desk review report, it was decided that background papers should be commissioned to provide independent overviews of experience from other sources, including experience of industrialized countries, in three key topic areas: engineering and economics, social and stakeholder issues, and environmental sustainability. After consulting extensively

Box 3: Summary of Goodland Paper on Environmental Impacts

Robert Goodland, an advisor on environmental assessment in the Environment Department at the World Bank, provides an overview of the debate embroiling the hydroelectric industry regarding the environmental sustainability of dam construction. Goodland examines ten major issues in the controversy over dams, including transparency and participation; demand-side management, efficiency, and conservation; the balance between hydro and other renewables; large dams vs. small and medium-size dams; Sectoral Environmental Assessments (SEAs); storage dams vs. run-of-river dams; involuntary resettlement; project-specific mitigation; and, finally, the damage costs of greenhouse gas emissions. On each issue, he summarizes the position taken by the proponents and opponents of dams. He argues that the main way of making dam construction environmentally sustainable is to integrate environmental and social criteria into the traditional least-cost sequencing through a Sectoral Environmental Assessment. The SEA will not only encourage better site selection, but also will allow a comparison of energy supply alternatives. It is acknowledged that ensuring that dam construction is environmentally sustainable will necessarily mean that some hydro projects do not go forward. But without higher standards, Goodland argues, the hydro industry will continue to decline, and coal and other fossil-fuel alternatives will flourish—an environmentally retrograde course.

Box 4: Summary of Churchill Papers on Future Challenges Facing the Hydropower Industry

Anthony Churchill, a senior advisor with the Washington Energy Group and former principal advisor for finance and private-sector development at the World Bank, argues that hydropower is at an international crossroads. The environmental and social problems associated with dams, particularly poorly conceived and executed resettlement programs, have tarnished the reputation of the hydro industry. Performance problems, such as cost overruns and project delays, have also plagued the industry. Further criticisms leveled at the hydro industry include poorly defined products, lack of discipline, and political, rather than economic, decision-making. As countries increasingly look to the private sector to finance hydro projects, all of these problems threaten to discourage future investments in hydropower. In order for hydropower to succeed in the future, the resettlement issue must be resolved. The industry must also become more competitive by developing new technologies to improve efficiency while improving its systems of accountability. One alternative is for the industry to create developers—that is firms with sufficient capital, technical skills and marketing ability to finance and manage the risks inherent in hydropower projects. Ultimately, what is needed, Churchill asserts, is a new model of public-private partnership, whereby the private sector agrees to undertake greater responsibility for project results, and the government agrees to treat electric power as a commercial business subject to the discipline of the market.

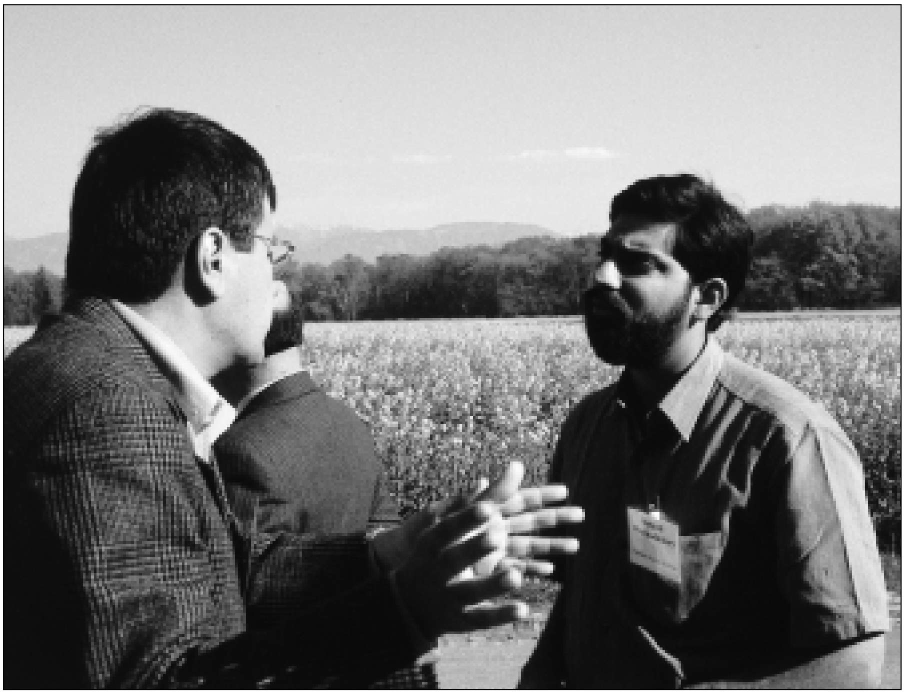
to identify individuals who would be widely viewed as well-qualified, papers were commissioned from Engelbertus Oud, Thayer Scudder and Robert Goodland. In addition, two previously published papers by Anthony Churchill were reproduced. (See Boxes 1-4 and full texts in Part II.)

A separate compendium of previously published documents, including relevant directives and policies of the World Bank and providing different viewpoints on key issues, was also assembled (see the list of papers distributed at the workshop Appendix C1). All of these background materials, along with biographical information provided by those attending, were sent to the invited participants in advance of the workshop.

Participants. There was a very high level of interest among key stakeholders in attending the workshop. Balancing the need to ensure diversity and to keep the numbers manageable, 39 participants were ultimately invited and accepted; they included seven from the World Bank, six from government agencies, seven from local NGOs (two of whom were unable to come at the last minute), five from IUCN, eight from private dam construction and consulting companies and industry organizations, and four from academia/research. The goals set to ensure a breadth of representation were substantially met, with the exception of participation by women (see Biographies of the Reference Group in Appendix C2). Four representatives of the international media (The Economist, Financial Times of London, Hindu and *Neue Zuercher Zeitung*) also participated as observers and reported on the workshop discussions under

Chatham House Rules, which allow for quotations from the proceedings without attribution to individuals.

Facilitation. Given the record of controversy, challenging issues to be addressed and the extremely short time available at the workshop, it was concluded that one person should chair and facilitate the entire process. Ideally, the individual would be a practicing facilitator and knowledgeable about the issues but not be identified with previous controversies concerning large dams. Tony Dorcey, a professor at the University of British Columbia with international experience in multi-stakeholder processes and river basin management, was selected and became involved in the detailed planning.



Andres Liebenthal of the World Bank and Shripad Dharmadhikary of the Struggle to Save the Narmada (NBA) continue the dialogue during a break.

Agenda. Many potential difficulties had to be anticipated in designing the agenda for Gland. There would be only two days in which to address highly complex and controversial issues. Only a small proportion of the participants were expected to know each other, and while they would offer a remarkable wealth of experience, this was rooted in a great variety of contexts and projects. In addition, they would bring strongly held views, along with varying histories of involvement in the controversies about large dams. The agenda therefore had to be designed with these and other considerations in mind.

Overall, the chosen strategy was to provide early opportunities for people to get to know each other and express their views, but to begin searching as soon as possible for where there might be grounds for agreement on next steps. To foster interaction, it was planned to make extensive use of three facilitated breakout groups, each consisting of a cross-section of the participants. Each group would be allocated one of the three topic areas examined in the overview papers (engineering/economic/finance, social and stakeholder, and environmental). To guide discussion, each group would be asked to address three questions based on the workshop objectives:

- What are the critical advances needed in knowledge and practice for the assessment and development of large dams?
- What methodologies and approaches are required to achieve these advances?
- Who should be involved, and what should be the process for follow-up action?

To ensure adequate consideration of each of the three questions and cross-fertilization of ideas among the groups, two complete iterations of the three were planned, with the groups reporting back on the results of the first iteration after the first day.

1.5 WHAT HAPPENED?

Overall, the strategy worked better than the organizers had dared to hope for. In large part, this was because all the participants were committed to making it work. There was a shared sense that this unique convening of the diversity of interests in large dams had to be made to work because, if it should fail, the opportunity to try again would be immensely difficult to recreate. For varying reasons, it transpired that the time was right to try a different approach.

This was not, however, immediately evident as the participants were gathering to meet each other in Gland. Earlier in the week, the International Rivers Network (IRN) issued a statement, endorsed by 49 other non-governmental organizations from 21 countries, that was highly critical of the OED review. In an article headlined "Ecologists square up for dam debate," the Financial Times of London (April 10, 1997) quoted the IRN as concluding the OED review was based on "seriously flawed methodology and incomplete and inadequate data." The evening before the workshop, in introducing themselves to one another and voicing expectations, the participants expressed hopes for progress but did not shrink from making clear their positions and stressing the legacy of mistrust and acrimony that would have to be overcome for any measure of success. In several cases, adversaries were meeting each other face-to-face for the first time.

The remarks made during the opening plenaries on the first morning reiterated and amplified many of the refrains of support, caution and criticism from the night before. The limitations of the OED desk review and its preliminary nature were acknowledged by the authors and other participants. Criticisms of its data, analysis and conclusions ranged from specific challenges of its estimation of costs and benefits to methodological issues, such as the discount rate used and the scope of its treatment of ecosystem impacts and social consequences. (For details, see statements included in the companion volume of papers tabled at the workshop.) There was widespread recognition that further work was essential and that it would need to be comprehensive in scope, transparent in conduct and defensible in its analyses.

The presentations after lunch, based on the commissioned papers, reinforced many of the morning's concerns but also advanced the discussion by suggesting ways in which they should be addressed in the next phase of work. Moving into the breakout groups, the discussions quickly began to pick up the various proposals and build on them in addressing the three assigned questions. By the end of the afternoon, as participants walked around to review the flip charts showing the results of each group's work, and afterward in discussions over dinner, it was evident to all that there was a surprising amount of agreement about how to address the questions concerning critical advances needed in knowledge and methodologies, which had received most attention in the time available.

The next morning the groups reconvened and, in a second iteration, refined ideas in the light of what other groups had proposed and focused particularly on developing the proposals for next steps and their implementation. Over lunch, representatives from each of the groups reviewed all the proposals and identified where there was general consensus on each of the three questions. When these were presented to the closing plenary, they were unanimously adopted following some fine-tuning adjustments. The relative ease with which they were accepted reflected the breadth of consensus that had been built over the two days. While nobody underestimated the difficulties that would be encountered in seeking to resolve the issues in the next phase of work, all were were cautiously optimistic about what might be achieved and committed to working together to make it happen.

2.0 MAJOR CONCLUSIONS AND RECOMMENDATIONS

The major conclusions and recommendations from the workshop are highlighted in this section. Based on the final plenary and drawing on all that preceded it, they are presented here so as to focus attention on the next steps that were agreed to. They are expressed in specific terms as articulated by the participants. It was, however, recognized that the specifics may well need to be reconsidered by all of the stakeholders involved during the process of implementation.

2.1 A WORLD COMMISSION

The most important achievement was the agreement to establish, by November 1997, a two-year World Commission with the following terms of reference:

- To assess the experience with existing, new and proposed large dam projects so as to improve (existing) practices and social and environmental conditions;

■ To develop decision-making criteria and policy and regulatory frameworks for assessing alternatives for energy and water resources development;

■ To evaluate the development effectiveness of large dams;

■ To develop and promote internationally acceptable standards for the planning, assessment, design, construction, operation and monitoring of large dam projects and, if the dams are built, ensure affected peoples are better off;

Two days of discussions and working groups break new ground on how to move forward on the large dams issue.

■ To identify the implications for institutional, policy and financial arrangements so that benefits, costs and risks are equitably shared at the global, national and local levels; and

■ To recommend interim modifications—where necessary—of existing policies and guidelines, and promote "best practices."

The Commission would be composed of five to eight members, including an internationally recognized chairperson. The members would have appropriate expertise and experience and would be widely regarded as having integrity and being objective, independent and representative of the diversity of perspectives including affected regions, communities and private and public sectors. Most members would be part-time, although one to three commissioners could be full-time.

A consultative group would be established and comprised essentially of the participants who attended the workshop, plus others invited by the Commission (for example, NGOs, the European Union, the Organization for Economic Cooperation and Development, governments, multilateral development banks, and other government and private financing agencies) to ensure effective and balanced representation of all stakeholders and key actors. As the name suggests, the group would be used as a sounding board for ideas from the Commission. Members of the group would join task forces or working groups and recommend specialists who might be involved.

The Commission would be supported by a small Secretariat of full-time professionals who might be provided at least in part by secondments. One possibility would be for the Secretariat to operate under the auspices of the IUCN.

The Commission and Secretariat would operate through study groups, hearings, task forces, contracted studies and so on. The overall process would involve stakeholders in a full and meaningful way throughout. Wherever possible, it would work with other organizations that have appropriate expertise and already have relevant studies underway. Early in its work the Commission would confirm that its proposed program of studies and expected products meet decision-makers needs.

The products from the Commission's work would include recommendations on policies, standards, guidelines, best practices and codes of conduct to ensure the affected parties are better off as a result of building and operating large dams. The results would also include an understanding of the accuracy of predictions of costs and benefits used in the dam planning process and of their overall development effectiveness and the need for restoration and reparation where necessary.

The Commission would require a budget that is adequate to ensure its independence and to fulfill its mandate. Views were variously expressed that this implied a budget of several million dollars even if various forms of in-kind contributions were made.

2.2 THE PROPOSED AGENDA

Through the discussions in the breakout groups and drawing on all the background materials, it was recognized that the specific items needing to be put on the agenda for the World Commission are fundamentally determined by an evolving paradigm of large dam development. Ideas about development in general and dam construction in particular have begun to shift over the past decade. In looking at the future of dams it is necessary to learn from the past by reviewing the success or failure of earlier projects in the context of the situation in which they were conceived, designed and built and to develop guidelines for the future based on those lessons and the concepts, expectations and reality of an emerging new era.

In the past, development issues were often considered sector by sector in isolation. For example, a ministry of agriculture would identify a single priority for development: namely, the need for more food. The belief in human domination of nature and unquestionable benefits of large dams meant that often only a single option was considered. The dam would be designed on the basis of narrowly defined least economic cost.

In recent years a new paradigm has begun to emerge. The development process should be based on analysis of multiple criteria, including food, water, energy, foreign currency, health, employment, human rights, equity, sustainable use of natural resources, and conservation of natural ecosystems and their genetic stocks. The analysis should involve consideration of the long-term and quantitative and qualitative values. Decision-making should be more transparent and accountable and made through consultation with multiple stakeholders, including local communities, numerous authorities and government departments, industry and NGOs. The role of many stakeholders should also change, with more development being financed by the private sector, communities becoming empowered, and action being taken through partnerships. Choices should be made by considering multiple and integrated development options, such as including demand management, a run-of-the-river hydropower scheme, conjunctive use of surface and groundwater, and development of traditional local water management and agricultural practices. Overall, the choice of projects should be put in the larger contexts of sectoral (e.g., energy, water) and national and regional development plans and strategies along with international commitments (e.g., U.N. Framework Convention on Climate Change). The final choice should be the one with maximum acceptance, or least regret.

Implementing the evolving paradigm will not be without its costs. The information needed for sound multiple criteria decision-making are far higher, the methods are far more complex, the coordination is more demanding, and the consultative process is more time-consuming. Managing the process will involve new skills for the decision-maker to learn, and new manuals and guidelines are certainly required. Indeed, new decision-making processes and policies will be required when it is recognized that altering ecosystem functions is viewed as much as a social choice and philosophy as a simple technical option.

It was in this context of the evolving paradigm that proposals were developed for the specific items that should be on the Commission's agenda (i.e., the critical advances needed in knowledge and practice for the assessment and development of large dams, and the methodologies and approaches required to achieve these advances). In Boxes 5 and 6 the items that were identified are listed for the three issue areas considered by the breakout groups: engineering and economic/financial issues, social and stakeholder issues, and environmental issues. Further details on each of the listed items, based on the notes from the breakout groups, are summarized in Appendices A1 and A2.

2.3 IMPLEMENTATION STRATEGY

Agreement was also reached on an implementation strategy to take effect immediately at the end of the workshop. David McDowell, director-general of IUCN, agreed to establish by May 31, 1997, an Interim Working Group (IWG) composed of IUCN and World Bank staff. The IWG would draw on participants in the workshop for advice and support in establishing the Commission. The chairperson for the Commission would join the Working Group upon selection, and the earlier, the better.

Box 5: Critical Advances Needed in Knowledge and Practice

(See Appendix A1 for elaboration of each item)

Engineering and economic/financial issues

- Dam engineering—Structural design and operation to meet ecosystem objectives
- Competitive markets—Trade-offs of financing by development agencies vs. private sector
- Internalizing externalities—Incorporating all impacts of the dam in cost-benefit analysis
- Discount rate—Relationship between discount rate and sustainability of projects
- Technical information—For example, water needs of downstream ecosystems
- Decommissioning of dams—Anticipating the need to pay for it
- Appropriate technology—Suited to local skills base
- External impacts of hydro-power generation and other technologies (e.g., greenhouse gases, or GHGs)
- Technical flexibility—For example, to release sediment or artificial flood releases when needed

Social and stakeholder issues

- Definition of affected groups—Who are the stakeholders?
- Appropriate level of participation—Stakeholders involved at all stages
- Transparency in decision-making—Must be seen to be fair
- Equitable sharing of costs, benefits and risk—Allow all stakeholders to contribute
- Health—Risks of diseases such as rift valley fever and schistosomiasis
- Indigenous knowledge systems—Make use of traditional technologies and systems

Environmental issues

- EIA policy—To include a comprehensive evaluation of alternatives
- EIA process—To include environmental health and social well-being
- EIA financing and responsibility—Who pays for restoration and reparation?
- EIA quality control and consistency—EIAs should be independent
- Participation in EIAs—Decisions made through discussion and information sharing
- Biodiversity, ecosystems and hydrology—Water requirements of ecosystems

Cross-cutting issues

- Multidisciplinary approaches—Involving many specialists, from engineering to sociology
- The scale of planning—e.g., integrated river basin management
- Monitoring and evaluation—Large dams projects should have a long horizon

By the end of October, the Working Group would establish full terms of reference for the Commission and its Consultative Group, membership of the Consultative Group, membership of the Commission, capabilities and location of the Secretariat, an outline program and budget for the Commission and Secretariat, a funding strategy for the two years of the Commission, and a date for the first meeting of the Commission and Consultative Group.

3.0 EPILOGUE

Immediately after the workshop, David McDowell wrote to James Wolfensohn to report on the outcome and to initiate the implementation strategy (see correspondence in Appendix B3). In his response, Mr. Wolfensohn expressed his support for the next steps and identified the senior members of the World Bank's staff who would participate in the Working Group to advance the implementation strategy.

In early June, the first meeting of the Working Group was held in Washington, D.C. It was co-

Box 6: Methodologies and Approaches for Assessment

(see Appendix A2 for elaboration of each item)

- Definition of terms—e.g., environment and sustainability, overexploitation and safe yield
- Trade-offs—Between financial performance and impacts on people and the environment
- Valuation of non-traded goods and services—e.g., ecosystem functions
- Discount rates—Research on the relationship between discount rates and project sustainability
- Definition of stakeholders—Methodologies for defining stakeholders
- Stakeholder involvement—Guidelines on how to involve stakeholders
- Institutional capacity development—e.g., training needs assessment workshops
- Ethics—Guidelines on ethics and tribunals of inquiry to hear grievances.
- Ecosystem approach—Interaction and interdependencies between all elements
- Implementation of treaties and conventions—e.g., Ramsar or Biodiversity Conventions
- Proactive EIA approach—To evaluate alternative proposals
- Water requirements of ecosystems—Such as wetlands
- Conservation of biodiversity—Procedures for assessing and conserving threatened species
- Planning—e.g., multiple criteria analysis
- Demand management—Methodologies for reducing water demand
- Scale—How does the scale of a dam relate to impacts, decentralization and privatization?
- Private sector—How does the private sector values risk?
- Responsibilities—Who pays for data collection, impact evaluation and decommissioning?
- Interdisciplinary teams—Methodologies for collaboration between specialists

Anticipating the time and budget constraints that the Commission would face, the group made suggestions for employing a carefully selected set of case studies in addressing the above issues. The set would be chosen to include possibilities for assessments of projects which are:

- Existing, under development and proposed (i.e., learning from not only assessing past experience but also experimenting in ongoing design, development and operations);
- Different in their biophysical and socioeconomic contexts (i.e., understanding the implications of the range of different environmental and developmental situations in which large dams are built);
- Differing in their primary purposes (i.e., examining the opportunities and constraints associated with flood control, water supply, hydroelectricity production and various mixes of these purposes);
- Differing in their sizes and technologies (i.e., learning what the trade-offs are between large and small dams and the opportunities associated with appropriate and emerging technologies); and
- Successes and failures (i.e., learning from what works and what doesn't).

In selecting, designing and carrying out such case studies and assessments, the Commission would put into practice the principles that define the new paradigm and would be expected in any future development of large dams.

chaired by George Greene (IUCN) and Andrew Steer (World Bank) and resulted in agreement on the elements of a work plan for meeting the goal of establishing the Commission by November. Members of the Reference Group are being kept informed of developments and involved in the discussions by Internet and fax. The next meeting of the Working Group, to include some of the Reference Group members, was scheduled for the middle of August so that it can be held in conjunction with the Seventh Stockholm Water Symposium.

The Swiss Agency for Development and Cooperation, under its agreement with the Operations Evaluation Department of the World Bank, agreed to contribute funding to the initial costs of this interim process, while additional support would be sought from other contributors.

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PART II

OVERVIEW PAPERS

ENGINEERING AND ECONOMIC ASPECTS
Of Planning, Design, Construction and Operation of Large Dam Projects

PHOTO COURTESY OF THE WORLD BANK

Men working on the service spillway at the Tarbela Dam, Pakistan

By **ENGELBERTUS OUD** and **TERENCE C. MUIR,** of Lahmeyer International GmbH

Paper Contents

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Note: This paper was commissioned by IUCN from the authors for the joint IUCN The World Conservation Union/World Bank workshop. Any personal opinions should in no way be construed as representing the official position of the World Bank Group or IUCN.

ABSTRACT

Large dams have become the focus of an intense worldwide debate. After publication of the August 1996 report on the World Bank's experience with large dams, the World Conversation Union (IUCN) and the World Bank organized a joint workshop in April 1997 to move forward the debate in terms of a new set of principles to guide future decision-making about large dams. As a contribution to the workshop, this paper summarizes the lessons learned and trends in the planning, design, construction and operation of large dam projects, specifically addressing engineering and economic aspects. Environmental and social issues are addressed in two accompanying papers, which were also presented during the workshop.

This paper summarizes the main trends for large dam projects as follows:

- Increased understanding and awareness of complex technical, environmental and social issues that are inherent to large dam projects, and realization that the development of large dam projects involves a trade-off between the benefits gained against losses.

- Increased awareness that environmental sustainability and high discount rates are in conflict.

- Increased public scrutiny of large dam projects and increased public interest in large dam projects as a result of campaigns by non-governmental organizations (NGOs).

- Increased public consultation in identifying and screening of projects.

- Increased private-sector financing and, as a consequence, drive to cut costs and the duration of design and construction, and to reduce financial risks.

- A number of technological developments which make the planning and construction of large dam projects more efficient.

- The recognized need for independent monitoring and control of project cost, dam safety and environmental and social impact during all phases of project design, construction and operation.

- Increased need for safety inspection and environmental management of existing dam projects.

- Increased interest in modernization and upgrading of existing schemes.

CAVEAT: The authors have specifically been asked to focus on engineering and economic issues. This does not imply that they believe that these aspects can be seen in isolation, as if there would be no interface with environmental and social issues. The contrary is true, as environmental and social issues are increasingly affecting the selection, planning and evaluation of large dam projects, and the authors wish to register that they wholeheartedly support this trend.

1. DEFINITION OF LARGE DAMS

The International Commission on Large Dams (ICOLD) defines “large dams” as dams with a height of 15 meters or more. If dams between 10 and 15 meters high have a crest length over 500 meters, a spillway discharge over 2,000 cubic meters, or a reservoir volume of more than 1 million cubic meters, they are also classified as large dams. Using this classification, worldwide there are about 40,000 such large dams and an estimated 800,000 small dams.

The International Journal on Hydropower & Dams uses the term “major dam project” for projects that fulfill one or more of the following criteria: dam height of more than 150 meters; dam volume of more than 15 million cubic meters; reservoir volume of more than 25 billion cubic meters; and installed capacity of more than 1000 MW. There are more than 300 dams of this category worldwide. Large dams are principally required only for major power production, irrigation and, to a lesser extent, water supply schemes.

2. TRENDS IN PLANNING

THE OLD APPROACH

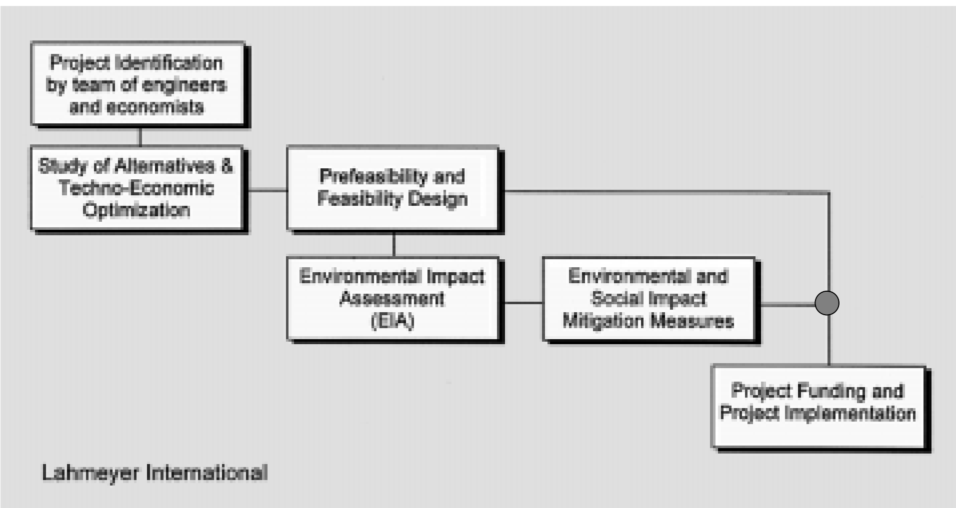
Until recently, the terms of reference for planning studies for large dam projects generally required a future demand (water, power) to be covered in a least-cost manner. The planning procedure was to develop alternative technical solutions, to select the least-cost option, and to mitigate the environmental and social impact of the plan or scenario to a minimum. ’Least-cost’ was defined as the minimum present worth of investment, operating and maintenance costs over a specified planning period, applying real-term discount rates of 10 to 12 percent (in developing countries), and often ignoring external costs associated with control and mitigation of the environmental and social impacts.

In the industrialized countries some form of public discussion and feedback on design has been ensured through legislative and regulatory processes involving hearings. In the developing countries, however, decisions on development options have generally been taken in isolation by governments and utilities together with the international funding agencies, following the previously mentioned least-cost approach.

The reaction to this techno-economic planning approach has been the call for a more ’sustainable development’ and to the formation of interest groups that wanted more attention to be paid to non-technical and non-eco-

Development of Large Dam Projects

OLD PLANNING PROCEDURE



nomic issues. For a considerable time these groups, generally NGOs, were seen as project opponents seeking to obstruct development.

The more stubborn the reaction of the technocratic world to this opposition, the more fanatic and spectacular became the opposition of the NGOs. This has been, of course, ideal food for the media and opposition politicians, and the result has been that many projects, in particular large infrastructure projects, stalled during the planning process as decision-makers and/or funding agencies did not want to burn their fingers. Painful examples from the recent past are the withdrawal of the development banks from large irrigation projects (India) and hydropower projects (Nepal).

Other large projects were implemented in spite of considerable opposition but turned out to be no longer the least-cost project as a result of costly delays and modifications during the implementation phase. Nuclear power plants are a perfect example in this respect.

Disregard for civil rights of primitive people living in the forest and rural communities by those in charge of decision making, often a clique of upper-class urban families and/or insensitive military or autocratic rulers used to commandeering lower ranks, has led to numerous flagrant violations of human rights during the planning, construction and operation phase of large dam projects, which are typically built in remote areas rather than in urban areas. The issue of appropriate Operational Directives of the World Bank addressed this problem and has been instrumental in better protecting the rights of minority groups.

THE NEW APPROACH

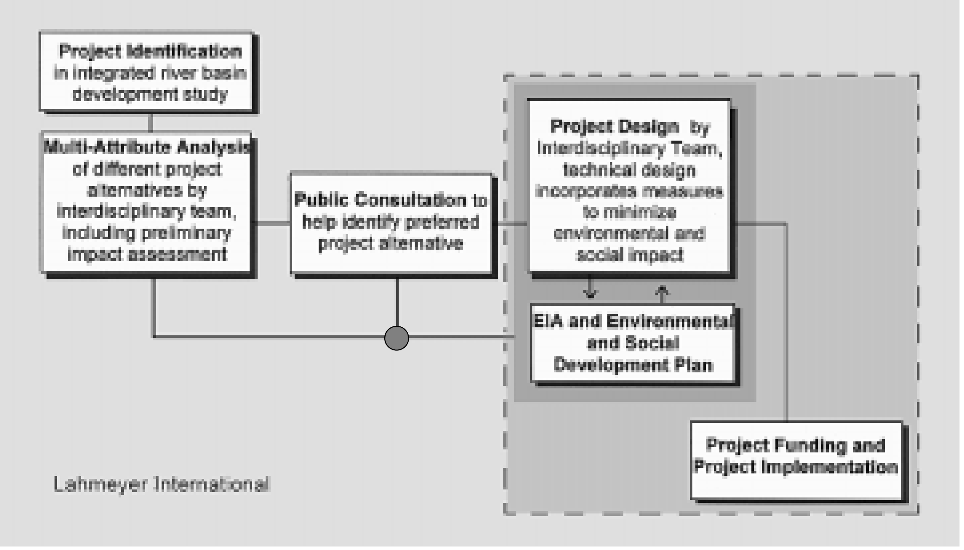
Planning should avoid unnecessary expenditure and effort on projects that in the end will not be carried out. Planning procedures must therefore be geared toward maximized acceptance (or minimized regret).

To ensure broad acceptance of projects or system development alternatives, it is important to present and discuss as early in the planning stage as possible all the pros and cons of competing scenarios with interested parties, including the persons directly affected by the project and NGOs, taking into account technical, economic, financial, environmental, social, institutional, political and risk factors. The interested parties should jointly formulate a limited number (say, five to eight) of alternative plans to cover the future demand. These plans should be diverse with respect to their impacts and should include plans featuring demand-side measures (such as promotion of energy-saving lamps in the power sector or drip irrigation in the agricultural sector) as well as the no-project option.

Subsequently, the necessary studies should be done to quantify and evaluate the alternative plans in sufficient detail to be able to outline the consequences of each plan. Workshops should then be organized in which all interested parties can discuss the results and try to reach consensus about the best plan to be adopted for implementation.

Development of Large Dam Projects

NEW PLANNING PROCEDURE



It is beyond the scope of this paper to describe this process of consensus-seeking in great detail. One method would be for interested parties to first receive a fairly comprehensive presentation of the results of the study of alternatives, then split up into relatively small specialist working groups to discuss and give ratings to each of the project alternatives with respect to, say, economy, environment, impact on local population, etc. The expert group on environment, for example, would first rank and then assign weights to possibly numerous environmental factors to be considered. These weights would be uniformly applied to each of the competing alternatives. Then the individual members of the working group would be asked to give scores to the various factors under consideration. The scores would be multiplied by weights and then summed to arrive at an overall rating for environmental issues for each alternative.

The working groups would also be asked to verbally describe their main findings. Thereafter, the parties would jointly look at the trade-offs between the overall ratings of major disciplines. Inferior (Pareto sub-optimal) and other unacceptable solutions would be discarded (e.g., a hydropower option that would produce power at twice the cost of an alternative thermal power plant). The remaining range of acceptable choices would be discussed until most parties can agree on the alternative proposed for implementation. The entire process should be controlled by an independent and unbiased facilitator who however should be able to broadly understand the type of project or projects under discussion.

This would be a very democratic approach but may be rather novel and even considered unacceptable in some countries, since decision-making is carried out at an autocratic political level without direct consultation with the people affected. Thus, there may be limits as to how open this kind of workshop can be made in practice. The development banks should nevertheless pursue a policy that ensures maximum participation of project stakeholders, and if this is altogether rejected by a particular government, then the international funding agencies should refrain from becoming involved.

The major difference from previous planning practice would be the attempt to reach a consensus of all parties concerned at as early a stage as possible, thus avoiding last-minute surprises after years of development expenditures, as has happened with several large dam projects in the recent past.

THE ROLE OF PRIVATE DEVELOPERS

With few exceptions, the development, ownership and operation of large dam projects in the past has been the responsibility of governments and national utilities. In industrialized countries such projects were financed from internal sources or balance sheet borrowings; in developing countries concessionary capital from multilateral and bilateral agencies was used.

In the last ten years, irrevocable changes have occurred in this regard. Governments everywhere are experiencing greater difficulty in raising finance for large infrastructure projects. This is particularly true of power sector investments which are increasingly being perceived as commercial. In developing countries there has been an accompanying shift in concessionary lending priorities from physical infrastructure to social infrastructure. With an accelerating demand for power-sector investment capital, the private sector has been encouraged to fill the void through private-sector financing and ownership.

In summary, the increasing role of private sector development leads to:

- Emphasis on financial project efficiency, resulting in reduced availability of time and funds for planning, investigation and construction work, and also an emphasis on cost-cutting operation and maintenance procedures;
- Externalization of the indirect costs associated with the project to the maximum extent possible;
- Levying of water (or power) tariffs that guarantee an attractive financial internal rate of return on the investment, with these rates typically being higher than those projects financed conventionally in the past from grants and concessionary loans; and
- Off-loading of as much risk as possible onto other parties, particularly onto the government.

It is clear that there is a strong need for adequate regulation and control in order to maintain standards of safety and workmanship, guarantee reasonable tariffs and government benefits, avoid government exposure to undue levels of financial risk, and mitigate environmental and social impacts.

Private developers want to limit upfront planning and preparation cost to a minimum and will try to shift as much of the costly design work to a point in time where it has secured financing of the scheme. Financial closure requires an accurate cost estimate and time plan for implementation. Public opposition could delay or even halt the implementation of a project and it is, therefore, in the interest of a developer to select a project that can be assured of broad endorsement by the public but which may not necessarily be the least-cost option. This can only be achieved through public consultation in the planning process as described above.

Particularly in developing countries, private developers see themselves exposed to major political risks, for example, the threat of nationalization or difficulties in converting local currency revenues into the hard currencies needed to repay the loans. The international development agencies may be willing to insure the developers against that sort of political risk. This implies that the agency's operational directives need to be followed, particularly those dealing with environmental and social concerns. The directives of the international development banks also call for public participation and consultation.

The emerging planning process for schemes funded by the private sector, but with involvement of the international development banks, appears to be as follows:

- Formulation of a limited number of diverse project alternatives number (say, five or six, one being the no-project option);
- Rapid analysis of these alternatives, considering technical, economic, financial, environmental, social, political and risk factors;
- Election of the best overall solution through a consensus-seeking approach that involves all project stakeholders, including the people affected by the project as well as government and non-government organizations;
- Preliminary arrangements for project financing (memoranda of understanding with banks and development agencies, tariff negotiations);
- Project optimization and feasibility design, including elaboration of environmental and social mitigation and compensation measures;
- Financial closure (arrangement of project funding and final tariff negotiations); and
- Detailed design, tendering and project construction, and implementation of socioenvironmental action plans.

The change to private-sector development poses several other questions. Will governments concerned have the ability and resources to negotiate appropriate terms and conditions with a fair sharing of benefits and risks? Will developers, who are increasingly from countries without an established history of environmental protection, recognize the need for adequate social and environmental mitigation measures? Will there be sufficient time and investment to identify key problems or fatal flaws?

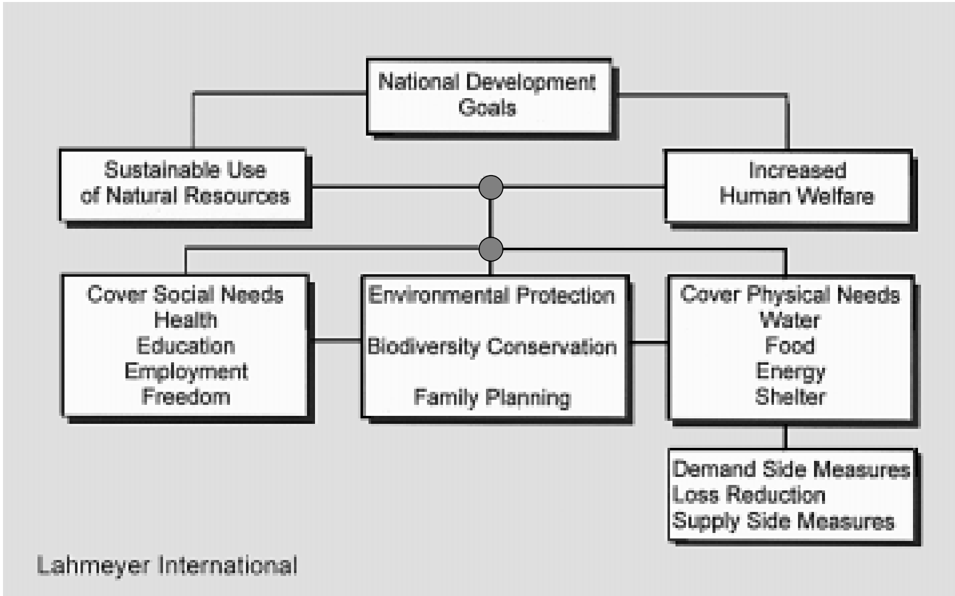
It goes without saying that the projects to be developed by the private sector must still be embedded into an overall water resources development plan for the country concerned and that the development of this plan similarly requires participation and consultation of the public on a wide variety of issues. Here government authorities and international development agencies can and should play a major role.

3. CONFLICTS BETWEEN ECONOMIC AND FINANCIAL PLANNING

Economic planning has begun to internalize external costs in the planning process. External costs are economic costs borne by society, but are not reflected in tariffs. A good example here are penalties for emissions from thermal plants, such as CO_2, causing global warming; SO_2 and NO_X, causing acid rain; and PM_{10}, causing respiratory illnesses. External costs associated with large dam projects could, for example, be the loss of a major waterfall, the loss of biodiversity in the area inundated by the reservoir, the disappearance of migratory fish in the river due to the construction of the dam, CH_4 emissions from irrigated paddy fields, which lead to increased global warming, and so forth. The values that are to be attributed to the various external factors are not always clear in the absence of established procedures. It would be a big step forward if the international development banks would agree on and publish acceptable procedures and typical values for the most important externalities.

Development of Large Dam Projects

PLANNING CONTEXT (1)



The trend toward private-sector financing will inevitably lead to a reduced focus on economic optimality and greater focus on financial viability. In other words, the results of financial analysis will have greater impact on decision-making by the private sector than the results of (socio-)economic analysis. Targeted rates of return for the private sector are, for projects in developing countries, often in the range of 15 to 20 percent, equivalent to 12 to 17 percent in real terms, still higher than the 10 to 12 percent economic discount rate (opportunity cost of capital) which the development banks have typically used for the planning of major infrastructure projects.

High discount rates do not support sustainable development, as the long-term damages or costs associated with a project are simply discounted away. The cost of decommissioning a nuclear power plant, for example, is in the same order of magnitude as the construction cost, but accrues only after 30 to 40 years of operation. If discounted at 10 percent per annum, the decommissioning cost becomes totally irrelevant, equivalent to only a few percent of the total construction cost. Similar examples for water resources projects are the increase in soil salinity and reduction of soil fertility due to irrigation, the increased use of fertilizers and the effect on groundwater quality in the long term.

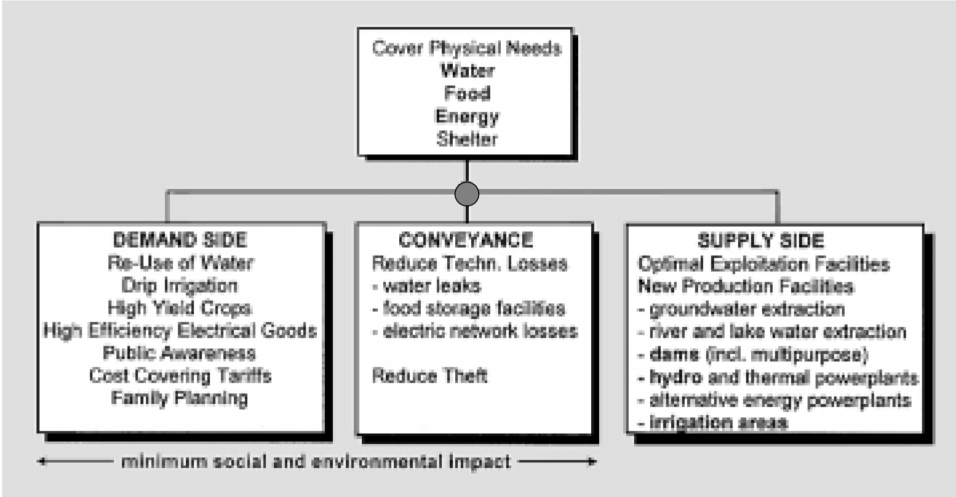
Moreover, financial analysis considers only monetary cash flows, and external costs are not taken into account, which again jeopardizes sustainable development. If, for example, certain fish species become extinct in a river downstream of a major dam, there is normally no financial penalty for the project developer, but costs are borne by society as a whole.

In several environmental studies—for example, those dealing with global warming—a discount rate (social preference rate) of 0 to 3 percent per year is used. A real term rate of 3 percent per annum is incidentally also the real term return on U.S. dollar government bonds, which in a way should reflect the perceived "value of the future."

It appears that it is high time to reconsider the discount rate and the inclusion of external costs. A solution the authors favor, but is flatly rejected by the World Bank, would be to select and "optimize" projects (not just large dams, but all projects with major socioeconomic and environmental impact) based on the social rate of preference, say 3 percent per annum, explicitly considering external costs and benefits. This would be a major step toward achieving long-term sustainable project concepts and would stimulate the use of water conservation measures as against the construction of oversize dam projects. Once projects have been formulated, they can be adopted by the government or private sector for implementation. As a result of the low 3 percent discount rate used to formulate the scheme, financial support may be needed to make it financially viable, and here the international donor community can play an important role.

4. OPTIMIZATION OF PROJECTS IN SYSTEM CONTEXT

Development of Large Dam Projects
PLANNING CONTEXT (2)



Large dam projects, particularly those producing hydropower, need to be optimized in a system context. First, this means that in selecting the best dam sites, it should be kept in mind what the other developments in the river basin can be and how these affect each other. Second, it means that the project should be optimized as part of the overall power system and not just be compared to a thermal plant of a particular type, which would often lead to projects that are too large. The systems analysis requires the use of complex hydrothermal operation models, and the analysis of a range of alternative power system expansion plans—with and without the project, with and without demand side management measures—needed to select the overall best plan. The trends in system expansion planning are:

- A move from single-objective toward multi-objective models, as well as a move away from deterministic least-cost optimization toward detailed multi-objective simulation. These detailed simulation models produce an array of useful data, for example thermal plant emissions, risk indicators, employment figures and so on, which are relevant in selecting the best overall plan;

- Increasing use of chronological models even for long-term planning, using hourly time steps rather than seasonal load duration curves, allowing more detailed simulation of system behavior;

- Improved simulation of the behavior of IPP projects, which try to exploit the power purchase agreement and are not necessarily operated in merit order;

- Models increasingly able to simulate power pool arrangements, where several utilities cooperate in providing power to their consumers;

- Planning models that have become financial rather than economic models, able to simulate commercial arrangements and to predict the income, debt service and profit of individual plants extracted from the data generated by means of complex system operation simulations; and

- System operation models extended beyond the reservoirs to include the rivers and groundwater areas affected, considering both water quantity and water quality.

PROBABILISTIC INVESTMENT ANALYSIS AND AVOIDANCE OF RISK

The likelihood that a project becomes an economic or financial success depends to a large extend on the following factors: probability of cost overrun, probability of delays during construction, availability and value of water, robustness of the water and/or power demand forecast, and probability of difficulties during the operation period.

An important consideration is to assess to whom the risk actually occurs. Governments and developers can insulate themselves from risks by lump-sum fixed price contracts with adequate liquidated damages provisions. The turnkey contractor then bears the full risk, reflected in a higher turnkey contract price, of course.

PROBABILITY OF COST OVERRUN

The availability of modern software for the dimensioning, costing and evaluation of hydro projects enables rapid answers to questions such as:

- What is the effect on the total project costs if tunnel X is not in good rock for 80 percent of its length but, say, only 50 percent, and the remaining part is in poorer rock classes?

- What is the effect on total project cost if the left bank excavation is not 5 meters but 8 meters deep?

- What is the effect on project cost if the permeability rating at the dam site is worse than expected?

- What is the effect of an increase in cement costs of, say, $90 per ton to $110 per ton?

By asking the various experts involved in the project about the probability of such deviations from the adopted base case, various possible cost estimates can be prepared and, assuming unconditional probabilities, a distribution function of expected project costs can be prepared, showing the probability that the cost of the project will exceed certain levels.

Of course, the actual price paid for the project also depends on bidding conditions, market conditions, loan conditions, inflation rate and so forth, and these can be taken into account in a similar manner.

PROBABILITY OF DELAYS DURING CONSTRUCTION

Detailed construction scheduling is necessary in order to understand the interdependence of construction and manufacturing activities, expected weather conditions, etc. By critically examining the probabilities that certain activities may be subject to delay (and cost overrun), a number of construction scenarios can be developed, each with their own likelihood. If, for example, the diversion works would be overtopped with a frequency of once in 20 years, then there is a given probability that the construction site will flood during the diversion period and that delays are to be expected. Or if major water intrusions occur during tunnel excavation, these may also have an impact on the construction schedule.

These data can be superimposed over the distribution curve for project costs.

AVAILABILITY AND VALUE OF WATER

Actual flows may deviate from the mean flow, and the start of commercial operation of the project may coincide with a cluster of dry or wet years. The following procedure allows such effects to be considered in the analysis. The hydrologist could, for example, estimate that there is a 5 percent probability that the mean flow will be 10 percent lower than the estimated value and a 20 percent probability that it will be 5 percent lower; likewise, there could be 5 percent and 10 percent probabilities that the long-term mean flow would be 10 percent or 5 percent higher.

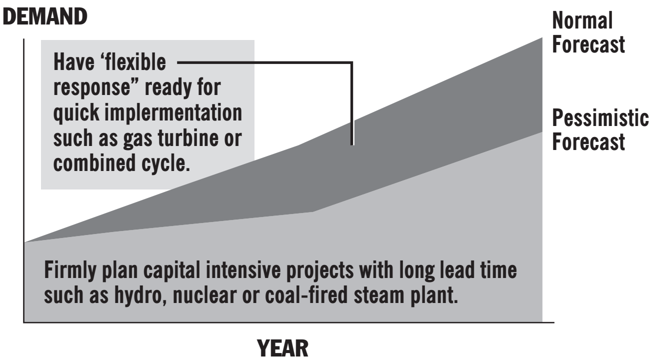
Then, for the cash flow analysis, which extends over the economic lifetime of the project, the hydrological cycle would be superimposed over the period of cash flow analysis and rotated. For example, for Case 1 the operation year 2000 would coincide with hydrological year 1950, 2001 with 1951, etc. For Case 2, 2000 would coincide with hydrological year 1951, 2001 with 1952, and so forth, thus creating as many potential outflow, or power and energy generation, series as there are years in the hydrological reference period.

These series can then be used to calculate the benefit cash flows. Benefits may not be just one value, but could be a range of values or time-variant values—for example, three possible fuel price scenarios in a power system expansion plan, each with the same probability. This process can be automated, and the result would be a distribution function of the expected benefits.

ROBUSTNESS OF WATER OR POWER DEMAND FORECAST

Benefits cannot be realized if the demand for water or power has not grown as fast as predicted. This could happen because there are delays in the development of the irrigation area to be supplied by the project or because of a slowdown in the electricity demand growth.

Most power and energy demand forecast models link in one way or another growth in electricity demand to GDP. Since the correlation is between *historic* GDP and historic growth of the electricity demand, an error is made in using the model with future GDP growth *targets* set by the government, which are almost always over-optimistic. The only thing that can result is an over-optimistic forecast of the electricity demand. It would be worthwhile to correlate historic GDP performance with projected GDP forecasts made in the past in order to understand how optimistic the GDP targets of the government have been. Then, the necessary adjustments to the forecasting model could be made. With increasing welfare, the GDP-demand elasticity usually declines,



and this factor should also be taken into consideration.

Two other factors also lead to over-optimistic demand forecasts. First, a too low demand forecast leads to power supply interruptions, which are extremely expensive, whereas a too high forecast leads to over-investment in plant and transmission lines, which is less costly. It may therefore be better for the forecaster to err on the high rather than low side. Second, in the past, power sector investments largely depended on the availability of grants and concessional loans to finance the capital-intensive projects needed. When opportunities arose to obtain financing under favorable terms or when market prices for equipment were very low, it was best to make use of the situation and to implement a project perhaps a few years earlier than actually needed by the system, given the risk that these finance or market conditions would be less attractive in the future. Then, of course, demand forecasts needed to demonstrate that the project was "needed," and this was in some instances done by predicting a (too) high growth of the demand.

Particularly dangerous are schemes that make each other feasible, such as a hydropower project and an aluminum smelter. The construction of the hydropower plant must start well ahead of the smelter. If then there is a slump in demand for aluminum and the construction of the smelter is delayed, there would arise the potentially unfortunate situation that the hydropower project is being built in the complete absence of an assured market.

Also, political risks must be considered here. It is obvious that the demand forecasts for countries or regions suffering from political instability are less robust than those for stable democracies.

The project benefits should be determined for a number of forecast scenarios, with each scenario being assigned a probability of occurrence, and this should be considered in the overall probabilistic investment analysis.

It is beneficial to cover at least part of the future demand by a "flexible response" plant, such as a gas turbine or combined cycle, with short lead time and (compared to the overall system demand) small capacity, equivalent to, say, not more than 50 percent to 100 percent of the expected annual growth in capacity. This facilitates a flexible response to actual demand growth by deferring or accelerating these projects as needed. Capital-intensive projects with long lead times, such as large dam projects, should be planned on the basis of a rather pessimistic demand forecast, so that expensive mistakes can almost certainly be avoided.

The main lesson is to make sure that capital-intensive projects can almost certainly be used even under a pessimistic forecast. A pessimistic demand forecast is associated with a poorly performing economy, and under these conditions you cannot afford costly mistakes.

DIFFICULTIES DURING THE OPERATION PERIOD

Factors that could affect the economic and financial performance of the project during the operation period include: unexpected reservoir leakage (such as Samanalawewa, Sri Lanka); reservoir sedimentation greater than expected, or more sudden (especially after a severe earthquake, volcanic eruption and/or major typhoon, as happened in the Philippines); a landslide causing dam overtopping with a resulting widespread devastation (Vaiont, Italy) or damage to the power facilities (Guymush, Armenia); and upstream regulation or water extraction by later constructed projects (planned dams in Ethiopia would reduce flows to the proposed Baardheere project in Somalia).

While it is not necessary to be overpessimistic and while it is not possible to assign probabilities of occurrence to such events, it is prudent to determine if such an event would have a severely adverse affect on the project economy.

RISK AVERSION

The results of the above analysis are distribution functions of the present values of project costs and project benefits. A distribution function of the benefit/cost ratio can be produced, which would show with what probability the benefit/cost ratio would fall below unity and by how much.

Large schemes may have lesser relative risks than small projects (because they have been subject to more study), but if they go wrong, they can exert a potentially disastrous effect on even a national economy. In many instances, it would be less risky to build a number of smaller schemes with equivalent total capacity, even if this would be achieved at a higher overall present value of cost, as this would spread the risk. A series of smaller projects has a lesser chance of ending up as an overall economic failure, which developing nations in particular can ill afford. The higher overall cost can be seen as an insurance premium against disastrous economic performance.

THE IMPORTANCE OF COMPREHENSIVE FIELD INVESTIGATIONS

Comprehensive field investigations prior to construction is the cheapest way of risk avoidance. However, due to the cost pressure on preparatory work, particularly in the case of private sector funded schemes where the developer does not have long-term expertise in hydropower projects, there is a tendency to economize on fieldwork. Topographic mapping, hydrological measurements and geological investigations are reduced to a minimum. This is a worrying trend and should be countered from the outset.

The hydrometric and meteorologic networks in many developing nations have deteriorated due to lack of funds and lack of understanding that good hydrological information is fundamental for the accuracy of benefit projections of water resources and other types of infrastructure development. Increased support of donor and funding organizations is necessary to expand existing networks, to include more sediment and water quality sampling and to automate data collection and processing.

Comprehensive field investigations include the fieldwork required to determine the environmental and social impacts of the dam project, to identify mitigation measures and to determine if they will work. The investigations need to be done *before* a final commitment is made to the project by the developer and the government since the study could find the project to be fatally flawed or to require inordinate mitigation measures.

ENVIRONMENTAL ASPECTS

In developed countries there is a strong trend away from environmental assessment of completed design, to the incorporation of environmental teams into the design team. This is in recognition of the importance of environmental matters. The environmental team prepares the Environmental Impact Assessment (EIA), which is usually subject to independent review by consent authorities, such as the environment ministry. The independent review process is often weak or absent in developing countries.

Some argue that the EIA team should be separate to the planning and design team. This is the old way, in which the latter would complete the design, followed by work on environmental mitigation measures. It is much better to incorporate the environmental expertise into the planning and design team from the start, where it can have its greatest influence, *before* the project design becomes firmed up. This way assessment and mitigation of impact becomes an integral part of the study.

Independence is important for public confidence in the environmental assessment process, and is achieved through an independent review by either the authority or, if this does not exist or does not have the necessary capacity, by an independent panel of experts.

STANDARDS AND

STANDARDS AND CHECKLISTS FOR STUDIES

Annex 1 shows the minimum requirements for reconnaissance, pre-feasibility and feasibility studies for large dam projects.

Annex 2 shows a checklist for environmental and social issues that need to be addressed during the project planning and design phase. Environmental and social issues are also handled in two other papers to be delivered during the workshop.

5. TRENDS IN DESIGN

Whereas the previous section deals with trends in planning, the following sections deal, in a somewhat scattered way, with individual design aspects, which are almost all related to the desire to build large dam projects cheaper and faster. Some design changes are also the result of increased awareness of environmental issues.

Another aspect is that of the need for involvement of independent panels of experts already during the design phase, particularly for projects financed by the private sector, to make sure that safety and workmanship meet internationally accepted standards.

Reservoirs. The trend is away from reservoirs that inundate relatively large areas of valuable land, major settlements, areas occupied by indigenous people or areas with unique habitats. Generally, there is a tendency towards smaller-size reservoirs. This could cause problems with sediment deposition in the reservoir itself but reduce problems with upstream aggradation and downstream degradation. Multiple use of water is becoming more and more important.

Reservoir clearing before impoundment is generally seen as necessary. Remaining vegetation needs to be burned before the last rainy season prior to impoundment to let rains wash away much of the organic ashes, which would otherwise be trapped in the reservoir and cause eutrification.

Dams. One of the major breakthroughs in dam construction has been the development of the roller compacted concrete (RCC) dam. The lower cement content and the mechanized placing of the concrete yield a relatively low unit cost of around $30 to $40 per cubic meter of dam body, less than half the price of conventionally placed concrete. The RCC technique enables rapid placement; dams can grow by 60 centimeters (two compacted layers) per day, making it possible to build a 200-meter-high dam in less than a year. Due to the lower cement content, less heat is developed during hardening, which is an added advantage. With RCC dams, river diversion during construction is often in-river, rather than by means of diversion tunnels. This also saves time and money.

So far, only gravity dams have been built using RCC, but soon also arch gravity and arch dams will be able to make use of the same technology, using computer-controlled infrared or radar guided construction machinery to obtain the right shape.

The RCC technology has made many dams feasible that in the past appeared to be economically unattractive.

Another type of dam that has gained increased popularity is the concrete-faced rockfill dam. Not only does it have a smaller volume than a rockfill dam with a central core or an earthfill dam, but an added advantage is that placing can continue even during inclement weather conditions, thereby reducing the cost and the risk of delayed completion.

Major dams are now generally built with drainage and inspection galleries and are well equipped with sensitive electronically controlled instruments to be able to monitor from a central control room any settlement, movement and seepage.

For smaller structures dams with geomembrane lining (up to 80 meters high) and inflatable rubber weirs (up to 15 meters high) are becoming acceptable alternatives to concrete weirs and low rockfill or earthfill dams. The maximum depth of bentonite filled cutoff trenches for controlling seepage has gradually increased over time and now can go down to 60 to 80 meters.

Spillways. Spillway hydraulics are now better understood, particularly with respect to chute aeration requirements, and this has led to the use of higher specific discharges, with an upper limit of about 200 cubic meters per meter width of the spillway chute. This has had a cost-saving impact.

Scouring in the plunge pool area, downstream of the spillway flip bucket, is also now better understood, and by ensuring a safe distance there is less danger of undermining the stability of the dam.

Better forecasting techniques and spillway monitoring can lead to improved safety. Flood warning systems for the downstream inhabitants can help to evacuate people in a timely manner during extraordinary flood events. It is necessary to carry out flood zoning along the downstream river and delineate areas that will, with the dam in place, be subject to, say, a once-in-ten-year or once-in-one-hundred-year design flood or possible dam break. Housing in the area subject to frequent (for example, once in ten years) flooding should generally not be permitted. Flood warning systems should be in place in areas subject to the hundred-year flood and contingency plans must be available to evacuate people during more severe floods or a dam break.

Water intakes. The water quality and water temperature in the upper 10 to 15 meters of a reservoir are normally the best. There is a definite trend to variable-level intakes that allow water to be taken from the top layer—examples are Bakun (Malaysia), Kaeng Krun (Thailand) and Katse-Mohale (Lesotho). Intake levels were determined after extensive reservoir water quality modeling. The release of water without oxygen or with a temperature very different from that of the downstream river should be avoided to prevent adverse effects on fish downstream of the dam.

Water conduits. Tunnel-boring machines are becoming more attractive for various reasons: They allow construction of tunnels and inclined shafts of increasingly large diameters; they cut construction time (which is most important in privately financed schemes); and they are much more reliable than in the past. The steel lining of underground pressure shafts is increasingly substituted by much cheaper heavily reinforced concrete lining, prestressed by means of pressure grouting after placement of the concrete lining.

Underground water conduits are attractive from an environmental point of view, particularly for the absence of aesthetic disturbances in the landscape. Surface penstocks, especially those with smaller diameters, are now often galvanized in order to cut down maintenance cost. In flat alluvial areas, increased mechanization allows major cost reductions in the excavation and lining of power and irrigation canals, with substantially reduced water losses compared with unlined canals.

Powerhouses and control rooms. There is a tremendous drive to cut costs and manufacturing time of hydroelectrical equipment. This has led to increased employment of computer-aided manufacturing, a trend to welding rather than casting turbine runners, and to the design of low-maintenance equipment.

It appears that there is a trend toward enlarging the head range that can be covered by Francis turbines, which have a cost advantage over both Kaplan (low head) and Pelton units (high head). For very large projects, unit sizes are becoming bigger to capitalize on the economy of scale.

Particularly for underground powerhouses, where the setting depth of the turbines imposes little extra cost, Francis turbines with very high speeds can be chosen, hence reducing not only the cost of the turbine but, even more significantly, the cost of the generator.

The increasing popularity of the electronic digital governor and clever software makes it possible to reduce cost and at the same time increase operational flexibility of the power plant.

The digital era has also led to simpler and more interactive project control rooms. Improved and cheaper data archiving, analysis and graphic presentation permit quick and comprehensive statistical analysis of operational data and abnormal events.

Reregulating ponds and fish ladders. For dam projects with a peaking hydropower plant, it is necessary to provide a reregulating pond at the power outlet unless the project discharges directly into a downstream reservoir. Besides regulating the water so that it can be used for irrigation and will not cause damage to downstream boating and fishery, it sometimes has the added advantage that the water temperature can become closer to that in the natural river downstream.

Since the outflow is regular and the head is low, fish ladders may be effective (they are certainly not effective in high dams). Migratory fish can be lured into a container by means of electric inducers and transported to the river reach upstream of the man-made lake.

Irrigation components. Large dams are often associated with major irrigation schemes, and lessons learned in irrigation affect the planning and design of large dams. Old irrigation systems often involved "recession"; i.e., the lands would be planted as the river receded after a flood and the irrigated lands would be subject to considerable variation in water levels during the year.

More or less constant river levels with barrages and/or pumping lead to more continuous irrigation. The water table rises, leading to waterlogging, and when the water table is within reach of the surface, capillary action brings salt dissolved from the soil matrix to the surface. River water itself has a small salt content, and this concentrates in the plant root zone, leading eventually to water rising to the surface, evaporating and leaving behind the salt, which is toxic to plants. Dam projects can also raise the groundwater table in their vicinity generally, sometimes with similar result of water logging and salinity problems.

Modern irrigation design incorporates surface and/or subsurface drainage to keep the groundwater table at a safe distance from the surface and to carry away the saline drainage water.

Older irrigation systems tended to be inefficient, especially when featuring unlined canals and surface flooding. The general trend, especially in water-poor areas, is toward more efficient systems, including sprinklers and drip-irrigation. Modern lining techniques for canals help to reduce the conveyance losses involved in bringing water from the dam to the irrigation areas. The increased efficiencies reduce the stored reservoir volume requirement and the amount of water lost to percolation rather than evapotranspiration from within the plant root zone.

Geographical information systems (GIS), integration of satellite imaginary and terrestrial survey data, and highly automated design, cost estimation and bid document preparation have now reduced the engineering cost of large-scale irrigation systems. Extensive use of modern construction machinery leads to efficient canal excavation and, using the same machine, immediate concrete lining with slip-forms. Laser-controlled earthmoving equipment facilitates the preparation of flat irrigation areas. This high degree of automation and mechanization cuts development costs and reduces time and cost overruns.

HV transmission. High voltage direct current (HVDC) transmission is becoming cheaper and permits efficient long-distance transmission of large amounts of power, even if the electrical systems sending and receiving power are not synchronized. This may permit the construction of large, remote hydropower stations that serve distant load centers and may encourage regional and cross border transfers of electricity.

Design tools. Enhanced finite-element analysis in, for example, rock mechanics, more detailed mathematical models for hydraulic and water quality simulations, and sophisticated, yet user-friendly computer-aided design software are now commonplace and allow the designer to work more quickly and yet more accurately. This is not to say that computer models replace experienced engineers, but rather that experienced engineers are able to work more efficiently and thoroughly.

Just like the models for economic and financial analysis, software used during the design phase is becoming more and more "probabilistic," replacing "deterministic" models. An example is the calculation of the risk of dam-overtopping, a potentially catastrophic event that could trigger the destruction of the dam. Here various events, each with their own probability, may be superimposed on each other: the initial degree of fullness of the reservoir and the initial "wetness" of the catchment, the occurrence of a major storm and the path it follows in passing over the catchment, the direction and force of the wind causing wave action and the likelihood that one or more gates of the spillway will not function. Similarly, other factors affecting dam safety can be analyzed in a probabilistic manner, including the effects of earthquakes, internal erosion due to piping and/or foundation problems. None of these problems in isolation may be reason for a dam failure, but in combination they could be.

The choice of an "acceptable" level of risk needs some thought. First, people are less prepared to accept "involuntary" risk than "voluntary" risk. A person who smokes may for safety reasons protest against the planned construction of a chemical factory nearby, although the real risk for his health associated with smoking is far greater than the risk of, say, a catastrophic explosion of the chemical factory. Second, the perceived risk levels of rare events are generally overestimated, and those associated with everyday dangers are underestimated. A person may happily, without even being aware of any risk, climb a ladder to replace a light bulb, but be extremely afraid to board an airplane for an international flight. However, the likelihood that he dies of an electric shock or falls off the ladder is several orders of magnitude greater than the likelihood that he dies in an airplane crash. The behavior of people depends on how they *perceive* risk, rather than what the true risk is. This is why, for example, airplanes are designed to a much higher safety standard than, say, ladders.

The coming decade will see a tremendous drive toward visualization of the project, based on GIS, computer-aided design and animation techniques. This is increasingly important in an age where non-technical people have to participate in the decision-making process.

Design work by utilities, contractors and manufacturers. Increasingly, utilities from Western countries seek to expand internationally in the absence of a growing domestic market. They have excellent but underused design teams, which can be used to carry out planning and design work for overseas projects in which the utility would like to invest.

In the era of privatization, there is also a trend for the detailed construction design, previously much the domain of international consultants, to be carried out by civil works contractors and equipment suppliers, particularly if they form part of the developer group.

Quality insurance by independent panel of experts. Particularly in an era of increased private-sector involvement and the resulting time pressure on engineering, it appears important that experienced and competent engineers are recruited to examine the design of large dam projects. The importance of quality assurance by a panel of independent experts in reviewing the design and safety of all project structures during the ongoing design stage cannot be overemphasized.

6. CONSTRUCTION

Overall project management. As a result of the increasing cost pressures and the desire to limit financial risks to a minimum, professional project management using modern information tools to coordinate and control construction time schedules and to keep a check on expenditures is becoming ever more important. Increasingly, project managers are requested to have excellent communication skills and to be sensitive to environmental and social issues.

Inclusion of resettlement and environmental mitigation. Implementation of a large dam project is not restricted only to the physical construction of the scheme itself, but equally importantly includes the successful realization of environmental and social mitigation measures. The costs of these measures are part of the normal cost of the scheme and form part of the project equity.

Influx of workers. The desire to build large schemes faster and more efficiently, crucial for private sector financed projects, will often mean that cheap but well-trained skilled labor from other countries is hired by contractors. This may cause local unrest because the local population feels cheated by not having enough access to well-paid construction jobs. The influx of foreign workers may also lead to the unwanted spread of hitherto unknown or rare diseases in the area. Well-paid employment of local laborers in all stages of the resettlement activities, the provision of vocational training to the local population in technical and administrative skills and extensive preventive health care can help in such cases.

Monitoring by independent panel of experts. The regular inspection of ongoing construction and equipment manufacture as well as socioenvironmental mitigation measures by an independent panel of experts is necessary to ensure that the developers, contractors and equipment manufacturers follow prescribed standards and work specifications. The panel should be able to discuss and help solve unexpected problems of whatever nature. For privately financed projects, independent experts should safeguard the interests of the government.

Training of operator personnel. Operator and administrative personnel should receive training during the construction period. This training can take place in similar schemes already in operation and/or on the premises of equipment manufacturers. Those who will be responsible for operation and maintenance of equipment should participate in the erection of it. Training should specifically include safety and environmental monitoring activities. For projects in developing countries, it is wise to train about twice the number of people needed to counter the usually high fluctuation of staff.

7. CONSIDERATIONS DURING THE OPERATION PERIOD

Project operation and management. Lessons from the past are that only a well-trained and well-equipped project staff with sufficient authority can ensure reliable and efficient operation. In developing countries it would often be advisable to engage a number of expatriate specialists, under whose guidance the project is run and maintained during the first few years of operation, while local staff are trained and duties are progressively handed over.

Regular operational tasks can now be scheduled, monitored and administered by computer, greatly facilitating the project administration. Operation and maintenance manuals can be available on computer, with on-line help functions.

For reservoir storage projects in particular, it is recommended that monthly or ten-day water releases be optimized in a strategic way to maximize revenues and minimize environmental impact of the project. The look-ahead period should be one year, and be updated every month. Short-term operation models would then optimize hourly releases and, in the case of hydropower plant, actual unit commitment.

Catchment management and protection should be seen as part of normal project operation and is of common interest to the project developer and environmentalists. Likewise, attention should be paid to mandatory releases to the downstream river, the trend here being away from constant releases toward a pattern that to some extent follows the natural seasonal flow cycle, albeit at a reduced discharge level, for the benefit of the downstream aquatic ecology.

Project operation during abnormal events. Just as aircrews are trained for emergency landings of a plane, personnel of large dam projects should be trained to react decisively and correctly to any emergency situation that could possibly arise, such as passage of extreme floods that threaten to flood downstream settlements; malfunctioning of the project spillway; fire in the project control room, power station or access tunnel; abnormal seepage or settlement of the dam or spillway; or damage to any of the major project structures due to landslides.

Contingency plans must be available, the chain of command must be clear, regular drills should be organized so that the operations staff is prepared for any eventuality, and systems should be in place and tested to warn or even evacuate the downstream population. Flood forecasting and, when appropriate, controlled releases of flood waters to minimize flood damages, should become the rule rather than the exception.

Outsourcing operation and maintenance. Many of the private developers of large dam projects are not familiar with the operation and maintenance of such schemes. To ensure the highest efficiency and to reduce outage times, they outsource project operation and maintenance to specialist companies.

Safety inspections. An independent panel of expert should carry out regular safety inspections. This panel should have full and unlimited access to all operation data and logging devices.

Monitoring environmental and social impacts. The monitoring of environmental and social impact of the project is best carried out by independent organizations, funded by the proceeds of the dam project. Such monitoring should include regular measurement of water levels, flows, water quality parameters and sedimentation in the reservoir, and upstream and downstream of the project; observation of wildlife, fish and fish migration, fauna and flora in and around the reservoir area; health monitoring, active prevention of diseases and medical care for the affected population; monitoring of employment and income levels of the affected population; and control of tourism, hunting and other activities.

Every five years or so a comprehensive ex-post evaluation should be carried out to verify whether project expectations have been met and to determine where further remedial action, to be paid by the project, is required. Ex-post evaluations play an important role in understanding the real environmental and social impact of large dams.

8. REHABILITATING AND UPGRADING OF EXISTING DAM PROJECTS

Review of safety

As existing dams grow older, it becomes increasingly important to regularly reassess their safety aspects. This would best be done by independent experts, rather than by the owner's personnel, to avoid coverups of findings that might embarrass maintenance personnel or perhaps lead to expensive repairs for which the owner would be reluctant to pay.

A thorough review of the safety aspects of existing dams every ten years or so could help to avoid potentially catastrophic situations, such as:

- The magnitude of the design flood may be higher than previously estimated, based on new hydrological data, possibly affected by climatic change;
- In the absence of appropriate regulations and due to a false sense of security given by the absorption of major floods in a reservoir since construction of the dam, housing areas and other infrastructure may have encroached upon the areas that would be subject to flooding during the occurrence of major floods;
- As a result of aging and wear and tear, spillway gates and other outlets may be in poor condition;
- The dam instrumentation may no longer be up-to-date or functioning properly;
- Piping or seepage may have caused deterioration of the dam embankment;
- Deterioration of concrete may have taken place. Cores from old gravity dams are sometimes very degraded; sedimentation may have blocked the bottom outlet; or
- Project operators and downstream community leaders may not have (or may not have been trained to use) contingency plans for emergency conditions.

The review of safety aspects could lead to design changes (for example, additional spillway capacity), installation of additional instrumentation, changes in operation, additional operator training, installation of warning systems, and so forth. The growing importance of environmental awareness, established recreational activities and new project duties may lead to changes in modes of project operation.

Upgrading existing dam projects

It is often possible to boost the performance of existing projects, with relatively little incremental environmental or social impact, and to avoid, or delay, the construction of new dam projects. Depending on the characteristics of the scheme, the following aspects should be checked: replacing or reconditioning of existing turbines and generators in hydropower plants; adding additional turbine units to existing plants; raising existing dams; diverting additional water into existing reservoirs; lining, or repairing the lining of, irrigation canals, cutting conveyance losses; using on-farm irrigation techniques that use less water; improving cropping patterns on existing irrigation schemes; and improving reservoir operation to better exploit the reservoir storage.

9. LONG-TERM TRENDS

Increasing importation of water rights. The growing world population and the increasing needs will make water an increasingly precious commodity. The competition and conflicts about water will increase. It will become increasingly important that national and international water rights are recognized and honored.

The poor's increasing difficulty of paying for water. Increased use and competition of water will also lead to higher costs, and this has two main consequences: There will be increasing emphasis on water conservation and water reuse; and with higher prices, it will become more difficult for the poor to pay for drinking and irrigation water. Social considerations in the planning and design of dam projects may therefore become an important issue.

Greater use of pumped storage plants. In the long term, the role of renewable energy production, particularly solar and wind power, will increase. Some sort of energy storage will be required to offset the considerable fluctuations inherent to solar and wind power plants. Compensation can be provided by conventional hydropower plants, provided they have a reasonable size reservoir, but also by pumped storage schemes, which are particularly suited to even out short-term fluctuations from minute to minute and over the day. The role of pumped storage plant is therefore likely to increase in the long term. This includes underground pumped storage plants, which would make use of disused underground mines. Other storage devices that are getting increased attention are SMES (super magnetic energy storage), battery storage and storage of compressed air in underground caverns.

10. SUMMARY AND CONCLUSIONS

This paper provides a broad overview of the lessons learned and trends in the planning, design, construction and operation of large dam projects, specifically addressing engineering and economic aspects.

In conclusion, the main trends for large dam projects seem to be:

- Increased understanding and awareness of complex technical, environmental and social issues that are inherent to large dam projects; and realization that the development of large dam projects involves a trade-off between the benefits gained against losses; increased awareness that environmental sustainability and high discount rates are in conflict;
- Increased public scrutiny of large dam projects and increased public interest in large dam projects as a result of NGO campaigns;
- Increased public consultation in identifying and screening of projects;
- Increased private-sector financing and, as a consequence, drive to cut costs and duration of design and construction, and to reduce financial risks;
- A number of technological developments that make the planning and construction of large dam projects more efficient;
- The recognized need for independent monitoring and control of project cost, dam safety and environmental and social impact during all phases of project design, construction and operation;
- Increased need for safety inspection and environmental management of existing dam projects; and
- Increased interest in modernization and upgrading of existing schemes.

In summary, the most important are the move to private-sector financing and the increasing public interest in large dam projects. This leads to changes in planning procedures, design and operation.

The review of EIAs, project design, construction and operation by independent panels of experts will play a key role in providing suitable assurance to the public, owners, lenders and government. With increasing public scrutiny of environmental and social impacts, the trade-offs between the benefits of dam construction and the losses will be more explicit to the decision makers.

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ANNEX ONE: A General Guide to the Scope and Accuracy of Hydropower Project Studies

Level: INVENTORY	Level: PREFEASIBILITY	Level: FEASIBILITY
Objective: Establish a comprehensive catalog of project options for the candidate reach or site(s).	**Objective:** Determine provisional ranking of options taking into account optimal integrated development of river reach.	**Objective:** Demonstrate technical, environmental, economic and financial feasibility of project.
Topography: Minimum requirement aerial photography at least 1:60,000, preferably 1:25,000, for stereoscopic interpretation (geometric, geologic, agronomic). Vertical control and river profiles by surveying altimeter. Contour maps by photogrammetric interpretation covering possible dam sites and reservoir areas (for elevation/area/volume curves). Field surveys of cross-sections at dam, powerhouse and other hydraulic works for topographic maps at 1:5,000 with 5 or 10 meter contours.	**Topography:** Photogrammetric survey of reservoir area, altimetric precision corresponding to 1:5,000 up to 1:25,000 scales with 2 or 5 meter contours. Verification of 1:5,000 topography at sites by additional cross-sections. Linkage of surveys (and water level gauges) with regional or national geodetic network.	**Topography:** Field surveys at structure sites and compilation of 1:2,000 maps with 2 meter contours. Surrounding areas at 1:5,000 with 2 or 5 meter contours. Verification of profiles, reservoir area/volume curves and maps prepared during earlier studies.
Hydrology: Historical discharge series of about 30 years, either recorded at (or near) site or reconstituted by regression with records at nearby locations and/or by catchment model. Probabilistic assessment of severity of streamflow deficiency periods included in series. Estimated probability curves of flood peaks and volumes, possibly from regional analysis. Evaluation of regionally available data on sediment transport for estimation of accumulation rates in reservoir. Approximate assessment of precipitation/evaporation balances in reservoir area.	**Hydrology:** Verification of streamflow series established at inventory level. Derivation of design flood hydrographs at various probabilities for spillway and diversion works. Detailed analysis of any sediment load measurements made since inventory, for better estimation of deposition rates and design of any trapping and separating structures. Determination of stage discharge relationship at dam sites and powerhouses based on staff gauge readings and discharge measurements.	**Hydrology:** Updating of previously derived streamflow and meteorological series, flood hydrographs and sediment deposition rates by incorporating any further data obtained since previous study.
Geology: Surface reconnaissance to enable inferences to be made on depth of alluviums, tectonic features, availability of construction materials, pervious formations and slope stability at dam site and reservoir area. Possibly some subsurface investigation by geophysical methods for larger project after preliminary screening of options.	**Geology:** Subsurface investigation by geophysical methods (seismic and/or electrical resistivity) to yield more accurate interpretation of foundation conditions for major hydraulic structures. Verification of previous assessments of slope stability and perviousness of formations in reservoir area and at dam site. In special circumstances, limited mechanical drilling at specific sites of larger projects.	**Geology:** Comprehensive subsurface investigations by mechanical drilling at sites of major surface structures and underground works (tunnels, caverns), supplemented by trenches and exploration adits at dam abutments, along tunnel alignments and in area of underground powerhouse. Complementary investigations by geophysical methods if necessary. Detailed verification of previous evaluations of slope stability, perviousness of formations and availability of construction materials.
Socio-environment: Sufficient agronomic and demographic information to quantify loss of agricultural land and commercial enterprises, number of families or persons to be resettled, etc. Qualitative evaluation of impacts relating to biodiversity, erosion, forest habitat, aquatic ecology, health, archaeology, legal aspects, etc.	**Socioenvironment:** Field surveys to improve inventory level estimates of resettlement and inundation of agricultural lands and business enterprises. reassessment of potential social and environmental problems for IEE report to development bank requirements.	**Socioenvironment:** Verification of prefeasibility estimates of resettlement and inundation of agricultural lands and commercial enterprises. Detailed evaluation of socioenvironmental benefits and potential problems, with recommendations for solutions. Preparation of detailed plans and costings for measures to be undertaken during construction and operation. Fulfill EIA report to World Bank requirements.

ANNEX ONE, continued: A General Guide to the Scope and Accuracy of Hydropower Project Studies

Level: INVENTORY	Level: PREFEASIBILITY	Level: FEASIBILITY
Design: Consideration of several project layouts, including variations of dam axis location, waterway alignment and powerhouse location. Use of generalized types of dam (earthfill, rockfill, concrete gravity dam), hydraulic structures and electromechanical equipment, avoiding unconventional designs intended to reduce costs. Standard criteria for selection of nominal installed capacities and reservoir operating levels. Presentation as single drawing showing general layout and sections through principal structures, supplemented by technical data sheet.	**Design:** Consideration of various project layouts (maximum operating levels and powerhouse locations), for optimum development of river reach or site. Variations around pivotal design (dam height/installed capacity) to permit optimization. Use of specific solutions for major project features such as diversion works, dam, spillway, waterways, powerhouse.	**Design:** Economic optimization of principal project features such as flood surcharge (trade-off spillway capacity and dam crest elevation), diversion works size, waterway dimensions, etc. Preliminary stability analysis of major structures. Particular consideration of construction methods and schedules and their influence on project cost. Details of drawings sufficient for offtake of volumes and costs, including access roads and construction site installations.
Costing: Consistent criteria and standard procedures to obtain homogenous cost estimates of project components, indirect costs and contingencies. Individual unit or total costs represented as functions of specific project variables, on basis of information from suppliers and actual civil works costs incurred on completed projects. Estimates of operation and maintenance costs based on experience in existing projects. Breakdown of costs into labor, equipment and materials, foreign and local currency.	**Costing:** Standard cost estimating procedure similar to that used at inventory level, possibly with greater desegregation into project components.	**Costing:** Use of standard procedures applied during inventory and prefeasibility studies as a basic reference for detailed cost estimate. Determination of unit cost composition of main construction items, taking into consideration capability of local labor, performance of construction equipment, costs of supply and handling of materials, meteorological conditions, access, etc. Combination of cost estimates with construction schedule to yield investment schedule.
Evaluation: Computation of energy production and capacity availability over period of recorded or reconstituted streamflow series, taking into account reservoir elevation area/volume relationships, evaporation and seepage, turbine performance characteristics, existing and planned river basin developments and other uses (irrigation, water supply, flood control), using independent operating policies. Assessment of power and other benefits to yield estimates of net benefits and unit values of kilowatts and kilowatt-hours for projects and alternatives, applying cost allocation procedure to multipurpose projects.	**Evaluation:** Assessment of energy production, capacity availability and power and other benefits for project variants (range of dam heights and installed capacities), applying procedures similar to those used during inventory study, possibly incorporating in some form an optimization model, to arrive at a development of the river reach or site which maximizes total net benefits. Refinement of the scheme, in particular more detailed assessment of installed capacity based on system approach or assumed PPA terms and conditions.	**Evaluation:** Demonstration of technical feasibility of constructing project. Economic evaluation and detailed financial analysis based on estimated investment schedule and possible sources of finance. All assumptions to be stated and sensitivity testing of plausible adverse outcomes included. Benefits, risks and returns for participants to be clearly identified.

All three levels of investigation provide input data to the continuously ongoing planning process, which in turn yields technical and economic bases for:

i) identifying river basins or reaches for study at prefeasibility level
ii) selecting individual projects for study at feasibility level
iii) deciding to construct a project

ANNEX TWO:

CHECKLIST FOR KEY POTENTIAL ENVIRONMENTAL AND SOCIAL IMPACTS CAUSED BY LARGE DAM PROJECTS

Impact Area	Effect of Dam	Consequence	Basic Impacts	Aspects to be Evaluated
❑ upstream catchment	❑ better access	❑ new settlements	❑ clearing of forest cover	❑ increased sedimentation, loss of habitats
			❑ increased agriculture	❑ increased sedimentation, loss of habitats, water pollution due to increased use of fertilizers and pesticides
			❑ new villages, more tourists	❑ wastewater and garbage disposal problems, loss of habitats, poaching, increased forest exploitation and fishery, health problems
	❑ need for watershed protection	❑ erosion control	❑ control vegetation cover	❑ planting of trees, terracing, turfing
			❑ regulate development	❑ limit influx of people, limit agriculturally used areas
❑ upstream river	❑ reservoir backwater	❑ higher water levels	❑ increased sedimentation	❑ increased flooding upstream
			❑ higher groundwater levels	❑ water logging, salinisation, problems with latrines
			❑ slower water velocity	❑ effect on water-borne diseases
	❑ disconnection from downstream river		❑ reduced fish migration	❑ loss of biodiversity, less fishery, lower protein intake local population, health problems
			❑ no boat connection	❑ transport problems
❑ reservoir areas	❑ inundation of land	❑ loss of settlements	❑ resettlement of inhabitants	❑ occurrence of indigenous people, availability of adequate resettlement areas, time needed for a well-planned resettlement, problems with flooding of burial grounds, places of religious or cultural importance, disruption of ethnic integrity
			❑ regional demographic effects	❑ fragmentation of coherent societies, loss of trading and communication patterns, effect on regional economy
		❑ loss of habitats	❑ loss of biodiversity	❑ occurrence of endangered species (fauna, flora, wildlife, fish), disturbance of delicate biological balances
			❑ regional imbalance	❑ fragmentation of larger habitats, effects on migratory patterns of fish, birds, wildlife
		❑ loss of landscapes	❑ loss of scenic beauty	❑ occurrence of unique waterfalls, rapids, panoramic views, wonders of nature, impact on tourist industry
		❑ mineral resources flooded	❑ impact on mining	❑ existing mining operations, occurrence and value of mineral deposits
			❑ minerals dissolve in water	❑ occurrence of salts, evaporities and minerals which can possibly undergo chemical reactions with acid water in hypolimnion
		❑ biomass flooded	❑ effect on water quality	❑ quantities of green, non-green and underground biomass affected
			❑ reservoir clearing	❑ time and costs of clearing, effect on local labor market, effect on prices of sewn timber, plywood and charcoal in the region
		❑ loss infrastructure	❑ relocation of roads, etc.	❑ access to previously pristine areas, logging, poaching, loss of established trade routes profit sharing from timber sales, prospects for burning remaining vegetation and washing ash out prior to inundation
	❑ creation of water body	❑ deep standing water	❑ sediment entrapment	❑ limitation of life storage, limitation project life time, blockage of water intakes, erosion of turbines if sediments reach power intake
			❑ improved navigation	❑ oil spills, noise, new possibilities to travel to and from hitherto isolated areas, establishment of commercial boat transport
			❑ changes in water quality	❑ stratification into epi- and hypolimnion, anaerobe rotting processes in hypolimnion, possible emission of hydrogensulphate and methane possible inversion, colder river water may dip into hypolimnion leading to nutrient deficient top layer of reservoir, effect on aquatic ecology
			❑ changes in aquatic ecology	❑ disappearance of riverine species, proliferation of lacustrine species, development lake fishery, possible introduction of non-endemic species with unknown effects, breeding of vectors for waterborne diseases
		❑ creation new habitats	❑ attraction new species	❑ birds, wildlife
			❑ water weeds, algae	❑ increased evaporation losses, blockage of intakes, increased rotting of biomass, effects on navigation, prospects for biological control (weevils), alga blooming and die-offs
		❑ water recreation	❑ increased tourism	❑ employment in service and sports sectors, industry, danger of pollution, waste disposal and sewerage problems, increased building activity
		❑ micro-climatic changes	❑ increased wind speeds	❑ wave action on man-made lake, affect on reservoir slopes, dam crest elevation and navigation
			❑ increased evaporation	❑ morning mist, locally increased cloudiness and rainfall, reduced temperatures around lake
		❑ higher waterlevel	❑ higher groundwater levels	❑ water logging, salinization, problems with latrines
		❑ greater local mass	❑ increased seismicity	❑ effect on dam safety, other major structures, fear of local population
❑ power plant	❑ high pressure conduits, turbines	❑ fish entrainment	❑ fish kill	❑ damage due to abrupt pressure differences, turbine mortality

CHECKLIST FOR KEY POTENTIAL ENVIRONMENTAL AND SOCIAL IMPACTS CAUSED BY LARGE DAM PROJECTS

Impact Area	Effect of Dam	Consequences	Basic Impacts	Aspects to be Evaluated
❑ downstream river	❑ flow regulation	❑ flood control	❑ lesser inundation of floodplains	❑ nutrient supply to flood plain, need to use and pay for fertilizers, effect on micro-organisms encroachment of people to floodplains with increased damages during major floods which cannot be regulated
			❑ improved navigation	❑ oil spills, noise, new possibilities to travel to and from hitherto isolated areas, establishment of commercial boat transport
		❑ low flow augmentation	❑ increased irrigation	❑ see: irrigation areas
			❑ increased water use	❑ industry: increased employment, improvement regional economy, waste water problems, air quality problems, influx of people to the region
				❑ industry: increased employment, improvement regional economy, waste water problems, air quality problems, influx of people to the region
			❑ less salt water intrusion	❑ estuary: change in water salinity, effect on habitats
				❑ water extractions downstream can increase
		❑ less water level variation	❑ less riverine habitats	❑ less fish, birds, mammals; effect on food chain, effect on nutritionless fish, birds, mammals; effect on food chain, effect on nutrition
	❑ reduced flows (upstream diversion)	❑ lower water levels	❑ lower groundwater level	❑ drying up of groundwater wells, problems for water supply, desertification due to groundwater level falling below rootzones of trees
			❑ navigation problems	❑ less boating transport, higher transportation costs, effect on regional economy, effect on fish migration and spawning, effect on mammal migration
			❑ increased salinity intrusion	❑ estuary: change in water salinity, effect on habitats
	❑ less sediments	❑ erosion of riverbed	❑ lower groundwater level	❑ drying up of groundwater wells, problems for water supply, desertification due to groundwater level falling below rootzones of trees
			❑ caving in of river embankments	❑ loss of overbank habitats, loss of infrastructure
			❑ undercutting foundations	❑ problems for foundations of existing bridges, weirs, jetties, underwater cable crossings, etc.
	❑ changed water quality	❑ less nutrients	❑ less fish	❑ reduced income fishermen, increase fish price, less protein intake poor population, malnutrition effects on bio-chains, i.e. less fish-eating birds
		❑ oxygen deficiency	❑ fish kills	❑ see above, beware of releases through low level outlets of reservoir
		❑ acidity of water	❑ fish kills	❑ see above, beware of releases through low level outlets of reservoir
			❑ increased corrosion	❑ metal objects, such as boats, gates. powerhouse equipment, may be affected
			❑ minerals dissolve in water	❑ potential problem if river sediments contain heavy metals, pesticides, etc. water may become toxic
	❑ disconnection from upstream river		❑ reduced fish migration	
			❑ no boat connection	❑ transport problems
	❑ less sediments to estuary	❑ coastal erosion	❑ loss of habitats and infrastructure	❑ effect on biodiversity, local economy and recreation
	❑ less nutrients to estuary	❑ disturbance aqautic ecology	❑ less fish and other sealife	❑ loss of biodiversity, effect on food chain, reduced income fishermen
❑ stream receiving diverted flows	❑ increased flows	❑ higher water levels	❑ higher groundwater levels	❑ water logging, salinisation, problems with latrines
			❑ increased flooding	❑ crop losses, damage to infrastructure, damage to habitats,
			❑ less shallow water	❑ less spawning, effect on fish, effect on food chain
			❑ improved navigation	❑ oil spills, noise, new possibilities to travel to and from hitherto isolated areas, establishment of commercial boat transport
		❑ low flow augmentation	❑ increased irrigation	❑ see: irrigation areas
			❑ increased water use	❑ industry: increased employment, improvement regional economy, waste water problems, air quality problems, influx of people to the region
	❑ less sediments (relative to discharge)	❑ erosion of river bed	❑ lower groundwater level	❑ drying up of groundwater wells, problems for water supply, desertification due to groundwater level falling below rootzones of trees
			❑ caving in of river embankments	❑ loss of overbank habitats, loss of infrastructure
			❑ undercutting foundations	❑ problems for foundations of existing bridges, weirs, jetties, underwater cable crossings, etc.
	❑ changed water quality	❑ less nutrients	❑ less fish	❑ reduced income fishermen, increase fish price, less protein intake poor population, malnutrition effects on bio-chains, i.e. fewer fish eating birds and mammals
		❑ oxygen deficiency	❑ fish starvation	❑ see above, beware of releases through low level outlets of reservoir
		❑ acidity of water	❑ fish starvation	❑ see above, beware of releases through low level outlets of reservoir
			❑ increased corrosion	❑ metal objects, such as boats, gates, powerhouse equipment may be affected
			❑ minerals dissolve in water	❑ potential problem if river sediments contain heavy metals, pesticides, etc.: water may become toxic

ANNEX TWO, continued:

CHECKLIST FOR KEY POTENTIAL ENVIRONMENTAL AND SOCIAL IMPACTS CAUSED BY LARGE DAM PROJECTS

Impact Area	Effect of Dam	Consequences	Basic Impacts	Aspects to be Evaluated
❑ irrigation areas	❑ increased application of water	❑ higher groundwater levels	❑ water logging	❑ salinization of soils unless good drainage provided, loss of soil fertility in long term
		❑ increased agricultural activity	❑ higher food production	❑ reduced malnutrition, reduced food import, increased food exports, emergence of agro-industry, increased employment effect on regional and national economy, increased need for service industry
			❑ increased use of chemicals	❑ effect of increased use of fertilizer and pesticides on surface and groundwater quality, increased dependency on cash crops
			❑ mechanization	❑ change of farming methods, which small holders can ill afford
			❑ move to cash crops	❑ higher economic vulnerability to crop failures, lower production of traditional staple foods, higher food prices which poor cannot afford
			❑ adaptation to new techniques	❑ stress, fear, higher expenditure on machines and agricultural inputs,
		❑ increased drainage	❑ increased salinity of return flow	❑ effect on fish, drinking water intake
❑ HV transmission lines	❑ new corridors	❑ clearance of land	❑ disturbance of habitats	❑ fragmentation of habitats, invasion by new species, new access to pristine areas
			❑ visual impact	❑ disturbance of natural landscape
		❑ electro-smog	❑ noise impact	❑ humming sound
			❑ electro magnetic fields	❑ especially for very high voltage lines, possible health impact
		❑ potential security problem	❑ vulnerability to sabotage	❑ sabotage to towers in remote areas, effect on project income, effect on power supply security in the country
❑ resettlement areas	❑ new settlements	❑ influx of people	❑ social disruption	❑ ethnic conflicts, resentment in host communities for preferential treatment of settlers, homesickness, adaptation to new environment and lifestyle, destruction of intact social network, decreased mutual support
			❑ marginalization	❑ integration with host community, competition for labour and services
		❑ change of natural environment	❑ health impact	❑ spread of communicable diseases to or from host community, increased stress and traumata
			❑ health impact	❑ waterborne diseases, build up of vectors
			❑ increased pressure on resources	❑ degradation of natural forest, loss of habitats, threat to food security
		❑ waste disposal	❑ increased pollution	❑ waste disposal, sewerage treatment, sanitation standards
❑ construction areas	❑ construction activity	❑ labour demand	❑ employment of local labor	❑ temporary increase of income, neglect of traditional work particularly subsistance farming, acquiring new skills, exposure to health risks
			❑ employment of immigrant labor	❑ social disruption, spreading of disease, prostitution, use of drugs and alcohol, opportunities for shops and restaurant
		❑ disturbance of surroundings	❑ effects on landscape	❑ quarries, spoil areas, temporary roads, cutting of trees, garbage disposal, wastewater problems, soil erosion, increased sedimentation
			❑ noise and dust	❑ noise drives animals away, visual and health impacts due to dust
		❑ exposure to unnatural risks	❑ increased traffic to and from site	❑ road accidents, injuries and deaths
			❑ construction accidents	❑ injuries and deaths
❑ country/region	❑ hydropower generation	❑ less thermal power generation	❑ reduced fuel imports	❑ effect on balance of payment, reduced vulnerability to supply interruptions or price hikes, effect on harbors/refineries, fuel transport
			❑ reduced emissions	❑ less acid rain, less smog, less dust, less contribution to global warming
	❑ irrigation	❑ increased agricultural output	❑ reduced imports, more exports	❑ effect on balance of payment, reduced vulnerability to price fluctuations of imported foods, increased vulnerability to price fluctuations exported
	❑ cumulative impact		❑ better prospects agro-industry	❑ economic development employment effects, potential environmental impact
		❑ higher overall impact	❑ loss and changes to biodiversity	❑ effects on vegetation, fish, wildlife, birds, mammals, human beings; food chain
			❑ accumulation effects	❑ hydrological regime, water quality, sedimentation, accumulation level of dangerous chemicals (heavy metals, pesticides, hormones, etc.)
	❑ increased foreign debt	❑ less funds for other sectors	❑ slowdown of other developments	❑ health, education, basic infrastructure, communication etc.
❑ global	❑ less thermal generation	❑ less global warming		
		❑ slower depletion of fossil fuels		
	❑ impact on unique habitats	❑ threat to endangered species		

SOCIAL IMPACTS
of Large Dam Projects

PHOTO COURTESY OF THE WORLD BANK

Women working in a rice paddy near the Victoria Dam, Sri Lanka.

By THAYER SCUDDER, California Institute of Technology

Paper Contents

Thayer Scudder is Professor of Anthropology and a co-founder of the Institute of Development Anthropology at the California Institute of Technology.

THAYER SCUDDER

Thayer Scudder is professor of anthropology and a co-founder of the Institute of Development Anthropology at the California Institute of Technology. Mr. Scudder has researched the socioeconomic impacts of large dams and river basin development projects on project affected people within reservoir basins and below dams in many parts of the world. He has also served as a consultant on large dam and river basin development projects in North America, Africa, the Middle East and Asia.

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ABSTRACT

This paper asserts that the adverse social impacts of dam construction, whether short-term or cumulative, have been seriously underestimated. Large-scale water resource development projects unnecessarily have lowered the living standards of millions of local people. According to the World Bank's senior environmental advisor, "Involuntary resettlement is arguably the most serious issue of hydro projects nowadays." There are a range of difficulties, yet for those removed and the host populations among whom they are resettled the goal of resettlement must be to become project beneficiaries. The income and standard of living of the large majority must improve to the greatest extent possible. The historical record suggests that realizing this goal is possible but very difficult to achieve. Besides resettlers and hosts, other people affected by dam construction include rural dwellers residing downstream from a dam. They are often neglected in project assessments because it is assumed that they will benefit from the project, but evidence suggests that there are significant negative impacts. While the World Bank has attempted to improve its performance, it continues to underestimate adverse resettlement outcomes and downstream impacts. Scudder suggests a number of ways in which all project affected people can become project beneficiaries. These include increasing local participation, improving the design and implementation of irrigation schemes, providing training and technical assistance to utilize the reservoir fisheries, and conducting strategic flood releases that can benefit downstream users and habitats. Multilateral donors are essential in ensuring that more local people become project beneficiaries.

1. OVERVIEW

Whether short-term or cumulative, adverse social impacts are a serious consequence of large dams. When combined with adverse health impacts, it is clear that large-scale water resource development projects unnecessarily have lowered the living standards of millions of local people. The emphasis in this paper is on the low-income rural majority that live in subtropical and tropical river basins. The analysis will deal mainly with resettlers, host populations and those other project affected people (OPAPS), especially downstream residents, who are neither resettlers nor hosts.

RESETTLERS

According to the World Bank's former senior advisor for social policy and sociology, "Forced population displacement caused by dam construction is the single most serious counter-developmental social consequence of water resource development." The Bank's senior environment advisor concurs: "Involuntary resettlement is arguably the most serious issue of hydro projects nowadays."

A wide range of difficulties is involved. They include the complexity of the resettlement process; the lack of opportunities for restoring and improving living standards; the problem of sustainability of what development occurs; the loss of resiliency and increased dependency following incorporation within a wider political economy; inadequate implementation of acceptable plans due to such factors as timing, financial and institutional constraints; unexpected events, including changing government priorities;

lack of political will on the part of governments; host-resettler conflicts; and the lack of empowerment of relocated and host populations.

For those removed, and for the host populations among whom they are resettled, the goal of resettlement must be to become project beneficiaries. This means that the income and living standards of the large majority must improve. Analysis of the global record in regard to resettlement suggests that realizing this goal is possible but very difficult. The main resource is those relocated. The global experience is that resettlers can contribute to the stream of project benefits if appropriate opportunities and security of tenure over their natural resource base are present.

If more local people are to become beneficiaries, not only must World Bank-type guidelines for resettlers be extended to all project affected people, but the horizon of environmental and social impact assessments must be expanded to include all habitats and human populations that are likely to be affected.

The main theoretical framework dealing with dam resettlement is a four-stage model developed during the late 1970s. Briefly, the four stages are characterized by: one, planning; two, efforts by the resettlers to cope and to adapt following removal; three, economic development and community formation; and four, handing over and incorporation. Successful resettlement takes time. At the minimum it should be implemented as a two-generation process.

Following the initial planning and recruitment stage, the second stage is characterized by the struggle to adjust to the loss of homeland and to new surroundings. That stage is characterized by multidimensional stress, with physiological, psychological and sociocultural components synergistically interrelated. During the initial year following removal, income and living standards can be expected to drop. If new opportunities are available, the third stage of economic development and community formation can begin once a majority of resettlers have adjusted to their new habitat and gained a measure of household self-sufficiency. The tragedy of most resettlement to date is that a majority of resettlers never reach stage three. Rather as the resettlement process proceeds, they remain, or subsequently become, impoverished.

Stage three development must be sustainable into the next generation for the resettlement component to be considered successful. Stage four commences when the next generation of settlers takes over from the pioneers and when that generation is able to compete successfully with other citizens for jobs and other resources at national and local levels. It is also characterized by the devolution of what management and facilitation responsibilities may be held by specialized resettlement agencies, nongovernmental organizations (NGOs) and others to the community of resettlers and to the various line ministries.

HOSTS

Even when political leaders among the host population agree to the movement of resettlers into their midst, sooner or later conflicts between the two can be expected. They arise because of competition among a larger population over a diminished land base, as well as over access to job opportunities, social services and political power.

It is best to anticipate the inevitability of host-resettler conflicts. The best approach for minimizing them is to include the host population in the improved social services and economic development opportunities intended for the resettlers. While such an approach will increase the financial costs of resettlement in the short run, in the long run it will enhance the possibility of multiplier effects as well as reduce the intensity of conflict. Unfortunately, such incorporation of the host population within resettlement programs is rare.

OTHER PROJECT AFFECTED PEOPLE (OPAPS)

Large-scale river basin development projects speed the incorporation of all project affected people, including resettlers and hosts, within wider political economies. Theoretically that should be a plus in terms of national development. The studies that have been completed suggest, however, that such incorporation is more apt to reduce than improve the living standards of a majority. This is especially the case with OPAPS living below mainstream dams.

Aside from run-of-the-river installations, a major function of dam construction is to regularize a river's annual regime. Though few detailed studies have been completed on the impacts of such regularization, those that exist have shown them to have a devastating effect on millions of people. The topic has been best researched in West Africa in connection with mainstream dams on the Senegal River and a number of dams in Nigeria. After three years of studies, an Institute for Development Anthropology team showed that the Manantali Dam as managed by the trinational Senegal Valley Development Authority (OMVS) was adversely affecting up to 500,000 people below the dam. Below the Kainji Dam on the Niger, adverse downstream impacts include reductions in swamp rice and yam production and in the productivity of the riverine fishery. On a Niger tributary further upriver, costs of the Bakolori Dam to downstream villagers is estimated to exceed the benefits realized from the project.

As for OPAPS living in the vicinity of large-scale dams, Hydro-Quebec's James Bay Project illustrates the impoverishing impact on an entire cultural area. For example, the 1975 James Bay and Northern Quebec Agreement split the Cree into eight geographically isolated bands whose exclusive control of surface rights involved only 5 percent of their former lands. More specifically, implementation of the La Grande Phase of the project has had two quite different types of negative impacts. One is the mercury contamination of reservoir fish to the extent that mercury contamination of some Cree, for whom fish are an all-important dietary component, significantly exceeds World Health Organization standards. Causality in this instance can rather easily be ascertained. Such is not the case with the other type of impact, which includes an increased incidence of sexually transmitted diseases and social pathologies such as spousal abuse and suicide, especially among young women.

IMMIGRANTS

Immigrants, both temporary and permanent, from without a particular river basin are major beneficiaries of river basin development projects. Seeking the new opportunities created by a project, they frequently are able to out-compete local people. Two major benefits of large dams are the reservoir fishery and irrigation. Though both involve project affected people as well as immigrants, the latter tend to dominate unless a special effort is made to select and increase the competitive abilities of local people.

HELPING PROJECT AFFECTED PEOPLE BECOME BENEFICIARIES

Increasing local participation. In recent years, the need for local people to have greater involvement in project planning, implementation, management and evaluation has been increasingly emphasized. That emphasis is welcome and important. As with the implementation of plans that actually make project affected people beneficiaries, however, the extent to which local people have actually been involved has been disappointing. Aside from lack of political will on the part of governments to actually decentralize decision-making, there are several other issues that must be dealt with. These include differences in definition as to what local participation means, failure to link decentralization of decision-making with decentralization of financial resources for implementing those decisions, and social disorganization at the community level.

Ironically, increased emphasis on the need for local participation is occurring at a time when customary participatory institutions are weakening because of increasing incorporation of local communities within wider political economies and growing emphasis on private ownership of resources. Moreover, within communities, educated individuals are placing increasing emphasis on household and individual interests, as opposed to extended kin groups and customary institutions of cooperation.

Such circumstances must be dealt with if local participation is to play the role it should in improving the living standards of project affected people. A prerequisite will be participatory appraisal. While customary institutions may be adjusted to new conditions, new socioeconomic and political institutional forms will probably be required.

Regardless of the type of institutions utilized or developed, effective local participation must involve a much broader range of actors than just project affected people. At the national level, commitment must be reflected in the necessary legislative and judicial framework. The assistance of NGOs in institution-building would also be necessary in many cases, as would be the financial assistance of various donors. Also important would be private-sector involvement in various joint ventures as well as assistance from universities and research institutions to develop appropriate monitoring and evaluation capabilities.

Irrigation. Well-designed, implemented and maintained, major irrigation schemes can produce significant increases in both production and living standards in an environmentally sustainable fashion. The main disadvantage of irrigation projects for project affected people is when they not only are unincorporated within a project but are actually evicted from their land to make way for it. As land and water resources become scarcer, political elites will be increasingly tempted to either access them at the expense of project affected people or use them to achieve political goals.

Reservoir fisheries. Critics of large dams have tended to underestimate the importance of reservoir fisheries for project affected people. To benefit, however, training and technical assistance are required, as is protection of the entry of project affected people during the early years of a new fishery. Otherwise, more competitive fishers from existing reservoirs and natural water bodies can be expected to dominate the new fishery. While a major policy deficiency has been failure to anticipate the decline in productivity that characterizes the formation of new water bodies, techniques exist to at least partially compensate for such a decline by expanding the fishery to capture a wider range of species and to use a wider range of techniques.

Improved design and management of existing and future engineering works for making controlled releases. Where dams are to be constructed, design and operations options should include controlled flood releases at strategic times for the benefit of downstream users and habitats. Controlled flooding is not a panacea, however. It may involve tradeoffs with hydropower generation, for example, and the floods that are released may be ill-timed. Moreover, only rarely can they provide a substitute for natural river regimes. Nonetheless, where feasible, the advantages of controlled floodwater releases can be expected to outweigh disadvantages.

ACTIONS TAKEN OR INTENDED BY THE WORLD BANK

In the World Bank's 1994 review of their experiences with involuntary resettlement, a series of "Actions to Improve Performance" are listed. Most important is the recommendation to improve project design in ways that "avoid or reduce displacement." To improve government capabilities when removal is required, the recommended strategic priorities were to "enhance the borrower's commitment" by only financing projects with acceptable policies and legal frameworks, "enhance the borrower's institutional capacity," "provide adequate Bank financing" and "diversify project vehicles," whereby the Bank complements the financing of physical infrastructure with standalone resettlement projects.

Other recommended strategic priorities include the need to "strengthen the Bank's institutional capacity" so as to improve the Bank's ability to deal with the different stages of the project cycle, and to improve "the content and frequency of resettlement supervision." Where possible, "remedial and retrofitting actions" are also emphasized in connection with previously funded, but inadequately implemented, Bank-assisted projects. Finally, the Bank emphasizes that more attention will be paid to promoting "people's participation" and NGO facilitation of "local institutional development."

On the other hand, Bank documents continue to present an unrealistic optimism; a "can-do" advocacy attitude that is uninformed by case and comparative studies. The text of the Bank's 1996 desk study of large dams is an example. The case studies in the second volume, for example, tend to underestimate adverse resettlement outcomes and downstream impacts.

2. INTRODUCTION

This workshop is occurring at a time of increasing criticism of large dams. Such criticism is overdue and welcome because benefits have often been inflated and costs underestimated. Much less has been written on social impacts (aside from those relating to resettlement) than on environmental impacts; hence well-designed long term research is urgently needed. Due to its absence, the arguments presented here rely to a large extent on case studies. What is known indicates that, whether short-term or cumulative, adverse social impacts often are serious. When combined with adverse health impacts (Hunter et al., 1993), it is clear that large-scale water resource development projects unnecessarily have lowered the living standards of millions of local people.

3. DEFINITIONS

Generally speaking, environmental impact analysis has dealt with impacts on the physical and non-human biotic components of ecosystems while social impact analysis has dealt with impacts on sociocultural systems (SCOPE, 1972). In this chapter, an equally broad definition of social impacts will be used, with particular emphasis on the impacts of large dams on the lifestyles of affected communities, households and individuals.

The topic is a vast one, since in effect it includes impacts on entire societies. To make it manageable, some restrictions are necessary. Emphasis throughout will be on the low-income rural majority that lived in subtropical and tropical river basins prior to being affected by one or more large dams. The analysis will deal mainly with three categories of people: those who must be relocated because of project works and future reservoir basin inundation (the resettlers), those whose communities must receive resettlers (the host population or hosts), and those other project affected people (OPAPS) who are neither resettlers nor hosts. A fourth category, immigrants, will be dealt with more briefly.

Because environmental and social impact assessments, as well as supervisory and project completion reports, have tended to ignore project impacts on OPAPS, they will be dealt with in some detail. They include three major types. The first includes those who live in the vicinity of the project works, including not just the dam site and township but also access roads and transmission lines. The second consists of those who live in communities within reservoir basins that do not require relocation or incorporation of resettlers. The third type, which tends to be by far the most numerous, involves people who live below dams whose lives are affected—for example, by the implementation of irrigation projects or changes in the annual regime of rivers in whose basins they reside. Taken together, such other project affected people usually outnumber resettlers and hosts. Therefore failure to assess impacts upon them can be expected to distort feasibility study results.

Regrettably, the restrictions outlined above deemphasize several important categories of people, including immigrants from without the river basin and inhabitants of cities, mining townships and other major industrial complexes both within and without a river basin. Since these categories—as opposed to local rural communities—tend to be the major beneficiaries of water resource development, in terms of rising living standards resulting from increased supplies of industrial and residential electricity and water, it is important for readers to realize that this paper is biased toward those who, to date, are most apt to be adversely affected. While some effort will be made to correct this bias, it is intentional in order to emphasize two points. The first is that the tendency worldwide to ignore (in the case of OPAPS) or underestimate (in the case of resettlers and hosts) the costs of major dams to large numbers of people has inflated their benefits to the extent that insufficient attention has been paid to other alternatives. The second is that there are ways for increasing the likelihood of making a larger proportion of all categories of project affected people beneficiaries in cases where future dams are selected for implementation.

4. NUMBERS

Little accurate data exists on the total number of people affected by even a single dam. The major exception is where a project impacts upon a easily defined area with a relatively small population whose number is already known. An example is Quebec's large-scale James Bay Project, whose components will have a direct impact on approximately 11,000 Cree Indians and an equal number of other residents. In that case the number of resettlers and hosts would constitute only a small minority of the total, a relatively small number of people lived below dam sites, and no major cities would be involved. In contrast, where projects impact upon large numbers of downstream residents—as with the Kariba Dam on the Zambezi, the Kainji Dam on the Niger, the Aswan High Dam on the Nile and the Gezouba and Three Gorges dams on the Yangtze—numbers of those impacted can run into the millions.

5. RESETTLERS

THE GOAL OF DAM-INDUCED RESETTLEMENT

For those removed, and for the host populations among whom they are resettled, the goal of resettlement must be to become project beneficiaries. This means that the income and living standards of the large majority must improve to the extent that such improvement is obvious both to themselves and to external evaluators. Such a goal is justifiable in terms of both human rights and economics. Inadequate resettlement creates dependence and impoverishment and lowers the stream of project benefits through its failure to incorporate whatever contribution those relocated might make, on the one hand, and by creating an increased dependence on safety nets, on the other. It also jeopardizes the life of the project by increasing siltation and decreasing water quality, since poorly relocated and impoverished people within a reservoir basin have little alternative but to overutilize their environment.

Analysis of the global record with resettlement also suggests that the goal of raising the majority's living standards is possible but very difficult. The potential beneficiaries are mainly the relocated people themselves. Although far more research is needed on the later stages of the resettlement process, what little evidence exists suggests that within a few years of removal, the majority may be more receptive to development than their neighbors who were not displaced. That is partly because resettlement is apt to remove a range of cultural constraints to future entrepreneurial activities and initiative, including land tenurial, political and economic constraints. That hypothesis, however, should never be used as a reason for resettlement for two major reasons. One is the multidimensional stress associated with resettlement's initial years. The other is the difficulty of keeping land, other natural resources and of employment opportunities available while sustaining a process of development once it has commenced.

THE SCALE OF DAM RESETTLEMENT

Scale. According to the World Bank, "The displacement toll of the 300 large dams that, on average, enter into construction every year is estimated to be above 4 million people" (1994: 1/3), with at least 40 million so relocated over the past ten years. The construction of dams and irrigation projects in China and India are responsible for the largest number on a country-by-country basis. In China, over 10 million people were relocated in connection with water development projects between 1960 and 1990 (Beijing Review, 1992), while Fernandes et al. have estimated that a still larger number—many of whom were of tribal origin—have been relocated in India over a forty-year period (1989).

Resettlement counts for specific projects are relatively accurate where governments attempt to calculate numbers for compensation and other purposes. To date, the largest number of resettlers from a single project was 383,000, in connection with China's Danjiangkou Dam on a Yangtze tributary. Completion of the Three Gorges Dam on the main Yangtze will require the resettlement of over 1 million people.

Impacts. According to Michael M. Cernea, the World Bank's senior advisor for social policy and sociology until his recent retirement, "forced population displacement caused by dam construction is the single most serious counterdevelopmental social consequence of water resource development" (1990: 1). The Bank's senior environment advisor, Robert Goodland, concurs: "Involuntary resettlement is arguably the most serious issue of hydro projects nowadays." He goes on to add, "it may not be improving, and is numerically vast" (Goodland, 1994: 149). Add the adverse effects that most resettlement to date has also had on incorporating host populations and on habitats surrounding resettlement sites, and the impact magnitude increases still further.

RESETTLEMENT THEORY AND POLICY IMPLICATION

The main theoretical framework dealing with dam resettlement continues to be the four-stage model I suggested in the late 1970s (1981 and in press; Scudder and Colson, 1982). In evolving that framework, I drew heavily on earlier work by Robert Chambers (1969) as well as on Michael Nelson (1973), both of whom presented three-stage frameworks dealing, respectively, with institutional and economic issues involved in land settlement schemes. I also drew heavily on Elizabeth Colson's and my long-term study of those Gwembe Tonga, who were relocated in the 1950s because of the Kariba Dam scheme in what is now Zambia and Zimbabwe. Especially influential was Colson's <u>The Social Consequences of Resettlement</u> (1971), which I believe remains the best single case study of the resettlement process.

Throughout, my focus has emphasized resettler behavior at different periods. Briefly, the four stages are characterized by planning; efforts by the resettlers to cope and to adapt following removal; economic development and community formation within resettlement areas; and handing over and incorporation.

The influence of Chambers is clear in the emphasis placed on the need for facilitating agencies to hand over eventual responsibility to resettler institutions; the influence of Nelson is clear on the need for success to be defined not just in terms of increased production but also improved living standards for the majority.

Successful resettlement takes time. At minimum, it should be implemented as a two-generation process. Barring the impingement of unfavorable factors external to the resettlement process, if success cannot be passed on by the first generation of resettlers to their children, then resettlement has failed. Following an initial planning and recruitment stage, the second stage is characterized by the struggle to adjust to the loss of homeland and to new surroundings. That stage is characterized by multidimensional stress, with physiological, psychological and sociocultural components synergistically interrelated. Increased morbidity and mortality rates are indicative of physiological stress, while psychological stress relates to the loss of home and habitat and anxiety about the future. The non-transferability of various natural resources and knowledge, and cessation, at least temporarily, of a wide range of behavioral patterns, statuses and institutions, cause sociocultural stress.

As a result of such multidimensional stress, I have hypothesized that a majority of resettlers cling to familiar routines and rely on kin, neighbors and co-ethnics to the extent possible during this stage. I also have hypothesized that they are risk-averse, behaving as if a sociocultural system was a closed system. Although a minority may not be affected, such stage two behavior appears to be associated with at least the initial year or two immediately following physical removal.

At least during that initial year, living standards also can be expected to drop to well-planned and well-implemented schemes, since resettlers are faced with the daunting tasks of familiarizing themselves with a new natural resource base, new neighbors and new government expectations while simultaneously developing new production systems and settling into new homes. Hence the cautious, risk-adverse stance continues for a majority of the first generation of resettlers, at least until they have adjusted to their new habitat and gained a measure of household self-sufficiency. Then, if new opportunities are available, the third stage of economic development and community formation can begin. The tragedy of most resettlement to date is that a majority of resettlers never reach stage three. Rather, as the resettlement process proceeds, they remain, or subsequently become, impoverished. Based on comparative analysis of development-induced rural and urban resettlement, Cernea has identified eight impoverishment risks (Cernea, 1990 and in press), all of which are applicable to dam relocation. They are: landlessness, joblessness, homelessness, marginalization, increased morbidity, food insecurity, the loss of access to common property and social disarticulation. As a ninth risk, I would add the loss of resiliency.

As for the third stage, I have hypothesized that it is one of the paradoxes of resettlement that after the initially stressful cessation or inapplicability of a wide range of behavioral patterns and indigenous knowledge, important statuses and institutions may subsequently foster a more dynamic process of economic development and community formation. Less inhibited by previously restricting customs (relating, for example, to land tenurial patterns and community rituals) and by entrenched leaders, aspiring entrepreneurs and leaders are apt to find themselves in a more flexible environment. If true, and more research is required, this finding has important policy implications since attempts by government, NGOs and other institutions to provide appropriate opportunities for resettlers and host communities could speed the arrival of stage three and reduce the trauma and lower living standards that are associated with stage two. They could also increase project benefits by allowing resettlers and hosts to become project beneficiaries rather than liabilities.

On the other hand, I am aware of no cases where timely external assistance can allow a majority of resettlers to bypass stage two entirely. Involuntary resettlement involves trauma that most resettlers cope with in the conservative fashion described. But the extent of that trauma can be lessened, and the length of stage two shortened, by the immediate provision, for example, of upgraded educational and medical facilities. Security of tenure is another prerequisite, whether of housing, land or other important household and community natural resources.

Joy A. Bilharz's study of Seneca relocated in the 1950s in connection with Pennsylvania's Kinzua Dam strongly suggests that resettler participation in the planning, implementation and evaluation of the resettlement and development processes has a positive effect on those involved as well as on their children (in press). We are confronted here with a tricky issue since we have cases where participation has undermined local leadership (since that leadership was seen in the eyes of their constituencies as accepting the undesirable) and where it has strengthened it. How participation can occur and local leaders become involved would appear to be a delicate issue that requires careful comparative research.

Since the early 1980s in the tropics and subtropics, and much earlier in the United States, institution-building for such participation has been facilitated by assisting NGOs whose purview includes developmental as well as environmental and human rights issues. As advocates for potential resettlers, such NGOs, as well as experts hired by local communities, have also been able to bring pressure to bear on governments and donors alike to improve planning and plan implementation in ways that can increase the odds of resettlers eventually becoming project beneficiaries.

Where it helps to empower local communities and to improve their capacity to make informed choices, such assistance can be invaluable. In some cases, as with the Orme Dam in the United States, it can even play an important role in stopping projects that would involve destructive resettlement (Khera and Mariella, 1982). Such assistance, however, also involves risks for local communities. That is especially the case where the agendas of NGOs and potential resettlers vary, or where assistance, including legal challenges, not only fails to stop resettlement but increases the associated trauma by prolonging the period of uncertainty prior to the move.

Again, it is important to repeat that while the above "improvements" can reduce the trauma associated with stage two, the theory holds that they cannot eliminate that stage. As for its termination, there are a number of indicators that characterize movement toward the third stage of economic development and community formation. These include the naming of physical features and increased emphasis on community as opposed to household development as reflected in the establishment of funeral and other social welfare associations and places of worship, including churches, temples and mosques. Cultural identity is apt to be reasserted and even broadened, as in the case of Egyptian Nubians resettled in the mid-1960s in connection with the Aswan High Dam (Fernea and Fernea, 1991). Indeed, I hypothesize that stage three tends to be characterized by a resurgence of cultural symbols, almost a renaissance, as community members reaffirm control over their lives.

As for institutional development, it continues and broadens throughout stage three. Because large dams incorporate project affected people within a wider political economy, the horizons of resettlers expand if new local, regional and national opportunities exist. Economic development is fostered as households increasingly pursue dynamic investment strategies to access those opportunities. Here again, based on comparative analysis, I hypothesize similar trends around the world. Farmers initially begin shifting from a reliance on consumption crops to higher value cash crops. Increased emphasis is also placed on the education of children. Production systems at the household level also begin to diversify, not so much as a risk avoidance strategy as earlier, but as a means for reallocating family labor into more lucrative enterprises, including livestock management and small-scale nonfarm enterprises. Small businesses are run from the household's homestead allotment with subsequent expansion to service centers within the resettlement area and, if especially successful, to urban centers, including national capitals, where real estate investments may also be made.

Stage three development must be sustainable into the next generation for the resettlement component to be considered successful. Stage four commences when the next generation of settlers takes over from the pioneers and when that generation is able to compete successfully with other citizens for jobs and other resources at both the national and local levels. It is also characterized by the devolution of what management and facilitation responsibilities may be held by specialized resettlement agencies, NGOs and others to the community of resettlers and to the various line ministries.

Having relocated the largest number of development-induced resettlers (40 million since the 1950s in connection with construction projects alone, many of which involve dams) it is significant that China's first national research center for the study of resettlement issues has evolved a quite similar four-stage framework for describing a successful resettlement process (Hohai University, 1996).

DIFFICULTIES IN TRYING TO ACHIEVE SUCCESSFUL RESETTLEMENT

I have dealt at length in two recent publications with why successful resettlement is so difficult to achieve (Scudder, 1995 and 1997). A wide range of difficulties is involved. They include the complexity of the resettlement process; lack of opportunities for restoring and improving living standards; the problem of sustaining what development occurs; the loss of resiliency and increased dependency following incorporation within a wider political economy; the inadequate implementation of acceptable plans due to such factors as timing, financial and institutional constraints; unexpected events, including changing government priorities; the lack of political will on the part of governments; host-resettler conflicts; and lack of empowerment of relocated and host populations. Restoration and improvement of living standards and sustainability warrant special emphasis.

IMPROVEMENT OF LIVING STANDARDS

Given the extent of the disruption caused by involuntary resettlement, I do not share the optimism of colleagues within the World Bank that implementation of World Bank guidelines (1980 and 1990) can restore the living standards of a majority in Bank-financed projects. I refer specifically to the Bank not to denigrate its policies but rather because it is the Bank, more than any other institution, that has been responsible for trying on the one hand to reduce the extent of development-induced involuntary resettlement, and on the other hand to improve its implementation where necessary. But most Bank's practitioners are, in my opinion, too optimistic about the extent to which their policies can be expected to restore and maintain living standards over the longer term.

While commending the Bank's guidelines as a major step forward, they contain, in my opinion, the self-defeating statement that while the improvement of pre-removal living standards should be the goal of all resettlement plans, at the very least they must be restored. Restoration of income and living standards, however, is not enough; indeed, in a majority of cases the mere restoration can be expected to increase the various types of impoverishment included within Cernea's impoverishment risk model.

Several reasons support this conclusion. The first one relates to the nature of the resettlement process. During the years immediately following resettlement, and in some cases during the years immediately preceding removal, income levels tend to drop. A second reason relates to the long planning horizon for major dams. During that time period, the people, government agencies and private-sector investors will undertake less development than is the case in adjacent non-project areas. For that reason, resettler living standards will already be lower before removal than they would have been without the project.

Third, where farm land and access to common property resources are lost or reduced, expenses following resettlement are apt to be greater than before. Increased costs are especially a problem for resettlers who have to purchase food supplies that they were able to produce previously, or where less fertile soils require the purchase of such inputs as improved seed and fertilizers, or where new production techniques require loans that lead to indebtedness.

Fourth, even where pre-resettlement surveys are undertaken—and adequate ones are rare—there is a general tendency to underestimate people's incomes at that time. Fifth, merely restoring living standards does not compensate resettlers for the negative health impacts and the sociocultural trauma a majority can be expected to suffer. What is involved here are the wider aspects of what Cernea refers to as homelessness and social disarticulation—namely, Downing's Social Geometrics (forthcoming) and Altman and Low's Place Attachment (1992). There is no way that social cost-benefit analyses can accurately reflect the hardships involved; hence the need to at least partially compensate for them by raising living standards.

Sixth, assuming that peoples' living standards have not been worsened by a project also assumes that no development among those people would have occurred without the project during the years that mere restoration requires. In some cases that would be an unjustified assumption.

Because of the Bank's influence, the unfortunate acceptance of mere restoration of living standards has also crept into even the best national policies. China's policies are a case in point. In the 1991 State Council Regulation on Land Acquisition and Resettlement Regulation for the Construction of Large and Medium-sized Water Conservancy Projects, Article 2 states that "all resettlers shall be assisted to improve or at least restore their former living standards in steps."

SUSTAINABILITY

The difficulty of sustaining a successful resettlement process into the next generation has been seriously underestimated. There are two major reasons. The first is the tendency for the large majority of donor-funded and government projects to deal only with the initial years of resettlement. Project completion reports are finalized at too early a date to be able to assess whether or not initial success is sustainable. The second is the absence of research that deals with resettlement's later stages. As global populations increase and habitats degrade, resettlement areas are increasingly problem-prone, with more people competing for less resources. Relatively unpopulated rural resettlement areas are apt to have a less favorable natural resource base, in terms of land and water supplies, than the resettlers' habitats of origin—that is why they are relatively unpopulated to start with. Elsewhere, whether rural or urban, resettlement usually increases population densities with resettlers, hosts and immigrants competing for natural resources, jobs and other employment opportunities, social services and political influence.

Whether in Africa, Asia, Latin America or the Middle East, land for agriculture is becoming less available for farming populations. Planners talk about replacing land with jobs, forgetting that land is a heritable resource that can support generations of families while jobs, if they are permanent, are rarely heritable, and therefore only benefit a single generation. I am especially concerned by the lack of attention paid by policy-makers and planners to passing on a viable resettlement habitat to a second generation.

Another problem is the tendency of better-educated, more experienced and better-capitalized immigrants to outcompete resettlers for what rural opportunities are available or for hosts, with existing networks and business activities, to outcompete resettlers in establishing or maintaining commercial activities.

6. HOSTS

Though donors may emphasize the importance of involving the host population in project benefits, few planning documents attempt to calculate the size of the host population. Aside from time, personnel and financial constraints to enumeration, there is a problem of defining who is a host. The simplest way would be to restrict enumeration to inhabitants of settlements that physically receive resettlers, but that would place too much emphasis on the housing component as opposed to the impact of those resettled on the arable and grazing lands and other natural resources, as well as employment opportunities and social services of the recipients. Since resettlement always reduces access of a recipient population to land, all such recipients should be considered hosts.

Even when political leaders among the host population agree to the movement of resettlers into their midst (as was the case at Kariba), sooner or later conflicts between the two can be expected. They arise because of competition of a larger population over a diminished (in terms of per capita) land base, as well as over access to job opportunities, social services and political power. Conflicts over grazing can be expected from the start (as illustrated by the Indian Krishna subproject), while securing adequate provisions of water, forage and sustenance for livestock are chronic weaknesses of resettlement programs. Conflicts over arable land can be expected to intensify as the children of resettlers and hosts seek fields to support newly established families. Since political leaders are apt to welcome resettlers as a means of enlarging their constituencies, their resentment can be expected to grow when initially hesitant resettlers appoint their own leaders, some of whom may take over the position of host leaders, especially where resettlers are in the majority.

Few resettlement projects have been documented where host-resettler conflict has not appeared. In the Lusitu resettlement area for the Kariba project, where resettlers outnumbered the host population, initially relationships between the two categories were good. That was in the late 1950s and early 1960s. Then land was plentiful, with hosts providing fields to resettler "friends" in return for various kinds of assistance. Today those hosts increasingly are requesting the return of that land, while their chief has accused the chief of the resettlers of usurping his custodianship of the land.

In Mahaweli's System H, nervous Sri Lankan resettlers and voluntary settlers told Vimaladharma and the author of threats by the host population to drive them off project lands which originally belonged to the hosts. In the catchment surrounding the Kotmale reservoir basin, where over 40 percent of the Kotmale Dam resettlers chose to stay, Ben-Ami reported that the combination of increased population densities and environmental degradation was creating a critical situation not just for the habitat but also in regard to conflicts between the resettlers and the host population (1989 verbal communication).

Some ten years after resettlement in connection with Ghana's Kpong Dam, fighting broke out in early 1989 between resettlers in one of the six villages and the host population. At least ten people died. In that situation, conflict was triggered by the decision of the resettlers to fill a chieftaincy vacancy with one of their own people. Pointing out that their current land had been given to them by the government, they insisted on their right to appoint their own chief. The hosts disagreed and fighting—no doubt exacerbated by tensions over arable land and grazing—broke out.

It is best to anticipate from the outset the inevitability of host-resettler conflicts. The best approach for minimizing them is to provide the host population with access to at least some of the improved social services and economic development opportunities intended for the resettlers. While such an approach will increase the financial costs of resettlement in the short run, in the long run it will enhance the possibility of multiplier effects as well as reduce the intensity of conflict. Access to new schools and medical facilities, as well as to extension services, is probably the cheapest approach. These services are necessary but in most cases not sufficient, simply because increased population densities sooner or later will require some intensification of production among both hosts and resettlers.

Unfortunately, such incorporation of the host population within resettlement programs is rare. One of the few examples relates to planning rather than implementation, but it comes from China, where Three Gorges planners have included the hosts within their agricultural development program should the dam be built.

Granted the importance of incorporating hosts within project development plans, the treatment of host populations in the initial draft of the World Bank's current reformatting of the 1990 resettlement Operational Directive (OD 4.30) into a set of Operational Policies, Bank Procedures and Good Practices is a step backward. OD 4.30 states that plans "should address and mitigate resettlement's impact on host populations … Conditions and services in host communities should improve, or at least not deteriorate." The emphasis on improvement is dropped, however, in BP 4.12 Annex A (l), having been moved into the advisory Good Practices (paragraph 12).

The change is a major one, since the connotation of mitigation is the reduction of negative impacts on the host as opposed to implementing policies that incorporate both resettlers and hosts within a project's benefits. Since the potential for resettler-host conflict is an ever-present one, not to require that hosts also benefit is a short-sighted policy that can be expected to cause eventual conflict.

7. OTHER PROJECT AFFECTED PEOPLE (OPAPS)

Large-scale river basin development projects speed the incorporation of all project affected people, including resettlers and hosts, within wider political economies. Theoretically that should be a plus in terms of potential national development. Studies completed among affected rural populations suggest, however, that such incorporation over the longer term is more apt to reduce rather than improve the living standards of a majority. This certainly has been the case with Kariba, the first main stream dam on the Zambezi. Today, nearly forty years after project completion, the majority of the more than 100,000 project affected people in the reservoir basin are worse off due to environmental degradation and inadequate development influenced by resettlement-related increases in population densities, higher adult mortality rates, reduced incomes and social disorganization. Hundreds of thousands of downstream riparian residents are also worse off due to the adverse effects of the Kariba and Cahora Bassa dams on reduced Zambezi flows, and especially reduced annual flooding, on their production systems. The time factor has been important, with conditions worsening as the years go on.

On the other hand, millions of downstream rural residents between the Aswan High Dam and the Mediterranean are probably better off today than they were before the dam due to improved irrigation, flood control and rural electrification (White, 1988). But are such benefits sustainable over the longer term? In an analysis of the impact of the High Dam and other factors such as rising sea level on Nile delta erosion, a recent conclusion is "no" (Stanley and Warne, 1993). Egypt's breadbasket, the delta is by far the nation's most important agricultural resource. There, however, "human intervention … has caused northern Egypt to cease as a balanced delta system." After postulating a range of interventions for reversing declining conditions, caused, among other factors, by loss in the High Dam reservoir of the Nile's high sediment load, the authors conclude that "at current levels of population growth … these measures will be inadequate." (page 634).

DOWNSTREAM PROJECT AFFECTED PEOPLE

Very few detailed studies have been made of the impacts of large dams on the many millions of people living downstream, the assumption being that flood control benefits would more than compensate for any disbenefits. Worldwide, informed people are beginning to realize, for several reasons, just how wrong that assumption is. As in the Mississippi and Rhine river basins, various flood control mechanisms have, in conjunction with urbanization, led to increased flooding by reducing farm land and water absorptive wetlands and channeling more and more water into a river's primary channel. That is one reason.

Another reason is the growing realization of the very high productivity of riverine habitats, wetlands in particular (IUCN, ongoing), and the need to enhance rather than reduce their extent and productivity. Related to that, a third reason—of primary concern here—is the fact that millions of contemporary people are dependent on the productivity of those wetlands and flood plains. Where dams reduce them, local people are impoverished. Developers and donors rarely take that into consideration. If they had in the past, and the necessary broader feasibility studies had been carried out, many completed projects would have been shown to be uneconomic.

Flood plain utilization has played a major role in the formation of city states and of civilization in Africa, Asia, the Middle East and the Americas, as shown by archaeological studies. Oddly, few socioeconomic studies have dealt in detail with the contemporary utilization of flood plains. Those that have been done emphasize the extent to which flood plains constitute by far the most important resource in local production systems (Scudder, 1962, 1980 and 1991; Horowitz, Salem-Murdock et al., 1990). Annual flooding is not only critical for maintaining that resource, but for the survival of dependent communities. As floods recede, for example, communities throughout the arid and semi-arid lands of Africa practice flood recession agriculture. As the dry season progresses, the much higher carrying capacity of flood plain grazing allows cattle and small ruminants to survive until the coming of the rains, while the flood cycle itself is necessary for sustaining productive fisheries and recharging aquifers.

DAMS AND FLOOD REGULARIZATION

Aside from run-of-the-river installations, a major function of dam construction is to regularize a river's annual regime by augmenting low-flow periods and greatly reducing periods of flooding in order to make available a more constant water supply for hydropower generation, navigation and commercial irrigation. Though few detailed studies have been completed on the impacts of such regularization, those that exist have shown them to have a devastating effect on millions of people (Drijver and Marchand, 1985; Horowitz, Salem-Murdock et al., 1990; Adams, 1992; Hollis et al., 1993; Scudder, 1994; and Acreman and Hollis, 1996).

The topic has been best researched in West Africa in connection with mainstream dams on the Senegal River and a number of dams in Nigeria. After three years of studies, an Institute for Development Anthropology team showed that the Manantali dam, as managed by the trinational Senegal Valley Development Authority (OMVS), was adversely affecting up to 500,000 people below the dam (Horowitz, Salem-Murdock et al., 1990). In his 1994 analysis of the Kainji Dam project on the Niger, Roder notes that adverse downstream impacts include an estimated 60 to 70 percent reduction in the riverine fishery and a 30 percent reduction of seasonally flooded (fadama) land that has lowered swamp rice production by 18 percent. Although I have seen no confirmation of his figures, in a 1979 FAO technical paper (Welcomme) Awachie stated that Kainji had also been at least partially responsible for a 100,000-ton reduction in yam production further downriver, in which case we can assume that the dam's impoverishing effects involved hundreds of thousands of people. On a Niger tributary further upriver, Adams (1993) estimates that the costs of the Bakolori Dam to downstream villagers in terms of reduced crop, livestock and fisheries production actually exceeds the benefits realized from the project.

Elsewhere in Nigeria, dams constructed mainly for irrigation purposes in the Hadejia-Jama' are system have significantly reduced downstream flood plains—once again at the expense of local producers. Indeed, in at least one major case, evidence suggests another project-related loss, with Barbier et al. demonstrating that the net economic benefits of flood plains that have been significantly reduced by river control mechanisms were at least $32 per 1,000 cubic meters of water versus only $0.0026 for the irrigated Kano Project when all costs (including operational costs) are included (referenced in Acreman and Hollis, 1996; see also Hollis, Adams and Aminu-Kano, 1993).

THOSE WITHIN A PROJECT'S VICINITY: THE JAMES BAY PROJECT AND THE CREE

Hydro-Quebec's James Bay Project provides an excellent case history in that it illustrates the impoverishing impact on an entire culture area (as opposed to just resettlers and hosts), and the difficulties that local people must face in trying to modify, let alone cancel, projects. Like the Lesotho Highlands Water Project, the James Bay Project is one of the five largest contemporary river basin development projects in the world. If completed, the total generating capacity of more than twelve dams would be about 25,000 megawatts, of which the generating facilities for 10,000 megawatts have either already been completed or are under construction in the first (La Grande) phase.

Advocates of the project point out that virtually no compulsory relocation is necessary, the engineering works and reservoirs require the movement of not a single Cree village. Rather the only relocation, and numbers of people are probably less than a few hundred, pertains to a relatively small number of trapline camps. Most of those, if not all, can be re-sited within each family's trapping territory, so that the number of hosts is even smaller. In other words, well over 90 percent of the people (OPACs) adversely affected by the project are neither resettlers nor hosts.

SOCIAL IMPACTS (THE 1975 JAMES BAY AND NORTHERN QUEBEC AGREEMENT)

At the time Quebec's premier announced the James Bay Project, in April 1971, there had been no Cree involvement in project planning or design, nor had any form of social impact analysis been carried out. With construction already under way by the mid-1970s, the emerging Cree leadership believed, probably correctly, that they had little hope of stopping the first phase of the project. By agreeing to its implementation and becoming signatories of the JBNQA, at least they received in return a promise of a degree of self-government and an innovative program for maintaining trapping, hunting and fishing activities.

Such benefits led anthropologist Richard Salisbury and other friends of the Cree to see JBNQA in a positive light. Certainly it had an impact-mitigating influence. More important, it led to the formation of the Grand Council of the Cree and the Cree Regional Authority, which provided the Cree with a degree of political self-determination and an institutional structure for facilitating economic development. On the other hand, the land settlement provisions of the JBNQA split the Cree into eight geographically isolated bands whose exclusive control of surface rights involved only 5 percent of their former lands, with another 15 percent set aside for their exclusive hunting, fishing and gathering. Aside from preferential access for the Cree to certain mammals, the remaining 80 percent in effect was handed over to Quebec's James Bay Development Corporation.

The implementation of the La Grande Phase has had two quite different types of negative impact. One is the mercury contamination of reservoir fish (with inundation increasing the release of methyl mercury), to the extent that mercury contamination of some Cree, for whom fish are an all-important dietary component, significantly exceeds World Health Organization standards. Causality there can rather easily be ascertained. Such is not the case with the other type of impact, which includes a high incidence of sexually transmitted diseases (STDs) and such social pathologies as increasing spousal abuse and suicide, especially among young women. Unlike the situation on other reservations in both Canada and the United States, the Cree have been able to avoid a dependency on provincial and federal welfare. Unemployment insurance, for example, and aid to dependent children make up a relatively small proportion of Cree income: only 6 percent in 1985, for example. Can the increasing rates of STDs and social pathologies be associated, therefore, with the project-related, accelerated rates of contact with outsiders and outside ideas, which Cree elders and leaders also tend to associate with an erosion of cultural values? Quite possibly they can.

To summarize, the James Bay Cree agreed to the project in the 1970s in return for a degree of political self-sufficiency at the expense of maintaining control over the development of their homeland. Thereafter neither the federal government of Canada nor Quebec Province delivered what they had promised the Cree under the James Bay and Northern Quebec Agreement. Furthermore, the James Bay Development Corporation has largely ignored the Cree in planning and implementing development projects. Tourist and other facilities along the north-south access road, which fell under JBDC jurisdiction, were almost exclusively run by outsiders in 1994 with minimal Cree involvement, including employment.

8. IMMIGRANTS

Immigrants, both temporary and permanent, from without a particular river basin are major beneficiaries of river basin development projects. The largest number of temporary immigrants are associated with a project's construction phase. While employment on advanced infrastructural and the main civil engineering contracts are often listed as a benefit for local people, in fact local workers tend to be only a small minority of the labor force. For example, during construction of the first stage (La Grande) of the James Bay Project in Quebec, less than 5 percent of the labor force were Cree Indians, in spite of the existence of available and otherwise unemployed manpower. There are several reasons for this situation. Most important is the fact that local people seldom have the skills required by contractors, with crash training programs seldom bringing skills up to the desired level—as the Lesotho Highlands Water Project found out. Moreover, contractors often bring a significant portion of their labor force with them or recruit immigrant workers with previous construction experience. On completion of China's Gezouba Dam, for example, many of the 40,000 workers stayed in the area expecting to join the labor force for the construction of the Three Gorges Dam.

Though a small minority of temporary workers choose to remain in the area after their contracts end, most immigrants come after the completion of the construction phase. Seeking the new opportunities created by the project, they frequently are able to out-compete local people. Two major benefits of large dams are the reservoir fishery and irrigation. Though both involve project affected people as well as immigrants, the latter tend to dominate unless a special effort is made to select and increase the competitive abilities of local people.

9. PROJECT AFFECTED PEOPLE AND RESISTANCE MOVEMENTS

Planners are apt to attribute local opposition to large dams to outside agitators. The British colonial administration blamed resistance to Kariba on the north bank of the Zambezi, for example, on the growing influence of external political organizers agitating for national independence. That was in the late 1950s. When approximately 1,000 local citizens vilified senior officials at a meeting to protest the arrival of equipment in late 1990 for initiating the first phase of the Southern Okavango Integrated Water Development Project (SOIWDP), the government of Botswana blamed international environmentalists and largely expatriate-owned, safari firm interests.

In both the Kariba and Okavango cases, however, resistance came primarily from project affected people who believed construction would be at their expense (Colson, 1971; Scudder et al., 1993). Opposition in both cases appeared to be close to universal. Among project affected people in SOIWDP's impact areas, opposition was based on the people's conviction that their lives had deteriorated following previous attempts to manipulate Okavango flows. The misgivings of those affected by Kariba have been shown to be correct: inundation of the fertile alluvial soils cultivated by villagers before removal has been one factor in the deterioration of their living standards in recent decades.

To date, resistance movements have involved resettlers more than hosts and other project affected people (Scudder, in press). Worldwide, with only a few exceptions, a majority of those involved in thousands of water resource development projects have resisted removal. Exceptions themselves are illuminating. The construction of the Aswan High Dam in the 1960s appears to have been welcomed by those remaining in Nubia only because the earlier construction of the Aswan Dam, plus two dam heightenings, had so impoverished those who had relocated to the reservoir margins that up to 100 percent of the men in some of the villages closest to the dam had to seek employment in the urban centers of Egypt and the Sudan. Resettlement in the 1960s was welcomed by men and women alike because they believed it would reunite families in the downstream Kom Ombo resettlement area that had been split up because of earlier relocation impacts. In the case of TVA's Norris Dam, the majority initially welcomed the project because, as tenant farmers and poor land owners, they believed, erroneously, that completion would bring industry and higher-paying industrial jobs.

Looking to the future, resistance movements can be expected to increase because of the increasing opposition—as currently in Brazil and India—of national and international human rights and environmental NGOs who are willing to become advocates for project affected people. Their arguments in turn will be supported by increasing emphasis on the rehabilitation and reorientation of existing facilities, by the extent to which benefits have been overestimated and costs—especially to project affected people and the environment—underestimated, and by increasing evidence that greater benefits in many cases can accrue from the implementation of alternatives that do not require major engineering works. The growing sophistication and recent international networking of indigenous people affected by major projects will also strengthen resistance—for example, the James Bay Cree played a major role in the suspension during 1994 of Hydro-Quebec's Grande-Baleine Project.

10. HELPING PROJECT AFFECTED PEOPLE BECOME BENEFICIARIES

INCREASING LOCAL PARTICIPATION

In recent years, governments, donors, academics and NGOs all have been emphasizing the need for local people to have greater involvement in project planning, implementation, management and evaluation. That emphasis is welcome and important. As with the implementation of plans that actually make project affected people beneficiaries, however, the extent to which local people have actually been involved has been disappointing. Aside from lack of political will on the part of governments to actually decentralize decision making, there are several issues that must be dealt with.

One is a difference in definition as to what local participation means. In Botswana, for example, government presents its use of customary meetings, at which local people discuss vital issues with their leaders, as a form of local participation. Such meetings are used more to inform local people of the government's intentions, and to solicit their reactions to those intentions, than to actually involve them in the planning process. A second issue relates to government and donor hesitation to link decentralization of decision-making with decentralization of financial resources for implementing those decisions; yet the first without the second is meaningless.

A third issue relates to local populations themselves. Ironically, increased emphasis on the need for local participation is occurring at a time when customary participatory institutions are weakening because of increasing incorporation of local communities within wider political economies. Whether by governments, donors or local people themselves, increasing emphasis is being placed on private ownership of resources as opposed to customary systems based on limited access to communal resources. Within communities, educated individuals are placing increasing emphasis on the household as opposed to extended kin groups and customary institutions of cooperation, such as work parties. Moreover, households themselves are becoming increasingly fractionated due to differing interests among members (Dwyer and Bruce, 1988).

Such circumstances, including also the increasing differentiation within communities, must be dealt with if local participation is to play the role it should in improving the living standards of project affected people. A prerequisite will be participatory appraisal (Kumar, 1993), whereby local people and planners work together to determine how best to institutionalize local participation. In some cases, customary institutions such as funeral and other social welfare groupings and cooperative labor parties may be adjusted to new conditions. More often, however, new institutional forms will probably be required. An effective example of this is the Grand Council of the Cree, which arose during the 1970s in response to the Province of Quebec's James Bay Project. Another institution extending beyond specific communities, which would appear to be especially applicable to project affected people clustered within a defined area, is a People's Trust (Reynolds, 1981). Proposed as a Highlands Trust for the Lesotho Highlands Water Project (Maema and Reynolds, in press), the People's Trust idea also would be especially applicable to the 11,000 Cree affected by the James Bay Project.

Key features of a People's Trust involve placing funds allocated for benefiting local people in a trust under their control. Such funds should be available at the beginning of the project cycle so that local people can be actively involved during feasibility studies. Although it did not extend beyond such studies, one recent example is the instance in which Hydro-Quebec made funds available to the Grand Council of the Cree so that they could carry out their own analysis during the 1990s of the impacts of the Grande-Baleine component of the James Bay Project.

Should a decision be made to proceed with a project, funds allocated for resettler, host and other project affected people's development would be added to the Peoples' Trust. Trustees would be locally selected from project affected people, rather than government officials, and would have the authority to decide how those funds should be used, while at the same time, subject to the appropriate oversight. Other features of the trust concept look especially attractive if applied to project affected people. One is its linkage to a hierarchy of periodic markets that link local communities as producers to government administrative centers as providers of services. Government and private-sector institutions (such as banks providing credit), for example, would send representatives to the local markets so that local people would not have to make expensive, and often futile, trips to district and other government centers.

Regardless the type of institutions utilized or developed, effective local participation must involve a much broader range of actors than just project affected people. At the national level, commitment must be reflected in the necessary legislative and judicial framework. Where revenue-sharing occurs too late in the project cycle—as in China, where revenue for development purposes comes primarily from electricity sales—multilateral, bilateral and NGO donors may be asked to provide some funding. The assistance of NGOs in institution-building would also be necessary in many cases. So, too, would the private sector's involvement in various joint ventures with local communities, such as linking agricultural outgrowers to processing facilities, or developing tourism or other nonfarm industries. Assistance from universities and research institutions could also be anticipated for helping project affected people develop appropriate monitoring and evaluation capabilities.

IRRIGATION

Advantages

A major option for assisting project affected people to become beneficiaries is to incorporate them within irrigation schemes. One of the best examples of such incorporation was during the earlier phases (Systems H and C) of Sri Lanka's Accelerated Mahaweli Project where resettlers and downstream hosts were given priority over all other categories of participants.

If well-designed, implemented, managed and maintained, major irrigation schemes can produce significant increases in both production and living standards in an environmentally sustainable fashion. There are examples of such successes from all geographical areas. Adjacent communities (those not within command areas) may also benefit in a major fashion, as Epstein's Indian research in Karnataka has shown (1962 and 1973), while Goldschmidt's research in California's Central Valley showed that irrigation schemes based on family farms can be expected to generate more multiplier effects in terms of enterprise development and employment generation in market and service centers than large-scale agribusinesses (1978).

Disadvantages

The most disadvantageous situation for project affected people is when they are not only unincorporated within an irrigation project, but are actually evicted from their land to make way for it. There are innumerable cases where the land base of unincorporated project affected people has been reduced to make way for irrigation projects on which government selected settlers are predominantly immigrants. Although cases where hosts to a scheme are evicted from their lands without compensation are far fewer, the danger exists that their proportion is increasing as more and more people compete for less and less natural resources. Large dams are especially vulnerable to political considerations (Fredericksen, 1992; Ribeiro, 1994; and Waterbury, 1979), with large-scale projects frequently influenced by the political ideologies of heads of state (Scudder, 1994).

As land and water resources become scarcer, political elites will be increasingly tempted to either access them or use them to achieve political goals. Three examples illustrate the risks to project affected people. In recent years the governments of both Mauritania and Somalia passed land registration acts that favor individual tenure of those with capital over customary systems of land tenure at the village level. In both cases, politically well-connected immigrants in search of land to irrigate have used those acts to displace local people below the Manantali Dam on the Senegal River and the proposed Baardeera Dam on the Juba River. In the third case, a cabal within the Mahaweli Authority of Sri Lanka plotted to displace Tamil-speaking hosts from now arable lands in a later phase (left bank of System B) of the Mahaweli project by a massive land invasion of poor Singala-speaking settlers in order to split in half the Tamil-speaking minority to the north and east (Gunaratna, 1988). Though the land invasion failed, government-stated policies to not mix settlers of different religious affiliation in the same community, and to select settlers from all ethnic groups according to their percentage in the national population, have been ignored. In spite of major international funding in all three examples, in no case did donors (the World Bank included in two of those cases) try to intervene.

Disadvantages where project affected people are included within irrigation projects are the same as those for all participants where projects are poorly designed and maintained. Environmental problems affecting project life include siltation of reservoirs, water logging and salinization, and loss of biodiversity. Public health problems include increased incidence of malaria, schistosomiasis and other waterborne diseases, as well as dysenteries. Socioeconomic problems arise from insecurity of tenure and poor land preparation and water distribution as well as from poorly designed production and marketing systems that prevent settler households from raising their living standards beyond a subsistence level. A separate problem is the frequency with which focus on a single cash crop lowers the status of women, especially in cases where they had their own pre-project fields or crops. Notwithstanding such problems, incorporation within an irrigation project is still a better option for project affected people than exclusion. Technical and participatory (e.g., water use associations) solutions to all of the above disadvantages exist and are well known. What is lacking is their incorporation within plans followed by their implementation.

RESERVOIR FISHERIES

Critics of large dams have tended to underestimate the importance of reservoir fisheries for project affected people. In order to make them beneficiaries. however, training and technical assistance are required, as is protection of the entry of project affected people during the early years of a new fishery. Otherwise, more competitive fishers from existing reservoirs and natural water bodies can be expected to dominate the new fishery as has been the case with Ghana's Volta reservoir (still the largest artificial reservoir in the world) and Mali's Manantali Reservoir.

The development of the Lake Kariba reservoir fishery illustrates effective ways for incorporating project affected people. For an initial five-year period the fishery was closed to immigrants. During that time a training center was built that offered short courses to small-scale commercial fishermen. Improved boats were designed with local carpenters trained in their manufacture. Credit was made available to buy boats and other gear. Lakeside markets were provided with accessible feeder roads for exporting fresh and smoked sun-dried fish.

Although they did not previously have the technology for fishing mainstream Zambezi waters, the response from local people was rapid, with over 2,000 resettlers, hosts and other project affected people catching over 3,000 tons annually within a four-year period. Not only were loan repayments over 90 percent, but savings were invested in ways that enabled a majority of fishermen to shift to other activities when the now predictable decline in the reservoir's initial productivity occurred. Especially important was investment in cattle (and especially plow oxen), which played a major role in the rapid development of mixed farming, including cash cropping of cotton and cereals and sale of livestock by small landholders. Small village stores and other commercial enterprises were also established. Education of children was emphasized, which allowed many children to proceed on to a secondary school education, and higher earning opportunities, which their families otherwise could not have afforded. The fishery also provided a major mechanism for further incorporating village women within a market economy by providing them with an outlet for the sale of village produce and the manufacture of beer within the fish camps.

The major policy failing was not anticipating the decline in productivity that characterizes the formation of new water bodies. Anticipatory planning can at least partially compensate for such a decline by expanding the fishery to capture a wider range of species and to use a wider range of techniques. Use of cages, as in Indonesia and China, has the potential of significantly increasing production. Other means include placing barriers across inlets to create small water bodies when reservoir levels rise so they then can be stocked with fingerlings and fertilized. Appropriate introductions can also significantly raise productivity. While landings during the height of the Kariba gillnet fishery between 1963 and 1964 probably did not exceed 7,000 tons annually, stocking of the reservoir's open waters during the late 1960s with a small sardine-like fish (Limnothrissa miodon) can produce annual yields of approximately 20,000 tons.

The Limnothrissa fishery, however, is capital-intensive and until recently all equipment has been owned by immigrant entrepreneurs. Nonetheless, employment of over 1,000 local people on the fishing rigs and in processing and marketing activities has provided an important source of income in an otherwise suffering economy (Scudder, 1993). An incentive system based on nightly catches has increased yields and income for both owners and employees. And in the last few years purchase of rigs by local councils and NGOs has begun to bring a larger share of the benefits to at least some local communities.

IMPROVED DESIGN AND MANAGEMENT OF EXISTING AND FUTURE ENGINEERING WORKS FOR MAKING CONTROLLED RELEASES

Where dams are to be constructed, the design and operations should include controlled flood releases at strategic times for the benefit of downstream users and habitats (Scudder, 1991; Acreman and Hollis, 1996). In exceptional cases such releases may be negotiated after construction, as with South Africa's Pongolapoort Dam and the Manantali Dam on the Senegal. However, since dam design may preclude them, the best approach is an attempt to influence policy during the planning and design stage.

Controlled flooding is a relatively new concept primarily initiated by researchers and planners. Local residents, when involved, have been highly supportive. Government responses have been mixed, while donors have largely ignored such an option. Controlled flooding is not a panacea, however. It may involve trade-offs with hydropower generation, for example, and floods released may be ill-timed or insufficient to offset dam-induced downstream costs.

Nonetheless, where feasible, the advantages of controlled floodwater releases can be expected to outweigh disadvantages. The best examples are where previously constructed dams were unable to retain flood magnitude with the result that sluices were built to pass, for the benefit of downstream habitats and users, silt and nutrient-laden waters during the initial flood. Those sluices were then closed to capture in the reservoir what were then relatively silt-free flows, the original Aswan Dam being one example. While some contemporary dams, such as the Aswan High Dam and Kariba, were not designed to allow controlled flooding, others, such as Cahora Bassa further downstream on the Zambezi, could be so operated to benefit downstream wetlands, including the important delta and riparian communities. In off-shore waters, according to Gammelsrod, catch per unit effort of shrimp could be increased by 17 percent along the Sofala Bank by altering distribution of run-off. Even when such operations might reduce hydropower generation, developing international grids, as is currently the case in Southern Africa, would allow individual dams to serve a wider range of development purposes.

Advantages

The Aswan Dam, as originally built in 1902 and heightened in 1913 and 1933, was designed to pass most of the silt-laden annual flood of the Nile through its sluices. In recent years the importance of such releases have been emphasized for a number of reasons. Williams' analysis has shown that properly managed releases from the America River's Folsum Dam in California would preclude the need for further dam construction, including that of the Auburn Dam (1993). California is also pioneering controlled releases for the benefit of fisheries and the ecological health of the Sacramento Delta.

Controlled releases for the benefit of project affected communities is a more recent concept (Scudder, 1980), which has been tested in only a few cases. Theoretically, both reservoir basin communities and communities below a dam should benefit. Where dams are located well upstream, downstream beneficiaries could number in the millions. For them, increased flooding by well-timed controlled releases would benefit fisheries and recharge aquifers for the benefit of community wells and riparian forests. Farmers once again could practice some of the flood recession agriculture that a more regularized regime would have curtailed. They would also benefit from an increase in flood recessional grazing.

Within reservoir basins, controlled releases would also increase the extent of the drawdown area for both recessional cultivation and grazing. Both have proven to be valuable, and underestimated, benefits for lakeside communities. Drawdown cultivation at Lake Kariba, for example, has provided the most important single source of food for thousands of people during five serious drought years since the early 1980s. Drawdown areas around Ghana's Lake Volta provide an important source of vegetables, while residents in the Kainji Lake basin reap and sell drawdown fodder. In none of those cases, however, were dams designed to expedite controlled downstream flows. If they had been, the benefits to lakeside communities, as well as to downstream residents, would be significantly increased.

Careful research has attempted to quantify the benefits that would accrue from controlled releases from the recently completed Manantali Dam on the Senegal River and dams in Nigeria's Hadejia-Nguru system. Based on several years' analysis of the importance of natural flows for over 500,000 riverine inhabitants, the Senegal research has shown that economic benefits accruing from controlled releases from the Manantali Dam would significantly exceed any costs arising from reduced hydropower generation (Horowitz, Salem-Murdock et al., 1990; Salem-Murdock, 1996).

Similar conclusions have been reached by government officials and academics alike in regard to Nigeria's Hadajia-Nguru river basin, where the benefits from controlled releases are significantly greater than use of the same water on government-managed irrigation schemes (Hollis et al., 1993; Acreman and Hollis, 1996). A third example comes from South Africa's Pongola River Basin in the province of Natal-KwaZulu. When an intended irrigation project there failed to materialize below the Pongolapoort Dam, fisheries biologists recommended experimentation with controlled releases for the benefit of downstream fisheries. Subsequently, experimentation was expanded for the benefit of all aspects of the local economy, including flood recession agriculture and pasture. Initially, the affected communities did not participate in making decisions about the timing and duration of releases. More recently, however, they have been brought into the decision-making process through the formation of water committees and a water committee executive (Bruwer, Poultney and Nyathi, 1996).

Disadvantages

While controlled flooding can improve the productivity of wetlands and riverine communities, in most cases the economies of those concerned would be better served by the natural flood regime. As Hughes has shown for Kenya's Tana River and generalized for other African flood plains (1988), even extreme floods play a vital role in the maintenance of flood plain productivity.

There are also policy, technical and environmental constraints to the implementation of controlled releases. Current droughts in western, central and southern Africa's semi-arid lands have adversely affected river flows, making it more difficult to work out the type of suboptimization strategies that controlled flooding would involve. Since the early 1980s, for example, Zambezi flows have been only approximately 50 percent of what they were during the previous 20 years, while reduced intakes into the Ivory Coast's Kossou Reservoir and Ghana's Volta Reservoir have had adverse economic effects on occasion. Even without drought conditions, the magnitude, timing and duration of controlled releases may not have the desired effect on productivity, as illustrated by releases from Zambia's Iteshiteshi Dam for the benefit of downstream communities using the wetlands resources of the Kafue Flats (Acreman and Hollis, 1996).

Technical constraints relate to capacities to know when to release flows in what volume for what duration. The necessary knowledge requires operation and maintenance of a sophisticated hydromet network; its utilization requires well-qualified personnel. Policy constraints are of several sorts. One is lack of political will to make the necessary releases. Notwithstanding the demonstrated economic and environmental benefits, the tri-national Senegal River Basin Authority has been unwilling to make controlled releases that would benefit downstream riparian communities since the completion of the Manantali Dam, even though operational turbines have yet to be installed. The releases that have been made were so poorly timed that they led to decreases rather than increases in local productivity (Horowitz, 1991).

A second policy constraint is tied to the unfavorable rural-urban terms of trade that continue to characterize so many countries. While realizing longer-term economic returns that are in the national interest, controlled releases benefit mostly low-income rural households at the short-term expense of either the urban sector or farmers on commercial irrigation schemes. For example, the hydropower that would have to be foregone under some circumstances would be more for the benefit of rural communities than of urban industrial and residential users. Donors also might favor maximizing power generation in order to facilitate debt repayment, since there is no easy way to siphon off funds from the rising disposal incomes of hundred of thousands of low-income rural households.

ACTIONS TAKEN OR INTENDED BY THE WORLD BANK

In the final section of their 1994 review, the World Bank lists a series of "Actions to Improve Performance." All are important; they warrant summarizing here. Most important is the recommendation to improve project design in ways that "avoid or reduce displacement." Some success has already been achieved in this area on previously Bank-financed projects (Indonesia's Saguling and China's Shuikou, for example). In the Saguling case, lowering the height of the dam five meters during the design stage reduced resettlement by nearly 50 percent. In the Shuikou case, protective works around Nanping City at the top of the reservoir, and similar works around several towns, also reduced resettlement significantly.

To improve government capabilities, recommended strategic priorities were to "enhance the borrower's commitment" by only financing projects with acceptable policies and legal frameworks, "enhance the borrower's institutional capacity," "provide adequate Bank financing" and "diversify project vehicles," whereby the Bank complements the financing of physical infrastructure with stand-alone resettlement projects. Though too few have been funded to date, financing stand-alone resettlement projects like the $110 million credit for the Xiaolangdi project on China's Yellow River is especially important. Two reasons are the increasing financial cost of adequate resettlement and the fact that resettlement with development takes more time than constructing physical infrastructure—hence the risk, as with Ghana's Kpong, that funds will be exhausted by the time they are needed unless they are from a protected source.

Other recommended strategic priorities include the need to "strengthen the Bank's institutional capacity" so as to improve the Bank's ability to deal with the different stages of the project cycle, and to improve "the content and frequency of resettlement supervision." Where possible, "remedial and retrofitting actions" are also emphasized in connection with previously funded, but inadequately implemented, Bank-assisted projects. One example is Kariba, where a rehabilitation study for project affected people by the University of Zambia's Institute for African studies is currently underway with funding though the World Bank and sponsorship through Zambia's

Electricity Supply Corporation (ZESCO). Finally, the Bank emphasizes that more attention will be paid to promoting "people's participation" and NGO facilitation of "local institutional development" (1994: 8/1-8/4).

11. RESEARCH NEEDS

I have outlined elsewhere (Scudder, in press) a more detailed research agenda dealing with resettlement. While there are a relatively large number of studies, including several longitudinal ones, of the resettlement process, the same cannot be said of the other categories of project affected people. This deficiency is especially serious in regard to large dams. Notwithstanding the fact that such projects frequently are the largest in national development plans in terms of financial costs and impacts on national heartlands, there are few projects for which implementing agencies or donors have completed a detailed, long-term evaluation. This omission is especially surprising in the case of the World Bank, which has, in its Operations Evaluation Department, a time-tested monitoring and evaluation capacity that only now is beginning to focus on the necessary studies (World Bank, 1996).

The necessary studies will involve methodological difficulties, especially in the assessment of cumulative impacts (Dickson et al., 1994). Problems relate not just to changes that would have occurred among affected people without a project, but also, in regard to longer-term cumulative impacts, to factoring out the relevance of other post-project influences. Such problems must not be allowed, however, to put off further the necessary studies, since the few long-term studies that have been undertaken, by academics largely, agree that longer term project-induced social impacts have been seriously underestimated (see, for example, Colson, 1971; Bartolome and Barabas, 1990; and Scudder, 1993).

A major problem concerns the inadequacy of pre-project benchmark studies against which subsequent impacts can be assessed. Even where such studies are undertaken, their initiation and completion tends to be out of phase with the engineering cycle. Hence in the case of the Lesotho Highlands Water Project, the completion of both epidemiological and socioeconomic benchmark studies occurred after construction activities had begun. The same was the case with detailed socioeconomic studies carried out in connection with System B of Sri Lanka's Accelerated Mahaweli Project.

The only solution to this situation is to initiate the necessary pre-project benchmark studies much earlier in the planning process. Much of the necessary data is required by the World Bank's guidelines, which state that borrowers must present a resettlement plan before project appraisal. Gathering data for such a plan provides the opportunity for integrating the necessary benchmark studies into the planning process. Once again, however, all too often construction activities are apt to proceed more rapidly.

While there is no alternative to undertaking detailed pre-project benchmark studies among potential resettlers, one reason why there are so few follow-on studies relates to arguments among social scientists and statisticians regarding methodologies for monitoring and evaluation. Ideally, it would be advantageous to follow a statistically significant random sample drawn from the original benchmark studies. This, however, is seldom done because of time, personnel and financial constraints. These appear to be insurmountable in part because the delay in providing results, a delay that can involve years as opposed to months, makes such follow-on studies of little use for dealing with key issues as they arise.

One cost-effective solution is to select a small, carefully stratified subsample of no more than 50 to 100 households, which are re-interviewed over an extended time period once or twice annually. Use of indicators relating, for example, to housing, water supply and sanitation, fuel and lighting and production technology, linked with questions relating to income and expenditures, allows the interviewer to conclude within an hour whether living standards are improving, remaining the same or deteriorating. Complementary questionnaires, following by group-focused interviews, can then be expected to identify the causes for change or lack of change. Such a methodology can provide planners with a problem-oriented report within a six- to eight-week period.

12. CONCLUSIONS AND LESSONS LEARNED

An obvious and major conclusion is that the adverse social impacts of large dams have been seriously underestimated. Not only is a much larger number of people involved than acknowledged by researchers, government planners and donors, but there has also been a failure to acknowledge the range and magnitude of impacts on the different categories of people; affects on resettlers, for example, differing from those on hosts as well as on other project affected people living below dams. This situation is partially due to a paucity of research, and especially of research designed to assess long-term impacts.

Another lesson learned, and one that has been insufficiently documented, is that large dam projects are more apt to be subverted during implementation due to political and broader ideological considerations. Sri Lanka's Accelerated Mahaweli Project has already been mentioned as an example. Large dams are sponsored by a powerful coalition including heads of state, multinational corporations of consulting engineers, contractors and suppliers, and multilateral and bilateral donors. As Gustavo Lins Ribeiro explains, multinational corporations to remain competitive must move smoothly from one project to another; indeed, "they stimulate the market for them by indicating and proposing new works" (1994: 50). Their involvement is facilitated by bilateral donors linking favorable credit arrangements (as through export-import banks) to contracts for nationally based firms and by the World Bank's insistence on International Competitive Bidding.

Heads of state like Franklin Roosevelt of the United States and Kwame Nkrumah of Ghana at least had visions, based on political ideologies and capital-intensive technology, of "their" projects stimulating regional development. It is this political component that John Waterbury has labeled "hydropolitics." According to the World Bank's Harald Fredericksen, "The conditions encountered in a country's water sector reflect the political demands and the wisdom and leadership in these matters more than any other factor" (1992: 4). In regard to specific cases, Waterbury's assessment of the Aswan High Dam concludes that "the history of this project is testimony to the primacy of political considerations determining virtually all technical choices with the predicted result that a host of unanticipated technical and ecological crises have emerged that now entail more political decisions." (op. cit: 4).

Ribeiro, who also used the phrase "hydropolitics" in the title of his analysis of the binational (Argentina/Paraguay) Yacyreta High Dam, notes statements by Argentine specialists of better alternatives to Yacyreta in the form of smaller dams, better sites for high dams and use of natural gas (an alternative equally applicable to Quebec's James Bay Project). He emphasizes several other factors supporting the decision to proceed with Yacyreta. One is project-specific, involving competition between Argentina and Brazil (with its binational Itaipu High Dam) for "regional hegemony" (op.cit.: 45). The other can be generalized to other national political economies. Rejecting the word "development," Ribeiro sees large-scale projects, like Yacyreta, as "a form of production linked to economic expansion" into "outpost" areas (ibid, 163).

Ribeiro's interpretation would also appear to be applicable to both the James Bay Project and the Southern Okavango Integrated Water Development Project (SOIWDP). In addition to economic expansion, the former project gives the province of Quebec increased control over indigenous lands of ambiguous legal status as far as that province is concerned. SOIWDP would not only channel more water to the diamond mines (and hence to the advantage of both the government and the DeBeers/Anglo-American multinational corporation), but also provide increased access for Botswanan elite from the more densely populated eastern regions to Okavangan resources in the form of water for irrigation and grazing and water for cattle. Rhetoric aside, in neither project are the intended beneficiaries are supposed to be local people. Impacts on such people are ignored or played down—to the extent possible—throughout the project cycle. Appropriate assessment of those impacts, because they are widespread, is expensive, which is another reason they are underassessed.

If more local people are to become beneficiaries, not only must World Bank-type guidelines for resettlers be extended to all project affected people, but the horizon of environment and social impact assessments must be expanded to include all habitats and human populations likely to be affected. The same guidelines, however, must also be applied to other options, including, for example, increased reliance on coal-generated electricity. Should that be done, in many cases, other alternatives to major project works would be seen as preferable. And where major dams continue to be the "least-cost alternative" such major changes in design and operation as controlled flooding would be called for.

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ANNEX ONE: Key Issues To Be Addressed in a Future Review Process

1. The guidelines on issues relating to people impacted by the construction of large dams, issued by the World Bank and other donors, as well as borrowers, do not reflect the present state of knowledge. In the case of the World Bank, Operational Directive 4.30 on Involuntary Resettlement exemplifies how guidelines are being weakened rather than strengthened.
2. Poor implementation of guidelines continues to be a major problem. Many country governments believe it is better to implement a mediocre plan well than to ignore an excellent plan, which may take several years to formulate with donors.
3. Contrary to the arguments of many, increased involvement by the private sector in the construction of dams requires a new and strong role on the part of international development agencies, including the World Bank and regional banks, if sustainable development is to occur.
4. Participation by project affected people is also essential but far more difficult than advocates realize. Allowing communities to be involved is a necessary but insufficient condition of project development. Community participation also needs to be complemented by appropriate laws, judicial systems, as well as the involvement of donors, NGOs and, in regard to natural resource management, the private sector.
5. For resettlers to become project beneficiaries, their living standards must be improved.
6. To date, guidelines have paid far too little attention to the nature of the downstream impacts of large dams on riverine populations and habitats.
7. A carefully selected sample of the most successful cases of large dams in which project affected people have benefited over an extended time period needs be studied in order to learn if a majority have, in fact, become project beneficiaries and, if they have, to determine the reasons for success.

Environmental Sustainability in the Hydro Industry
Disaggregating the Debate

PHOTO COURTESY OF THE WORLD BANK

The service spillway at the Tarbela Dam, Pakistan.

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Paper Contents

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ABSTRACT

This paper disaggregates the debates embroiling hydroelectric dams and specifies ways to make hydro environmentally sustainable. The main means to approach sustainability is site selection: to select the better dams in the first place. This means integrating environmental and social criteria into traditional economic least-cost sequencing in a Sectoral Environmental Assessment (SEA).

When a good site has been identified, then the normal project-level Environmental Assessment seeks to mitigate residual impacts, such as by lowering the dam or moving it upstream. While the project-level EA is essential and needs to be strengthened, using the SEA to select the better projects is far more powerful. In addition, the hydro industry needs to foster transparency and participation, as well as show that conservation is well in hand and that electricity pricing is adequate before new capacity is contemplated. The biggest impact of hydros, involuntary resettlement, needs the most attention. Oustees must be better off promptly after their move.

Finally, the power sector should play by the same economic rules; all power projects should internalize external environmental damage costs, including those of decommissioning and greenhouse gas emissions. To do less than that means that the playing field is not level. This promotes coal and penalizes hydro, an environmentally retrogressive course.

1. INTRODUCTION

Proponents[2] of hydro and other renewable energy sources are losing the fight to promote them. Hydros have not yet become fully environmentally sustainable. Hydro opponents have been so successful in pointing out inadequacies that hydro development is slowing and coal is burgeoning—precisely the retrogressive course. Hydro proponents have not been totally successful in persuading opponents that hydro's benefits clearly outweigh the costs. *(Figures 1 and 2)*[3]

Part of the controversy is caused by confusion on the precise nature of the issues between hydro proponents and opponents, even by parties who should be well informed *(see section titled "Damage Costs of Greenhouse Gas Emissions")*. This paper seeks to disaggregate the debate into at least ten related but separate debates. Clarification of the differences will, it is hoped, foster convergence on which disagreements are real, important and need much discussion, and which may be resolved more readily. Consensus-building is the main purpose of this paper. This paper was commissioned as the overview of what environmental improvements are needed to make hydro sustainable. It was provided to all participants of the workshop to frame the issues in advance and seeks to be relatively neutral and as unbiased as possible, although the author believes that much more environmental prudence than is customary in hydro development is urgent and overdue. To this end, the paper disaggregates the controversy into ten issues, and presents pros and cons of each.

CAVEAT: This workshop had two goals. First, it sought to learn from the past—what needs to be improved and what mistakes may have occurred. Second, the workshop looked to the future—how can hydros be improved and what should be done differ-

Figure 1: Examples of Controversial Dams

1. Thailand's 576-megawatt ($352 million) Nam Choan was indefinitely postponed by the Royal Thai cabinet in 1982 because the 140-square-kilometer reservoir would flood 4 percent of the 4,800-square-kilometer Thung Hai Wildlife Sanctuary. This sanctuary was (and is even more since) being actively logged and poached, both of which the project could have halted. This is just one example of the many hydro projects that are indeed dropped on environmental grounds.
2. Sweden has banned further hydro projects on half of its rivers. The new government may rescind this decision partly because of availability of Finland's nuclear energy.
3. Norway until recently derived 100 percent of its energy from hydro, which was considered good and sustainable. Norway has now postponed all new hydros because of excess capacity and opposition.
4. Slovakia is defying the EC and the EC-appointed tribunal looking into the Danube's Gabcikovo Dam. The dam is alleged to have lowered the water table in Hungary's prime agricultural area (yields dropped 30 percent) by 6 meters in the lower central part of Hungary's Szigetkoz wetland. Most Danube fish are reported to have since declined. Work was halted for a period in mid-construction.
5. In the United States, New York State (NY Power Authority) canceled its 20-year $12.6 billion contract to buy 1,000 megawatts of Quebec's James Bay power, reportedly for environmental and social reasons, in March 1992. Demand-side management in New York played a role too. HydroQuebec indefinitely postponed Great Whale hydro in 1994.
6. India requested that the World Bank cancel the outstanding $170 million Sardar Sarovar (Narmada) loan on March 31, 1993, partly because the contractual agreement schedule was unlikely to be met on time. This was the world's most intense dam controversy for years on environmental and social impacts, as amplified by Morse and Berger (1992).
7. Nepal's 401-megawatt Arun hydro, which created a 43-hectare reservoir and caused little resettlement, twice entered Nepal's Supreme Court in 1994 because of opposition related to the 122-kilometer access road and complaints about the lack of transparency. A petition was lodged with the World Bank's Inspection Panel in 1994, and the project was dropped in 1995 largely because of financial risk, although environment was criticized by opponents.
8. China's approximately 16,000-megawatt Three Gorges, the largest in the world, had U.S. support withdrawn in December 1993, when the U.S. Secretary of the Interior ordered the Bureau of Reclamation to cease collaboration. The U.S. Export-Import Bank withdrew support in 1994. According to World Rivers Review, the export credit agencies of Switzerland, Japan and Germany (Hermes-Buergschaften Ex-Im Bank) were involved as of 1997.
9. Chile's 400-megawatt Pangue hydrodam, the first of five planned for the BioBio river (IFC's first major dam, $150 million, approved in 1992 and completed March 6, 1997), came under litigation in Chile's Supreme Court in 1993, partly because the EA failed to address downstream impacts. An independent review commissioned by IFC and led by Jay Hair, former president of IUCN-World Conservation Union, is said to be very critical of both the project process and IFC; World Bank Group President James Wolfensohn threatened on February 6, 1997, to declare default to Finance Minister Aninat. On March 11, Chile severed ties with IFC by prepaying IFC's loan and obtaining cheaper money from the Dresdner Bank, with fewer environmental conditions.[4]

ently. To this end, the paper outlines what needs to be improved and suggests throughout how such improvements may be achieved. The many benefits of big dams are not the focus of this paper. However, the major benefits of big dams may not be as well-known or as frequently posed as what needs to be improved. Dam proponents may want to emphasize which dams have worked well, as that case is often assumed, rather than documented. The case that many big dams have created valuable economic rates of return is clearly portrayed in the Big Dams Review (World Bank, 1966). Recent major improvements in turbine efficiencies and the huge non-hydro benefits such as flood control, navigation, irrigation, water supply and river regulation to improve water use downstream must be acknowledged. This paper focuses on developing country hydro projects and only barely mentions irrigation and multipurpose

Figure 2: The General "Big Dams" Debate

PROPONENTS' CLAIMS	OPPONENTS' CLAIMS
It is possible to mitigate hydro's impacts significantly, given political will.	Historically, hydro's impacts have not always been mitigated, even when well-known, such as involuntary resettlement.
Developing countries need large power projects; many small power projects (deforestation, old diesels) can be environmentally and economically worse than the best hydro projects.	Developing countries are better served by less lumpy power investments than big hydro projects.
The impacts of hydro's alternatives (coal, nuclear) cannot be mitigated.	Lumpy power projects demote DSM, so small coal and gas turbines make DSM more likely.
Hydro generates much less GHG compared with coal alternatives.	GHG reduction by hydro is unlikely to be the least cost; transport sector improvements are more likely to be less cost.
Gas is best reserved for transport fuels or for chemical feedstock; costly for base load.	Natural gas should be used for the next decade or so or until other renewables become competitive.
Many countries still have good hydro sites left. The best hydro sites should promote local development. They can also provide opportunities to export electricity to neighbors to postpone coal or nuclear alternatives and to benefit the country by attracting energy-intensive industries.	Practically all good hydro sites have already been developed, especially in Europe and the United States.
The worst hydro sites should not be built, such as those in tropical areas, those with many oustees[5] and with much species loss and those that create large, shallow reservoir areas.	The really good hydro sites are non-tropical (that is, mountainous), with no biomass or resettlement, no fish or no endemics, and those with high head and deep reservoirs.
Government regulation is needed, and enforcement is possible.	Government regulation is unlikely and enforcement may be weakening.
After privatization, government regulation is still needed.	After privatization, government is less able to regulate the private sector.
Public and private power projects should follow least cost.	The private sector less likely to follow least cost. It prefers to externalize all it can.
Electricity sales help the country irrespective of the use to which the power is put. This includes electricity for export or for the already electrified elites.	More electricity for elites is not needed. What is needed is electricity for basic needs, including health, education and for the poor. These needs are not best met by big hydro projects feeding the national grid.
Water must not be allowed to "waste to sea," unharnessed.	Water flowing to the sea is not wasted, but used by ecosystems.
Large-scale hydro is necessary for urban, industries and surpluses, especially because their capability to pay is greater.	Poor and rural benefit less, if at all, from large-scale hydro projects. The priority should be to provide for the poor before industries.
Electricity subsidies to the rich can be cut, but pricing can help poor.	Large-scale hydro projects subsidize the rich and decrease equity.
Foreign contractors involved in large-scale hydro projects create jobs and transfer technology.	Less-developed countries are already too dependent on foreign exchange and contractors.
Less-developed countries lack the capacity to build large dams. The low maintenance cost and simplification of operations of hydro is suitable for LDCs.	Big hydro has huge capital costs, so in the beginning indigenous, smaller sources of electricity are more appropriate for LDCs.
Small hydro projects are not substitutable with large hydro projects.	Small and medium-sizd hydro projects can partly substitute for big projects and attain more equitable goals.

dams and those in industrial countries. The record of industrial country dams is probably better than that in developing countries for compelling reasons. Although not the focus of this paper, developing country multipurpose dams may not, in general, be as problem-free as some hydro—again for compelling reasons that must remain for another occasion. Part of the controversy is that hydro can be made sustainable and renewable, but only with more effort than is customary. Hydro is on the cusp between fully renewable and clearly non-renewable *(Annex 1)*.

Figure 3: The "Dam Controversy"

The Controversy Disaggregated Into Ten Main Issues:[6]

1. Transparency and Participation.
2. DSM, Efficiency and Conservation.
3. Balance Between Hydro and Other Renewables.
4. Rural vs. Urban Supply Balance.
5. Medium vs. Big Projects.
6. Sectoral Least-Cost Ranking; Social and Environmental Criteria.
7. Storage Dams vs. Run-of-river: Area Lost to Flooding.
8. Involuntary Resettlement.
9. Project-Specific Mitigation vs. Trade-offs.
10. Greenhouse Gas Emission Damage Costs.

The environmental impacts of hydro can be separated into nine topics listed in *Figure 4*. The important point here is that the old-fashioned approach of tit-for-tat mitigation for each individual impact is inherently weak. The project-level EA is being complemented by the much more powerful sectoral approach. The retail project-specific environmental assessment and mitigation cannot influence project selection. It is precisely during the project selection phase that most impacts can be prevented or minimized. Once the project has been selected, the weaker project-level EA should still be applied, but is severely constrained in what it can mitigate.

International best practice is converging on the notion that most impacts are better reduced in the selection process of low-impact projects or site selection, rather than mitigating impacts of previously selected projects. This sectoral EA approach is essentially integrating the tried-and-true economic least-cost analysis with environmental and social criteria. This is amplified in the section called "Sectoral Least-Cost Ranking." If environmental criteria are used in project selection, then only projects with the least impacts are selected. This is much more efficient and effective than any project-level EA.

The goal of both the sectoral and the project EA is to make hydro projects sustainable. *Figure 4* specifies what sustainability should be when applied to hydro. Specific impact mitigation is taken up in the section titled "Specific Mitigation." In addition to the sectoral EA approach, the other powerful means of reducing environmental impacts are:

- To foster transparency and participation
- To squeeze most demand-side management (DSM), efficiency and conservation out of the system before building new capacity
- Balancing rural with urban electricity supply
- Balancing medium and big hydros

Proponents and opponents converge that environmental impacts are better reduced by attending to these upstream sectoral opportunities, rather than by using the previous approach of starting environmental work when a project already has been selected. Thus a major shift of emphasis is underway: Continue with the traditional project EA, but attend to all these sectoral opportunities before the project is selected.

2. TRANSPARENCY AND PARTICIPATION

Dam proponents scarcely fostered transparency and participation of stakeholders in the past. Planning behind closed doors by expert hydro planners who knew best was the order of the day. Secrecy often reigned. Now dam proponents see that secrecy is no longer possible. In the last few years, especially since about 1995, pressure has mounted to make transparency and participation permanent features of the planning process. But proponents are nervous about exposing their schemes to public scrutiny, and governments are concerned about risks to sovereignty. The Mekong River Commission, a UNDP-sponsored project, is widely reported in the press to have not fully embraced transparency and participation on several occasions in 1994-96, flying in the face of UNDP's promotion of transparency. In addition, dam proponents often do not know how to foster transparency and participation, or are uncomfortable with them, so some initial attempts may not have been fully effective. But participation is here to stay and is slowly spreading worldwide.

Proponents and opponents argue that participation is essential for democracy, and that participation greatly improves project selection and design. Because the EA is performed by the proponents, external scrutiny and participation in the whole process is essential to reduce any possible conflict of interest. The World Bank now insists that EA reports become publicly available, and this is helping to raise EA quality. Now that civil society or non-governmental organizations are burgeoning, national governments and governance are weakening, and privatization is sweeping the globe, it is increasingly difficult to impose major investments covertly on taxpayers. New big proposals are increasingly subject to transparency and full participation from the earliest stages. Most importantly, participation and transparency can foster early agreement and build consensus on the project, thus reducing controversy and opposition later on. This in turn expedites implementation. These two relatively new aspects are mandated by an increasing number of governments and development agencies. They are best started at the sector planning stage (Sectoral Environmental Assessment), well before an individual new dam is identified.

Synthesis: In view of the fact that a growing number of governments and development agencies require transparency and participation, the planning of hydro projects is becoming an increasingly open process, no longer restricted to experts *(Figure 5)*. The People's Democratic Republic of Laos, until recently an almost closed society, held it first public three-day participation meeting in January 1997 on its biggest proposed hydro project, Nam Theun Two. Proponents of the Nam Theun hydro project are receiving many useful proposals from nontraditional stakeholders because of such participation.

Although transparency and participation are here to stay, they are not yet at all the norm. The giant hydro proponent, ABB Consortium, espouses transparency, but has not yet been able to persuade the owners of Malaysia's $6 billion Bakun dam to make the EA public (as of March 1997), not even to the affected people. ABB's tentative contract is worth $5 billion to ABB. The 2,400-MW project is scheduled to generate electricity commercially in 2003. Jayaseela (1996) writes that Malaysia's EA was never intended to address social issues, in spite of the fact that vulnerable ethnic minorities will be harmed. Apparently the Bakun dam was approved before the EA was completed. Jayaseela (1996) quotes distinguished opponents who claim Bakun[7] would never be permitted in relatively unpopulated and species-poor Sweden, so why is ABB, a partly Swedish-owned company, supporting it? Moreover, the dam will provide Malaysia with excess electricity, which it plans to sell by the beginning of the next century. So why invest in a damaging scheme rather than in renewables? On the other hand, proponents (Green, 1996) note major benefits. Malaysia is in need of considerable capacity expansion, as electricity demand grew at nearly 10 percent per annum in the 1980s and reached 14 percent in the early 1990s, resulting in blackouts. Most Malaysian new capacity will be gas-fired, reaching 70 percent of the national mix by 2000. Bakun will hedge by broadening the mix.

Proponents also point out that the dam will flood only 695 square kilometers of valuable tropical forest, which is two orders of magnitude less than jungle loss from current logging in Sarawak. Bakun will displace 5.5 million tons of coal or 11 million tons of CO_2 per year. Biomass rot from the reservoir will be the equivalent of 1.5 years of coal equivalent (at 17 terawatt-hours a year from 2,400 MW installed). As the SEA is not available, opponents suspect that the oustees may not participate in decisions affecting them, nor do they expect vulnerable ethnic minorities to survive involuntary settlement. The journal Power In Asia reported in February 1997 that Bakun is spearheaded by the Malaysian timber potentate and the Ekran Berhad Head, Ting Pek Khiing.

Figure 4: What is Environmental Sustainability in Hydro Reservoirs?

The starting point is the solar-powered hydrological cycle which is the quintessence of sustainability. Water flow is a renewable resource. The cycle must be harnessed so that the project continues to generate benefits (such as power, fish; in multipurpose dams irrigation, flood control, navigation, water supply) for a long period, certainly decades, preferably a hundred years or more. In the narrow sense, sustainability means the hydro's lifetime should be as long as possible. In the broad sense, sustainability requires that the environmental and social costs are low and do not increase, especially not for future generations, such as climate change (the intergenerational equity component of sustainability). Sustainability is NOT only a continuation of power output. A modest fraction of power sales allocated to social and environmental needs ensures their acceptability. The concept of environmental sustainability in general is elaborated in Goodland (1995) and Goodland & Daly (1996).

Involuntary Resettlement (includes all affected people): The number of oustees is zero or low (e.g. Nepal's Arun reservoir); those relocated are promptly better off after their move. To be no worse off means stagnation, so cannot be called development. Of course, "no worse off" would be much better than historic achievements. Diseases cannot be allowed to increase. Brazil and China call for fractions of power sales to be allotted to oustees. China's policy is to ensure oustees are better off, not "worse off." The impacts on affected people should be made acceptable.

Sedimentation: The reservoir generation capacity will not be curtailed because of sedimentation. Certainly, the dam's lifespan should last longer than the amortization of the loan. Opponents claim that 50 years of power is too brief a benefit to outweigh the environmental costs. Early designs need to calculate the ratio of live to dead storage to inform dam selection. In addition, catchment protection should be made an integral component of all relevant hydroprojects. It is important to determine current sediment loadings, and the expected life of the reservoir before sediment starts to curtail generation. Thereafter, if the dam operates as run-of-river, it is necessary to determine the implication of that. Other issues involve understanding the potential for de-silting for example, the use of bottom gates, and understanding the downstream effects of de-silting. Finally, it is important to calculate and monitor erosion processes upstream.

Fish: Sustainability means that the fish contribution to nutrition, especially protein, must not decline. Unless fish catch increases substantially and permanently, the new opportunity presented by the new reservoir will have been wasted. It is necessary to ascertain how many people currently depend on fish for their livelihood (self-consumption or barter or commercial sales). The value of non-marketed fish usually exceeds the value of marketed fish. A large proportion of so-called weekend or recreational fishing forms an integral part of poor household budgets, so it also must be included. The potential for fish cultivation in the new reservoir or elsewhere should be realized, including the high initial offtake. A dam's operating rules need to be implemented in such a way that optimizes fisheries and internalizes costs. Compensation must be made available for the reduction in fishing downstream caused by the construction of the dam.

Biodiversity: Species or genetic diversity should not decline as a result of the project. Sustainability means the project does not cause the extinction of any species. Moreover, migrations (e.g., seasonal, anadromy, catadromy, potadromy) should not be so impeded as to harm populations. For example, fish breeding or fish passage facilities should be proven in advance. It is necessary to determine if wildlife habitat will be lost? And if so, then, to determine if there are equivalent (or better) compensatory tracts purchasable nearby? Improvements in net biodiversity are not difficult, and should be sought.

Land Preempted: If agricultural production declines, then it is necessary to clarify that the net power benefits clearly exceed the net value of lost agricultural production. Equivalent areas need to be made available for the oustees.

Water Quality: Sustainability means that water quality will be maintained at an acceptable level. The project must ensure that the reservoir does not impair water quality. Can water weeds, decaying vegetation and the like be controlled so that water of acceptable quality will occur downstream? Determining the level of organic mercury[7] releases from rotting biomass and phosphorus is important. Sustainability cannot be defined as just meaning cleaning up dirty water that fills the reservoir, for instance as is done in the case of Mexico's Zimapan dam, which fills from the effluent of Mexico City.

Downstream Hydrology: Sustainability means preventing negative impacts on the downstream uses by people (e.g., irrigation, soil fertility restoration, recession agriculture, washing, cattle watering) and to downstream ecosystems (e.g., mangroves, deltaic fish, wetlands, flood plains). There are substantial benefits to be realized for water regulation downstream, whether it is flood control, urban and industrial water supply, and/or multiple use. Temperature of releases also needs to be controlled.

Regional Integration and Esthetics: The project is more sustainable if it is well integrated into the activities and future of the region. Losses to cultural property and aesthetics should be avoided (Goodland and Webb, 1989).

Greenhouse Gas Production: Total GHG production (from biomass, cement, steel, etc.) should not exceed the gas-fired equivalent. It is important to recognize that rotting biomass remaining in the reservoir after filling produces estimable amounts of CO_2 and CH_4.

Nevertheless, stakeholder analysis has become a useful tool in promoting participation. Major dam projects are improving in this regard. In an increasing number of countries, a major dam is likely to go ahead without massive opposition only if civil society has been fully involved and broadly agrees that the proposed project is the best (or least objectionable, and least-cost in terms of the environment and society) alternative to meeting the goals that have been agreed upon in advance by civil society and government, and supported by financiers and development agencies. Society as a whole bears the financial debts and the environmental and social costs, so society as a whole needs to be meaningfully consulted before such costs are incurred (Narayan, 1995; World Bank, 1994).

Transparency and participation mean that civil society exercises a role in the selection of criteria to be subsequently used for decision-making and in identifying stakeholders. These normally include affected people (eventually all taxpayers) or their advocates, government, academia, syndicates, consumer and safety organizations, as well as project proponents. Civil society's role is broad, assisting in the selection and design of studies needed before decisions can be made, in the interpretation of the findings of such studies, in the burden-sharing or relative weights given to demand-side management, pricing, conservation, efficiency on the one hand and new generation capacity on the other. The intervening organization that finances the project enables civil society to play its legitimate role, and is accepted by governments and development agencies.

3. DSM, EFFICIENCY AND CONSERVATION

Dam opponents urge that most of the potential for demand-side management, energy efficiency and conservation be squeezed out of the sector before investing in new capacity. Most conservation measures, including demand-side management, should be substantially in place before new dams are addressed. "Substantially in place" means that the marginal economic cost (including environmental and social externalities) of saving energy through conservation becomes as high as the marginal cost of a new hydro scheme. Proponents agree that many LDCs need to move on both DSM and new capacity fronts. The important point is not to jump to new capacity if there is a large scope for DSM. Opponents point out that pricing is very effective in fostering conservation, but that tariffs are rarely raised to equal long-run marginal cost of production. Opponents sometimes calculate that demand predictions are unrealistically high. This often subsequently proves to be the case. Proponents justify going ahead with the next dam partly by using high demand predictions, and before DSM and pricing benefits have been put in place. Early in 1997, India's huge states of Punjab and Kerala waived electricity charges for farmers. In such cases, how do power producers keep up with demand?

Dam proponents now admit that mature economies and sectors have substantial conservation potential, but that developing economies have less scope. Proponents in LDCs claim that the emphasis should be on increasing supply rather than reducing still small demand in those countries. To its credit, the OECD hydro industry is now focusing on revamping existing industrial plants to improve efficiency to low or zero impact. Utilities in mature economies are now espousing the fact that it is in their interest to help their consumers reduce consumption by means of DSM, pricing and conservation. Leading utilities in California, for example, only began promoting fluorescents over incandescents as recently as the early 1980s. Utilities are now seeing that it is in their interests to ensure that DSM is achieved and publicized well before contemplating new capacity. Only in this way can utilities raise bonds and other capital to finance new capacity.

Current Status: The basic theme is the win-win notion of reducing the price of final services — energy — while reducing the environmental costs. This means encouraging end-use efficiency. DSM should be vigorously promoted until the marginal economic cost (including environmental externalities) of thorough conservation becomes as high as the short-term marginal cost of new production. As conservation measures are always advancing, implementation will always lag behind savings potential. The aim is to minimize this gap. Because DSM has not yet been vigorously pursued in many countries, DSM projects will rise rapidly as they will initially often be part of

Figure 5: Historical Evolution of Transparency and Participation

Broadening the constituency of the design team

Design Team	Approximate Era
1. Engineers	Pre-WWII Dams
2. Engineers + **Economists**	Post-WWII Dams
3. Engineers + Economists + **an Environmental Impact Statement at the end of complete design**	Late 1970s
4. Engineers + Economists + **Environmentalists & Sociologists**	Late 1980s
5. Engineers + Economists + Environmentalists & Sociologists + **Affected People**	Early 1990s
6. Engineers + Economists + Environmentalists & Sociologists + Affected People + **NGOs**	Mid 1990s
7. Engineers + Economists + Environmentalists & Sociologists + Affected People + NGOs + **Public "Acceptance"**	Early 2000s?

Note: These dates hold more for industrial nations than for developing ones, although meaningful consultations with affected people or their advocates and local NGOs, and the involvement of environmentalists in project design, are now mandatory for all World Bank-assisted projects. The World Bank's mandatory environmental assessment procedures are outlined in the three-volume "Environmental Assessment Sourcebook" (World Bank, 1991). Environmental Impact Statements (EIS) were added on to the end of a completely designed project — a certain recipe for confrontation and waste.

the least cost.

DSM by population stability: This topic is neither well-known, nor widely accepted yet. It is essentially long-term. Stabilizing the numbers of electricity consumers is as important — if not more so — than managing electricity consumption. Urgently needed improvements in living standards and development itself also boost energy consumption. This section addresses demographic growth.

The world is expected to have a population of about 8 billion by 2020, up from 5.8 billion in 1997. Population stability — births matching deaths — is a necessary eventual condition for social and environmental sustainability. The importance of population stability in DSM calculations is that sustainability and DSM are possible for a stable population, but practically impossible for a growing population. In general, population stabilization (in other words, zero growth) is a necessary precondition for environmental sustainability in all sectors, not only the energy sector. Most environmental impacts will be eased to the extent population growth rates fall. People concerned with environmental sustainability have a big stake in reducing population growth rates.

Environmental sustainability is difficult to achieve even without having to double electricity supply every generation, and without having to supply electricity for 80 million new consumers each year. Sustainability cannot be achieved in a vacuum that excludes one of its most important components, population stability. All sectors of the economy should map out what it would take for them to become sustainable. Most sectors have a stake in population stability. Therefore, population cannot be the sole responsibility of the ministry of health or its equivalent, thus relieving other sectors for any role whatsoever. While dams should certainly not be burdened with righting all societal ills, it is clearly in the interest of hydro proponents to see their consuming population stabilize. Population stabilization will make per capita electricity supply increases easier or with lesser impact. Proponents have to repeat the case that more electricity is needed. As European Union consumption exceeds 1,300 watts per capita, and LDC per capita is one order of magnitude less (120 watts per capita), such an argument should be straightforward.

Hydro proponents may object that they should not meddle in population policies. But it was only a few

FIGURE 6: Historic Evolution from Warning, Consultation and Participation to Partnership

1. **Pre-1950s:** One-way information flow: Oustees were warned that they would be flooded in a few weeks or months and had to get out of the way for the greater good of distant citizens.
2. **1960s:** Primitive participation in resettlement site selection: Oustees were informed that they would be flooded out, and were asked where they would like to move to among a few sites selected by the proponent; compensation often inadequate.
3. **1970s:** Participation in resettlement site selection: Oustees were consulted about their impending move, and invited to assist in finding sites to which they would like to move.
4. **1980s:** Resettlement participation evolves into consultation: Oustees are meaningfully consulted in advance and can influence dam height of position on the river; oustees views on mitigation of resettlement are addressed.
5. **1991:** World Bank's "EA Sourcebook" mandates meaningful consultation in all EAs; EA is unacceptable without such consultation.
6. **1990s:** Resettlement consultation evolves into stakeholder consultation: Stakeholders views are sought on all impacts, not just involuntary resettlement.
7. **1992:** World Bank's EA Policy mandates participation.
8. **1996:** World Bank's "Participation Sourcebook" published.

very short years ago that the utilities achieved their biggest about-face in history and began to pay electricity consumers not to consume, or at least to stabilize their consumption. It is strongly in the interest of hydro proponents to support national population stabilization goals to the extent they are able, and it is in their interests to help in fostering family planning, as well as energy conservation.

4. BALANCE BETWEEN HYDRO AND OTHER RENEWABLES

Proponents of non-hydro renewables rightly claim there is much scope for such renewables in practically every country, and unless they are experimented with they will never catch on. Practically all nations have scope for installing 0.5-1 MW wind turbines in their best sites at commercially competitive rates. There is enormous commercial scope for photovoltaics (PV) use in isolated systems and small pumps worldwide.

The harsh reality is that there is limited scope for a rapidly industrializing country to meet their energy needs through non-hydro renewable energies. Even industrial countries may be moving in the wrong direction. The United States, for example, decreased its renewable energy from 0.4 percent in 1987 to about 0.2 percent in 1997 (World Bank, 1997). Photovoltaics and tidal energy have yet to reach the 1 MW mark. Wind generators are only scaling up in the 5-plus MW range, but 0.5 MW models are commercially available. Solar-thermal has exceeded 300 MW in one experimental plant and shows promise for countries with a patch of desert near ocean (for the water needed). Non-hydro renewables are positive contributions in many counties, but do not yet contribute substantially to any industrialized nation. For example, the share of wind energy is declining in the two world's leaders, United States and Denmark.

The impact on energy demand of an additional 80 million per year resulting from population growth is enormous. As a consequence, world energy consumption is expected to double between 1990 and the year 2020. Practically all new capacity is already in developing countries, rather than in OECD countries. More than two-thirds of the world population use 20 gigajoules per person or 15 kilowatt-hours a day. This is one-tenth the energy use in OECD countries. However, the facts also show that the price of non-hydro renewables is declining fast and will be competitive sooner if they are tried on an experimental scale now. In light of the fact that environmental sustainability will necessitate phasing down coal use until greenhouse gas emission costs can be stemmed, the faster coal has to be subjected to the same economic cost-benefit analysis as hydro and other renewables, the sooner hydro and other renewables will outcompete coal. When coal becomes more expensive by virtue of the fact that its environmental costs will be internalized (Goodland and El Serafy, 1997), hydro and other renewables will burgeon. Later, probably in a decade or so, non-hydro renewables will outcompete all but the very best hydros, and the world's energy sectors will be reaching sustainability.

5. RURAL VS. URBAN SUPPLY BALANCE

Proponents are more interested in supplying electricity to the national grid for urban and industrial areas, rather than for supplying rural users, because the costs to link each consumer are relatively lower in densely populated areas, and urban/industrial consumers consume much more electricity than rural consumers. In addition, urban/industrial consumers are more likely to be able to afford the supply. It may cost an order of magnitude more to connect a rural consumer compared with an urban consumer. The rural consumer normally would use little electricity for the first several years: a couple of light bulbs, then a radio, and only later a TV or small machine such as a rice dehusker, and that only sporadically. This is a typical "who benefits" question.

Opponents point out that this exacerbates the urban-rural bias. Rural societies bear the impacts of hydro schemes, while city dwellers reap the benefits. This is a philosophical debate on the nature of economic development. Historically, development has benefited mainly city dwellers and intensified rural-to-urban migrations. In the case of dam construction, overseas firms have profited, while the rural poor, who are most impacted by the project, have paid the costs. Now, in today's environmental crisis, opponents ask if this bias should be redressed in order to approach environmental sustainability and more directly alleviate poverty. In Nepal, for example, is national sustainability fostered more by increasing benefits, such as electricity, for the load centers and relying on trickle-down to help non-consumers? Or would sustainability be better approached by balancing the current status by more emphasis on rural electrification and isolated small (1 MW, for example) hydro projects supplying a group of a dozen villages? Opponents of big hydro projects point out that mini-hydros tend to retard environmental degradation, such as deforestation for fuel wood, erosion or loss of precious topsoil. Mini-hydros also make eco-tourism more sustainable. In fact, for a country or region, promoting sustainable eco-tourism may be a more appropriate course to follow toward development, rather than yet more conventional industrialization.

Synthesis: Certainly, the balance between development targeted to rural vs. urban sites is real and involves much more than just hydro. Governments are progressively short of resources to subsidize expensive isolated hydros. The private sector is more profit-motivated and is unlikely to find isolated hydros more profitable than supplying the grid. Until the very real but little recognized costs and benefits of sustainability, poverty alleviation, the rural exodus, rural environmental protection and urban slums can be better calculated, there will be little progress on this front.

6. MEDIUM VS. BIG HYDRO PROJECTS

The "size" of a dam is primarily a function of how it fits into overall river basin development. Big dams are mainly for big rivers (for example, the Nile and Indus), in which case the main purpose is irrigation or flood control, and hydro is a secondary benefit. Proponents of big dams point out that, in general, no dam should stand by itself; the use of the basin's water resource should be optimized. Proponents sometimes also claim that big dams are needed by countries with few alternatives to earn foreign exchange by exporting electricity. Thus the big vs. medium trade-off can be separated into supply for the national grid vs. foreign exchange, and trade/environment issues. To the extent big hydro is for export, as is often the case, the medium vs. big dams debate overlaps the trade/environment debate. Proponents claim that if all impacts are internalized in the cost, the fact that the exporter bears such costs becomes irrelevant. This too is very much a "who benefits" question. Private developers can be leaders in planning for the internalization of social and environmental costs, such as the NTEC Consortium proponents of Lao's Nam Theun Two hydro project.

Proponents want to internalize formerly external costs, and this sums up the entire history of the environmental movement worldwide: the internalization of environmental costs. It took centuries to internalize the cost of black lung disease to coal miners; decades in the case of Minimata victims. Today, one of the most pressing issues is how to internalize the costs of greenhouse gas emissions. Most project economists, whether the project is for coal, gas or hydro, resolutely persist in externalizing these costs (see "Damage Costs of Greenhouse Gas Emissions"). While development agencies, in principle, seek to internalize environmental and social costs, this is overridden by the much more important (to them) priority of free trade. The World Trade Organization stringently promotes free trade, but is not stringent at promoting environmental and social standards, and resolutely against any country seeking to protect an efficient national policy of internalization of environmental costs.

Opponents of big dams claim that exporting electricity burdens the exporter with the environmental and social impacts precisely because such costs have never historically been internalized in the price of production. Japan now imports all of its timber, although it has plentiful and good quality forests. Much of Japan's steel and aluminum also are imported, thus avoiding the environmental and social costs of their production. Such imports are "cheaper" to Japan because their social and environmental costs are externalized. Most electricity from Brazil's $8 billion Tucurui hydro supports the aluminum smelters that export to Japan, creating only 2,000 jobs in Brazil (Fearnside, 1997). Such costs are not fully factored into prices, opponents claim, because the environmental and social standards of the exporter (e.g., Brazil, Philippines, Indonesia, Lao PDR) are much lower than in Japan. This pushes hydro projects into the debate over the environmental impacts of free trade (Daly and Goodland, 1994). A country internalizing environmental and social costs into its prices will be at a disadvantage in unregulated trade with a country that externalizes such costs.

Proponents of medium-size dams — that is, dams in the 50 MW to 300 MW range — urge that a balance be sought between catering to the export market and meeting domestic demands. Such proponents prefer to emphasize national needs before exports. This preference has to do with concerns about the unreliability of export markets, if a big importer decides not to pay for or to reject the electricity after the dam has been built or, more importantly, after the impacts have been caused. Proponents are concerned that the exporter bear the impacts, which are more severe in larger projects than in medium-size ones. Proponents point to the fact that some medium-size hydro are run-of-river or outstream diversions, which can have fewer negative impacts compared to those from a large storage reservoir. Oud and Muir (1997) point out that it is less risky to build a number of smaller schemes rather than one big one with equivalent total capacity, even if this would entail a higher present value of cost, as this would spread the risk.

There are fewer opponents of medium-scale hydro projects. Utilities encourage the private sector to invest in national grid supply partly because power cuts are extremely costly (about 10 times the tariff per kWh). Thus utilities may be forced to pay higher tariffs simply to avoid outages. If domestic demand is low, such as in Laos or Nepal, and there is a power-hungry neighbor, such as Thailand, India or Vietnam, that can pay, the private sector may be interested. Even so, power exporters need to conquer a market which leads to downward pressure on the tariff.

Synthesis: We can dismiss the concern over exporting *per se:* No one criticizes Idaho for exporting its potatoes. But the value-added debate is germane. Idaho would be better off exporting potato chips (now priced higher than smoked salmon!), potato latkes, instant french fries or whatever higher-value products consumers can be induced to eat. Or even distill potatoes into poteen or potable alcohol if that is more profitable. The situation is similar in tropical timber, where international debate is raging over the balance between the export of crude logs vs. the export of value-added wood products (doors, windows, tiles, veneer, particle board, etc.) by domestic processing (Goodland and Daly, 1996). In the case of water, it is normally not possible to stop water flowing from one country to a downstream riparian who does not pay for it. How much better then to turbine it and use the head of the upstream country to add value before the natural water resource is lost downstream. By analogy, it would help the hydro-rich country more by exporting products embodying much electrical energy manufactured at home, rather than exporting only electricity. For example, Paraguay's population is less than five million and it receives half the electricity generated by the 12,600 MW Itaipu, the world's biggest hydro project. It expects to receive half of the output from the 2,700 MW Yacyreta shortly, and of Corpus (about 2,000 MW) eventually, but can consume less than 10 percent even of its half from Itaipu. Understandably, Paraguay is seeking electricity-intensive manufacturing industries. Meanwhile, Paraguay sells much of its half of the energy to Brazil and Argentina.

7. SECTORAL SOCIAL AND ENVIRONMENTAL LEAST-COST RANKING

This section contains the most important recommendation of the paper — the use of the sectoral EA. Dam opponents are very keen to start environmental prudence before the next individual project is selected. Once a project is selected there is only modest scope for reducing impacts such as by lowering dam height. The biggest opportunity to reduce impacts is by integrating social and environmental criteria into project analysis. In practice this means expanding traditional least-cost sequencing in a sector to include social and environmental criteria in order to find the true least-cost path. Sectoral Environmental Assessment (SEA), a relatively new tool, is starting to be applied to the hydro subsector by means of coarse and fine screening so that the lowest-impact projects are taken up first. The world's best example is Nepal's superb SEA, which was devised in 1996-97 and is based on coarse and fine screening and ranking of an inventory of 132 potential projects. Through the SEA, Nepal has narrowed down the choices to the seven economically and financially feasible projects with low or the least environmental and social impacts.

Dam proponents normally invest in the single project that meets their own criteria of what type of dam, the timing of its implementation, the size of investment they have experience in, and which project is likely to have the higher returns on capital. Proponents, particularly private investors, cannot get involved with the whole sector; that is clearly the government's role. Pre-construction planning and investigation time is often less generous with a private investor than with government. The private sector would like the government to accept as much as possible the sectoral needs, feasibility studies, pre-construction planning and risks. Development agencies can indeed help with sectoral planning and feasibility costs.

The project-level EA seeks to ensure that the project identified is indeed the least-cost one. This is usually sought by the less-than-ideal "analysis of alternatives" undertaken after identification of the next proposed project mandated in Bank-assisted EAs. Such analysis of alternatives is a desperate and tardy attempt to second-guess that the project identified should indeed be the next one taken up, or is the best solution. Experience shows that SEA is much more effective in promoting least-cost sequencing than is analysis of alternatives.

Current Status: Environmental assessments historically have focused on individual projects. Indeed, in the past, EAs used to be performed after the project had been designed. In the late 1970s, EAs were added on to the end of a previously designed project. In the last few decades, EAs have moved "upstream," so that many now start more or less at the same time as project design. By the time the project has been designed, environmental and social concerns would be fully internalized. While this is a huge improvement over the add-on of the EA to a previously designed project, it is now clear that project-level EAs are inherently weak, and many are low in quality. Project-level EAs have to focus on the project identified and being designed. For example, if an EA of a highway proposal is requested, that precludes the more important modal choice between highway and rail. Similarly, the EA of one proposed atomic energy reactor may be able to improve site selection, design of the containment vessel, and safety of radioactive transport and disposal. However, it is not useful if the preferred choice was natural gas imports, for example, instead of atomic energy.

Sectoral vs. Project-Specific EA: The EA of a proposed dam may be able to site the dam on another river than what was originally proposed, reduce impacts by lowering dam height, or move it upstream, as was done with Thailand's Pak Mun hydro. Similarly, Indonesia's Saguling dam was lowered by 5 meters to halve the number of oustees. But the project-specific EA could not make it less useful in making the case that alternatives to the proposed hydro — for example, gas, wind, or solar — could possibly be even less costly overall. These considerations have led governments and development agencies to adopt a "Sectoral EA" (Goodland and Tillman, 1996). The sectoral EA environmentally scrutinizes the whole sector as part of the least-cost analysis. Least-cost sequencing now should integrate the conventional economic least-cost criteria with social and environmental criteria. This is easy to do reliably at the first approximation *(Figures 7 & 8)*. All rehabilitation and expansion of existing dams should be substantially completed before new dams are started. As this is almost always achieved at much less environmental and economic cost than construction of new dams, it should routinely be part of the least-cost analysis. The sectoral EA, related to analysis of alternatives, ensures that the subsequent project-level EA is quick, cheap and reliable.

8. STORAGE DAMS VS. RUN-OF RIVER: AREA LOST TO FLOODING

In general, there is much scope for greatly reducing environmental and social impacts by selecting projects with no reservoirs (outstream diversions), or very small reservoirs, such as weirs or run-of-river (ROR) projects. Large storage reservoirs generally create the most severe impacts *(Figure 8)*.

Opponents of big dams point out that historically there has been little attempt to calculate the area of land lost to the reservoir, and little attempt to select small reservoirs over larger ones. It is very difficult to ascertain reservoir area from the literature. In fact, OED's review (World Bank, 1996) was not able to find the area of some of the reviewed reservoirs. Reservoir area is one of the most crucial environmental and social variables, but has not commonly been allocated much importance nor even provided by hydro proponents.

Proponents of big dams are learning that small dams or run-of-river dams (no storage, therefore little or no reservoirs) cause less impacts, so may attract less criticism than big dam projects. But the term "run-of-river" means different things to different groups. In 1994, the Mekong Secretariat published a major study for a series of half a dozen main-stem dams across the Mekong, entitled "Run of River" (Mekong Secretariat, UNDP, 1994), which concluded that "environmental impacts of the proposed projects are expected to be … not severe." This caused international disagreement, partly because the same report (fish chapter) concluded the opposite: The proposed dams "may cause a wholesale decline in the fishery throughout the lower Mekong River." And partly because there is disagreement on how such dams could be labeled run-of-river as the nine reservoirs would have flooded 1,000 square kilometers, displaced more than 60,000 people (Rothert, 1995), and would create extensive storage reservoirs in the low flow season — ranging from 75 to 200 kilometers in length. All of the dams exceeded ICOLD's 15 meter height definition of a "large dam," as they are all 30 to 60 meters high. Some of the nine dams would extend to the next dam upstream. Given that previous Mekong mainstem dam proposals, dating from the 1950s to the 1970s, would have flooded out up to 120,000 people, this was a big improvement.

We need to agree on definitions. Strictly, ROR means the river is not dammed; the river runs over and around any structure. A true ROR hydro can be an axial tube turbine either sitting on the river bed or at least below the surface of the river, but without a barrier to water movement. An undershot waterwheel would also be ROR. Others claim ROR has to raise at least some head for energy. Zaire's Inga hydro is ROR, as part of the river is diverted into a headrace canal while most of the river continues unimpeded. In this case, the storage is the river itself, which is so voluminous and has the unique advantage of benefiting from wet seasons on either side of the equator. Can an outstream diversion be ROR if some of the river is diverted into a tunnel while the rest continues free-flowing? A weir can be defined as a dam over which water passes. For how long can the water not pass for a weir to become a dam? If a weir halts fish migrations upstream, should it be called a dam? How high must a be to be called a dam? How much daily pondage can a ROR have and still retain its label? Can daily or weekly pondage be part of an

ROR definition, but any seasonal or annual storage cannot?

Possibly, opponents and proponents could discuss the possibility of cooperating on the best tributary dams if much higher-impact mainstem dams are postponed. Cramming all dams on a few tributaries in cascades, like PRC's superb Pearl River cascade, while leaving a sample of the nation's rivers free-flowing, should be debated and become more routine. In general, the higher up a dam is in the river basin, the lower the impacts. For example, higher tributaries have lower productivity but higher endemicity than in the mainstem. In 1996, the EA conducted for Sogreah Engenerie, the dam proponent for Laos's tiny Nam Leuk hydro, was so roundly criticized at the ADB's board that it had to be redone (by Dr. M. Kollelatin, in 1997). While deficient EAs should indeed be redone, sometimes this debases the EA into a *post hoc* justification for the already designed project. The Mekong ROR controversy led UNDP to request the Mekong Secretariat promptly integrate environmental and social concerns fully into hydro design. As mentioned above, we need more clarity in the definitions of run-of-river vs. storage reservoirs, weirs vs. dams, and pondage vs. storage. "Water in equals water out" cannot be the definition of run-of-river schemes, as these could create extensive reservoirs in the lean season. "Water in equals water out" applies to all schemes where evapotranspiration, irrigation or outstream diversions do not occur. Environmentally, the barrier nature of the dam or weir is critical (mainly its height); socially, the area flooded may be critical.

Proponents of big reservoirs rightly point out that storage capacity is needed in the mix of most or all national energy systems in order to provide electricity in the dry season and for peaking. Storage is also importantly needed in multipurpose and irrigation reservoirs to provide water stored in the wet season for irrigation when it is needed in the dry season. As agricultural intensification normally creates lower net impact than extensification in the urgent population/food supply race (Goodland, 1997), irrigation (i.e., storage dams) need to be expedited. However, this paper is restricted only to hydro projects. Proponents also point out that the distinction between storage and run-of-river is one of degree. Certainly, storage (annual/seasonal), run-of-river and pondage (daily/peaking) need to be defined and discussed.

The length of river that becomes dried up as a result of a project can be the biggest impact of a project. In addition, in some projects, the downstream impacts can exceed the upstream impacts. For these reasons, the two proxies of oustees and reservoir size can be rough guides only. While environmentalists seek to minimize dewatered length, there is no doctrinaire solution. If the reach to be dewatered is uninhabited, already dammed downstream or not significant from the point of view of fish biodiversity or fisheries, nor for dry season animal or plant watering, then possibly a mutually acceptable compromise can be reached. This generic problem demands attention, as each cubic meter released can reduce profit for the nation by $1 million! Can weekly pulses of water to refresh pools suffice? Could animal watering points be supplied at less cost, in places more accessible to wildlife?

Definition of the "area of influence" of hydro projects still causes difficulties. The World Bank's definition has withstood the test of time but is not well known. It includes the whole watershed and airshed of all project-related activities (reservoir, downstream to estuary, delta and offshore, wetlands downstream, resettlement sites, access roads, power transmission corridors, migration routes of wildlife, including fish), and also includes indirectly affected areas, such as existing roads that experience heavier use during construction. Of course, not all such airsheds and watersheds need receive the same scrutiny, but all are legitimate areas for inclusion in EA work. The days are largely gone when the lone ecologist, arriving often just before construction or sometimes after, asks to see something, only to be told by the proponent, "No, that will not be impacted so you cannot go there." In the case of China's Three Gorges dam, one initial resettlement site was proposed in the desertic semi-autonomous province of Sinkiang several thousand kilometers away, so it is not always easy to carry out EA work. In the case of Lao's Nam Theun hydro, the area between Yunnan and Tonle Sap will be included.

Figure 7: How To Distinguish Better Hydros From Worse

A First Approximation of a Coarse Environmental and Social Screening and Ranking of Potential Hydro Sites

The First Step of a Sectoral EA: Integrating Environmental and Social Impacts into Conventional Least-Cost Sequencing

Opponents and those seeking to improve dams claim that a reliable first approximation to distinguish between 'better" dams and "worse" are two simple and robust proxies: first, the number of oustees, and second, the area lost due to the filling of the reservoir. These two figures suffice to rank, crudely but reliably, most sites. A second approximation disaggregates these two numbers on further criteria. After these two, the next ranking should include downstream impacts, including the number of affected families, the length of river that will dry up, fish migrations and the minimum dry season release regime.

1. Social Rank

Number of oustees: Figure 8 shows the number of oustees per megawatt. There is a huge scope for taking up projects with zero or very few oustees. It is necessary to disaggregate type of oustee by proportion with land and dwelling lost, land lost but not dwelling, and partial losses. Rural oustees should weigh more than urban. One question is whether replacement land is readily or scarcely available. The World Bank endorses the notion that it should be possible to resettle oustees successfully (World Bank, 1994). As this has rarely been the historical experience, this number needs to be stringently minimized in all future projects.

Vulnerable Ethnic Minorities: The proportion of affected people in this category is important, as they are extremely difficult to relocate adequately. If it is the case that involuntary resettlement of such people has never been successful, then perhaps the project should not go ahead. The recent extension of the Bank's policy on vulnerable ethnic minorities to less vulnerable minorities may not best serve truly vulnerable societies.

2. Environmental Rank

Intact Habitat Lost: The size of the flooded area is the single most relevant proxy for environmental impact, yet proponents of dams rarely calculate it in advance and it is difficult or impossible to ascertain from dam publications. Historically, reservoir area has not been accorded great importance by dam proponents. Area flooded per MW ratio (Figure 8) shows how much scope there is for selecting projects with little or no reservoir (those in uninhabited rocky canyons), run-of-river or outstream diversions to reduce impacts. For aquatic biodiversity, perhaps the best proxy measurement is the kilometers of stream or river flooded. Generally, moist forest contains more biodiversity than dry ecosystems. Intact ecosystems are more valuable than agriculturally modified agro-ecosystems or barren landscapes. If part of the "land lost" due to dam construction is a national park or other conservation unit, that would weigh much heavier in the ranking.

Conclusion: If projects are ranked on such social, environmental and downstream criteria, and if only projects with good scores are considered further, impacts will be significantly less than in the past, when EA started after a project was identified.

9. INVOLUNTARY RESETTLEMENT

Opponents and proponents agree that involuntary resettlement must — and can — be improved. Resettlement is an inescapable companion of infrastructure development. Involuntary resettlement (IR) and its impacts on people in general have become the most contentious of all socioenvironmental issues of dams. Adverse social impacts of big dams have been seriously underestimated (Scudder, 1997; Cernea 1997), and this is nearly always the case, not the exception. Open-cast coal mines, ash disposal sites and mine drainage ponds also displace thousands of people, and displace more as the project operates through the years. Reservoirs displace millions of people, but only before operation, so the number of affected people does not increase with time. Reduction of downstream agricultural productivity, or harm to recession agriculture (e.g., Zambezi) also increases displacement of people.

Until recently, many social costs of dams were externalized. Violence, bloodshed and murders are reported in many cases involving controversial dams,

Figure 8: Rank of Hydropower Generated

Following the two proxies of the number of oustees and the area of reservoir[9]

Country	Project Name	Megawatts	Hectares	Oustees	ha/MW	Oustees/MW
China	Three Gorges	18,200	110,000	1,300,000	6	71
Brazil/Paraguay	Itaipu	12,600	135,000	59,000	11	5
Venezuela	Guri Complex	10,300	426,000	1,500	41	0
Brazil	Tucurui	7,600	243,000	30,000	32	4
United States	Grand Coulee	6,494	33,306	10,000	5	2
Canada	Churchill Falls	5,225	665,000	0	127	0
Pakistan	Tarbela	3,478	24,280	96,000	7	28
China	Ertan	3,300	10,100	30,000	3	9
Brazil	Ilha Solteira	3,200	125,700	6,150	39	2
Argentina/Paraguay	Yacyreta	2,700	172,000	50,000	64	19
Turkey	Ataturk	2,400	81,700	55,000	34	23
Malaysia	Bakun	2,400	70,000	9,000	29	4
India	Tehri	2,400	4,200	100,000	2	42
Egypt	Aswan High	2,100	400,000	100,000	191	48
Mozambique	Cabora Bassa	2,075	380,000	250,000	183	120
Pakistan	Ghazi Barotha	1,450	2,640	899	2	1
Brazil	Sobradinho	1,050	415,000	65,000	395	62
India	Narmada Sagar	1,000	90,820	80,500	91	81
Pakistan	Mangla	1,000	25,300	90,000	25	90
Ghana	Akosombo/Volta	833	848,200	80,000	1,018	96
Nigeria	Kainji	760	126,000	50,000	166	66
Laos	Nam Theun 2	600	34,000	4,500	57	8
Chile	Pehuenche	500	400	10	1	0
Nepal	Arun III	402	43	775	0	2
Thailand	Khao Laem	300	38,800	10,800	129	36
Brazil	Balbina	250	236,000	1,000	944	4
Sri Lanka	Victoria	210	2,270	45,000	11	214
Laos	Nam Theun-Hinboun	210	630	0	3	0
Laos	Nam Ngum	150	37,000	3,000	247	20
Thailand	Pak Mun	34	6,000	4,945	176	145
Indonesia	Kedung Ombo	29	4,600	29,000	159	1,000
Burkina Faso	Kompienga	14	20,000	1,842	1,426	132

and are deplored by proponents and opponents alike. But human rights violations bolster the case of dam opponents. People at India's Narmada project suffered greatly (Morse and Berger, 1992); Guatemala's Chixoy (the 375 women and children massacred in the early 1980s may have been victims of the civil war rather than because they were oustees, according to the report of the 1996 forensic exhumation team); Lesotho Highlands Water Project's Muela dam management fired 2,300 strikers in September 1996. Police then shot and killed five workers, seriously wounded 30, while another 1,000 sought sanctuary in a nearby church. This was a labor dispute, not related specifically to the dam. Proponents realize such events do not help their cause, and seek to prevent them. Violence is socially regressive, as it penalizes the poor more than the rich, as noted earlier. The worldwide, sad record of involuntary resettlement, since it was started on any scale after World War II, is well documented by the World Bank's 1994 report

"Resettlement and Development." Recent years have seen a worldwide struggle to internalize the environmental and social costs of power development numbers of people involved are staggering and increasing. IR must be perceived as a grand opportunity to help the poor, not as a constraint to providing more power. Oustees should be offered training so they or their children can benefit from project-related employment.

Dam proponents claim that while IR may have not been adequate in the past, this time it will be markedly better. Proponents realize that although adequate IR has historically proved elusive, it is not impossible to achieve. Proponents realize too that unless IR markedly and promptly improves, the future of the hydro industry will be jeopardized. Many if not most proponents, increasingly the private sector, which has little experience with social issues, say that IR was mishandled in the past, but this time they have learned from previous mistakes. The next phase of IR will be a radical departure from the track record.

Dam opponents ask why the next IR component is likely to be greatly different from the last one. What is the evidence that robust historical trends worldwide in similar projects will be significantly different in the next project? Opponents also question the goal of IR. The goal of IR, where it has to take place, is development; the oustees must be not worse off during the resettlement; oustees must be better off immediately after, and the resettlement should be prompt. This has recently become official policy in China and Brazil, for instance, but not yet in development agencies. Skeptics may claim that it is not possible to make oustees even modestly better off promptly after the resettlement. Future oustees often disinvest in the several years before the move, and then regress for a year or more immediately following the move.

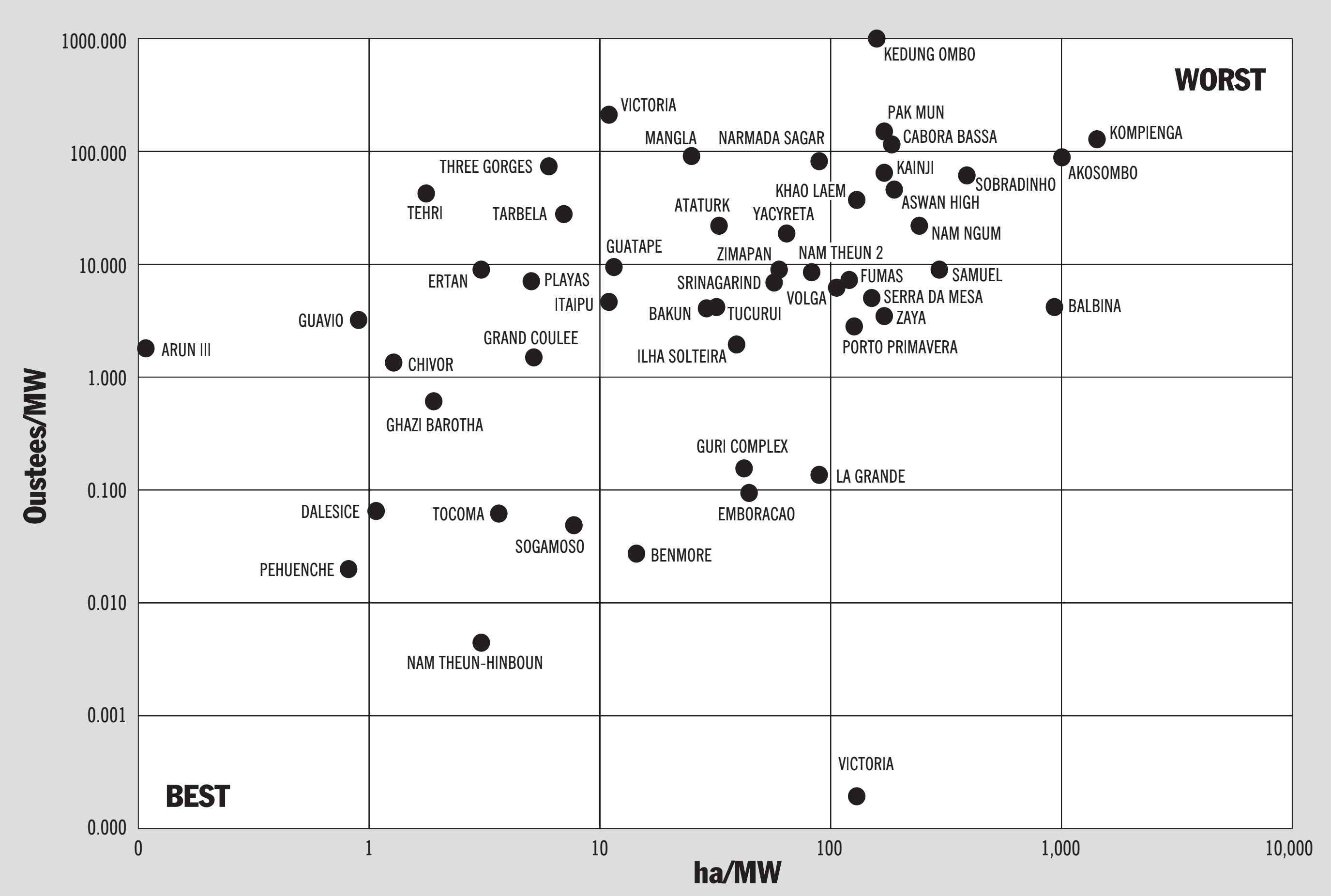
If affected peoples really cannot be made even modestly better off after their move, a fundamental rethinking of resettlement is imperative. If development cannot improve the lot of affected people, the whole role of development could be called into question. Some stress is unavoidable, but provision of land, schools, water, housing, clinics, community facilities, income restoration and rural electrification should be ensured so that oustees are indeed promptly better off. The lack of political will to want the affected people to be promptly better off may be the main constraint. *(See Figure 9)*

Poverty must be reduced, not perpetuated or exacerbated. Eventual restoration of previous income levels and standards of living can no longer be the goal of power proponents. If income is restored only several years after the move, that means a lower average income over the oustees' lifetime. This means poverty has been exacerbated, thus contradicting development's overarching goal: poverty alleviation. Non-declining income implies stagnation, and this cannot be called development. Practically all oustees are poor, and the main aim of development — poverty alleviation — will not be achieved by such a policy.

Dam opponents, and those promoting poverty alleviation, insist that oustees must not be penalized for the greater good of the nation. This used to be viewed as idealistic, just as practically any provisions for IR were considered idealistic 50 years ago. Then a government loudspeaker truck informed the villages to be displaced that they had two weeks to get out. Some may have dropped a few bales of roofing thatch, but not much more. The question is: Should "development" substitute for human welfare? Of course, it is possible to achieve higher income levels, such as by income supplements until incomes start to rise above pre-move levels and have made up for lost income during the move. Possibly such supplements are not the best way to go, but they show that poverty can indeed be reduced, given political will.

Opponents urge upgrading involutary resettlement policy. They assert that rarely is 100 percent of any policy goal achievable, but in the case of involuntary resettlement, the goal — the eventual restoration of income to pre-resettlement levels — is set too low, causing poverty to increase rather than decrease. Because the reduction of poverty is the goal of development, oustees must be modestly or incrementally better off afterward, including taking account of income lost during the move itself. Since the overall welfare of the nation is supposed to improve as a result of dam construction, compensating oustees should be feasible.

Figure 9: Hydropower 'Efficiency' Ratios of Installed Capacity to Involuntary Resettlement and Reservoir Area



The first goal of dam project proponents must be to stringently to abbreviate the duration of the move itself. To make people wait for a couple of years in a temporary holding camps, after they have had to leave their homes and before they are given access to their new sites, is a recipe for disaster and dependency. The goal is to make the move as painless as possible. Having to live in a temporary camp is very counterproductive. In some instances, interim access to both old and new sites can be useful. Oustees can go on using their old land while their new land starts to bear. The second goal must be to maintain income during the move, and the third to raise incomes promptly after the move. Scudder (1997) makes the important point that resettlement attention must continue for decades or even to the next generation. This is a legitimate cost to be borne by hydro proponents that should come out of project proceeds and that will encourage monitoring.

Proponents and opponents agree that involutary resettlement can be avoided in two ways. First, wherever possible, project sites should be selected such that IR is not needed. This emphasizes the crucial need for sectoral EAs in selecting the best projects — that is, the ones with no or very little IR. If the higher costs of ensuring that the affected people are promptly better off ultimately deters the project from being taken up, fine. That is a good cost-benefit analysis in action. The second way to avoid involuntary resettlement is to convert IR into voluntary resettlement by making the conditions attractive. Avoiding IR by site selection follows from the improved least-cost process, conservation and demand-side management. Involuntary resettlement is both difficult and expensive in terms of social trauma and therefore best avoided altogether.

Make Resettlement So Attractive That It Becomes Voluntary: Practically all individuals have a price at which they become willing to move. Offering anything less is ultimately involuntary or coercive resettlement. Involuntary resettlement appears cheaper, at least to begin with. Thus, affected peoples are subsidizing beneficiaries. The terms of resettlement should not be minimized by proponents seeking a higher return. The project is a development project; affected people need to be promptly better off as a result. There is a strong but overlooked economic argument for making resettlement voluntary. When a corporate executive, spouse and children are resettled overseas by a multinational corporation, the deal is sweetened so much that involuntary resettlement becomes voluntary. Inducements include free furnished housing, servants, utilities, generous moving and entertainment allowances, foreign supplements, tax-free status, pay raises, free car and driver, frequent home visits, and so on. Moreover, when potential oustees are very poor, landless laborers, debt-bonded or debt peons, they may welcome resettlement because anything is better for them than their present lot. Landless oustees — that is, people without paper titles to their land — deserve special attention. They are almost always poorer, even than poor titled families, and should not be penalized because their poverty has prevented them obtaining title. The legally respectable category of usucapion should be implemented more than is the case today, so that propoments can provide titles to the land that the landless have been using.[10]

Oustees should be the foremost beneficiaries of any project that forces their IR. Projects should be designed with resettlers' needs in mind, especially jobs. While jobs are not inherited, boosting human capital by education should, if done judiciously, help ensure that the children of oustees continue to develop. Dam proponents have to acknowledge that without the sacrifice and cooperation of oustees, there would be no project. The economic argument is that payment to settlers is part of the opportunity cost of the project even when migration is voluntary (at a sufficient payment). When migration is involuntary, any payment to the oustees is likely to underestimate the true opportunity cost of the move. The true opporutunity cost reflects how much money is needed to persuade individuals to agree to move. Under *laissez-faire* economics, all transactions are based on voluntary exchange, so when exchange is not voluntary, the economic argument is sacrificed. While it is possible to estimate the costs of "forced choice," the previous generalization still holds.

While resettlement ideally should be Pareto optimal (i.e., no one should be worse off), in practice there are losers. The winners should compensate the losers, but determining how much compensation is required rapidly becomes subjective. That is why a modest earmarking of, say, 2 percent of power sales allocated to social and environmental concerns, especially to retraining of the oustees, would be useful. One way is to provide productive assets — land is the most common — such that incomes are exceeded in the first year. Another way may be to offer once or twice the average national income for life, if their incomes never reached anywhere near the national average. Escrow accounts and similar means can encourage investments likely to foster rehabilitation. The following sequence is suggested: First, start discussing the project concept, pros and cons with all stakeholders and especially with affected people. Second, minimize resettlement by project selection, siting and design. Third, permit property sales only to the project sponsors very early on so that normal attrition over the decade of planning and design reduces the numbers still further. Fourth, create incentives to leave voluntarily. The problem is likely to be greatly reduced if these measures are adopted.

Financial Adequacy: Compensating oustees for involuntary resettlement is not a privilege to be bestowed *ex gratia,* but a right. It ought to be counted as part of the expenses incurred in the course of completing a power project. Frequently the IR costs are usually underestimated, and resettlement arrangements have erred on the parsimonious side. Scudder concludes after four decades of hands-on research worldwide: "It is clear that large-scale water resource projects unnecessarily have lowered the living standards of millions of people" (1997, and see 1993, 1994). Population counts, demographic rates, land valuation and the costs of necessary improvements (such as sites and services) are usually underestimated. The infrastructure of involuntary resettlement has often been provided minimally, grudgingly or paternalistically. The concept of compensation is adversarial; the proponents usually offer less, while the oustees plead for more.

Historically, proponents' demands have prevailed, and oustees have had to accept what they are offered, which shows that IR still has not been fully recognized as rights rather than privileges. These rights are full and essential components of power projects, as are cement, coal and turbines. Admittedly, IR was recognized as something dam builders had to attend to only as recently as the 1930s and '40s in developed countries. Even the U.S. Tennessee Valley Authority of the 1930s was not successful in all its IR schemes. This component of hydro projects has yet to be fully internalized and conscientiously implemented. IR budgets are often the first to be cut. Cost estimation must be rectified to err on the generous side. It is most encouraging that several recent projects have earmarked a modest fraction of power sales from the outset for social and environmental expenditures for the life of the project. Acceleration of this trend would be highly effective in reducing social and environmental problems of dams. But checks and balances will be necessary to ensure appropriate allocation of such funds should political will waver. Leaving IR cost estimation to the proponent has invariably led to underestimation.

10. PROJECT-SPECIFIC MITIGATION

When all the above sectoral prerequisites, DSM, pricing and least-cost have been met, and when national agreement has been reached that additional generation capacity is needed, and that a dam in this case is indeed the least social, economic and environmental cost, dam-specific social and environmental precautions need attention. Proponents and opponents agree, however, that sectoral environmental precautions have to precede project level precautions, and that sectoral measures are more powerful than project measures — although both are essential.

Conventional project-specific environmental assessment is becoming routine (World Bank, 1991), although still not satisfactory (World Bank, 1996). It has been a big struggle to begin a project EA as soon as a project is identified. Most project EAs used to begin at about the time of project appraisal. A project-level EA is still started some years after identification in too many cases, when the design is advanced. This debases EA into a *post hoc* cosmetic justification and is to be stringently avoided. While project-specific tit-for-tat impact assessment and mitigation needs to be strengthened, it is inherently much weaker than selecting low-impact projects from the beginning. This is partly because, at least in the past, specific impact mitigation works only up to a point. In addition, not all impacts are identified. And some are never fully mitigable. For example, conscientious implementation of whatever the malaria or fish biodiversity experts advise certainly improves the situation. If individual impact mitigation achieves 80 percent of its goals, the project will be better off. However, in addition to individual impact mitigation, a really well-designed project would from now on include a bold measure to account for all the unmitigable 20 percents, and ensure that the area is unambiguously better off. In the case of hydro, the conservation in perpetuity of a large tract of biodiversity in the watershed is the paradigm. Ironically, the most affected biodiversity, aquatic biodiversity, is the least mitigated; therefore, conservation of these biological resources needs to be enhanced. On the social side, ensuring that all villages in the region have wells, schools, health campaigns, rural electrification or a package of benefits, even if not directly impacted, is the sort of measure needed to elevate a possibly questionable project to an unequivocally beneficial one.

The latest example is Brazil's biggest hydro under construction, the 154-meter-high Serra da Mesa, planned to generate 1,293 MW on the Tocantins River upstream of the Tucurui hydro project (Goodland, 1978). The $1.1 billion Serra da Mesa has no final EA, the biomass has not been removed, and $115 million of commercial timber will be flooded. The 1,784-square-kilometer reservoir (Brazil's most voluminous) is now filling for the next 18 months, while 40 kilometers of the river below the dam is dry, and as a consequence, killing all aquatic and those terrestrial organisms dependent on the river. About 10 percent of the reserve of the nomadic Ava'-Canoeiro, a vulnerable ethnic minority, will be flooded. Their compensation, in addition to more land elsewhere, will be $100 for every $1 million earned by the proponent, Furnas. By way of contrast, following a thorough 1996-97 GHG/biomass calculation, Lao's Nam Theun Two hydro clearly demarcated the forest planned to be flooded, and is well on the way to removing most biomass, not only commercial timber.

The lesson is that if the EA is to be at all effective, it must start as soon as the specific hydro design starts, and it must also be transparent and participatory. The whole EA process must be in the public domain from the beginning. When project-specific EA follows sectoral EA, the former will be much easier, agreement will be expedited, and opposition less likely.

Specific impacts that are not yet fully mitigated are fish and aquatic resources, sedimentation, biodiversity, water quality, human health, and downstream impacts. These are enumerated in *Figure 4.* This paper proposes that resolution of hydro's broad debates (transparency, DSM, balance of hydro size and type, sectoral least-cost project selection) will reduce impacts much more than a reliance on project-specific EAs. Even so, a project EA remains necessary, according to the World Bank (1996). So this section notes the status of each impact, and how well such impacts are indeed mitigated. This does not mean these impacts are not important. On the contrary, they can sometimes be the most serious impacts in specific hydro projects — induced seismicity, for example. They are elaborated elsewhere in the literature cited.[11]

Fish: There are two separate issues with regard to fish and aquatic resources: subsistence and commercial fish production and fish biodiversity. The first is the nutritional and commercial aspects of fish. The accepted sustainability principle is that nutritional standards and commercial benefits should not decline. Nutritional standards and subsistence fishing often decline as they are non-marketed and are underestimated or completely overlooked in calculating compensation or mitigation. Some families may obtain most of their annual fish consumption in only a couple of fishing trips per year when the fish are more readily available. Sociological fish surveyors usually miss such crucial but sporadic events. Often so-called evening or weekend fishing is downplayed but is important for subsistence. Often fisheries burgeon in the few years or decades after impoundment so people near the new reservoir are often better off.[12] They may not adapt to catching reservoir fish and may be outcompeted by recently arrived commercial fisherfolk. People downstream from the dam normally are able to catch far fewer fish. This is related to the vexed problems of arranging for low-flow minimal releases, as well as to water quality.

Fish culture is possible, and this can greatly help the poor. But it does nothing for fish biodiversity and may decrease biodiversity if aggressive exotic commercial species outcompete indigenous species, as happened in Lake Victoria. The introduction of Nile Perch caused the extinctions of hundred of *Haplocromine* species.

Passage facilities such as fish ladders work for one family of fish, the *Salmonidae,* especially in the northwest United States, New England, Scotland and Scandinavia. Such fish passage facilities rarely work in tropical ecosystems, and opponents of dams claim there are biological reasons why they probably never will play much of a role. Electric luring of fish into containers or elevators (e.g., Yacyreta) may have a role. Recent research-stage findings may alter this gloomy picture (Acreman, 1996a,b).

The second major impact on fish relates to their biodiversity. A full one-fifth of the world's freshwater fish are endangered or have been extinguished in recent years; most of this loss relates to the introduction of new species of fish, dam construction and the resulting diversion of water, and pollution. Pollution can be reversed: Ohio's Cuyahoga River used to catch on fire a couple of decades ago; now it has been restored to a clean trout stream. Salmon have returned after centuries of absence to London's Thames, and to the Rhine. Dams, on the other hand, are not yet treated as reversible. The case to remove old dams has begun but has a long way to go before they and their impacts will be removed. In species-poor temperate rivers, cleanup and restoration is possible; it will not be possible to the same extent for tropical rivers rich in biodiversity. Many tropical aquatic species will be extinguished by dams before they are known to science — unless very special precautions are implemented. The introduction of exotic fish species, either accidently or purposely, often seriously damages local fish faunas. The main measure is to conserve a representative fraction of the national river system in a free-flowing state. For this a national aquatic biodiversity survey is needed. This is a relatively low-cost means of improving hydros.

Given that most dam construction is planned to take place in tropical countries, the fish fauna may be orders of magnitude greater than that encountered in temperate dams. Because dams are often now built in remote anthropogenically undamaged areas, the fish fauna may be extraordinarily rich, often intact and undocumented. Dams in wet lowlands with high rainfall may support rich faunas, but low endemicity. Sites in mountains and those fed by snow melt support species-poor faunas, but high endemicity. The other difficulty is that many tropical fish migrate seasonally as an essential part of their life cycle. If such migrations are stopped, such as by a dam, the fish species suffers or is extinguished. Because the biological character of most tropical rivers is not well-known, fish taxonomy surveys ought to be conducted to identify new or rare species. In addition, more studies are necessary to see if the new or rare species also live in adjacent rivers not slated for damming. Laos's Nam Theun dam is the only project I am aware of where this is happening. At present, the sustainability principle, which states that a representative sample of the nation's rivers be conserved in their free-flowing pristine state, is not being implemented widely and is not of major concern to private developers. Moreover, mitigation measures for fish biodiversity often do not effectively compensate for the impacts.

Sedimentation: As a relatively straightforward impact and one that can directly reduce profits by curtailing live storage, it is surprising that sedimentation persists as a big problem. Sedimentation takes planners by surprise for two reasons. First is that sedimentation increases exponentially, not arithmetically. When a catchment is developed by agriculture or roads, for example, sediment yield explodes geometrically. Second, most sedimentation is very sporadic. A river may carry little sediment for years, only to deposit enormous volumes in one night of a storm. Nepal's Kulekhani hydro project, now 92 MW, was estimated to have a useful life of 85 years when it was commissioned in 1981. Nearly half its 12 million cubic meters of dead storage capacity was filled with sediment by 1993, and the exceptional floods of late 1993 filled another 5 million cubic meters. Generation has to cease for a few months until mid-1997 until the estimated $40 million remedy can be completed (a new outlet from the dam at a higher lever above the mud, combined with many check dams upstream). The U.S. Army Corps of Engineers calculated the useful life of El Salvador's 135 MW Cerron Grande reservoir (Goodland, 1974) would be 30 years, rather than the originally estimated 350 years (McCully, 1996).

Biodiversity: Sustainability demands at least no net loss of species. Detection of no net loss means one has to know what is there to begin with — in other words, careful biotic surveys to determine all taxa needs to be conducted. This has never been done for any hydro project, as far as I am aware. Thus, the conservation of biodiversity is not fully integrated into the planning of hydro projects. The main de facto measure of conservation has become site selection and the resulting reservoir size. What amounts to on-site biodiversity conservation in hydro projects, then, is whatever adjacent areas happen to not be flooded by the project. In practice, the conservation of on-site biodiversity is dependent upon not flooding large areas, particularly intact habitat, such as tropical forest. The next main mitigatory measure is the conservation in perpetuity of an offset. For example, Lao's 450-square-kilometer Nam Theun Two reservoir proposes to conserve the 3,710-square-kilometer watershed. This has the added benefit of vastly reducing sedimentation risks and should be standard for all hydro projects. The basic principle on which an agreement is sought concerns the financing of the mitigation or offset. A small fraction (say, 1 percent each for environmental and social measures) of the hydro's income should be allocated in perpetuity to watershed management, conservation of biodiversity and prolonging dry seasonal flows.

Water Quality: Until very recently, little attention was paid to removing biomass from the area flooded (Ploskey, 1985). However, if even a small proportion of trees are profitable species, it may be worthwhile to remove them. Much biomass is unprofitable, such as brush and other non-marketable organic matter. In the case of 7,600 MW Tucurui dam, which created a

2,430-square-kilometer reservoir, the military pension fund corporation was contracted to clear portions of the adjacent area and is expecting to make an enormous profit. Unfortunately, it borrowed many millions of dollars from the Bank of Paris and then bankrupted itself (Goodland, 1978). Now that proponents are starting to internalize GHG production, biomass removal is a rising priority. As a result, water quality in the reservoir is expected to improve. The length of time water takes between entering and leaving the reservoir is the critical variable. Brief retention time (days) results in better water quality than sluggish retention time (months).

Water quality downstream is easier to fix by means of variable outlet structures in the dam. Multiple-level penstocks in the power house also can improve water quality and temperature of turbined water. Re-regulating ponds also can be useful in adjusting temperatures and oxygen levels of turbined water. Mercury is a relatively new water quality problem (see endnotes), and now silicate retention behind the dam may impair the growth of silicate-needing plants downstream.

Human Health: Sustainability demands human health shall not decline; development demands it shall improve. Health and sustainability are mutually supportive; investment in sustainability and health enhance each other. Historically, some hydro projects have damaged health; diseases related to irrigation projects damage even more. The sad fact is that development projects often exacerbate disease. Project-related health measures seek to prevent the introduction of diseases, and prevent their spread and aggravation. Reservoirs can cause epidemics of three water-related diseases: malaria, schistosomiasis and Japanese "B" encephalitis.

Malaria is intensifying worldwide, killing more than a million people every year, and sickens over two orders of magnitude that number. Malaria incidence in some villages exceeds 100 percent, as some people get it more than once a year. The cost of two or four weeks a year out of work due to malaria is onerous. The female *Anopheles* mosquito breeds in many tropical and subtropical reservoirs and is associated with development, as mosquitoes breed in tires, cans, wheel ruts and water tanks. Many *Anopheles* species are a vector to this parasite. Malaria is increasing largely due to the lack of political will and finance. Insecticide-impregnated bed nets are effective in reducing incidence. Education campaigns and vector breeding site destruction can significantly reduce the risk. Resistance of mosquitoes to common insecticides and resistance of the *Plasmodium* protozoan parasite make malaria increasingly expensive to control. Chemical prophylaxis and chemotherapy is available, at least for the well-educated rich.

Schistosomiasis is also carried by a water-related host, a few species of aquatic snails. Snail control is not easy and is expensive. Draining snail habitat and mollusciciding moist areas is very expensive initially. The initial enthusiasm for the main molluscicide, organic tin, has waned because it damages the ecosystem so severely. Now even tin-antifouling paint for hulls is widely banned. The difference from malaria is that once destroyed, snails immigrate very slowly, while mosquitoes can be blown many kilometers overnight to repopulate a sanitized zone. Education is important and a powerful preventive. Chemotherapy using the 1970s drug praziquantel is relatively cheap and relatively effective, and a person only needs one oral dose a year in most cases. It is also manufactured in developing countries. Similar to malaria, schistosomiasis is largely a disease of poverty and lack of education.

Japanese "B" encephalitis is different in that it is viral, and it is carried by several genera of mosquitoes, some of which breed in reservoirs and are associated with human settlements. A range of wild and domestic animals (birds, pigs, rodents) host this disease, which is severe for infants and the elderly. Prevention and therapy are similar to that for malaria.

A range of other diseases are not water-related but are dangerous in many development projects. AIDS is still incurable, increasing sharply and usually fatal. The main cheap measure is to reduce the incidence of common venereal disease, as VD victims are far more likely to catch AIDS. Free condoms reduce both diseases and it is in the interest of proponents to supply them easily. Intestinal parasites, TB, pneumonia, influenza, measles, dengue hemorrhagic fevers, and accidents often increase in development projects, reservoir-related or not. In theory, all these diseases need not be major risks. They are widely preventable. Unfortunately, the fact is that they commonly increase in development projects generally and in reservoir projects too. The World Health Organization should routinely be a partner in such projects (Hunter et al., 1993).

Downstream Impacts: Downstream impacts can exceed impacts above the dam in certain cases; hence they deserve much more attention than is common nowadays. Downstream social impacts can exceed upstream resettlement upheavals. For example, 10,000 Malinke, a tribe in West Africa, were resettled by Senegal's Manantali reservoir, while double or triple the number of riparians downstream have further impoverished as a result of the dam, and many will be forced to leave their plots because of declining productivity (Horowitz personal communication, 1997). Clearly, the number of downstream riparians harmed by the dam must be minimized, and fully compensated. If they have to resettle, they should be made promptly better off after their move.

There are additional impacts that are rarely addressed. These include cessation of annual fertile silt and moisture deposition, leads to declining crop yields, grazing impairment, fish declines and wildlife declines. Often aquifer recharge is impaired; wells dry up; water for crops and for vegetation decline. The decrease in vegetation accelerates deforestation, as people must search for fuel wood and lumber elsewhere. Declines in productivity and income accelerate labor migration from the area, especially among young men. This in turn further burdens the women, children and the elderly. Nutrition also worsens. In addition, the decline in water availability and agricultural yields increases conflicts for water and other scarce resources. Furthermore, the construction of a dam forces people who are long adapted to cyclical floods to switch suddenly to rain-fed livelihoods. The switch compounds the struggle to survive and usually triggers further impoverishment.

Managers of hydro facilities find it extremely difficult to accommodate the needs of downstream riparians. It is difficult because downstream water is needed during the dry season, precisely when it is in the shortest supply and the most expensive for dam operators to conduct a release. Flood releases (artificial flooding) for recession agriculture and other needs is normally not considered a priority. There is no hydro in the world that is operated to provide an artificial flood to simulate pre-dam regimes. The Manantali dam may be the single exception, but even there it is not clear if pre-dam floods will be replicated once all the turbines are installed. Mauritania's national plans assume that historic floodings will cease, and Mali has not signed on to the trinational draft agreement allocating the costs and benefits of the hydro project. Furthermore, downstream priorities are not mandated in the international agreements (Horowitz personal communication, 1997).

Even where they are achieved, controlled releases scarcely substitute for the pre-dam regimes on which many poor depend. This should be systematically addressed in design and operation. The Manantali dam on the Senegal River (Horowitz, 1991; Koenig and Horowitz, 1990) is one of the few where this could be addressed for the first time. Controlled flooding as a mitigation measure is not at all routine as of yet. This issue has a long way to go before it is resolved.

11. GREENHOUSE GAS EMISSION DAMAGE COSTS

Hydro proponents ask: Why ever should the hydro industry worry about greenhouse gas emissions? After all "hydropower plants produce no carbon dioxide," according to the U.S. Department of Energy's 1994 brochures. The editor of a leading U.S. hydro journal opined in late 1996 that hydro is "clean energy, producing no toxic gases like coal."

Opponents point out that such ignorance further tarnishes hydro's reputation. In fact, hydro produces some GHG but far less than coal-fired equivalents.[13] There are very few exceptions to this generalization; the Balbina dam in Brazil is the big exception. Decay from Brazil's large, shallow and densely forested 250 MW Balbina reservoir (236 square kilometers) may generate more GHG than a coal-fired equivalent (Junk and Mello, 1987; Fearnside, 1995). The message for the hydro industry is clear: Admit that all hydro projects produce some GHG from decay, and from cement and steel manufacture, but that coal-fired equivalents normally generate orders of magnitude more. All hydro proposals from now on should compare their GHG production with that of a coal-fired equivalent. In addition, the selection from among alternative dam projects should be influenced by how much GHG emissions a particular dam would generate. This new sustainability criterion will demote large shallow forested reservoirs, and promote small reservoirs in non-forested sites. Biomass removal will not be a panacea. New dams in tropical rain forest, if unavoidable, will find it very expensive to remove biomass. Tropical rain forest is often inaccessible, difficult to burn, and difficult to commercialize even high-value tropical timbers.

Proponents claim that the GHG emissions resulting from the manufacture of the dam's cement and steel, plus the energy used in the construction, amount to less than 10 percent of the annual CO_2 emissions of the fossil-fuel equivalent. The largest proportion of GHG emissions from a dam is caused by the decay of flooded biomass, which includes organic soil matter, peat, roots and vegetation. The types of biomass vary greatly, and the amount which will eventually rot also differs markedly. Biomass in mountainous, cold, deep, dark, anoxic water may not decay, not even anaerobically. Ancient wooden ships are recovered relatively intact from oceans and lakes, for example. Depending on circulation and stratification, anaerobic decomposition ceases below about 4°C. If marketable timber is removed before impoundment, the carbon will be sequestered until the product in the form of furniture or buildings, for example, rots or is burnt. Wood fuel extracted from the reservoir, even when burnt, might displace kerosene or dung and so may be a net carbon benefit. Trees left standing in the filled reservoir can be harvested years later or when they break off and float downstream. It is possible that the GHGs produced from large shallow reservoirs in densely forested sites may exceed the gas-fired equivalent. From a climate change perspective, these projects should not be taken up.

Two facts make it imperative to take the risk of climate change more seriously than at present. First, over 186 governments have signed, and about 100 (1996) have ratified, the U.N. Framework Convention on Climate Change (FCCC), which became international environmental law on March 21, 1994. Signatories to this convention seek to "achieve stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system." The targeted level should be achieved within a frame sufficient "to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner."

Some signatories seek to return their GHG emissions to 1990 levels by the year 2000. This means that governments are now looking for cost-effective ways to meet their CO_2 reduction targets. The current slow progress is increasing the risk of massive damage. The 150 governments met in Bonn in March 1997 but failed to agree on any specific targets or schedules. Australia is the sole OECD country resisting GHG reductions. The European Union now feels GHG emissions have to be cut by 15 percent below 1990 levels if major damage is to be prevented. Unless LDCs join GHG restrictions, investors may well transfer jobs and capital to LDCs as they will have lower standards than OECD nations. The competition to lower environmental standards already occurs in the hydro industry.

The second fact is that climate has already started to change faster than historic fluctuations, although scientific debate continues on the precise details of change. Now even conservative economists are admitting the gravity of the problem. Nobel prize winning economists Robert Solow and Kenneth Arrow, with support from 2,000 other economists, publicly acknowledged in 1997 that GHG was more serious that they had thought.

While it is still just statistically possible that these huge changes lie within "normal" climatic variation, the probabilities are falling. Globally, the insurance industry is betting in premium setting, insurance cancelations and risk calculations that climate trends will worsen. The industry is now lobbying governments to accelerate their actions to prevent climate change. Developing countries do not have the money to protect themselves from climate change as much as OECD countries can. In the case of developing coun-

Figure 10: Potential Areas of Agreement

1. a) Revamping, rehabilitation and updating (even upgrading) existing industrial facilities is often economically and environmentally cheaper than installing new energy capacity.

b) Permit new capacity only when revamping is substantially complete.

c) Permit new capacity only when most DSM, efficiency and pricing is substantially complete.

2. a) Removal of subsidies would level the playing field between coal and hydro and other renewables.

b) Because fossil fuels and nuclear power have been subsidized so much and for so long, is there a case for renewables to redress this historic imbalance, until the costs of the world's rapidly deteriorating environment can be internalized?

3. a) Internalize today's largely externalized environmental and social costs, such as SOx, NOx and GHG in economic cost-benefit analysis. While who pays is important, it is a separate question; compensation to LDC's internalizing such costs may be essential.

b) Facilitate GHG emissions trading.

c) Adopt the principle of binding GHG-reduction or emissions targets by all countries before the end of 1997; goals to be adjusted as evidence accrues.

4. a) Reverse current declines in research and development on renewables; increase R&D commensurate with increasing climate change risks.

b) One option is to encourage the OECD to agree on renewable R&D targets, for example, 25 percent of energy R&D by the year 2000.

c) Governments should also support some R&D on GHG sequestration and clean coal, including gasification.

5. a) Oustees must not be "as well off sometime after their move"; oustees should be better off promptly after their move.

b) The eventual goal is to abolish involuntary resettlement entirely, making all resettlement voluntary through financial and other incentives.

6. a) Ensuring sustainability could be achieved by allocating a small fraction of all power project proceeds to social and environmental needs in perpetuity.

b) Hydro projects should invest in the source of their raw material by catchment conservation.

tries, prevention, not a cure, is the only possibility.

The world derives about two thirds of its commercial energy from fossil fuels, of which two thirds is from coal. About half of greenhouse gas is carbon dioxide; most CO_2 (80 percent) is energy-related, and emissions now reach 22 billion tons of CO_2 annually. Electric power generation worldwide contributes 25 percent of GHG, mainly from coal. Because there is so much coal available worldwide — possibly 236 years' worth at current consumption levels — there is scant prospect for an impending fuel scarcity that would send the kind of price signal needed to phase down coal. Moreover, because developing countries persistently experience capital shortages, they are less likely to opt for higher-cost technologies, such as solar, on their own.

Methane contributes 13 percent to GHG accumulation, and a substantial part of this is from fossil fuel exploitation, such as coal mine gas. Although CH_4 is less abundant in the GHG mix, it is more than one order of magnitude more effective in forcing climate change than is carbon dioxide. Methane is produced in reservoirs by biomass rotting under anaerobic conditions; carbon dioxide is produced from more aerobic rotting. Biomass in deep, stagnant, stratified, cool, dark reservoirs is likely to decay anaerobically; biomass in shallow, light, warm reservoirs with brief water retention times is more aerobic and hence will produce carbon dioxide. Residence time and stratification in reservoirs should be routinely calculated during sectoral planning, as should the ratio of live to dead storage. The other characteristic of reservoirs that should be systematically calculated are the peri-

Figure 11: Suggestions for dam data to be divulged before permitting new reservoirs

1. Number of oustees or affected people, of which what proportion are vulnerable ethnic monitories.
2. Size of reservoir or area lost by flooding, including the types of ecosystem to be lost.
3. Ratios of energy per oustee and energy hectare lost, if hydro is the prime benefit.
4. Dead vs. live storage ratios.
5. Average depth of reservoir and stratification (anaerobic hypolimnion: H_2S, CH_4 vs. aerobic epilimnion: CO_2).
6. Tons of coal equivalent displaced; ratio of GHG produced by hydro vs. fossil equivalent.
7. Is the area seasonally exposed; in other words, what is the drawdown strip?
8. Is national aquatic survey complete? (Cascade vs. fewer dams on many rivers).
9. Dam height.

odically exposed drawdown strip (the strip between the reservoir's high-water and low-water marks), because this has major implications for ecological planning.

While natural gas produces much more energy with less GHG during generation, leaks from pipelines make gas almost as polluting as coal in some countries. As there are only about 40 years of oil and 56 years of gas left, coal is by far the most important fossil fuel to control. Proponents claim that proven hydro potential amounts to about five times what is currently exploited, the equivalent of today's annual oil production. The need to make the transition away from GHG production and toward hydro and other renewables is clear to both dam opponents and proponents.

Many countries face agonizing trade-offs between massively increasing the burning of coal, on the one hand, and constructing enormous dams, such as China's Three Gorges Dam and India's Narmada Dam, on the other. China's Three Gorges dam is projected to generate 84,000 gigawatt-hours, which is the equivalent of annually burning 40 million tons of local coal (based on the equivalency that 1 ton of coal equals about 2,100 kWh). The health and environmental effects of burning that amount of coal can be estimated. If the expected deaths from the next hundred-year flood are regrettably allowed to occur, presumably Three Gorges will sail ahead. One has to balance the trade-offs. If the approximately one million oustees can be made better off in that overpopulated nation, surely avoiding the burning of 40 million tons of coal annually is preferable. Proponents and opponents alike need to make such comparisons systematically and transparently.

Proponents and opponents both have big stakes in the rate at which GHG is internalized in cost-benefit analyses throughout the energy sector. If the hydro industry insists on a level playing field and on good economics, GHG will be internalized sooner and the transition to hydro and other renewables will accelerate. The irony is that reluctance to internalize dam externalities such as involuntary resettlement has led, in part, to a decline in support for dams. In contrast, the fact that currently there is less pressure to internalize coal's even more severe externalities, such as CO_2 and involuntary resettlement, has resulted in increases in coal use — an environmentally retrospective course.

Dam proponents, for a number of reasons, have been vulnerable to criticism. By focusing on dams and their the adverse impacts, dam opponents have allowed proponents of coal to escape criticism for their failure to internalize coal's social and environmental costs. In the competition between energy sources, dam opponents have, in effect, made coal more attractive to the market. This trend is socially, economically and environmentally imprudent.

12. CONCLUSION

The vision for dams is that they should support economic and social progress and be environmentally sustainable. *Figure 10* outlines areas of common ground in the hydro debate. Agreement in these areas would be an important step forward. Hydro proponents should be required to provide estimates of environmental and social data, such as those outlined in *Figure 11,* before they are permitted to build new reservoirs. The vision is for the best and most sustainable dams to become an interim stopgap measure on the transition to other renewables — the lesser of two evils, as opponents put it. The phase-down of coal to gas and hydro with other renewables needs to be accelerated. The transition to sustainability is urgent; limiting global warming to 2°C requires a 50 percent cut in GHG emissions. That is impossible without a major shift to hydro and other renewables.

Ensuring that hydro projects are sustainable necessarily means that some projects will not go forward. Opponents will argue that by the time all these preconditions and qualifications have been met, it is unlikely there will be enough eligible sustainable hydro sites to substitute substantially for fossil fuel. To the extent this is the case, hydro will displace only some fraction of the coal thermals that would otherwise be built. Without higher standards, hydro will continue to decline and coal will continue to increase. The fact is, it is economically imprudent to continue externalizing coal's social and environmental costs while at the same time internalizing those same costs of hydro projects. Proponents will claim that there are enough sustainable hydro sites available to displace substantial amounts of coal, and that sustainable hydro is an invaluable bridge to a solar/wind transition. Because the price of non-hydro renewable energy is tumbling, the hydro industry may have only a matter of decades to become sustainable or be outcompeted by other renewables.

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ENDNOTES

1. The author is environmental advisor to the World Bank based in Washington, D.C. He has visited or worked on environmental impacts of many big dams worldwide, such as Itaipu, Yacyreta, Three Gorges, Xiaolangdi, Ertan, Arun, Nam Theun and Tucurui. He served as independent commissioner for Canada's Great Whale James Bay hydro enquiry. He was elected president of the International Association of Impact Assessment, and metropolitan chair of the Ecological Society of America. Before joining the Bank he worked for the governments of Brazil, Malaysia and Bangladesh inter alia.

2. The term "proponent" is used here to mean those promoting dams, often hydro engineers who feel that dam benefits clearly outweigh their costs, as well as the hydro and related industries (turbine manufacturers). ICOLD does not promote dams; it seeks to establish guidelines for sound design and construction. "Opponents" is used to mean critics of dams in general, often those environmentalists wanting to ensure the benefits clearly outweigh the costs, particularly the environmental and social ones, and those questioning specific dams, such as IRN. This is clearly a generalization of two ends of a long disparate spectrum. The long track record of big dams in industrial countries and their benefits needs to be systematically used to ensure that dams in developing countries learn from the past. Partly because, by definition, developing countries are difficult places in which to ensure high standards, partly because tropical ecosystems are vastly more complex and less understood than temperate ones, and partly because developing countries are often overpopulated, hydro's track record is not improving fast enough. Hence the controversy.

3. By far the best documented and thorough account of the inadequacies of hydro projects is the recent book by McCully (1996). This is the starkest warning for the hydro industry to become environmentally sustainable. Further details are available in the three volumes by Goldsmith and Hildyard (1984-91), also in Pearce (1992) and Sklar and McCully (1994).

4. This is about the second time a major operation has cut its ties with the World Bank Group partly on environmental grounds. The first was the U.S.-based mining corporation Freeport-McMoRan, operators of the world's largest gold mine, in Indonesia's Irian Jaya. Freeport canceled its MIGA insurance just before an independent commission of enquiry was launched to assess allegations of human rights and environmental abuses in 1996. Unilateral insurance cancelation quashed the probe as MIGA became no longer connected to Freeport.

5. "Oustee" is a term meaning ousted people, such as people ousted by a reservoir. The term is used here because OED lists it (Giles Goodland, OED, personal communication, 1994), it is readily understood and widely used, and there seems no better choice. The synonyms "displaced person" and "resettler" are less precise. "Affected person" is a non-synonymous euphemism.

6. This paper is restricted to these ten major areas in the interests of brevity and because the workshop is unlikely to allocate as much time to the other very important impacts *(tabulated in Figure 4)* such as fish, sedimentation, biodiversity, water quality and downstream hydrology. These are crucial to making hydro sustainable. This list of ten topics is not ranked in order of importance; rather it follows a rough planning sequence (except for greenhouse gas production).

7. Mercury contamination in reservoirs is a relatively recently discovered impact. Mercury seems to arise from its use in recovering gold in the Amazon, from coal-fired thermal generating plants, and traffic in OECD and elsewhere, but is in some soils without such sources. It is accumulated in the organic (methyl mercury) form from sediment, especially in anoxic humus and peats, through algae and insects to fish. Poisonous MeHg accumulates up the food chain to such an extent that carnivorous fish consumption can harm vulnerable humans, such as children and pregnants. The U.S. FDA limit of 1.0 mug/g wet wt is commonly exceeded. See: Leino and Lodenius (1995), Bonzongo et al. (1996), Tremblay et al. (1996), Allen-Gil (1995), Meulman et al. (1995), Rudd (1995), Porvari et al. (1995), Iskander (1994), Rodgers et al. (1995) and Olem (1993).

8. Power In Asia of Jan. 13, 1997, and Feb. 10, 1997, outlines the controversy: Bakun has been called "a timebomb, unlawful, unsustainable, economically questionable." The king of Sweden's environmental advisor was fired from his Royal Swedish Academy of Sciences post just before Christmas 1996, just after he publicly criticized Bakun; later he called Bakun "an ecological catastrophe," "not tenable" and "outdated technology." He called the environmental report "insufficient." ABB Chair Percy Barnevik is reported to be defending Bakun against "environmental fascists."

9. It has been unexpectedly difficult to obtain "area flooded" by reservoirs as it is not commonly provided in the literature. This suggests that the area flooded has not been important to proponents. Similarly with oustees, the World Bank's OED report notes that oustee numbers are simply not known for earlier projects. Installed capacity (MW) is always easily available, but the far more meaningful GWh is exceptionally difficult to obtain, and of course varies from season to season. *Figure 8* should therefore be used with care, as GWh has not yet been systematically collected and this would make the rank more meaningful. However, use of 50 percent plant factor is unlikely to change the ranking unduly. Proponents should be required to count oustees well in advance and to provide reasonable estimates of area lost to flooding also well in advance. The other important caveat of *Figure 8* is that hydro is not the major benefit of several of the projects listed (e.g., Three Gorges, Tarbela, Aswan High, Mangla). A next approximation using GWh and non-hydro benefits thus will modify this first approximation ranking.

10. Usucapion is a legal category of land ownership whereby the landless use a plot well for some years, until they have earned the right to continue to use it.

11. As mentioned, the best general sources on hydro's impacts are McCully (1996) and Goldsmith and Hildyard (1984-91). Goodland and others (1978-1996) amplify hydro mitigation, as does Helland-Hansen et al. (1995). Pearce (1992) and Sklar and McCully (1994) provide useful details. Morse and Berger (1992) are the most thorough on the impacts of a single project (India's Narmada). The most recent is Biswas (1997). Most recent project-specific hydro EAs run to many volumes, commonly occupying several meters of shelving, are not commonly "published" in the conventional sense, and are not at all easily available, not even in IUCN or the World Bank.

12. Reservoir fishery optimization has a long way to go. A good introduction can be found in: Kapetsky and Petr (1984), Costa-Pierce and Soemarwoto (1990), De Silva (1988), Lu (1992), Moreau (1991), Petrere (1996), Sugunan (1995), Crul and Roest (1995) and Knapp (1994).

13. Oud (1993), Gagnon (1993, 1996 and 1997); Rosa and Schaeffer (1994), Rudd et al. (1993), Svensson and Ericson (1993).

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ANNEX ONE:

Environmental Ranking of New Energy Sources

LEAST IMPACT

1. EFFICIENCY AND CONSERVATION 2. SOLAR AND HYDROGEN 3. PHOTOVOLTAICS 4. WIND 5. TIDAL AND WAVES 6. BIOMASS	RENEWABLE & SUSTAINABLE
7. HYDRO 8. GEOTHERMAL	RENEWABLE & POTENTIALLY SUSTAINABLE
9. GAS 10. OIL 11. COAL 12. NUCLEAR	NON-RENEWABLE & UNSUSTAINABLE

MOST IMPACT

The main means to improve the environmental and social aspects of all energy is to gradually phase up this ranking, and to phase out those forms lowest on the ranking.

1. Energy efficiency and energy conservation: Since these are becoming recoginized as alternatives to increasing energy supply options, they top this list. They free up existing energy supplies used elsewhere, thus postponing the need for new capacity.

2. Solar power: Japan's Agency of Industrial Science and Technology, in collaboration with the International Atomic Energy Agency, is developing a solar hydrogen power system by electroysis of water with sunlight expected to be commercial before 2030. This system is 20 to 30 percent more efficient that today's best gas turbines, but without the CO2 pollutant and the depletion problem. Photovoltaics and batteries break down after a few years. In this relatively trivial sense, they are unsustainable.

3. Hydropower: This is or could be renewable due to the fact that it burns no fuel and is power by solar energy via the hydrolic cycle.

4. Geothermal: The environmental and social impacts are, in general, easily managed. It makes sense to exploit this resource.

5. All fossil fuels: These are unsustainable due to the fact that combustion releases CO2 into the atmosphere. Many nations have signed the Framework Convention on Climate Change because they feel the risks of global climate change should be minimized. Unlike sulfur oxides, nitrous oxides and particulates, CO2 is not controlled. The risks of climate change can be reduced only be phasing out coal well before supplies run out. It is estimated that there are about 300 years worth of coal supplies remaining. Gas and to a lesser extent oil are not as risky as coal because their supplies are more limited, only about 50 years, and emit much less CO2 than coal. Through the process of industrialization, energy users typically switch from a reliance on wood to coal to oil to gas. Accelerating this historic trend in which the ratio of carbon to hydrogen falls would greatly help to meet GHG emission reduction targets. If coal technology improves such that CO2 emissions can be mitigated or adequately sequestered, the prospects for coal would improve.

6. Nuclear: The nuclear industry has spent about 75 percent of the total R&D budget over the last four decades, but now only generates 3 percent of global commercial energy. Rather than earning a profit after all these subsidies, the abandonment of nuclear plants has caused $10 billion in losses to shareholders in the United States alone. In order to replace coal, as many as 10,000 to 20,000 new nuclear plants would be needed, which would require a new plant opening every three or four days for decades, but in light of the losses incurred in the United States this is highly inadvisable. Nuclear power's main proponent, the IAEA, forecasts only about 770 plants for this period. Should the victims of the 1986 Chernobyl accident exceed 4 million, as seems likely, this will postpone any recrudescence of nuclear projects. In 1996-97, advanced nuclear plant were canceled in Indonesia; and postponed until 2011 in Thailand. The Japanese nuclear program, whose nuclear program is considered one of the world's most advanced, had been crippled since the "very serious" accident on February 9, 1991, in Mihama. In 1992, Japan's Ministry of International Trade and Industry reported 20 major problems and incidents in 1992 alone. Further setbacks include the molten sodium leaks at the Monju fast-breeder reactor in December 1995, and the radioactive fire and explosion in March 1997 at the Tokaimura waste processing plant. The government of Japan is pressing criminal charges, as of April 15, against Donen, the state-owned Nuclear Energy Corporation, with regard to the Tokaimura explosion. Four out of six nuclear facilities operated by Donen have now been shut down following accidents, and it admitted on April 17 to 11 more unreported radioactive leaks over the last three years. If radioactive waste storage is solved, and if "inherently" safe nuclear reactor designs are achieved, uranium mining impacts are reduced, nuclear weapons proliferation halts and radioactive shipment becomes safe, then prospects for nuclear power would improve.

MEETING HYDRO'S FINANCING AND DEVELOPMENT CHALLENGES

PHOTO COURTESY OF THE WORLD BANK

Surveyor on the construction site of the Tarbela Dam, Pakistan.

By **ANTHONY A. CHURCHILL,** Washington International Energy Group

Paper Contents

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ABSTRACT

This article argues that hydropower is at an international crossroads. The environmental and social problems associated with dams, particularly poorly conceived and executed resettlement programs, have tarnished the reputation of the hydro industry. Performance problems, such as cost overruns and project delays, have also plagued the industry. As countries increasingly look to the private sector to finance hydro projects, these problems threaten to discourage future investments in hydropower. In order for the hydro industry to succeed in the future, the resettlement issue must be resolved. Governments must ensure that adequate funds are available for compensation and other costs of resettlement. The hydro industry must also improve the system of accountability in projects. Those deciding what projects are built, when, by whom and how must be held accountable for the final results. Moreover, to meet the challenge of increased competition from other sources of electricity, hydropower must develop new technologies to improve efficiency. Ultimately, what is needed, Churchill asserts, is a new model of public-private partnership, whereby the private sector agrees to undertake greater responsibility for project results and the government agrees to treat electric power as commercial business subject to the discipline of the market.

1. INTRODUCTION

Hydropower stands at an international crossroads. On the one hand, project owners face increasing economic, environmental and developmental challenges. There are the vocal and visible attacks by environmental interest groups on hydro projects, particularly those with large dams. There is competition from alternative energy sources, such as natural gas, whose shorter project lead times and lower capital costs give them a near-term advantage. And there is the drying up of inexpensive public financing for energy projects. These factors have led some critics to question the future of hydropower.

On the other hand, several factors warrant optimism about hydro and its future, especially in the developing countries. Two-thirds of the large dams built in the 1980s were in developing nations. The demand for electric power continues to grow rapidly in those countries, and many good sites still are available. Because hydro is a domestic resource, governments and utilities in developing countries often prefer hydro generation over electricity produced from fossil fuels, which must be imported or, if the nation has its own supplies, are valuable sources of export revenues. In addition, the relatively low maintenance costs and simplicity of operation associated with hydro projects are strong pluses in countries where the more complex maintenance and operating logistics of thermal plants pose serious problems.

The question is not whether hydro has a future but how the industry passes through the crossroads it now faces, resolves the environmental and economic problems of its past, and meets the challenges that lie ahead.

2. THE POWER MARKET GROWS

The World Energy Council (WEC) estimates suggest energy consumption worldwide will approximately double between 1990 and 2020[1]. The WEC expects almost all of this increase to occur in the developing world—and the estimate probably is on the conservative side.

How much of the new demand will hydropower supply? The WEC suggests that hydro energy production will increase from the present level of about 2,000 terawatt-hours per year to nearly 5,000 terawatt-hours by 2020. These estimates do not include small hydro development, which the WEC lumps with

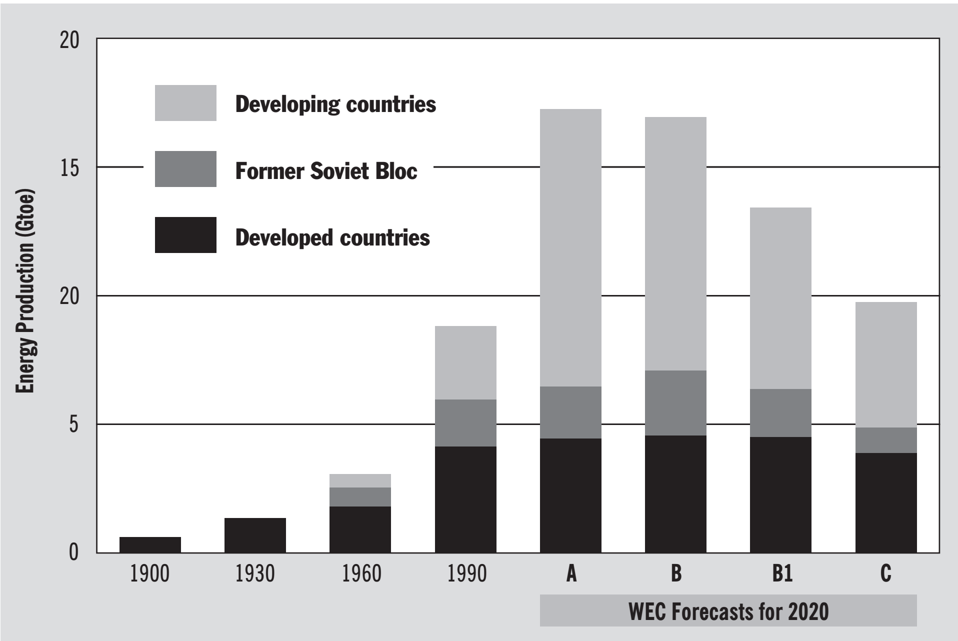

Figure 1: The World Energy Council expects developing countries to account for most of the forecast growth in world energy demand between 1990 and the year 2020. This graph shows energy demand in gigatons of oil equivalent (Gtos) through 1990 and WEC forecasts of demand in 2020, based on four scenarios. Case B is an updated version of the "moderate" growth projections presented at the WEC Congress in 1989. Case B1 is a variation of that case that assumes weaker expansion in central and eastern Europe and the former Soviet Union. Case A is a high-growth forecast, while Case C is the WEC's "ecologically driven" forecast.

other renewables. Even the very constrained and probably unrealistic supply scenarios of environmentalists show a doubling of energy from hydropower to 4,000 terawatt-hours per year over the same period[2]. *Figure 1* illustrates the WEC's estimates of energy demand growth in the future.

At present load factors, both these estimates suggest an increase in installed hydro capacity worldwide from nearly 680 terawatts (tw) in 1986 to more than 2,200 tw in 2020. That growth rate—about 4 percent per year—is about half the rate of the 1970s and 1980s. By 2020, on the basis of these estimates, the installed hydro capacity would increase from about 10 percent of the technically usable potential to some 30 percent.

Although this appears to be a feasible growth pattern for hydropower, some caution needs to be exercised in interpretation. First, the forecasts assume continuing advances in long-distance transmission and better utilization of low-head hydro potential as development sites move farther from power markets and toward more challenging locations. Second, about half of the hydro development in the next 25 years is likely to take place in the "Big Three" countries of China, India and Brazil, where market size is not likely to be a constraint. However, much of the remaining potential, particularly in Africa, is in countries where markets are small. Unless those countries overcome their reluctance to rely on internationally traded power, a significant portion of this potential may remain unexploited.

3. A LESS FRIENDLY ENVIRONMENT

In less than a decade, hydropower and the dams associated with many developments have gone from being viewed as the most environmentally benign source of power to among the most aggressively criticized. Even projects with relatively minor environmental effects—for example, the Pangue project on the Bio-Bio River in Chile—have drawn widespread public criticism for the harm they allegedly would do to relatively small local populations and the recreational opportunities of an even smaller number of rafting enthusiasts.

Are the new critics of hydropower projects right?

In some cases, yes. The developing world's record for dealing with the environmental and social issues associated with dams—particularly the resettlement of populations—is not very good. Poorly conceived and executed resettlement programs have tarnished the reputations of many governments and their electric utilities. Until the last several years, project developers, contractors and financiers tended to leave these issues to host governments, many of whom were not equipped to manage the problems.

What about the future? Can proper attention to environmental and resettlement issues erase the negative image? The answer has to be "maybe."

Many of the effects of hydropower and water resource projects are inherent in the underdeveloped conditions that surround many sites. Some can be traced to poorly defined property rights and human rights in those regions, and to a lack of institutional mechanisms with which to adjudicate those rights. Other issues result from a shortage of administrative resources in the underdeveloped parts of the world. These are relatively long-term problems that cannot be resolved within the context of a single project.

In some cases, it may be possible to overcome the constraints of the overall institutional environment, although at additional cost. For example, planning for the 1,800-megawatt (MW) Xiaolangdi project in China included extensive work on issues related to resettlement of more than 180,000 people. The World Bank in May 1994 approved some $570 million for project costs, nearly one-fifth of the money for land purchases and other support for the relocated people. In the case of other projects, the added costs of dealing with these issues sometimes ignored in the past may lower project returns below an acceptable level.

Under both domestic and international pressures, most governments have accepted the need to examine environmental effects and to plan for their mitigation. However, many countries lack the administrative and institutional capacity to implement that commitment. Failure to recognize that limitation and take it into account in energy planning and hydro project development has resulted in high post-project costs. As an example, the failure of both the project owner and the World Bank to anticipate the complexity of resettlement issues more than doubled costs at the 560-MW Guatape II hydro project in Colombia and delayed completion by three years. That delay, which in turn forced postponement of filling of the reservoir, effectively cost project owner Empresas Publicas de Medellin the equivalent of an entire year of energy generation[3].

4. IMPROVING ACCOUNTABILITY

Hydropower's record in dealing with environmental and social issues—both the reality of the industry's performance and the public perception of it—is damaged by unclear lines of accountability in planning and implementation of projects.

In most developing countries, hydro projects have been commissioned by large public monopolies. These monopolies are neither particularly effective in recognizing the need for change nor particularly sensitive to it. They are subject neither to commercial rules nor public scrutiny. They often have beneficiaries, not customers. In the construction of dams, they seldom have given adequate attention to social and environmental problems, preferring instead to focus on engineering issues with which they are comfortable.

Financial and other pressures are forcing governments to undertake major reforms of the sector. Private investment, more open regulatory systems, increasing competition to market electricity generation, system management, transmission services, and the rescinding of monopoly power all are part of the process. The structure being created by privatization of energy resources and public concern will be more accountable.

A badly handled resettlement program that results in project delays will adversely affect the profits of the developers. The increase in risks born by the developer and the financiers may well discourage investments.

A World Bank analysis of more than 80 hydro projects completed between 1970 and 1990 shows that resettlement costs contributed significantly to project budgets and—most damaging—to cost overruns. Resettlement expenses averaged 11 percent of all costs on the projects studied and ranged as high as 22 percent. On average, final resettlement costs were 54 percent above project estimates[4]. The effect of resettlement costs on project economics probably was even greater, if the cost of lost electricity sales that resulted from related project delays were factored in.

Governments will have to be prepared to better articulate their choices and trade-offs with regard to environmental and social issues. In the present climate of suspicion, project developers and their financiers find themselves under attack by both domestic and international environmental groups. These developers will back off unless governments produce the public support required to overcome the initial hostility.

5. PERFORMANCE PROBLEMS

Changes in the public's perception of the environmental and social consequences of hydropower projects rightly can be attributed to growing concern and expectations for those issues. The heightened level of concern caught governments, private developers, even the public itself unprepared, and it is not surprising that the hydro industry's performance has lagged behind ideal.

Changing perceptions cannot be blamed for other issues that are affecting hydro development worldwide. Hydropower project costs have tended to exceed estimates by substantial magnitudes. The World Bank review of 80 hydro projects completed in the 1970s and 1980s indicated that three-fourths had final costs in excess of budget. Final costs on half the projects were at least 25 percent higher than estimates; costs exceeded estimates by 50 percent or more on 30 percent of the projects studied. Costs were less than estimated on 25 percent of the projects, the study indicated. Figure 2 illustrates the findings of the study.

Viewed individually, the cases where costs exceeded estimates include a number where project participants can make the case that unanticipated problems increased costs after work initially had begun: cases where unexpected geologic conditions, funding delays and resettlement problems slowed the project and created additional expense. Together, however, the individual projects create a clear pattern of cost overruns that has damaged the image of hydro projects in the minds of members of the public and the financing community. Simply put, if three-fourths of hydro projects experience geological problems that cause delays and increase costs, geologic problems are the expected norm—not the unanticipated exception.

The bank analysis suggests many factors contributing to cost increases and delays in hydro projects have to do with capabilities of the project ownership and management team or problems in implementing project plans. In general, well-managed utilities or other project owners do a better job of planning projects, estimating costs and implementing plans. Similarly, projects that use experienced consultants, particularly those with a back-

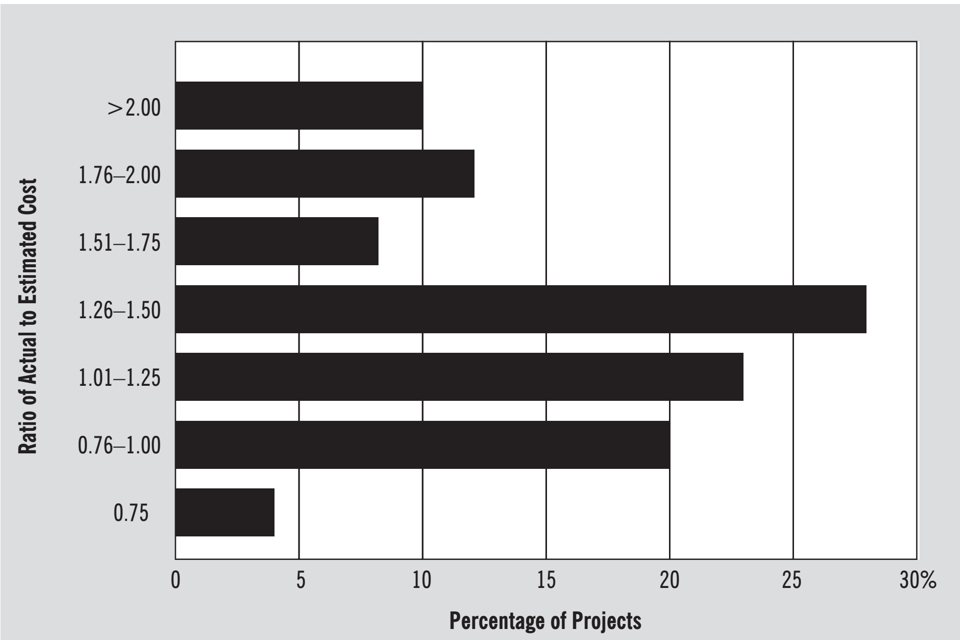

Figure 2: A World Bank study of 80 hydro projects completed in the 1970s and 1980s indicated that final costs exceeded budget in 76 projects. As indicated in this graph, final costs on half of the projects were at least 25 percent higher than estimates. Costs exceeded estimates by 50 percent or more on 30 percent of the projects studied. Costs were less than estimated on one-fourth of the projects.

ground in hydro projects, are less likely to exceed cost estimates or experience delays.

Whatever the cause, the upshot is that hydropower project estimates too often are being treated as unreliable and burdened by unacceptable high-side risks. With countries and utilities increasingly turning to the private sector to fund and build such projects, that perceived high financial risk will discourage investment.

Investors can be further discouraged when presented with uncertain costs and less-than-reliable revenue forecasts. If a project takes eight years to complete, the investor faces a situation in which he will have to lock in large amounts of capital on the basis of what cost and income are estimated to be nearly a decade down the road.

By their nature, the demand forecasts that are the basis of revenue estimates contain large elements of uncertainty. However, a World Bank study suggests that more than three-fourths of the electricity demand forecasts analyzed for the 1960-85 period were overly optimistic and that the degree of error increased with time[5]. Though perhaps expected, those facts have been especially deadly for hydroelectric projects in which gestation periods typically are extended.

Hydroelectric project development and finance also have been hindered by the historic project development structure in much of the underdeveloped world. Most such projects have been built as public works ventures. The owner (most often a government monopoly or agency) initiates the project, but its representatives typically do little of the planning, design or project supervision. Accountability can be fragmented, and the system frequently includes few private sector incentives for optimizing costs.

6. MEETING THE CHALLENGE: WHAT CAN BE DONE?

Financial agencies, environmental groups and the industry itself are pushing for improved policies in many of these areas, but their implementation has been handicapped by the weakness of existing institutional structures. Careful planning and attention to the details of environmental mitigation, population resettlement and financial issues in the early stages of specific projects will help, but ultimately the solutions will add to costs.

RESOLVING THE 'PEOPLE' ISSUE

Some empowerment of the local community is probably essential to provide checks and balances on the weaknesses of public administration in carrying out resettlement and addressing other social and public concerns of hydropower development.

The role of the power utility and government agency should be to ensure that adequate funds are available for compensation and other costs of resettlement, not to decide how each dollar is spent in the process. Why not insist that compensation be given directly to the individuals or communities affected by the project? In many developing countries, where individual property rights are weak, community-based solutions are necessary.

If the community and its residents are dislocated by a power project, estimate the compensation due and put the control of the funds in the hands of the community's leadership. Let the community decide what public or private goods it wishes to purchase and for whom. For example, in Turkey the resettlement programs permit each affected individual to select from a menu of public services and direct compensation offerings.

The government, financiers and project developers may wish to exercise some control, depending on the competency of local leadership. But the objective even in establishing those controls should be to move away from the usual paternalistic approach and put the process on a more businesslike basis.

Where possible, the wise hydropower developer should insist on local involvement in a specific project. More generally, the hydro industry should be encouraging the policy internationally and within the countries where it is most influential.

Governments also have a responsibility to convince the public that proposed projects are efficient solutions to real needs. This may be slow and difficult, but recent experience with a few hydropower projects demonstrates that it is now an essential ingredient of any successful venture. The success of the Chilean national government, Empresa Nacional de Energia S.A. (Endesa), and various interest groups in reaching agreement on resettlement issues was critical to private financing of the 450-MW Pangue project. (A ten-bank syndicate of European banks announced in May 1994 that it would loan $50 million to Pangue S.A., an Endesa subsidiary, for the project.) A private developer who gets involved in a project in a country where the government is either unwilling or unable to initiate such a dialogue is running unnecessary risks.

IMPROVING THE REPUTATION OF HYDRO

It is essential that the hydro industry come to grips with its record of cost estimation and project implementation. This record has caused the financial community to regard hydro projects as more risky than they are. This means that project owners and developers must rely on public funds or private financing packages with substantial public guarantees. In today's marketplace, that can be a serious constraint.

In many countries, electric power is being regarded as just another commodity to be produced and financed by the private sector under normal commercial terms. Given the many demands on their limited public funds, governments increasingly are reluctant to subsidize the capital requirements of hydropower. The availability of competing technologies at lower front-end costs, which the private sector is prepared to finance, adds to this reluctance.

Performance issues must be approached from two angles: better planning and more effective implementation. In both cases, the root causes of problems associated with project cost and revenues lie with the present organizational and institutional structure of the power sector in general and hydropower in particular. As long as these projects are treated as public works projects, high costs and poor performance will be a consistent danger.

Changing this will require a different way of doing business. Accountability will have to be pinned down. Those deciding what project is to be built, when, by whom, and how must be held accountable for the final results. Project designers, for example, will ensure that adequate allowances are made for geological uncertainties if they are to be held financially accountable for the failure to do so. Essentially, there is no alternative but to treat electric power as a commercial business subject to the discipline of markets. As long as there is a soft budget—where risks and costs are born by the public sector—the incentives for efficiency will be muted. In fact, unless there are shareholders who stand to lose from poor performance, improvements are unlikely. In recent independent hydropower projects in Colombia, India, and Guatemala, a major portion of the project developers' return on equity comes from delivering the project on time and within budget, and operating the project in excess of the agreed-on availability.

7. CHANGING TECHNOLOGY

Hydropower also is facing the challenge from without. In only a few years, the natural gas-fueled combustion turbine has become a dominant technology for producing electric power. Its physical and economic characteristics are almost the opposite of those of hydroelectric power: Project capital costs are relatively low and predictable with a high degree of accuracy; construction times are short; and fuel/operating costs are high. Where gas is readily available at what is at least for the foreseeable future a low cost, it has become difficult for hydropower to compete.

Of course, gas is not available everywhere, and in many cases hydropower is competing against traditional coal- and oil-fired plants. Hydropower has definite advantages in comparison with those sources, both from an environmental standpoint and because it is an indigenous resource. In many of the larger countries—China and India in particular—strong demand likely will warrant exploitation of all potential energy resources.

New technology also can play a role in broadening the potential of hydropower to meet future energy demand. For example, continuing developments in the efficiency and utility of turbines for low-head and small hydro sites will permit more effective use of more sites in a less environmentally intrusive manner. Recent successes in development of adjustable-speed generation and research into other new technology for large turbines will make it possible to rehabilitate, expand and develop other new sites. New technologies that permit the efficient movement of larger volumes of power over greater distances would allow developers to take advantage of remote sites where much of the future potential lies.

5. MAKING THE FUTURE WORK

Hydropower is, indeed, at a crossroads. Changes are taking place in the electric power business that will affect the growth of hydropower. The financial constraints of the public sector and the poor performance of most national electric power monopolies are forcing countries to consider alternative institutional arrangements for the sector. A major feature of this changed institutional environment is the introduction of competition and the private ownership and financing of power plants.

There are those who maintain that hydropower projects will only be built in the future with explicit public support. Some even go as far as to say private power will not build hydropower projects.

Under the present way of doing business, they are right. Significant private financial resources will be reserved for power projects that are reliably planned and minimize environmental and other risks. On the other hand, continuing public support as it is presently done, particularly in developing counties, will provide further ammunition to the critics, and weaken the longer-term competitiveness of hydropower.

What is needed is a new model of public/private partnership. The private sector would agree to undertake greater responsibility for project results in exchange for greater control over selection, design, construction and operations. The government, in exchange for a lower level of public financing, would agree to restructure the electric power sector so that it is a competitive business subject to normal commercial rules. In the transition period, public funds or guarantees will have to be an important part of the total financing. There should be, however, a clear understanding that it is a temporary measure and once the project (or industry) has demonstrated its capacity to perform, public funding would be reduced.

ENDNOTES

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HYDROPOWER: A NEW BUSINESS OR AN OBSOLETE INDUSTRY?

PHOTO COURTESY OF THE WORLD BANK

The Aksombo Dam on the Volga River, Ghana.

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Paper Contents

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ABSTRACT

This article reviews the hydropower industry's present poor performance and outlines actions that are needed. The criticisms leveled at the hydro industry are analogous to those leveled at the U.S. defense industry: poorly defined products, lack of discipline and political, rather than economic, decision-making. The weaknesses of the hydro industry are institutional in nature and are associated with public procurement. The industry is currently composed of diverse and specialized firms that compete for contracts in which all of the risk is undertaken by government. As such, it is not well-suited to a environment in which private capital is playing an increasingly central role. To survive, the industry must adapt by creating developers—that is, firms with sufficient capital, technical skills and marketing ability to finance and manage the risks inherent in hydropower projects. These firms will have to develop a diverse portfolio of projects in order to spread risks, and negotiate a better way to share risks with governments. The role of the developer is to develop plants, not run them forever. Only through a restructuring of the industry will firms emerge with the ability to compete in the international power market.

1. INTRODUCTION

The World Energy Council's Energy for Tomorrow's World suggests annual global production of energy from hydropower will grow from the present 2,000 terawatt-hours per year to 5,000 terawatt-hours by 2020[1]. This implies a growth rate of about 4 percent, or half that of the 1970s and 1980s. On the basis of this scenario, only 30 percent of technically feasible potential, up from 10 percent today, will be in production.

There are several problems with these scenarios. First, based on more recent data, the implied growth rate in energy demand in these and other similar scenarios is seriously underestimated. More recent information, and a more optimistic outlook for growth in the developing world, suggest that the increase in global demand could be double the present consensus outlooks. Second, the share of hydropower in this growing demand is not likely to increase. If we take the output of the industry of the last few years and project it into the future, a possible decline in hydro's proportion of new capacity is possible. For those in the hydro industry and those concerned with the possible adverse effects of increased fossil fuel consumption on global climate, this is bad news.

What has brought about this sorry state of affairs, and what can be done about it? Let us start with a review of the industry's performance and then move on to the major factors accounting for the record.

1. Hydro projects have become a source of environmental concerns. Almost every major project today faces a suspicious environmental community. In view of this opposition, potential sources of finance, both public and private, have backed away from financing these projects. The poor past performance of the industry in handling environmental issues, particularly where resettlement is involved, will continue to adversely affect public perceptions.

2. The industry's record of overruns is an embarrassment. Although not all projects have suffered from poor performance in this regard, enough have done so, and this in turn has resulted in a perception in the financial community that these are high-risk projects. Endless litigation between contractors, engineers, and owners has added to this perception[2].

3. This performance, in turn, has resulted in a loss of confidence in engineering and technical staffs. Cost estimates prepared by engineering firms, for example, are routinely factored up by multiple amounts based on the past record. The poor quality of site information, which produces expensive "surprises" in a majority of projects, adds to this lack of trust.

In response to this perception of its performance, the industry has tended to react in a defensive manner. Facts and figures are disputed. There are good projects that have come in on cost and on time. Not all projects have been environmental disasters. The industry is being unfairly judged relative to the alternatives—after all, fossil plants have their own environmental consequences. Hydro is capital-intensive and ought to receive financing at favorable interest rates. And so the debate continues. It may make those in the industry feel better, but it seldom alters public perceptions. In fact, the defensive nature of the responses probably adds to public suspicions.

2. THE STRUCTURAL ISSUE

The heart of the problem lies in the way the business has been conducted. The same criticisms leveled at the hydro industry are also leveled at the defense industries—for the same reasons. It has become another large public purchase with all the faults and weaknesses of public procurement. Poorly defined products, lack of discipline and political decision-making have combined to turn the industry into another fat sow elbowing its way to the public trough.

In the 1970s and 1980s, the hydro industry was effective in aligning itself with the national interests and became another product similar to defense. The existence of national public monopolies running the power industry made the job easier, as did the security concerns associated with rising oil prices. For that important public good, national defense, there are few alternatives, and through the centuries, the inevitable inefficiencies associated with the raising and maintaining of armies has been accepted as a necessary evil. Fortunately, armies are seldom tested, and inefficiencies can persist for long periods of time. Unfortunately, in the case of electric power, the inefficiencies tend to accumulate and become more visible with every passing year. In the case of electric power there are alternatives to treating it as a public good.

By the mid-1980s, governments, particularly in developing countries, found themselves increasingly unable to deliver electric power to their growing populations. The huge financial needs of the industry were bankrupting governments and the waste and inefficiencies were increasingly obvious to all. In response there was a notable slowing down in investments in electric power, as countries sought to define alternatives to public procurement. The environmental movement had grown in strength and was exposing some of the adverse consequences of hydro projects. Oil prices were falling and new technologies, notably the gas turbine, were proving their economic and technical feasibility.

In the final analysis, it is various combinations of all of these factors that threaten the hydro business as it was practiced through the 1980s. Electric power is moving from public procurement, with which the hydro industry feels comfortable, to a commercial business, where the hydro industry is uncomfortable. In order to compete in this new world, the hydro industry will have to strengthen its areas of weakness and work on improving its competitive advantage in an increasingly market-based industry.

The weaknesses of the industry are institutional in nature and are the result of its association with public procurement. Some of the issues that will have to be addressed:

Lack of accountability. The owner, usually a public monopoly, makes the basic decision on where and what to build. Behind this decision is a system planning exercise that lasts forever and where a great many assumptions are strung together to produce a "least cost" expansion plan. The planning and eventual construction process can last a decade. By the time the first kilowatt-hour is produced, the planners and decision makers have long gone. No one is accountable for the mistakes or the lack of reality in the planning exercise. Many hydro projects, for example, were justified on the basis that oil would be $100 a barrel in the 1990s.

Divided responsibilities. The major parties involved in any hydro project are the owning utility, its government, the engineers, the financiers and the contractors. None of these parties feels responsible for the eventual outcome of the projects. The owners hire engineers to do site investigation. At this point the owner is politically committed to the site and may well have the financing lined up. The owner is usually in a hurry and reluctant to spend too much on site investigation. In any case, bad news would be unwelcome at this point in time. The engineers have a vested interest in keeping the project going in order to obtain supervision and other work. The contractors are doing what they are told—changes to orders are welcome and "surprises" are an opportunity to claim more money. The larger the cost overruns, the bigger the engineering firms' commissions. The financiers do not depend on the project to be repaid but rather on the government; they have their government guarantees and will get paid whether the project is successful or not. Attempts to control costs through turnkey contracts do not work where responsibilities are so divided.

Lack of risk management. Project risks, particularly market and financial risks, are seldom adequately quantified, and risk mitigation strategies primitive at best. The risk of cost overruns, for example, is quantified in terms of plus or minus 10 percent or 20 percent on overall costs. In practice it is not unusual to find cost overruns of 50 percent to 80 percent. The cost of delays, an almost inevitable consequence of the financing mechanisms, receives only cursory analysis. Most projects have a significant proportion of their costs covered through allocations from the government budget, and the assumption is made that governments will make their contributions in a timely manner. This seldom happens and, as a consequence, is a major risk associated with any hydro project. Yacereta in Argentina and Porto Primavera in Brazil are examples of huge infrastructures partially in place with completion delayed by lack of funds. If these risks had been reasonably estimated, these projects would not have gone forward.

In a world in which hydropower has to compete with alternative technologies for private capital, the institutional structure described above is not compatible. No private investor or lender is prepared to risk capital in an industry unable to get its act together. Private capital will insist on all risks being quantified and assigned to responsible parties.

Engineers who do the site development work will have to be accountable for the results, and a failure to detect underground problems, for example, will result in real penalties for the firm. In a recent bid for an operations and maintenance contract for a private power plant, the winning firm was required to put up a $75 million security bond. For every day the plant fails to produce power as specified in the contract, the firm will have to compensate the owners for lost revenues.

Turnkey contracts are no longer flexible negotiating instruments to be adjusted over the life of the project. Governments may be willing to pick up the costs of failure to produce on time, at cost and with performance as specified, but private parties risking their own capital will not. Private lenders will not be prepared to risk their capital on projects dependent on promises of money from public budgets. They will insist the government disburses its share before they put in a penny. Neither will they advance funds before a clear resolution of land, resettlement and environmental issues.

3. MANAGING RISK

Engineers tend to focus on technical risks. In practice, with private power projects, the technical risks have seldom proved to be a problem. With very few exceptions, recent privately financed and built fossil fuel plants have arrived early, usually below cost and with better-than-specified performance. Although hydro presents some unique technical risks, I am confident that, given the right incentives, the engineers can solve the technical issues. It is other risks the industry needs to learn to manage better.

Market risk. In the world of government procurement, all market risks have been assumed by government. It is assumed there will be enough customers willing to buy the output of the plant at prices that cover costs and perhaps allow room for some profit. In the case of privately built and owned plants, it is common to have a long-term power purchase agreement with the utility and, in the developing world, usually with some form of government guarantee. The basic assumption behind these contracts is that the government determines the price and, in turn, must assume all of the market risk.

But what happens when electric power becomes just another commodity, as it has in a number of countries? In these cases the price of electricity is set by markets and not by governments. Where commodity prices are market-based it is unusual to find anyone willing to take 20-year positions. The owner of the plant has to take the risk that there will be a market for his product at adequate prices. There are no long-term contracts, and this type of plant is known as a merchant plant. Fortunately, as is the case in any commodity market, there are mechanisms that will allow the owner to hedge some of the risks.

Can hydro think of itself as ever building a merchant plant? Failure to do so could drastically curtail the business. In Argentina, Chile, the United Kingdom and growing number of countries, prices are increasingly market-driven and owners of new plant must assume the market risk. Most of the new plants built in these circumstances are fossil-fired. There is, however, an example in Chile, the Duqueco River, where a hydro project as a merchant plant has closed financing. In this case, the equity holders and the bankers had sufficient confidence in the market and its regulatory structure to be willing to undertake the market risk.

Financing risks. A critical factor in the financing of any project is how the risk are shared between debt and equity. Banks and creditors do not like to take risks. This is the job of equity. To the extent bankers believe hydro projects present substantial risks, they will insist on larger equity contributions. In the Duqueco project in Chile, the banks are willing to provide funds with only a 30 percent equity contribution, reflecting what must be a high degree of confidence in the market and the project. In the case of the Shaijao C project in China, a coal-fired project, the bankers insisted on a 50 percent equity contribution, indicating they viewed the project to have substantial risks.

Increased equity requirements will raise the cost of capital. Equity expects to be compensated for its risks. This may price many hydro projects out of the market. In today's markets, for example, it is unlikely mega-projects such as Bakun in Malaysia, James Bay in Quebec or Lower Churchill in Newfoundland could be financed with purely private capital. Substantial government guarantees or subsidies would be required to lower capital costs to the point where these plants might be able to compete.

There is little that can be done about the cost of capital. There is a great deal that can be done, however, to lower the perception of risks. The Chile project points the way. The bankers were confident enough in the way the risks were managed to find a 70/30 debt/equity ratio acceptable. I will say more about this later.

Site risks. Why is it cost overruns should be the rule rather than the exception? Why do projects always take longer than expected? Why are there always geological surprises on the site? Judging by the way most projects wind up in court or in arbitration, there is plenty of blame to go around. The contractual arrangements between the various parties invite each to protect his interests at the expense of the overall project. In most of the more recent private thermal power projects, equipment suppliers and contractors are equity participants. This provides a great incentive for all parties to work together to resolve problems, because they will all lose if they are not resolved. Undoubtedly this is the direction hydro projects will have to take. All parties involved in the project need to have an ownership stake.

Environment and resettlement risks. The industry is growing more sophisticated in the way it handles environmental issues. A great deal can be done to resolve these issues if they are faced up to in the beginning. Environmentally sensitive sites are best avoided, and where corrective measures are necessary, their costs have not proved overwhelming—if undertaken in a timely manner.

Resettlement is another matter. Environmental issues can often be dealt with through project designs, whereas resettlement is primarily a management issue. The usual practice is to leave resettlement to governments and their power companies. Neither does a very good job. Compensation is left to a myriad of government departments that have neither the interest nor the budget. Dam builders seldom understand or have much interest in resettlement. Government promises are worth little when the reservoir is filling and the army has to be called in to move people. If private capital is to finance hydro projects, it will have to undertake greater responsibilities in dealing with resettlement issues.

4. ADAPT OR DIE: CAN THE INDUSTRY RESPOND?

This is the main question in the minds of most industry observers. So far the results are not encouraging, and there is a tendency to avoid facing up to the central issue: who will provide the risk capital. Bankers are not in the business of providing risk capital. Engineering firms do not see it as their business. Contractors would rather someone else take it on. Equipment manufacturers are reluctant. Governments want to get out of the business. And so it keeps going around in circles.

What is missing is the developer. Where is the Enron of the hydro business? The industry needs firms with sufficient capital, technical skills, marketing ability and management to be able to both manage and finance the risks inherent in these projects. At present the industry is structured to meet the needs of the public procurement process, where diverse and specialized firms compete for contracts in which all of the risk is undertaken by government.

Inevitably, given the size of risks and the size of projects, the developers will have to be large and well-capitalized. No one firm in the industry meets these specifications. It will require consolidations and strategic mergers among existing firms to produce firms capable of taking on the broad range of risks associated with hydro development.6.

5. PROFILE OF THE SUCCESSFUL DEVELOPER

Deep pockets. Given the perception that this is a high-risk business, early entrants must be prepared to put up substantial amounts of equity. Equity requirements of 50 percent or higher should not be unexpected. Overtime, a good track record will attract greater debt capital. Project or limited recourse financing is likely to prove expensive and difficult to obtain. A corporation able to raise funds on its own balance sheet will have a competitive advantage.

Leadership. Most projects require bringing together a complex set of skills. Given the traditional divisions in the industry, no one firm is likely to have all of these skills. The successful developer will have to combine these skills in ways permitting clear lines of authority and accountability. Whether it is necessary to pull these skills together in one firm, through mergers and acquisitions, or to create strategic alliances is a matter of judgment. Having all parties participate in providing some of the equity is one possibility, but it may not be sufficient to address the need for closer working relationships among the project developer, the engineering firms and the site contractors. What is clear is that the developer will have to provide clear overall leadership and decision-making authority.

Entrepreneurship. Entrepreneurs take risks, but they are also good managers of risks. The risk management skills of the industry are underdeveloped. The traditional large firms in the industry, the equipment suppliers and the contractors, are unlikely to have the necessary entrepreneurial capacity. A few of the engineering firms might have this capacity, but they generally lack sufficient capital to become serious players. Perhaps new players from outside the industry will be required—similar to what has happened in the power business, where a gas supplier, Enron, has become a dominant player.

6. THE FIRM

Given these characteristics of a successful developer, how would one go about setting up the firm and what, in today's less-than-perfect markets, should be its strategies and tactics? Peter Drucker and other well-known management gurus all recommend that new or entrepreneurial activities should be started outside or apart from existing institutional structures. The directors of a traditional equipment supplier, for example, are going to have a difficult time understanding the nature of the new business and the risks involved and are unlikely to act fast enough to take advantage of market opportunities. Firms such as International Generating in the United States have been established by the more traditional parts of the power industry in order to exploit international markets.

Our hydro developer should probably combine the capital of a major equipment supplier and contractor, the engineering skills of an experienced hydro group, and the entrepreneurial skills of one of the leading international power developers. It should have sufficient capital ($300 million) to undertake one or two medium-size hydro projects a year. Above all, it should have sufficient independence from its founders to enable it to become entrepreneurial and to take calculated risks in what could be a profitable but risky market.

7. SOME TACTICS AND STRATEGIES

In order to spread risks, the firm would have to develop as diverse a portfolio of projects as quickly as possible. This suggests focusing on relatively small projects that can be developed in less than three years. Large projects, particularly if there is a substantial reservoir, inevitably experience delays. One possible tactic would be to buy into existing incomplete projects. Brazil has a number of opportunities worth exploring. Alternatively, many countries have projects in which preliminary work has been done but lack of funding has delayed further work. Offering to take over these projects is another way of getting a quick start.

Critical to taking over these projects will be the assignment of risks, particularly market and hydrological risks. Most governments recognize that in the current underdeveloped state of their power markets or because of delays in their reform programs, no developer would be willing to undertake all of these risks. The real issue is how can there be a better sharing of the risks. The developer, of course, should take on construction, completion and performance risks. Hydrological risks are a matter of judgment and risk preferences. If the developer is sufficiently confident in the hydrological data, he may be willing to take on this risk. On the other hand, if the data is weak, perhaps the government can be asked to take on the initial risk with the developer picking up more at a later stage. With market risk, too, there will have to be sharing. The twenty-year take-or-pay contract is probably the extreme. If, for example, the developer is able to negotiate a substantial peak/off-peak price differential, it will make taking on some of the market risks a more reasonable proposition. There are many forms of risk sharing which can benefit all parties. What is needed is a more imaginative approach that explicitly recognizes that the costs and benefits are different, depending on who takes on the risks.

Finally, the developer has to recognize his job as developing plants, not running them forever. The money to be made in this business is in capital gains. The developer's job is to establish an asset in a market applying a large discount to its value in the development stages. Once the asset is developed and producing revenue, the benefit of that market discount goes to the developer in the form of capital gains. In other words, the developer needs to sell all or some of his interest in the asset, using the proceeds as his profits and to finance the next project. There are various ways this can be done. The developer may chose to gradually sell his shares in the asset into the local capital market or perhaps to a partner that is interested in running the plant, thereby eliminating longer-term exchange risks and assisting in the development of local capital markets. Another interesting alternative is being undertaken by Enron: It has put all of its returns from its international projects into a fund and then turned around and sold shares in that fund in the capital market. In doing so, it is able to capitalize the gains from the revenue stream and apply them to new investments.

8. CONCLUSIONS

The world of the international power developer is extremely competitive. There are hundreds of firms trying to establish themselves in the business. A few are world class firms with billions in capital. In the next few years there is going to be a substantial restructuring of the industry as winners and losers are identified. One potentially important part of this market yet unexploited is hydropower. Most of the existing competitors are developing the ability to manage the risks associated with fossil plants and are not comfortable with the risks associated with hydro. Is this a gap that can be filled by some smart player with hydro experience?

I have outlined above a few of the actions that would need to be taken. And this is just a beginning. There are many ways the industry can strengthen its ability to compete in the international power market. The only question in my mind is whether the developer will come from within the existing firms in the industry or whether we are going to see an outside firm that understands the power business step in and take over the leadership.

ENDNOTES

1. World Energy Council, Energy for Tomorrow's World (New York: St. Martins Press, 1993).

2. For further details on performance see A. Churchill, "Meeting Hydro's Financing, Development Challenges," Hydro Review World Wide (Fall 1994).

PART III

APPENDICES

APPENDIX A: Summary of the Key Issues Discussed in the Working Groups at the Workshop

APPENDIX A1:

CRITICAL ADVANCES NEEDED IN KNOWLEDGE AND PRACTICE

During the breakout groups, the participants were asked to address the following three questions:

- What are the critical advances needed in knowledge and practice for the assessment and development of large dams?
- What methodologies and approaches are required to achieve these advances?
- Who should be involved, and what should be the process for follow-up action?

The responses to these questions are summarized in Part 1 of the report. In this and the following appendix, further details are provided on the points that were made in considering the first two questions.

The breakout group discussions were wide-ranging but were not necessarily comprehensive in considering all of the points raised in overview papers and plenaries because of the limited time available. Attention in the breakout sessions focused particularly on the identification of gaps and priority needs. There were differences among the groups in the approaches taken and the ideas generated. The following points have been taken from the summary notes that each group put on their flip charts. Listing of these does not imply agreements on their relative importance. The editors have tried to summarize the rich variety of ideas while resisting the temptation to go beyond what was recorded by the groups to fill in gaps or eliminate contradictions. This appendix focuses on the first question; A2 focuses on the second.

ENGINEERING AND ECONOMIC/FINANCIAL ISSUES

Technical aspects of dam engineering. By and large, it was felt that technical knowledge exists to address most requirements for the engineering design of dams, and considerable progress has been made on the technical side. For example, released water may be aerated to produce required oxygen levels or taken from different levels in the reservoir to maintain a given temperature. Dams may be designed so as to reduce the amount of sediments that they trap and to reduce the impact on some migratory fish species. More frequently, the problem is that the technology employed is limited by the finances available. In addition, the requirements for the dam are often not known, such as the amount of water needed to be released to maintain a downstream ecosystem.

Competitive markets. In the past, large construction projects were financed almost exclusively by governments with financial support from international institutions, such as the World Bank. Today the private sector is increasing its role in financing dams. The private sector values risks differently and compares economics and environment differently. Countries must evaluate the trade-offs of working with the development agencies or with the private sector.

Internalizing economic externalities. Traditional economic methodologies for the assessment of dam suitability often focused on the direct costs and benefits, such as the costs of construction and the benefits from electricity generated or irrigated crops grown; these are considered internal to the project. There are also important indirect benefits (e.g., those associated with irrigation and regional development) and costs (e.g., decline in fisheries downstream caused by lack of flood plain inundation) to be internalized. Internalizing these externalities involves including the value of all consequences of the dam within the cost/benefit analysis. One problem is that methodologies to value some non-traded goods, such as biodiversity, aesthetic pleasure and cultural heritage, are not well developed.

Discount rate. To attract investment in large dams, rates of return must equal or exceed those of other investment opportunities, such as buying U.S. government bonds. This is reflected in the economics of a project through the discount rate. High discount rates favor projects with short-term high return, while low rates allow incorporation of sustainability considerations and the interests of future generations. Either way the discount rate can significantly affect the economic viability of a project. The relationship between discount rate and sustainability is not well-defined and needs further research.

Technical information. Technical information for deciding between development options or how to mitigate the potential effects of dams are frequently lacking, especially in developing countries. Engineers are willing and able to find solutions to problems provided that the problems can be quantified, in terms of how much water an ecosystem, for example a wetland, needs to maintain wildlife or perform an environmental function, such as nutrient recycling.

Decommissioning of dams. In addition to the issues relating to the construction of dams, little attention has been given to the long-term role or status of dams once their effective life has finished. Dams may cease to operate once they are filled with sediment; thus effectively they will act as land terraces. In some cases, it may be appropriate to decommission dams by removal of all or part of the structure. This can be a costly exercise, and who should pay is not considered when dams are built.

Appropriate technology. In countries where skilled engineers and long-term financial resources are available, a sophisticated technological solution may be most appropriate, such as managing dam operations automatically using information on rainfall or river flows by telemetry from remote stations. However, in many countries investment in high technology is wasted, as resources and skilled manpower are not available to maintain equipment. Technology needs to be appropriate.

External impacts hydropower generation and other technologies. Hydroelectric power generation is often considered to be "environmentally friendly" in that it produces no nuclear waste and does not use nonrenewable resources, such as coal or oil. The immediate impression is that hydropower generation does not produce "greenhouse gases," such as carbon dioxide and methane. However, in tropical regions especially, the rotting of vegetation can produce substantial quantities of greenhouse gases. These external impacts need to be quantified and compared between power generation technologies.

Technical flexibility. The management of dams after construction is often different to that envisaged at the time of design. Few dams have ever been built that allow the passage of sediment or the release of large quantities of water to create artificial floods downstream. Dams need to be flexible so they can be removed or operated in a manner not intended in the original design.

SOCIAL AND STAKEHOLDER ISSUES

Definition of affected groups. One way or another, large dams, like many development projects, affect a wide range of individuals. A hydroelectric power scheme may bring benefits to a large area—indeed a whole country—if a national grid is in place. Furthermore, affected people may be in other countries if power is exported. Likewise, negative effects may also be widespread: Regulation of flows by a dam in the headwaters of a river may mean loss of agricultural land on a flood plain downstream or degradation of a shrimp fishery in a coastal delta. Resettlement may also affect a large area if people, wildlife or historical artifacts are moved from the reservoir site to a distant location. A major issue is therefore to define the affected groups, or at least those significantly affected.

Appropriate level of participation. Stakeholders, including local communities, need to be involved at all stages in the development of choices and in the planning, design, implementation and management of large dams. Before the final development option is chosen, the priorities of the stakeholders should be determined through participatory appraisal.

Transparency in decision-making. In addition to decision-making being fair and participatory, it has to be seen to be so, or people will have no confidence in the decisions. Meetings should be open with agreed actions, reports and data should be freely available, and the objectives and steps in any process should be clear from the start.

Equitable sharing of costs, benefits and risk. Although some net economic gain for a region may be calculated for a proposed dam project, who actually gains and loses is often not considered in detail. At present too much of the costs and risks are borne by local people, whether resettlers, host communities or downstream residents. For example, in many developing countries electricity has benefited the urban elite, commerce and industry. Because of little rural electrification, though, the rural poor do not benefit; in the meantime, they frequently suffer the costs of development from loss of natural resources and ecosystem functions. Greater efforts are needed to allow local people to contribute to the stream of project benefits in a way that is environmentally, economically and culturally sustainable.

Health. In many cases human and animal diseases have increased significantly following the commissioning of dams. Disease vectors, such as snails and mosquitoes, thrive in wet conditions, leading to outbreaks of diseases such as malaria and schistosomiasis.

Indigenous knowledge systems. In many cultures, traditional water management technologies and systems have often evolved to be in sympathy with the social structure of the communities. Many are sustainable with small populations but require development to satisfy higher demands from increased populations. There is a need to identify and evaluate indigenous knowledge systems to determine whether they can meet the aspirations of stakeholders in the future. As with local people's social structure and culture, better information on indigenous knowledge systems is required for assessing their applicability to changed circumstances.

ENVIRONMENTAL ISSUES

EIA policy. EIAs of dams need to include a comprehensive evaluation of alternatives that can provide the same or better development benefits, so that environmental considerations are integrated into the planning process, through a sectoral EIA, with participation at all stages by affected communities. The rules, regulations and processes need to be defined and implemented by the government authorities before any private-sector developer enters, and environmental assessment should last continuously throughout the life of the project, considering the very long-term implications, including decommissioning.

The EIA process. Agreed practices need to established for defining project boundaries for analyses. Key indicators of environmental health and social well-being need to be defined. These should be uniform across all energy sectors. Analysis of future trends should be undertaken with and without the project to consider the impacts from other factors, such as climate change or increasing pressure on natural resources.

EIA financing and responsibility. It is widely accepted that the investor should implement the environmental assessment, but the responsibilities need to be defined precisely. This should include who takes responsibility for restoration and reparation measures.

EIA quality control and consistency. EIAs should be independent to remove any vested interest. They should be controlled by particular obligations, quality standards and control mechanisms. Severe penalties should be levied where EIAs are not adequate.

Participation in EIAs. EIA should be an interactive, participatory process, including the perception of the environment from local communities, especially affected peoples. It should be open and balance conflicting environmental needs, such as natural resource use. Decisions should be made through meaningful discussion and information sharing.

Biodiversity, ecosystems and hydrology. Assessment of environmental impact is frequently hampered by lack of information, especially in remote areas where little is known about biodiversity. The hydrology of the catchment may also not be well understood, as long records of rainfall, river flows, groundwater levels and evaporation rates are required to assess water resources effectively and to detect any apparent climatic variability. Water quality and sediment transport rates are also normally not well understood, which precludes assessment of the long-term sustainability of reservoirs. Better knowledge of the water requirements of ecosystems would help to define likely downstream impacts.

CROSS-CUTTING ISSUES

Multidisciplinary approaches. Large dams, like many development projects, involve many disciplines, from ecology to engineering to sociology. A multidisciplinary approach is therefore needed to provide a comprehensive approach to the evaluation of trade-offs between development options, between environmental costs and development benefits and between development and social costs.

The scale of planning. The appropriate planning and management scale depends upon the relative importance of the components in the system. The fundamental unit for water issues is normally the drainage basin, as this demarcates a hydrological system, in which components and processes are linked by water movement. Hence the term "integrated river basin management" has developed as a broad concept that takes a holistic approach. The socioeconomic scale is more frequently a village, town or city and its hinterland with which it interacts. This may not coincide with a river basin. The practicalities of implementing an integrated socioeconomic and biophysical approach have not been precisely defined.

Monitoring and evaluation. Large dam projects should have a long time horizon. This should begin with adequate pre-project assessments involving participation of local communities. Close monitoring of the impacts on local communities should take place during project implementation, especially if resettlement is required. Post-project appraisal needs to be undertaken over a long enough period such that the long-term effects of the dam, in both benefits and negative impacts, can be determined to ascertain whether the measures are sustainable. For example, can resettled people and their children after them derive a higher standard in their new location? Because social effects continue well beyond the end of the construction phase, it is essential that they be carefully monitored and that sufficient financing be available over a longer time frame for implementing appropriate development plans.

APPENDIX A2:

METHODOLOGIES AND APPROACHES FOR ASSESSMENT

Please see the introduction to Appendix A1 for an explanation of the breakout group questions and discussions that led to the ideas summarized here. The ideas below focus on responses to the second question: What methodologies and approaches are required to achieve advances?

Definition of terms. Both the terms "environment" and "sustainability" are widely used but not well-defined. For an engineer, "environment" might refer to the hydrology, and to an ecologist, the functioning of a wetland ecosystem. In water resources, sustainability is closely related to other concepts, such as overexploitation and safe yield, each of which have a variety of definitions, some related to time scale. Precise definitions are needed so that dams can be assessed in terms of their environmental impacts and sustainability.

Trade-offs. Sound methodologies are required to assess trade-offs between financial performance and impacts on people and the environment. Cost-benefit analysis is often used as the decision-making tool, focusing on economic efficiency and maximization of the overall gain to society as the measure of success. However, a methodology is needed for taking account of distributional effects (i.e., who gains and who loses from large dams).

Valuation of non-traded goods and services. Methods for assessing values associated with non-traded goods and services, such as ecosystem functions, and internalizing externalities, need to be developed.

Discount rates. More research is required on the relationship between discount rates and sustainability of projects so as to resolve debates about whether short-term, high-yield projects prejudice choices against sustainable, lower-yielding projects.

Definition of stakeholders. More precise methodologies are needed for determining the stakeholders and the cut-off point for people most affected by large dams.

Stakeholder involvement. Guidelines are required on how to involve stakeholders, including procedures appropriate to differing levels of income, types of employment and living standards of local people (for example, housing and social services) and on what makes meaningful and appropriate levels of participation.

Institutional capacity. Assessment workshops need to be designed for evaluating the stakeholders' technical knowledge, ability to analyze information and organizational skills in providing for democratic representation. Training in technical issues and negotiation skills can be identified.

Ethics. Guidelines on ethics are required and tribunals of inquiry are necessary to hear grievances.

Ecosystem approach. The ecosystem approach is required throughout the planning, design, implementation and evaluation phases of development. The approach recognizes the interaction and interdependencies of the physical, chemical and biological as well as social and economic elements of a given area. Taking an ecosystem approach means identifying these interrelationships, predicting the impact of any proposed action and evaluating the consequences before taking any decision. New methodologies are required to better assess the abiotic-biotic and biotic-biotic interdependencies.

Implementation of treaties and conventions. It is essential to ensure that design, construction, implementation and management of large dams is undertaken in line with international treaties and conventions, such as Ramsar or Biodiversity Conventions, and in line with any water-sharing agreements between countries sharing international water bodies.

Proactive EIA approach. EIA tends to be a reactive process that looks at the environmental impacts in response to design proposals for a dam. Procedures are required to use EIA to evaluate alternatives that can provide development benefits in sympathy with conservation.

Water requirements of ecosystems. Methodologies need to be developed to assess the water requirements of ecosystems, so that effects of impoundment of water can be determined and strategies for ecosystem conservation, such as artificial releases, can be implemented.

Conservation of biodiversity. Procedures for assessing and conserving threatened species need to be established.

Planning. All planning needs to have clear objectives and criteria, for example that people are better off. Methods need to be developed for supporting decision-making based on multiple criteria analyses, considering multiple options trade-offs and going beyond simple cost-benefit analysis. The old paradigm of design on the basis of least cost is being replaced by one of maximum acceptance, or least regret by the stakeholders and affected people and wildlife.

Demand management. New methodologies for reducing water demand should be investigated to reduce the need for large dams such as water pricing, on-site sewage treatment and drip irrigation technology.

Scale. Research needs to be undertaken on how the scale of a dam relates to impacts, decentralization, privatization and devolution of authority to local communities.

Private sector. The involvement of private-sector financing is a relatively new phenomenon. Research is needed on how the private sector values risk, whether they have shorter- or longer-term horizons and how competition among the private and public sectors may affect choice of options. The roles of the various actors need to be defined, such as the public sector undertaking strategic planning and handing the project over to the private sector for implementation. Project appraisal is required on how private and public sector dams compare on economic, environmental and social grounds.

Responsibilities. The responsibilities among the various actors for environmental and social data collection, impact evaluation and decommissioning need to be defined. Questions such as who pays for higher standards need to be addressed.

Interdisciplinary teams. Guidance is required on the makeup of multidisciplinary teams, which might include professional experts (hydrologists, engineers, sociologists, ecologists, planners, epidemiologists, economists and others) and locals with particular knowledge of the ecosystem or cultural values.

APPENDIX B: Opening Statements to the Large Dams Workshop and Post-workshop Correspondence

APPENDIX B1:

OPENING STATEMENT BY

IUCN Director General
DAVID McDOWELL

May I welcome all participants to IUCN headquarters. The composition of this group is not accidental: it reflects the diversity of views globally on the utility of constructing large dams.

We have here:

- Our co-hosts from the independent Operations Evaluation side of the World Bank;
- Top people from three highly relevant areas of the World Bank Group: the Environment Department, the Energy Department and the International Finance Corporation;
- A group of civil society organizations, including some multi-country NGO networks;
- People from several national government ministries and public utilities;
- A good representation of private sector people from firms involved in the design and construction of dams;
- Several people from the media; and
- Managerial and technical staff members of IUCN-The World Conservation Union, a GONGO (government and NGO) hybrid with over 900 organizational members in 136 countries and extensive expert networks.

Why have the Bank and IUCN gotten such a disparate group together to talk about dams? The short answer is that a dialogue among these people is long overdue. To use the catchy phrase, we are all stakeholders in this activity — and it is time to talk turkey.

I welcome all of you to this place, particularly those who are here for the first time.

I welcome particularly the private-sector people. There has been an empty chair at otherwise inclusive IUCN gatherings over the years. It is the chair that should have been assigned to the corporates, for it is the private sector that invests in and manages much of the natural resources of the world. I now have a firm mandate from the Union membership to fill that chair on all occasions such as this. I welcome that recognition of the realities.

I also welcome the press presence. This will help increase the transparency of the whole process.

You may ask why IUCN and the World Bank are acting as co-hosts. The answer is that this is one result of an experiment in partnership which began nearly three years ago. Its origins go back beyond early 1996, when the Bank's Operations Evaluation Division was preparing its desk review of large dams. It was based on our side on the premise that it is better to join in the struggle than to howl from the sidelines — and on the calculation that when an institution like the Bank starts to give evidence of changing its spots it should be encouraged to go on doing so.

For my part, I regard this as a gamble which is paying off: We still argue strenuously with the Bank on many occasions and we do not see eye-to-eye on many issues, but we have been able to influence this somewhat implacable institution in directions we see as useful and we have done some very good work together in the field. And we have ourselves learned much from our closer association with the Bank.

So why does this Union have an interest in large — and indeed all — dams? The basic answer lies partly upstream and partly downstream from these sometimes productive, sometimes destructive, sometimes beautiful man-made interventions in the cycles and systems of nature:

- We are intensely interested as a Union in the ecologically sustainable use of natural resources like that life force that is fresh water.
- We are intensely involved in the theory and practice of managing freshwater ecosystems and indeed large river basins.
- We are intensely interested in the equitable use

of such resources — so the upstream and downstream effects on people as well as ecosystems interest us substantially.

■ We stand for the conservation of biological diversity in all its forms, not simply for aesthetic reasons — though these are valid — but also for sound scientific and indeed practical economic reasons.

It would be misleading to claim that there is a consensus among IUCN's diverse membership on the continued construction of dams. A succession of West African presidents have said to me that big and even medium-size dams are out and they will rely henceforth on traditional ways of using their often scarce waters — and our work with them on the comparative economics and productivity of wetlands and flood plains compared with irrigated areas in that part of the world largely supports this view. But on the other side of the world, ministers in Laos have pointed out that they have precious few other ways of raising foreign exchange and lifting the living standards of their long-suffering people than building hydro dams to export energy — and that other ways of using natural resources would be much more destructive of biological diversity in Laos.

The debate rages on and a variety of answers have some validity — not just regionally and nationally, but in particular sites.

What is certain is that the Union membership expects us to address such big issues, to use the convening power that springs from our mixed membership, to resolve damaging conflict where feasible and to contribute to the drawing up of environmentally, socially and indeed economically sound approaches and guidelines on whether or not and how to build dams, be they large or small.

I do not need to lecture this grouping on the history and politics of large dams or on the biology of fresh water. We all know that the history of dam construction is patchy — and open to dispute. We all know that some dams have been a disaster on several fronts, not least the social and environmental fronts. We all know that some have been beneficial in their net effects and have had a role to play in development and in meeting people's aspirations. We know that water is fundamental to the biochemistry of all living organisms; that the planet's ecosystems are linked and maintained by water, that evaporation drives the energy exchange between the land and the atmosphere, thus hugely influencing the earth's climate; that water provides a habitat for a variety of threatened plant, animal and fish species; and that water will replace oil as a major source of conflict among states in many regions in the next millennium.

But let me take a minute to make a special plea from this Union's perspective for seeing large dams not as a one-off intervention in one section of one river channel but as a major ongoing intervention in the hydrological cycle of an entire river basin and of the ecosystems which maintain this cycle. This Union is moving from seeing species conservation or limited habitat protection as sufficient techniques in themselves to achieving sustainability. We are seeking a more wide-ranging approach which aims to truly integrate river basin management, desirably involving the management of all of the major ecosystems in the river basin and an understanding of the biophysical processes upon which they depend. This involves careful and time-consuming study of the functioning of the different components of sometimes vast river basins.

This Union's hard-won experience is that unless and until you have done your basic scientific homework over entire river basins then all your other calculations — not least the social and financial calculations — will be flawed.

Let me illustrate this with two field examples. At the moment we are steadily remodeling an earth barrage dam in Central Africa and helping the government concerned to restore the highly productive flood plain downstream. We are doing this piece of restoration ecology because that is where the net social, ecological and especially economic benefits to the country lie. The original feasibility study largely ignored the ecological side and even got the hydrology wrong. So the economic calculations ended up hopelessly inaccurate. The 100,000-plus inhabitants suffered accordingly and so did the country's overall economy.

My second example comes from West Africa. For several years now, IUCN has been working with non-governmental partners to protect a series of wetlands in northeastern Nigeria known as the Hadejia-Nguru wetlands. Like many wetlands in the usually dry

Sahel, these seasonal wetlands are an oasis of life in the otherwise dry and dusty environment. But the rains are fickle and the flooding is not predictable. If the flood comes too early, it will drown out the rice too late and the rice will dry up. So for some time, IUCN has been working with the people of Hadejia-Nguru to help construct small micro-bunds around the rice fields that will allow the people to control the flow of water to the fields. At the same time, we are working with the whole community to raise the awareness and understanding of the underlying ecology of these life-giving wetlands. This involves jointly assessing the biodiversity, providing training in monitoring the hydrological cycles, and so on.

We now fear that much of this work will come to naught. Two large dams have been built several hundred kilometers upstream. The draw-down on the overall water flow has already caused the wetland areas to contract. A third dam is now being built. The impacts of this project on the wetlands could be dramatic. Our hydrological studies show that under certain circumstances this third dam may well completely dry up the wetlands, forcing the farmers, the nomadic herders and the fishermen of Hadejia-Nguru to go elsewhere. And that is to set aside the fate of the birds, fish, animals and plants that have flourished in these wetlands.

The moral of this story is that in conservation, as in dam-building, the river basin needs to be looked at as one large, interconnected freshwater ecosystem. What is done to one part of the system has impacts upstream and downstream, sometimes hundreds of kilometers away.

End of cautionary tales, but you will get my drift: We have to get the science right first, and we have to look well beyond the immediate site of operations to make true assessments of relative costs and benefits. This case for seeking true assessments based on full information across several sectors should not be seen as a recipe for indefinite postponement of decisions. Decisions have finally to be taken — and they will be taken. My argument is that there is a certain minimum of basic scientific and related information that has to be brought to bear before it is prudent to be making final assessments and investment decisions. And such assessments do have to include a thorough look at alternatives to the drastic intervention which a large dam represents.

Each of us in this room will have some such special perspective. I accept that that is inevitable. I have had my chance to have my say. I shall be interested to hear your points of view. May I underline:

- that you are encouraged to state your views freely;
- that we want to hear the hard arguments, for that is clarifying; and
- that we should not get bogged down in detail or slip into posturing mode (and environmentalists are just as likely as others to do that!).

But let me also make one additional point: that this is an unusual opportunity to have a hard look at the big issues surrounding large dam construction and to seek to work together to design some processes that may lead a year or two from now to changes in the way dam-building proposals are assessed and decisions on them are made. Let's resolve not to blow this chance to start getting it right.

Most of us here believe that in making such decisions, societies around the world should be in a position to make truly informed choices. By this we mean that all costs and benefits — in so far as we are able to assess them — must be studied, brought out into the open, traded off and then internalized into the final assessment.

I use here the language of the market place, but I am not talking about purely financial costs and benefits, or purely financial trade-offs. For the factors sometimes involved in dam-building are not easily susceptible to the techniques of the marketplace: What price do you put on a hydrological system undermined, on a species made extinct, on a way of life of a distinct human group effectively destroyed — or, for that matter, on the bringing of electric lights to a rural village?

These are some questions that need addressing.

I conclude by saying that IUCN, for its part — and I want to stress this — has a commitment to this whole process:

- We are prepared to play an active role in furthering it, for example, in terms of further study and field work.
- We are prepared to help facilitate an ongoing

process involving the major stakeholders.

- We would be keen to assist in producing new guidelines on assessing dam construction proposals and their potential impacts.
- We would be happy to work with others on improved management practices for existing but dysfunctional dams so that degraded riverine ecosystems may be restored.

May I thank our Bank colleagues for their initiative in engaging in this process of open dialogue and for their willingness to consider a potentially very significant role in redefining the parameters of the great global debate over the future construction and management of publicly and privately funded dams.

I invite you all to join with us in this fundamentally important endeavor.

April 9, 1997

APPENDIX B2:

OPENING STATEMENT BY

ROBERT PICCIOTTO

Director General,
Operations Evaluation,
The World Bank

We have assembled here today because the large dams question is emblematic of broader debates.

For some, large dams symbolize a failed, centralized, technocratic approach to development characterized by waste, bureaucratic bungling and insensitivity to people and the environment.

For others, large dams are "almost the equivalent of Gothic cathedrals—the supreme creation of an era, conceived with passion by unknown artists and assumed in image, if not in usage, by a whole population."

Both of these mythologies live because each contains a grain of truth. On the one hand, some dams are marvels of human ingenuity. They make deserts bloom, they tame floods, they produce clean energy—and they put nature to work. On the other hand, to paraphrase Pat McCully, a large dam can silence a river, destroy a landscape, endanger biodiversity and uproot whole communities.

According to Thoreau, "Rather than love, than money, than life, give me truth." What then is the truth about large dams? Thoreau also said: "A man is rich in proportion to the number of things he can afford to let alone." But can developing countries afford to let large dams alone?

These are the two basic questions this workshop is expected to address. First, the evaluative question—the Phase II Process. Second, the normative question—the standards for large dams. Underlying both concerns is our continuing search for an economic and social system that can provide more and better goods and services for all while sustaining a high-quality environment. So, the dilemmas posed by large dams are those involved in harmonizing development with the environment. And at the core of this challenge lies energy—the fuel of economic development from time immemorial.

Who says energy says carbon. And carbon is now the "most wanted" environmental culprit. Conversely, displacement of carbon for the energy system may be the largest single environmental challenge facing the planet. Progress has been slow but sustained over the past century. Since 1860, decarbonization has cut the tons of carbon to units of energy produced by 40 percent. In 1920, coal still provided three-quarters of global energy, and heavy smog lay over London and Pittsburgh. Today, carbon is struggling to sustain its market share of about 25 percent. The move from a polluting carbon economy to a non-polluting hydrogen economy is underway. It will have to be accelerated to keep global warming at bay.

Dams have a significant role to play in freeing the energy system from carbon. When built on time and on budget, they produce electric power at competitive prices. Electricity can substitute for wood, coal, kerosene and oil and therefore contribute to a cleaner, safer, healthier environment.

With electricity, deadly wastes associated with open fire and smoke in homes and workplaces decline and with it exposure to pneumonia, TB, diphtheria and other airborne diseases. Refrigeration also becomes possible, and this cuts into waterborne gastrointestinal diseases—another major killer.

Electricity used to be based on coal alone. Hydro is a viable alternative in certain situations. So is natural gas, which has increased its market share given its flexibility, quick gestation, low capital costs and the efficiency of combined cycle turbines. Natural gas is carbon trim—four hydrogens for every carbon. Coal uses one to two carbons per hydrogen. Oil uses two hydrogens per carbon, while wood uses ten carbons per hydrogen. So only nuclear and hydro can beat natural gas in the decarbonization game. But nuclear involves high risks and heavy costs, while hydro lies well within the technological reach of most developing countries.

Hydro is renewable and domestic-resource-based. By contrast, fossil fuels often require foreign exchange. Furthermore, hydro projects are easy to operate and maintain. No wonder then that two-thirds of the large dams built in the 1980s were in developing countries. The power market in developing countries is growing, and this is where the bulk of unexploited sites lies. According to the World Energy Council, a doubling of energy production for hydro from 2,000 terawatt hours to 4,000 terawatt hours per year from 1990 to 2020 is in store. This implies a trebling of hydro capacity and, if it occurs, would still leave 70 percent of the technically usable potential untapped.

Such a development would contribute substantially to reduced reliance on carbon as well as bring down the currently high energy intensities of the developing world. Measured in tons of oil, for example per U.S. dollar of GDP, Thailand resembles the United States in the 1940s, while India is comparable to the United States of a century ago. Keeping energy use at current levels in developing countries is an environmental fantasy that would confine them to perpetual poverty. Per capita, LDC residents use only 1/15th of the energy consumed by a U.S. resident.

I will not talk about the extraordinarily important use of dams for irrigation. But consider this simple fact. By raising wheat yields fivefold during the past few decades, Indian farmers have spared an area of cropland equal to the state of California. This yield revolution would not have taken place without surface irrigation used in conjunction with ground water.

So there is a strong economic and environmental case for large dams. But as dams are currently designed, constructed and implemented, a strong case can also be made against them. The damming of a river can be a cataclysmic event in the life of a riverine ecosystem. The construction of dams in densely populated, environmentally sensitive, institutionally weak areas can be very destructive.

Just as in real estate, location matters. Consultation matters too. But it is not a panacea. The protection of natural habitats and the resettlement of people displaced by dams call for institutions and implementation capacities that need nurturing over many years, even decades. These are not challenges that can be met efficiently one project at a time. The OED report suggests that 75 percent of the dams reviewed did not meet current environmental/resettlement standards at completion and hypothesizes that had they done so they would still have yielded an attractive rate of return. The Bank has now changed its policies, but compliance with them remains a massive challenge. It cannot be achieved through conditionality and paper plans. It requires country commitment, appropriate domestic legislation and adequate enforcement and implementation capacity. The constraint is not engineering hardware. It is the societal software, the rules of economic and social governance and the ability of local agencies to get things done. These institutional building tasks should lie on the critical path of dam construction programs.

This is where today's workshop comes in. It is part of an unfolding change process that is taking place globally as well as locally. Technologically, imitation, adaptation and sharing of experience has improved the ways dams are built. In particular, safety standards are now better understood and disseminated. The time has now come to promote a similar change process with respect to the human and ecological dimensions of large dams projects. Fact-finding is more effective than fault-finding. No society should be excluded from learning. Latecomers should be able to benefit from the costly experiments of pioneers. This is the challenge of evaluation and also of this workshop.

I put the idea of workshop to George Greene a few months ago and, with the support of the Bank's management and its Board, and a similar process within IUCN, we have moved forward. The "going" will undoubtedly get tough, but this a tough group and I am confident that it will get going.

Our joint approach to the workshop is straightforward. We have brought together leading representatives of major stakeholders in a neutral setting. We would have loved to have even broader consultations. But with a larger group, we would not have had the opportunity to get acquainted and listen in detail to each other's point of view. Broader consultation will be needed in future—that is for the workshop to discuss.

So, let's reason together and decide which are the most important issues that need to be addressed. The Phase I report identifies a few key issues and proposes specific areas for follow-up. We have also been privileged to have leading authorities prepare and present excellent overview papers covering economic/engineering, social and environmental issues. You will undoubtedly have many more ideas and proposals of your own, which you will have an opportunity to air and discuss in the working groups this afternoon and tomorrow morning.

There is not shortage of issues. They key is to identify those that are so critical that they deserve the scarce resources that we'll have at our disposal. Basically, we don't want to go back home with a long list of additional problems. We are here to put in place a framework and a process that will eventually get them solved. Once we select the priority ones, let us start on the next steps.

Methodology is certainly an issue. In the Phase I report, we used a cost/benefit framework. It forces everything onto a common denominator, and leads to a bottom line. It can be used to compare large dams with alternatives, and with any other application of the scarce human, natural and financial resources that a proposed project requires.

But the cost/benefit approach has its limitations. We are open-minded about other evaluative frameworks that promise a better integration of issues and/or a more acceptable comparison with alternatives given the objective of sustainable development.

We need to be concerned about the acceptance of whatever emerges from this workshop by the broader community. I am talking about potential investors, governments, affected communities, beneficiaries and others who have a stake in the future of large dams—particularly those that are involved in the 98 percent of the dams that are not financed by the World Bank. This is the challenge for the next phase. And it has implications for the way Phase II is conceived.

We need a rigorous, professional and transparent process for defining the scope, objectives, organization and financing of follow-up work. We need to develop basic guidelines for involvement by governments, the private sector and NGOs, as well as broader community and public participation, information disclosure and subsequent dissemination of results. We should not emerge from this workshop only with a warm feeling and a somewhat better understanding of each other's concerns. Our time together is too short to get into in-depth discussions of specific issues and cases. Perhaps we ought to focus on principles, processes and partnerships that will help address the critical issues in a manner that will find general acceptance.

Developing partnerships should be a key element for reaching out to the world of stakeholders outside this room. I don't think OED can or should handle Phase II on its own, and neither should the Bank. We are prepared to remain involved, but we don't need to be at the center, at the top, or in the most prominent seat. What is important to us is that the issues be effectively addressed; i.e., that the follow-up actions gradually lead to standards for the assessment, planning, building, operation and financing of large dams that are generally accepted by the governments and the peoples of the developing world as well as the external agencies, whether public, private or voluntary, with a stake in the development process.

So the challenge before all participants today and tomorrow is to invent a plan of action that will trigger real change. Generally accepted standards and best practice examples should be sought so as to get results on the ground. Equally, new ways of cooperation must replace the current gridlock of distrust and recrimination. Governments of developed and developing countries will have to be involved far more actively than they have been so far. The private sector will also have to be associated with the next steps. If ways are not found out of the current logjam, dams will continue to be built, but they will be built at a slower rate with great pain and at a higher human and environmental cost than necessary. If, on the other hand, the workshop succeeds, a win/win logic may eventually take over and the history of dam construction will evolve from confrontation to cooperation for the benefit of all. So let us try to make history today.

April 9, 1997

APPENDIX B3:

POST-WORKSHOP CORRESPONDENCE BETWEEN:

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IUCN
The World Conservation Union

Mr James D. Wolfensohn
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21 April 1997

Dear Mr. Wolfensohn,

This is to confirm what you will already have heard from your own people, which is that the workshop on large dams co-hosted by the Bank and IUCN on 10-11 April here in IUCN headquarters was most successful.

It was a success in terms of atmospherics - we got together a disparate group of people, proponents and opponents of large dams from the private sector, NGOs and involved international organizations - and they debated the issues warmly but in a rational and constructive way.

It was a success also in terms of outcome. We reached a firm consensus on how to carry the debate on large dams forward over the next two years or so and on a process to reach some agreed guidelines and standards that would improve the assessment, planning, building, operating and financing of such projects. You will have seen the press statement issued at the end of the session.

I do want to congratulate you on supporting this rather unprecedented open dialogue. It has engendered a good deal of goodwill among the participants. Robert Picciotto and his OED team took the lead and they had strong support from Andrew Steer and his staff, Richard Stern, John Briscoe and a whole array of other excellent Bank and IFC staff members, including Martyn Riddle.

We should keep up the momentum. It is my hope and expectation that your people and mine will now get together quickly in a joint working group to start drawing up an agreed game plan. This should lead to the establishment of a well qualified and high level group to look at experiences impacting on the case for and against large dams and to pull together new standards and guidelines.

Mr James D. Wolfensohn

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In the interim, we hope that the whole exercise will help improve practices on the ground in relation to dams being developed and in the planning stage.

I trust that we can rely on your continued strong personal support for this whole process and not least for a campaign to produce the substantial resourcing from within and outside the Bank Group which will be needed to carry out the agreed plan? We should probably jointly approach a range of donors and partners from the public and private sectors.

We all have every reason to feel pleased with the outcome of this joint exercise thus far, but recognise that the road ahead will take a good deal of effort and constant consultation to produce a satisfactory outcome.

With warm regards.

Yours sincerely,

David McDowell
Director General

The World Bank
Washington, D.C. 20433
U.S.A.

JAMES D. WOLFENSOHN
President

May 1, 1997

Mr. David McDowell
Director General
IUCN
Rue Mauverney 28
CH-1196 Gland
Switzerland

Dear David:

Thank you very much for your letter about large dams. I fully share your assessment: considering the sharp controversies which large dams continue to evoke, the workshop was surprisingly successful.

The promising decisions reached confirm the potential of the IUCN-Bank partnership. Indeed, Bob Picciotto tells me that the positive results were, in large part, due to IUCN's excellent performance in planning and hosting the event.

I am especially grateful for your own participation and your explicit expression of support for the changes I have set in train at the World Bank. I understand that this helped to create a businesslike atmosphere and that it proved possible for the Bank and the IUCN teams to engage critics and proponents of large dams in a highly professional mode.

Large dams constitute a major technical, social, environmental and developmental challenge. For this challenge to be met successfully, the World Bank is prepared to join with IUCN and other stakeholders in the private, public and voluntary sectors toward the creation of an appropriate framework focused on learning from experience and on the design and dissemination of adequate standards.

Like you, I am keen to see active follow-up and, in order to sustain the momentum, I endorse your proposal of a joint working group co-chaired by IUCN and the Bank to plan for the next phase. Several parts of the Bank Group will be involved in the follow up. To ensure effective coordination, we are putting together a strong team to work with designated IUCN staff. It will be headed by Andrew Steer and include John Briscoe, Richard Stern, Gloria Davis as well as OED and IFC representatives.

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Once the joint IUCN-Bank group has finished its work, I will personally vet its recommendations and get in touch with you regarding next steps. We will then need to work together to raise the funds needed for implementation and jointly select personalities capable of generating confidence among all parties to the large dams debate.

Sincerely yours,

James D. Wolfensohn

APPENDIX C: Papers Available at the Workshop, Participant Biographies

APPENDIX C1:

LIST OF PAPERS AVAILABLE TO THE WORKSHOP PARTICIPANTS

Author	Title	Date
Michael Acreman *in J.CIWEM*	Environmental Effects of Hydro-Electric Power Generation in Africa and the Potential for Artificial Floods	December 1996
John Besant-Jones *in Energy Issues: World Bank*	Guidelines for Attracting Developers of Hydropower Independent Power Projects	April 1996
Shripad Dharmahikary	A Critique of the World Bank OED Review of Large Dams and Suggestions for the Future Process	April 1997
Earth Island Journal	Tropical Dams and Global Warming	1996
The First International Meeting of People Affected by Dams	Curitiba Declaration: Affirming the Right to Life and Livelihood of People Affected by Dams	March 1997
Robert Goodland and Salah El Serafy	The Urgent Need to Internalize CO_2 Emission Costs	April 1997
Nicholas Hildyard *in The Ecologist*	Public Risk, Private Profit— The World Bank and the Private Sector	July/August 1996
International Commission on Large Dams	Position Paper on Dams and the Environment	November 1995
International Commission On Large Dams	Some Inescapable Facts Which May Put the Issue in Perspective	April 1997
International Rivers Network *in World Rivers Review*	Risky Business	January 1996
International Rivers Network in conjunction with NGOs from the around the world	Manibeli Declaration: Calling for a Moratorium on World Bank Funing of Large Dams	June 1994
E.A.K. Kalitsi	Management of Multipurpose Reservoirs — The Volta Experience	April 1997
Franklin Ligon, William Dietrich and William Trush *in Bioscience*	Downstream Ecological Effects of Dams	April 1997

Author	Title	Date
Patrick McCully	A Critique of "The World Bank's Experience with Large Dams: A Preliminary Review of Impacts"	April 1997
Jeffrey McNeely *in Conservation Biology*	How Dams and Wildlife Can Coexist: Natural Habitats, Agriculture and Major Water Resource Development Projects in Tropical Asia	October 1987
Bradford Morse and Thomas Berger	Letter to the President of the World Bank Regarding the Independent Review of the Sardar Sarovar Dam and Irrigation Projects	June 1992
Charlie Pahlman *in Watershed*	Build-Operate-Transfer	October 1996
Brian Smith *Presented at the IUCN Workshop on the Effects of Water Development on River Dolphins in Asia*	Guidelines for Considering the Needs of River Dolphins and Porpoises During the Planning and Management of Water Developmpent Projects	February 1997
Theo P.C. van Robbroeck *Presented at the Sixteenth Congress of the International Commission on Irrigation and Drainage*	Future Water Supplies Threatened– Large Dams: A Bane or a Boon?	1996
Theo P.C. van Robbroeck *Presented at the Geoffrey Binnie Lecture*	Reservoirs: Bane or Boon?	1996
World Bank *in OED Precis*	Lending for Irrigation	March 1995
World Bank *in OED Precis*	Learning from Narmada	May 1995
World Bank *in OED Precis*	Environmental Assessments and National Action Plans	December 1996
World Bank	OD 4.00 Annex B: Environmental Policy for Dam and Reservoir Projects	April 1989
World Bank	OD 4.01: Environmental Assessment	October 1991
World Bank	OP 4.04: Natural Habitats	September 1995
World Bank	OD 4.20 Annex A: Indigenous Peoples	September 1995
World Bank	OD 4.30: Involuntary Resettlement	June 1990
World Bank	OP 10.04 Economic Evaluation of Investment Operations	September 1994
World Bank	OP 4.37 Safety of Dams	September 1996
US Bureau of Reclamation, Daniel Beard	Remarks to the International Commission on Large Dams	November 1994

APPENDIX C2

BIOGRAPHIES OF THE REFERENCE GROUP

Michael Acreman is head of River Basin and Hydroecological Management at the Institute of Hydrology, a component of the Natural Environment Research Council in the United Kingdom. Mr. Acreman is responsible for hydro-ecological research on the impacts of dams on the habitat of aquatic species and for developing methods of physical habitat assessment. Since 1993, Mr. Acreman has also been an advisor on freshwater management to IUCN, advising on projects concerned with impacts of dams and reservoir management on wetlands in Africa.

Sanjeev Ahluwalia is a senior fellow at the Tata Energy Research Institute (TERI), a nonprofit research organization in New Dehli, India, focusing on policy, technology and institutional issues for the promotion of clean and efficient energy technologies. TERI has conducted studies on the comparative environmental impacts of thermal, nuclear and hydropower; the role of hydro power in system management; and the potential for large hydro projects as a GHG mitigation option. Mr. Ahluwalia coordinates economic analysis of energy- and environment-related public policy options.

Peter Bosshard is secretary of the Berne Declaration(BD), a public interest organization located in Zurich, Switzerland, that promotes more equitable relations between Switzerland and the countries of Africa, Asia and Latin America. Mr. Bosshard, who specializes in the social, environmental and economic impacts of large dam projects, is in charge of BD programs on international financial relations, including the monitoring of Swiss banks, multinational corporations, governmental programs and multilateral development banks.

John Briscoe is the senior water advisor at the World Bank. Mr. Briscoe is responsible for the oversight of the Bank's programs in water resources, irrigation, hydropower, water environments and sanitation. He has also worked as chief of the Water Supply and Sanitation Division at the Bank. Prior to joining the Bank, Mr. Briscoe worked on water resource issues for the governments of South Africa and Mozambique. Having taught water resource issues at the University of North Carolina, he currently serves on the Water Science and Technology Board of the National Academy of Sciences.

Wenmei Cai is a professor at Beijing University at the Institute of Population Resources, an interdisciplinary center focusing on training and research in economic, social, technical and family demography. In addition to teaching courses on population issues, Ms. Cai has conducted several investigative research projects on reservoir migration throughout China, including Three Gorges Dam, Fu-Shan Reservoir, Mei-Shan Reservoir, Long-Yan-Xia Dam and Xin-An-Jiang Reservoir.

Stuart Chape is country representative of the World Conservation Union's (IUCN) Country Office in the People's Democratic Republic of Lao. Mr. Chape, who is responsible for developing and implementing IUCN's program in Lao PDR, is currently managing the development of environmental and social action plan for the Nakai-Nam Theun Catchment Area as part of the assessment for the Nam Theun Two hydropower project. He is also a member of the IUCN Asia Regional Directorate.

Eduardo De La Cruz Charry is environmental and marketing manager at a Colombian power company that has developed, built and operated several hydroelectric plants throughout Colombian territory. Mr. De La Cruz Charry, who participated in the creation of the Environmental Corporate Structure at ISA, is responsible for public affairs, development of environmental policies and strategies, and environmental auditing.

Shripad Dharmadhikary is a full-time activist with the Struggle to Save the Narmada (Narmada Bachao Andolan—NBA), a mass-based organization opposed to the large Sardar Sarovar (Narmada) dam project in Western India. NBA studies, documents and disseminates information challenging the viability of the project. Mr. Dharmadhikary is involved in a number of activities, including popular mobilization, press and media relations, as well as litigation opposing the project.

Mbarack Diop administrates and manages Tropica Environmental Consultants Ltd., a private consulting firm in Dakar, Senegal, that has coordinated and assessed activities funded by the World Bank and U.S. Agency for International Development relating to dams and other water resource projects in West Africa. He has been involved in health issues, such as water-disease control, and environmental impact assessments. More recently, Mr. Diop has addressed resettlement issues.

Tony Dorcey is a professor in the School of Community and the Institute for Resources and Environment at the University of British Columbia in Vancouver, Canada. His teaching and research has focused on collaborative approaches to water resources and river basin management. Mr. Dorcey, who also has served as chair of the Fraser Basin Management Board, a multi-stakeholder governing board that pursues environmental, economic and social sustainability in the Fraser Basin, served as facilitator for the Large Dam Workshop.

Steve Fisher is manager of operations at Intermediate Technology Development Group, an international NGO, located in the United Kingdom, that works to increase technology choice for rural communities in developing countries. Mr. Fisher is responsible for overall direction and day-to-day management of U.K. contributions to field projects, especially in the area of energy. Mr. Fisher has recently been involved in providing support to the Quaker initiative to promote constructive discussion of hydropower development.

Robert Goodland is the principal economist in the Environment Department at the World Bank. Mr. Goodland has worked on the World Bank's environmental impact assessments on many large dams worldwide, including Itaipu, Three Gorges, Arun and Nam Theun. He has also served as Independent Commissioner on the inquiry for Canada's Great Whale Hydro Project in James Bay.

George Greene is assistant director general of IUCN. Mr. Greene is responsible for the development of IUCN's regional and country offices, as well as furthering cooperation with other international organizations and the private sector. He has also served as director general of policy development at the Canadian International Development Agency. Mr. Greene has led the IUCN team in the development of the joint IUCN-World Bank Large Dam Initiative.

David Iverach is director of the Nam Theun Two Electricity Consortium (NTEC), an organization consisting of five international companies involved in the ownership, construction, operation and financing of this hydroelectric project. Mr. Iverach is responsible for the preparation of the environmental assessment and management plan, the resettlement action plan and compliance with World Bank operational directives.

E.A.K. Kalitsi is chief executive of the Volta River Authority (VRA), a statutory organization created by the Ghanaian government and responsible for the construction of the Akosombo and Kpong Dams. Mr. Kalitsi is in charge of the direction and management of the VRA. He was responsible for planning and administration of the resettlement program of 80,000 persons displaced by the reservoir, and for providing health and social services to them. Mr. Kalitsi has also served as managing director of Ghana's main power distribution agency, Electricity Corporation of Ghana.

Andreas Liebenthal is principal evaluations officer in the Infrastructure and Energy Division of the Operations Evaluation Department, an independent evaluation unit of the World Bank. Mr. Liebenthal is responsible for the evaluation of energy and environmental projects. He prepared the report "The World Bank's Experience with Large Dams: A Preliminary Review of Impacts." Mr. Liebenthal has also been involved in the appraisal and supervision of the World Bank-financed Shuiko hydropower project in China, and the Saguling and Cirata projects in Indonesia.

Richard Meagher is chairman and chief executive officer of Hazra Engineering Company, an international consulting firm of engineers and scientists specializing in the development of water resources for conservation, electric power, irrigation, land reclamation, flood control, water supply and pollution abatement, located in Chicago, Illinois. Mr. Meagher, who began his career with Hazra, has been involved in such projects as the 10,000-MW Guri Hydroelectric Project in Venezuela and the 1,000-MW Karun River Project in Iran.

Patrick McCully is campaigns director of International Rivers Network, a nonprofit organization based in Berkeley, California, that is committed to reversing the social, environmental and economic damage caused by large dams and other internationally funded large-scale river development projects. Mr. McCully, who is closely involved in monitoring international involvement in a number of dam projects around the world, is the author of Silenced Rivers: The Ecology and Politics of Large Dams.

Jeff McNeely is coordinator of the Biodiversity Policy Program and chief scientist at IUCN. In addition to advising the director-general of IUCN on science policy, Mr. McNeely promotes the integration of biodiversity considerations in sectoral development activities. He has also worked on irrigation issues in Indonesia and in the Lower Mekong Basin and Sri Lanka on the design of habitat-protected areas in conjunction with water resources development programs.

Kathryn McPhail is the senior social scientist in the Environment Department at the World Bank. She provides support to governments, private-sector clients, regional colleagues in IBRD, IFC and MIGA on social assessments and public consultation for environmental assessments. Ms. McPhail has worked on social impacts of dams in India, Thailand, Ghana and most recently on Nepal Arun and Lao PDR Nam Theun Two. She was task manager for the 1993 OED study "Early Experience with Involuntary Resettlement."

Reatile Mochebelele is chief delegate leading the Lesotho delegation to the Joint Permanent Technical Commission, a joint organization of the Lesotho and South African governments responsible for the oversight of the Lesotho Highlands Water Project. Mr. Mochebelele participates in the monitoring and approval functions of the Commission over its two implementing agencies. He has focused in particular on water resources and other environmental issues.

Ricardo Luis Montagner is founder and executive coordinator of Movimento dos Atingidos por Barragens (MAB), a social movement based in Sao Paolo, Brazil, and organized by citizens who have suffered from the social and environmental impacts of large dams. Mr. Montagner strives to win legal rights for displaced people and works with families to resolve the social and environmental problems caused by large dams.

Engelbertus Oud is head of the Water, Power and Land Development Department of Lahmeyer International GMBH (LI), the largest German consulting engineering company that specializes in power, water, transport, environment and project management for large infrastructure projects. Mr. Oud, who has been team leader of several hydropower development studies, is currently the project manager of the study of alternatives for the 680-MW Nam Theun Two hydropower project in the Lao PDR.

Bikash Pandey is co-founder and coordinator of the Alliance for Energy, an advocacy group based in Katmandu established in 1993 to promote a wider public debate on the development of hydropower in Nepal. The organization successfully challenged donors' support for the Arun III project. Mr. Pandey, who also currently studies at the Energy and Resources Group at University of California at Berkeley, has worked to promote micro and mini hydro systems to rural communities.

Elias Diaz Pena is coordinator of the Environmental Sector at SOBREVIVENCIA: Friends of the Earth, Paraguay, a nonprofit organization dedicated to the support of native communities for the restoration and conservation of the quality of their environment. Mr. Pena, having originally worked as a consultant in the hydrologic studies and design of mitigation plans for the Yacyreta Hydroelectric Project, now coordinates the monitoring of the social and environmental problems created by the project.

Thomas Philippe is project manager in the International Division of the Electricite de France (EDF), the largest generator of hydroelectric energy in Europe. Mr. Philippe is responsible for all of EDF's international project activities. He is currently the EDF Project Manager for the Nam Theun Two hydro project in Lao PDR.

Robert Picciotto is director general of the Operations Evaluation Department (OED) at the World Bank. Mr. Picciotto oversees the OED and reports to the World Bank's board of directors. Additionally, he has supervised several major recent OED studies on dam-related issues, including "The World Bank's Experience with Large Dams: A

Preliminary Review of Impacts" (1996). In previous positions at the Bank, Mr. Picciotto has been involved with dam-related projects and policies in South Asia, Europe/North Africa and Latin America and the Caribbean.

Jean Yves Pirot is the coordinator of the Ecosystem Management Group at the World Conservation Union (IUCN). Mr. Pirot coordinates IUCNís efforts to promote an integrated approach to ecosystem management. While at IUCN, he has developed a portfolio of activities relating to flood plain management and restoration, including the mitigation of impacts of dam construction the Senegal and Chad basins.

Martyn Riddle is manager of the Environment Department at the International Finance Corporation, the private-sector financing arm of the World Bank Group. He is responsible for the review and, if appropriate, clearance of all IFC projects in order to ensure compliance with World Bank policies and guidelines. He is also in charge of monitoring approved projects during implementation. Mr. Riddle previously has been involved in preparing EIAs for several large dam projects.

Thayer Scudder is professor of anthropology and a co-founder of the Institute of Development Anthropology at the California Institute of Technology. Mr. Scudder has researched the socioeconomic impacts of large dams and river basin development projects on project-affected people within reservoir basins and below dams in many parts of the world. He has also served as a consultant on large dam and river basin development projects in North America, Africa, the Middle East and Asia.

Aly Shady is president of the International Commission on Irrigation and Drainage, an organization composed of 86 country members whose mission is to promote the development of techniques in managing water and land resources for irrigation, drainage and flood control. Mr. Shady, who has worked as an academic, consultant and public official, is also currently a senior advisor to the Canadian International Development Agency. He is author of the recently published textbook <u>Management and Development of Major Rivers</u>.

Andrew Steer is director of the Environment Department at the World Bank. He leads the World Bank's efforts to assist its member countries in addressing environmental problems as well as social policy and resettlement. Mr. Steer, who has worked on economic and natural resource policy issues in Nigeria, Thailand, Bangladesh and Indonesia, was the principal author of the World Bank's annual World Development Report for 1992, "Development and the Environment." Most recently, he co-authored <u>Making Development Sustainable—From Concepts to Action</u> with Ismail Serageldin.

Achim Steiner is senior policy advisor for the Global Policy and Partnership Unit at IUCN in the Washington, D.C., office. His principal task is the coordination of IUCN's policy dialogue and strategic partnerships with the World Bank, UNDP and the Global Environment Facility. He also provides support to a range of international NGO networks. Mr. Steiner has been involved in environmental and economic development policy and programs in South Asia and southern Africa. He has coordinated the joint IUCN-World Bank Initiative on Large Dams.

Richard Stern is the Director of the Industry and Energy Department at the World Bank, responsible for the Bank's overall energy policy. He is also Manager of the Energy Sector Management Assistance Program (ESMAP), a joint technical assistance consortium that includes about 15 public and private donors. Mr. Stern has served as Chief of the China Industry and Energy Division at the World Bank, and has worked for UNDP in Ethiopia and the Institute of Development Studies in the United Kingdom.

Jan Strömblad is Senior Vice President of Environmental Affairs at ABB, a global energy firm involved in all types of power generation, including hydroelectric plants and power transmission. Mr. Stromblad is responsible for the coordination of ABB's environmental management programs in 43 countries. He has participated in the planning and implementation of environmental management systems in several hydroelectric projects, including the Bakun Hydroelectric Power Project in Sarawak, East Malaysia.

Theo Van Robbroeck is President of the International Commission on Large Dams, a non-governmental international organization that provides a forum for the exchange of knowledge and experience in dam engineering. Mr. Van Robbroeck is responsible for the affairs of the Commission as it ensures that dams are built safely, efficiently, economically and without detrimental effects on the environment. He previously served as Deputy Director General in the Department of Water Affairs in the Republic of South Africa.

Pietro Veglio is Advisor to the Swiss Executive Director at the World Bank. Mr. Veglio is responsible for assessing Bank operations, and, in particular, environmental and energy issues and resettlement. He has actively participated in the internal discussions on the World Bank report on resettlement and the OED report on large dams. Mr. Veglio has also visited World Bank projects involving large dams and resettlement, including National Thermal Power Ltd. in Gingrouli, India.

Martin ter Woort is senior manager of development planning at Acres International Limited, a Canada-based international consulting company involved in the planning, engineering and project management of hydroelectric and water resource developments. Mr. Woort has been responsible for directing the resettlement and socio-environmental studies associated with hydropower development in China, Lao PDR, Nepal, Panama and Thailand. He is also actively involved in advising governments on resettlement policy.

Tanlin Yuan is deputy director general of the Office of Foreign Investment Management in the Ministry of Water Resources of the People's Republic of China. Mr. Yuan is responsible for the evaluation and management of foreign-financed dam projects in China. He has been involved in the planning, design, construction and administration of a number of hydro projects in China, including the Three Gorges Dam Project and the Xiaolangdi Dam Project.

Mishka Zaman is program coordinator at the SUNGI Development Foundation, a nonprofit organization, located in Pakistan, that has worked on dam displacement since 1991. Ms. Zaman is responsible for SUNGI's campaign on the Ghazi-Barotha Hydropower Project, whose planned construction threatens to displace 120,000 people already resettled once before in the 1970s, as a result of the construction of the Tarbela dam just seven kilometers away. Working with community-based organizations, Ms. Zaman lobbies the government and World Bank and monitors the project through an eight-member NGO standing committee.

Robert Zwahlen is the senior environmental advisor at Electrowatt Engineering Ltd. (EWE), a company of consulting engineers with core business in energy, water management, transportation, and construction planning. EWE, located in Zurich, Switzerland, has been involved in more than 100 large dams worldwide. Mr. Zwahlen is responsible for coordinating and conducting environmental impact statements, mainly for water resource development projects. He has also recently published on human resettlement and environmental issues.

IUCN

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been a subject of growing international debate and controversy. They have played a key role in ment, meeting a variety of purposes, including electricity generation, flood control and irrigation. nvironmental, social and even economic impacts are increasingly noted. In 1996 the World Bank ation Department completed an internal review of 50 large dams funded by the World Bank. Conservation Union and the World Bank agreed to jointly host a workshop in April 1997 to dis- of the review and their implications for a more in-depth study. The workshop broke new ground her representatives from governments, the private sector, international financial institutions and izations to address three issues:

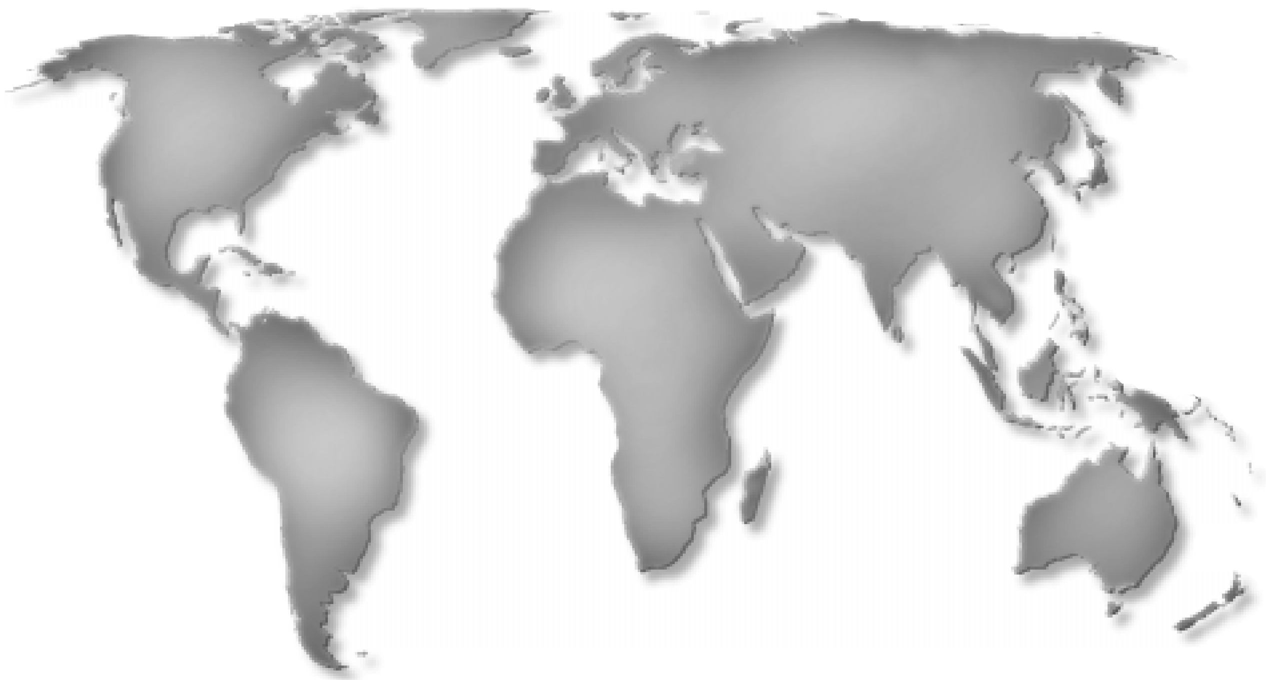
es needed in knowledge and practice

and approaches required to achieve these advances

follow-up process involving all stakeholders

king together achieved a remarkable consensus on how to move forward. Most notably, agree- d for IUCN and the World Bank to facilitate the establishment a two-year international commis- r 1997. Its mandate is to review the development effectiveness of dams and to develop standards, lines to advise future decision-making. Part I of these proceedings summarizes the workshop commendations for future action. Part II contains a series of overview papers commissioned for four key topics: engineering and economics, social and stakeholder issues, environmental sus- ure challenges facing the hydro industry.

ancial support from the Swiss Agency for Development and Cooperation.



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