MANAGING THE SOCIAL AND ENVIRONMENTAL ASPECTS OF HYDROPOWER
GÉRER LES ENJEUX SOCIAUX ET ENVIRONNEMENTAUX DE L'HYDROÉLECTRICITÉ

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Water is a vital resource that supports all forms of life on earth. Unfortunately, it is not evenly distributed by season or geographical region. Some parts of the world are prone to drought, making water a particularly scarce and precious commodity. In other parts of the world, floods that cause loss of life and property are major problems. Throughout history, dams and reservoirs have been used successfully in collecting, storing and managing water needed to sustain civilisation.

1. Introduction

According to water resources availability, there are significant variations among countries regarding the importance of hydropower. In most developed countries, hydropower is not a high-profile issue in the eyes of the general public. A large part of the world's hydropower plants are discreetly generating electricity and revenues while largely hidden from public view, either because the sites are remote, or because the facilities are often underground. Other hydro projects are in full public view, and contribute much more than renewable energy through the storage capacity of reservoirs by providing essential services such as water supply, flood control, irrigation, improved condition for navigation and water-based transport, fisheries, and recreational opportunities, which are taken for granted by large segments of the population.

However, some activist groups in civil society are deeply concerned by the social and environmental issues related to hydropower. Indeed, few would deny that there are some poor dam projects when judged by their environmental impacts or by the way people affected by the project were treated. There are about 45,000 large dams in the world, and the 50 or 100 least successful ones can be logically expected to have serious shortcomings. Somewhat surprisingly, the proportion of problem dams in the overall total is not well-known. The main inventory of the world's large dams, the ICOLD database, is not intended to provide information on environmental and social parameters. In the absence of a comprehensive study of all dams, or a statistically representative sample, most studies have selected a smaller or larger number of case studies, which are usually chosen precisely because they are controversial or raise interesting problems.

An increased awareness of environmental issues and concern for minority rights have led to important changes in how governments decide on hydro projects or, for that matter, on all large infrastructure projects. These same trends have also led to changes in the public's perception of hydro projects. Whereas in the post-war period almost every hydro project was considered a good project, and many governments nationalised the hydropower facilities in their country because of their benefit to society, perceptions are more differentiated today. It is now more widely recognised that hydro projects have both advantages and disadvantages. Weighing the former against the latter, and then reaching a decision, is a challenging and complex task for the policy-maker and politician, because many factors entering into the decision are neither quantifiable nor even comparable. There are no neat prescriptions and solutions, and there is no formula that can give an answer once the right numbers are plugged in.

In deciding on hydropower projects, governments have to consider a whole range of important policy objectives that are not internalised in market prices, such as:

- maintaining secure primary energy supplies whilst preserving a certain independence from fuel imports;
- reducing undue fluctuations in electricity prices, and maintaining an uninterrupted electricity supply;
- protecting the lives and property of citizens from floods and droughts;
- preserving the established rights of citizens with respect to expropriation;
- maintaining or enhancing living standards and economic equity among citizens;
- improving air quality, especially in urban centres;
- reducing greenhouse gas emissions to slow down climate change; and
- protecting the natural and cultural heritage.

Some or all of these competing, and occasionally conflicting, policy objectives inevitably bring major hydropower decisions into the political arena. All in all, there is no obvious way to arbitrate among the claims of persons who are positively and negatively affected by hydro projects, nor among the economic, social and environmental benefits of a project versus its adverse impacts. Therefore an open, participatory, transparent, fair and efficient decision-making process involving all stakeholders is crucial to develop successful large-scale infrastructures like hydropower projects.

Yet, compared to other generating options, one of hydropower's distinctive features remains that it entails only positive effects on the global level; whereas its negative impacts are limited to the local or regional level. Adverse effects on this scale are manageable and can mostly be mitigated or compensated.

The following sections will first present an overview of important social and environmental hydropower aspects, then discuss specific mitigation measures that have proven their efficiency in tackling both environmentally and socially sensitive issues raised by hydropower projects.

2. Social aspects of hydropower

Aspects sociaux de l'hydroélectricité

Both the positive and the negative social aspects of hydropower give rise to issues that need to be addressed. On the positive side, a hydropower facility generates a lot of revenue from a natural resource, a river. Inevitably questions arise about the sharing of these revenues among local communities, government and investors, which are often government corporations. In some countries, individuals and companies can own water rights, in other countries they are leased, and in yet other countries the government owns all water rights.

Independently of the legal provisions, the good will and cooperation of local communities in the project area are very important for its success, and the developer will usually work out arrangements to share some of the benefits with local communities. This may take many forms including business partnerships, royalties, development funds, equity sharing, job creation, improvements of roads and other infrastructures, recreational facilities, sharing of revenues, payment of local taxes, or granting preferential electricity rates and fees for other water-related services to local companies and project-affected populations. Aside from the revenues, the water resources themselves are often shared among irrigation, fisheries, flood and drought management, navigation, recreation and tourism, etc. The necessity to share creates a fundamental need for sound water resources policies on which processes can be constructed to arbitrate among competing claims and to manage sharing arrangements on a day-to-day basis.

On the negative side, those hydro projects that include a dam and a reservoir sometimes require the involuntary displacement of people from the area to be inundated. Throughout the world, expropriation has become increasingly difficult for all types of infrastructure projects, including hydropower projects. Unfortunately, the historic record is not unblemished: there are too many instances where displaced populations were not treated fairly. Today, disrespect of basic human rights is no longer tolerated. Modern communications have empowered civil society and interest groups to make their voices heard. The solution is easy to say, but difficult to do: make sure that affected people are better off after the project, both in the short and the long-term. Experience has been gained with resettlement problems and there are now a number of 'good practice' projects where this issue was handled successfully.

The question of fisheries is both an environmental and a social issue. The environmental aspect involves avoiding or compensating for damages to species and habitats. The social aspects concern fisheries as a livelihood, a source of protein in the diet or a recreational opportunity.

In warmer climate zones, and especially in tropical areas, the creation of still standing water body such as reservoirs can lead to increases in water borne diseases. Hydropower planners and operators must be aware of these risks, and take appropriate measures to prevent them.

3. Environmental aspects of hydropower

Aspects environnementaux de l'hydroélectricité

The facts that hydropower is renewable, produces very low greenhouse gas emissions and creates no atmospheric pollutants are its main environmental advantages. At the same time, hydropower projects modify aquatic and riparian ecosystems, which can have significant adverse effects according to the project's specific site conditions. Nevertheless, these disadvantages have to be weighed against the advantages.

There are some widely held misconceptions on this subject. One is that 'small hydro' is always more benign than 'large hydro' and for this reason small hydro should be included widely in renewable energy programs and large hydro not. In fact, stressing the principle of eco-efficiency, one large hydro project can well be more benign than 100 small ones generating the same amount of electricity. A second misconception is that large hydropower is renewable, but not 'sustainable' because of its negative impacts. A factor possibly contributing to this misconception is the enormous diversity of existing hydro projects, and consequently the variety of environmental impacts that may be encountered under different circumstances. For new projects, it is often possible to avoid or mitigate most of the impacts through good planning, design and operation, so that in the end the benefits prevail over detriments.

4. Effective mitigation measures

Mesures d'attenuation efficaces

This chapter reviews the most effective mitigation measures collected by a specific IEA working group. This task force's achievements are built on case studies and on the professional experience of a wide range of international experts from private companies, governmental institutions, universities, research institutes and international organisations working in this area. The group's five-year research program is based on the assessment of no fewer than 130 hydropower projects, involving 112 experts from 16 countries, the World Bank and the World Commission on Dams.

By far the most effective measure is impact avoidance, weeding out the worst alternatives early in the design stage. It is thus very important that environmental and social considerations be taken into account from the very outset of a project, which should include expertise in public participation and capacity building. Though some impacts are unavoidable, they can be minimised or compensated. Experience in successful mitigation exists and must be broadly shared.

This study has identified 10 sensitive issues that must be considered to achieve sustainable hydropower projects. These issues are either of a biophysical or socio-economic nature and relate to the following themes:

Biophysical issues:

- reservoir impoundment
- biological diversity
- reservoir sedimentation
- water quality

- hydrological regimes
- barriers for fish migration and navigation.

Socioeconomic issues:

- involuntary displacement
- public health risks
- impacts on vulnerable groups
- sharing development benefits.

4.1. Reservoir impoundment

La creation de réservoirs

Creating a reservoir transforms a terrestrial ecosystem into an aquatic one and entails important modifications to river flow regimes. The most suitable site for a reservoir needs to be thoroughly studied, as the most effective impact avoidance action for reservoir impoundment is to limit the extent of flooding. Many issues have to be considered: human population density, water quality, wildlife or wilderness reserves, national parks, valuable agriculture, valuable forestry, seismic activity, etc.

The most effective impact avoidance action of reservoir impoundment is:
Minimising areas to be flooded per unit of energy produced, on the basis of technical, economic and environmental concerns.

Generally, reservoirs are good habitat for fish. However, the impacts of reservoirs on fish species will only be perceived positively if species are of commercial value or appreciated for sport and subsistence fishing.

Successful measures for the development of fish communities and fisheries in reservoirs include:

- creation of spawning and rearing habitats;
- stocking of adults or fries of commercial species that are well-adapted to reservoirs;
- building access roads, ramps and landing areas;
- clearing trees prior to impoundment along navigation corridors and at fishing sites;
- providing navigation maps and charts;
- recovering floating debris;
- introducing fish farming technologies; and
- developing facilities for fish harvesting, processing and marketing.

Users may refuse to harvest reservoirs for ideological, cultural, religious or other reasons. In such cases, and also if water quality proves to be inadequate, measures to enhance the quality of other water bodies for valued species should be implemented in cooperation with affected communities. Once mitigation and compensation measures have been implemented in the reservoir area, enhancement measures for aquatic habitats or fishery enhancement programs can be implemented in neighbouring lakes and on reservoir tributaries.

Successful measures for the development of fish communities and fisheries beyond reservoirs boundaries include:

- creation of spawning and rearing habitats;
- diversification of aquatic habitats;
- opening up new river stretches through fish ways or reconfiguration of falls and rapids;
- building flow control devices, such as artificial riffles, dikes or weirs;
- stocking of adults or fries; and
- installing fish incubators.

As reservoirs take the place of terrestrial habitats, it is also important to protect and recreate the types of habitats lost through inundation. In general, long-term compensation and enhancement measures have turned out to be much more beneficial than the conservation of terrestrial habitats.

Successful programs to restore terrestrial habitats include:

- protection of land areas and wetlands that have an equivalent or better ecological value than the land lost;
- conservation of valuable land bordering the reservoir for ecological purposes and erosion prevention;
- creation of ecological reserves with rigorous and effective protective measures;
- conservation of flooded emerging forest in some areas for brood-rearing waterfowl;
- enhancement of reservoir islands for conservation purposes;
- partial clearing of timber zones before flooding;
- selective wood cutting for herbivorous mammals; and
- development or enhancement of nesting areas for birds and nesting platforms for raptors.

When reservoirs are operated with large drawdown zones, this area is not appropriate for habitat restoration. The significantly changing water levels may cause erosion and sedimentation problems that in turn may be the source of impacts on aquatic, riparian or terrestrial habitats. In order to minimise such effects, some revegetation or erosion control measures may be applied following reservoir impoundment.

4.2. Biological diversity
Biodiversité

Whereas many natural habitats are successfully transformed for human purposes, the natural value of certain other areas is such that they must be used with great care or left untouched. Human societies can preserve natural environments that are deemed sensitive or exceptional. The establishment of protected areas generally constitutes an effective means for ensuring the long-term viability of such environments.

The most effective steps to avoid loss of biological diversity are:

- choosing a reservoir site that minimises loss of exceptional ecosystems;
- limiting as much as possible reservoir size per unit of energy produced;
- conducting specific inventories to learn more about the fauna, flora and specific habitats within the area studied;
- protecting nearby an area equivalent to the flooded zone; and
- preserving a part of nearby ecosystems pristine, assuming that unknown species will be protected.

4.3. Reservoir sedimentation
Accumulation de sédiments dans les réservoirs

In some regions, sedimentation is a major concern for the life span of a reservoir. It has a direct influence on the costs and even on the feasibility of a hydropower project. The most common reservoir sedimentation problems are caused by rivers that transport very high concentrations of suspended or entrained particles. If excessive reservoir sedimentation is unavoidable, appropriate attention must be paid during project planning to the establishment of a storage volume that is compatible with the required lifetime of the project. Protection of the natural vegetation in the watershed is one of the best ways to minimise erosion and prevent sediment loading.

Effective mitigation measures to prevent reservoir sedimentation include:

- selecting the proper site;
- determining precisely long-term sediment inflow characteristics to the reservoir;
- protecting adequately banks and natural vegetation in the catchment area;
- extracting coarse material from the riverbed;
- dredging sediment deposits;

- using gated structures to flush sediment under flow conditions comparable to natural conditions;
- using a conveyance system equipped with an adequate sediment excluder;
- using sediment trapping devices; and
- using bypass facilities to divert floodwaters.

4.4. Water quality
Qualité de l'eau

Water quality problems associated with the impoundment of reservoirs are among the most difficult to mitigate. Most water quality problems, however, can be avoided or minimised through proper site selection and design based on reservoir morphology and hydraulic characteristics. The two main objectives are to reduce the area flooded and to minimise water residence time in the reservoir.

Selective or multi-level water intakes may limit thermal stratification, turbidity and temperature changes both within and downstream of the reservoir. They may also reduce oxygen depletion and the volume of anoxic waters. Hydropower facilities have been successfully equipped with structures for re-oxygenation, mostly downstream of the reservoir. Downstream gas supersaturation may be mitigated by designing spillways, installing stilling basins or adding structures to favour degassing.

While some specialists recommend pre-impoundment clearing of the reservoir area, this must be carried out carefully because, in some cases, massive regrowth may occur prior to impoundment.

During the planning and design phase, the most effective measures to prevent water quality problems are:

- selecting the proper site and controlling upstream pollution;
- using selective or multi-level water intakes;
- reducing water residence time in reservoirs, especially in tropical or subtropical regions;
- ensuring proper spillway design or adding structures to favour degassing; and
- adding re-oxygenation devices.

Increased water turbidity can be mitigated by protecting shorelines that are highly sensitive to erosion, or by managing flow regimes in a manner that reduces downstream erosion. Planning periodic peak flows can increase aquatic weed drift and decrease suitable substrate for weed growth.

As reservoirs constitute a focal point for the watershed catchment, municipal, industrial and agricultural waste waters entering the reservoir exacerbate water quality problems. In such cases, proponents and stakeholders must properly assess and manage this issue throughout the project's planning, design, construction and operation phases. In order to reduce the proliferation of insects that are vectors for waterborne diseases, mechanical and/or chemical treatment of shallow areas is useful, but entails high costs and requires delicate and continuous operations. Improvement of public health conditions in locally affected communities may prove to be more effective for controlling waterborne diseases.

During construction and operation phases, the most effective measures to increase water quality are:

- watershed management, including stakeholders participation;
- clearing before impoundment, when feasible;
- controlling shoreline erosion;
- mechanical and/or chemical treatment of shallow areas to reduce proliferation of insects carrying diseases;
- mechanical elimination of waste and wastewater treatment; and
- preventing excessive doses of fertilisers and pesticides in the watershed area.

4.5. Hydrological regimes
Régimes hydrologiques

Depending on the type of hydropower project, the river flow regime is more or less modified. Run-of-river projects can use all the river flow or only a fraction of it, but leave the river's flow pattern essentially unchanged, reducing downstream impacts of the project. Hydropower plants with reservoirs alter significantly the hydrological cycle downstream. Some projects involve river diversions that modify the hydrological cycle both upstream and downstream of reservoirs through: a) flow reduction downstream of the diversion point; and b) proportional flow increase along diversion routes. Rivers with reduced or increased flows, however, still follow a natural hydrological cycle.

Downstream of control structures, flow regimes are different from natural discharges, both in terms of frequency and volume. Physical and biological changes are related to variations in water level. The magnitude of these changes can be mitigated by discharge management. There is also a trend to incorporate an ecological minimum flow in the operation of water control structures.

River diversions lead to a general decrease in aquatic habitats. Ecological minimum flows should be established at the design stage. Otherwise, control structures must be added to the dam later on. The discharge can be constant or variable depending on the purposes. These requirements should be discussed and accepted by a stakeholder committee. Major changes in the flow regime may entail modifications in the estuary, where the extent of salt water intrusion depends on the freshwater discharge. Another impact associated with dam construction is decreased sediment loading to river deltas. As coastal plains are often intensively used for agriculture, fish farming and other activities, a rigorous flow management program must be ensured to prevent loss of habitats and resources.

The most effective mitigation measures related to modifications of hydrological regimes include the following:

- flow management with stakeholders;
- establishment of an ecological minimum flow;
- banks' restoration techniques;
- controlled floods in critical periods;
- fish habitat restoration programs;
- protection of coastal habitats; and
- construction of weirs to prevent salt intrusion.

4.6. Fish migration and navigation
Migration des poissons et navigation

Hydropower dams create obstacles for the movement of migratory fish species and for river navigation. Barriers for migratory fish movement may reduce access to spawning grounds and rearing zones, leading to a decrease in migratory fish populations and fragmentation of non-migratory fish populations. However, natural waterfalls also constitute obstacles to upstream fish migration and river navigation. Many dams are built on such falls and therefore do not constitute an additional barrier to passage. Most hydropower dams constitute a threat to fish during downstream migrations by causing mortalities or injuries.

Locks are the most effective technique available to ensure navigation at a dam site. For small craft, lifts and elevators can be used with success. Navigation locks can also be used as fish ways with some adjustments to the equipment. Sometimes, it is necessary to increase the upstream attraction flow. In some projects, by-pass or diversion channels have been dug around dams.

There are numerous examples of fish ways and fish ladders, but their effectiveness depends on fish species, river size, water head, design etc. Other common devices include fish elevators, and the capture and transportation of fish upstream.

The most effective techniques to ensure upstream movement include:

- locks, lifts and elevators for watercraft;
- fish ways, by-pass channels, fish elevators, with attraction flow or leaders to guide fish to fish ways; and
- capture and transportation of fish upstream.

Most fish injuries or mortalities (adults and juveniles) during downstream movement are due to their passage through turbines and spillways. Improvements in turbine design, spillway design or overflow design have been proven to successfully minimise fish injury or mortality rates. More improvements may be obtained by adequate management of the power plant flow regime or through spillway openings during downstream movement of migratory species.

Once the design of the main components (plant, spillway, overflow, flow management) has been optimised for fish passage, some avoidance systems may be installed (screens, strobe lights, acoustic cannons, electric fields, etc.). The effectiveness of such devices varies, especially in large rivers. It may be more useful to capture the fish in the headrace or upstream and release the individuals downstream.

The most effective techniques for downstream fish movement include:

- improvement in turbine, spillway or overflow design;
- management of flow regime or spillway during downstream movement of migratory fish;
- installation of avoidance systems upstream of the power plant; and
- capture and transportation of fish downstream.

4.7. Involuntary population displacement
Déplacements involontaires de populations

The most sensitive socioeconomic issue surrounding hydropower development revolves around involuntary displacement, which consists of two closely related yet distinct processes: a) displacing and resettling people; and b) restoring their livelihoods through the rebuilding or ‘rehabilitation’ of their communities.

Involuntary displacement is viewed increasingly as a development issue and, as such, resettlement programs should be built around a development strategy. A consensus is emerging to the effect that resettlement programs should ensure a prompt and measurable improvement of the lives of displaced people and host communities by:

- fostering the adoption of appropriate regulatory frameworks;
- building required institutional capacities;
- providing necessary income restoration and compensation programs; and
- ensuring the development and implementation of long-term integrated community development programs.

New development strategies put forward for resettlement frequently emphasise private ownership of resources in rural communities in the developing world, as opposed to customary systems based on limited access to communal resources. A greater emphasis is also put on publicising and disseminating project objectives and related information through community outreach programs, to ensure widespread acceptance and success of the resettlement process. Finally, the active participation of affected communities in the decision-making process is of the utmost importance.

In order to minimise or mitigate social impacts related to involuntary displacement, projects should be planned and implemented according to the following principles:

- Avoid or minimise involuntary displacement.
- When involuntary displacement cannot be avoided, resettlement must be carried out through systematic implementation of established guidelines.
- Improve livelihoods, on the basis of sound social analysis, reliable demographic assessments, technical expertise in planning for development-oriented resettlement,

and effective executing organisations that respond to local development needs, opportunities and constraints.
- Allocate resources and share benefits, based upon accurate cost assessments and commensurate financing, with resettlement timetables tied to civil works' construction.
- Promote public participation in setting resettlement objectives, in identifying reestablishment solutions and in implementing them.
- Move people in groups.
- Rebuild communities.
- Consider 'host' communities' needs.
- Protect indigenous peoples.

4.8. Public health risks
Risques reliés à la santé publique

Higher incidences of waterborne diseases as well as of behavioural diseases linked to increased population densities are frequent consequences of building dams and reservoirs, particularly in tropical or subtropical environments. It is generally recognised that to ensure the long-term success of a hydropower project, public health impacts must be considered and addressed from the outset of the project.

Reservoirs that are likely to become the host of waterborne disease vectors require provisions for covering the cost of healthcare services to improve health conditions in affected communities. Recurring costs for health education should also be included in the recurrent operational costs of such schemes. Health maintenance costs after the completion of an impoundment scheme could be partly supported from the revenue generated by that scheme. In order to manage health effects related to a substantial population growth around hydropower reservoirs, the influx of migrant workers or migrant settlers must be controlled. As well, the flooding of inhabited areas must be minimised.

Examples of public health measures at the initial planning and design stages include:

- avoiding or minimising public health risks at the very outset of the project;
- gaining a good understanding of current health conditions and strategies in the project area;
- providing a health specialist in the project design team, with the necessary support;
- planning the announcement of the project in order to avoid early population migration to an area not prepared to receive them;
- establishing an efficient communication network with public health officials and NGOs;
- developing a program of early interventions to take into account population migrations; and
- planning and implementing disease prevention programs.

Examples of public health measures during and after construction include:

- waterborne disease vectors control programs;
- accessible medical clinics and dispensaries in project-affected communities and in areas where population densities are likely to increase;
- hiring and training of the required staff and regular support for disease control;
- urban and industrial wastewater management and air pollution control around the reservoir;
- case detection and epidemiological monitoring programs; and
- public health education programs directed at the populations affected by the project.

Although efficient systems are not easy to establish, several developing countries have worked out the necessary tools to implement them. If project planners cannot count on an organised and efficient national health system, they should at least design their project on the basis of a proper understanding of its potential effect on local health conditions and of the institutional support needed to implement adequate mitigation measures.

4.9. Vulnerable minority groups

Minorités vulnérables

Hydropower development projects in indigenous or traditional resource-based areas can have far-reaching cultural and social effects at the community level. The extent of such impacts is difficult to ascertain, considering the number of outside influences to which these communities often are exposed (encroachment on traditional land, extraction of local resources, migrant labour, schools, commercial exchanges, etc.).

It is very difficult to mitigate or fully compensate the social impacts of large hydropower projects on indigenous or other culturally vulnerable communities for whom major transformations to their physical environment run contrary to their fundamental beliefs. Minimising such impacts requires that such communities be willing partners in the development of a hydropower project, rather than perceiving it as a development imposed on them by an outside agency with conflicting values. It also requires that such communities be given sufficient lead time to assimilate or think through the project's consequences and to define on a consensual basis the conditions on which they would be prepared to proceed with the proposed development. These conditions are not always easy to fulfil for outside development agencies.

Examples of measures to minimise impacts on vulnerable minority groups:

- ensuring early involvement of concerned communities in project planning;
- reaching agreements on proposed developments and economic spin-offs between concerned communities and proponents;
- granting legal protections so that affected communities retain exclusive rights to the remainder of their traditional lands and to new lands obtained as compensation;
- training community members for project-related job opportunities;
- restricting access of non-residents to the territory during the construction period;
- establishing compensation funds for the development of community infrastructure and services; and
- ensuring long-term financial support to maintain and promote activities that define local cultural specificities.

Compensation for changes to community traditions and ways-of-life can be achieved to a certain extent through improved housing, education, social services and healthcare. However, such forms of compensation may not always be sufficient, particularly in the case of indigenous or ethnic minority groups that are dependent on local natural resources. Even when such communities benefit economically from the implementation of a hydropower development, they often perceive the project as an implicit rejection of their cultural values. In such cases, ensuring the long-term financial support of activities that define local cultural specificities may also be required in order to minimise impacts brought about by the project.

4.10. Sharing of development benefits

Le partage des bénéfices reliés au développement

There is no doubt that well-sited and designed hydropower projects have a substantial potential to generate significant national and regional economic benefits. It is difficult to overstate the economic importance of hydropower and irrigation dams for densely populated countries that are affected by scarce water resources for agriculture and industry, limited access to indigenous sources of oil, gas or coal, and frequent shortages of electricity. In many cases, however, hydropower projects have resulted both in winners and losers: affected local communities have often borne the brunt of project-related economic and social losses, while the regions to which they are connected have benefited from better access to affordable power and to regulated downstream water flows and water levels.

Although economic benefits are often substantial, effective enhancement measures exist to ensure that local and regional communities fully benefit from the hydropower project. Some measures apply specifically to the construction phase of a project, others may continue throughout the operation phase.

Examples of measures for sharing development benefits of hydropower include:

- developing equity-sharing partnership solutions with local and regional institutions;
- creating a jointly managed environmental mitigation and enhancement fund;
- setting up a regional economic development committee with local economic stakeholders;
- splitting construction contracts in order to allow smaller regional companies to bid;
- encouraging large contractors to use local businesses to supply part of the services;
- preferential hiring of local workers for construction work and related services;
- training local workers in order to improve their employment chances;
- designing and implementing river basin management plans that take into account the water needs of concerned stakeholders, in the reservoir area and downstream;
- long-term efforts to develop and sustain reservoir fisheries and drawdown agriculture, as well as commercial and public services, such as recreational navigation, sport fishing or tourism and associated infrastructures; and
- ensuring that project-affected people become beneficiaries of new development schemes by protecting their entry during the early years of such schemes.

Although the international debate on hydropower is not settled by any means, a consensus is gradually emerging that the question is not whether to construct hydropower and water resources projects, but how to construct them in a sustainable way.

Comparing all available options to produce electricity, life-cycle analysis results show that hydropower is the most environmentally friendly option for power generation, and is the single best hope for reducing on a significant scale greenhouse gas emissions in the power sector.

However, hydropower does affect aquatic and riparian ecosystems, and communities in the project area. How to avoid, minimise, mitigate or compensate for these adverse affects has become a central part of the planning and design of new projects. A large amount of expertise and experience has been acquired on these subjects and in most modern projects an important share of the project budget is allocated to addressing these concerns. Both the IEA report and the WCD report recognise that large dams will continue to be needed in our societies, and have formulated recommendations and guidelines for how such projects should be handled. There is agreement that the remaining potential should definitely be developed, but that does not mean that every proposal should be approved. It will all depend on how the project is structured and designed, and on the process that has been used to arrive at compromises in balancing environmental, social and economic issues.

5. Conclusion

The debate about large dams has become globalised and opponents of specific projects or of hydropower in general have appealed to global public opinion. One interesting question that arises from the current global debate is which issues are global and which issues are local. Among environmental issues, greenhouse gases and biodiversity are widely recognised as being global concerns. Among the social issues, however, there is much less clarity, and the involuntary displacement of people is a particularly thorny question. Standards of compensation and notions of fairness vary widely from country to country.

It is thus quite difficult to formulate practical guidelines in this area, and even more difficult to apply them without infringing on the sovereignty of governments.

The IEA report recommended that each country should make such decisions in accordance with its own developmental, economic, environmental and social priorities and taking into account its own culture and value system. The report prepared by the World Commission on Dams (WCD) advocated a set of international social and environmental standards, which should be applied to all dam projects wherever they are.

In order to promote greater consideration of environmental, social and economic aspects of sustainability in the assessment of new hydro projects and the management and operation of existing power schemes, the International Hydropower Association (IHA) has produced a set of guidelines, which is based on the findings of the two reports mentioned above.

IHA recognises that the WCD report raises issues that are at the heart of the development debate (e.g. equity, governance, justice, power) and contains interesting ideas on how to start tackling these problems. Its members are in accordance with WCD core values and strategic priorities.

However, in the three years since the WCD report was issued, no country that is building dams has adopted the 26 WCD guidelines. The World Bank has concluded that “the approach to project preparation recommended by the WCD is not practical and would virtually preclude the construction of any dam” and the Bank “will not comply with the 26 WCD guidelines”.

Therefore, the IHA has developed guidelines that are:

- hydro-specific; and
- practicable.

Thorough sustainability assessments should ensure that detrimental social and environmental impacts are avoided, mitigated or compensated. Of necessity, the principles are generic since each particular power scheme and development project will have its own unique set of circumstances influenced by scale, geographic location, and social, legal and political context. The guidelines will need to be adapted to the specific context of each particular project.

The IHA guidelines have been worked out to assist hydropower developers and operators with the evaluation and management of often competing environmental, social and economic issues that arise in the assessment, operation and management of hydropower projects. This will ensure that hydropower projects can continue to make a significant contribution to sustainable development. Managing social and environmental aspects is a fundamental component of social responsibility, sound business practice and careful natural resource management.

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