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Sustainable Hydropower – Issues and Approaches

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1. Introduction

Meeting the growing demands for electricity creates difficult decisions for many countries. The context for decision-making is also changing, particularly in light of climate change imperatives encouraging a move away from greenhouse gas emitting energy sources.

Hydropower is a mature technology, harnessing the energy moving from higher to lower elevations. It comes in various shapes and sizes from large reservoir projects to small run-of-river facilities. Hydropower is renewable, and has low greenhouse gas emissions. It is a premium energy source, providing a range of services. These include baseload and peak load generation, and support for other forms of electricity generation, particularly renewables.

Despite these strengths, hydropower developments over the past decades have been highly controversial due to accompanying social and environmental concerns. A challenge for hydropower developers and operators, as well as government planners and regulators, has been to develop tools that promote good practice and sustainable hydropower projects. Financiers and development partners have similarly developed their own approaches.

Importantly, there has been some convergence in these efforts to assess and guide hydropower sustainability. At this point in time there is a good global understanding of the key sustainability issues that must be addressed by the hydropower sector, and also of the pathways towards continuous good practice for those different issues.

2. Understanding the term “sustainability”

Sustainability is a major challenge facing the world. Do a simple google search on sustainability and 97 million results are presented in an 11 second search. Looking at these results shows that all over the world, countries, regions, institutions, businesses and projects are trying to figure out how this word applies to them and what they should be doing about it. Major global conferences, think-tanks and processes have been in train for decades around this theme, and countries and states are increasingly creating departments and legislation which have sustainability as part of their mandate.

Figure 1 shows some of the leading global events which have shaped our understanding of the term sustainability, and the progression of actors involved.

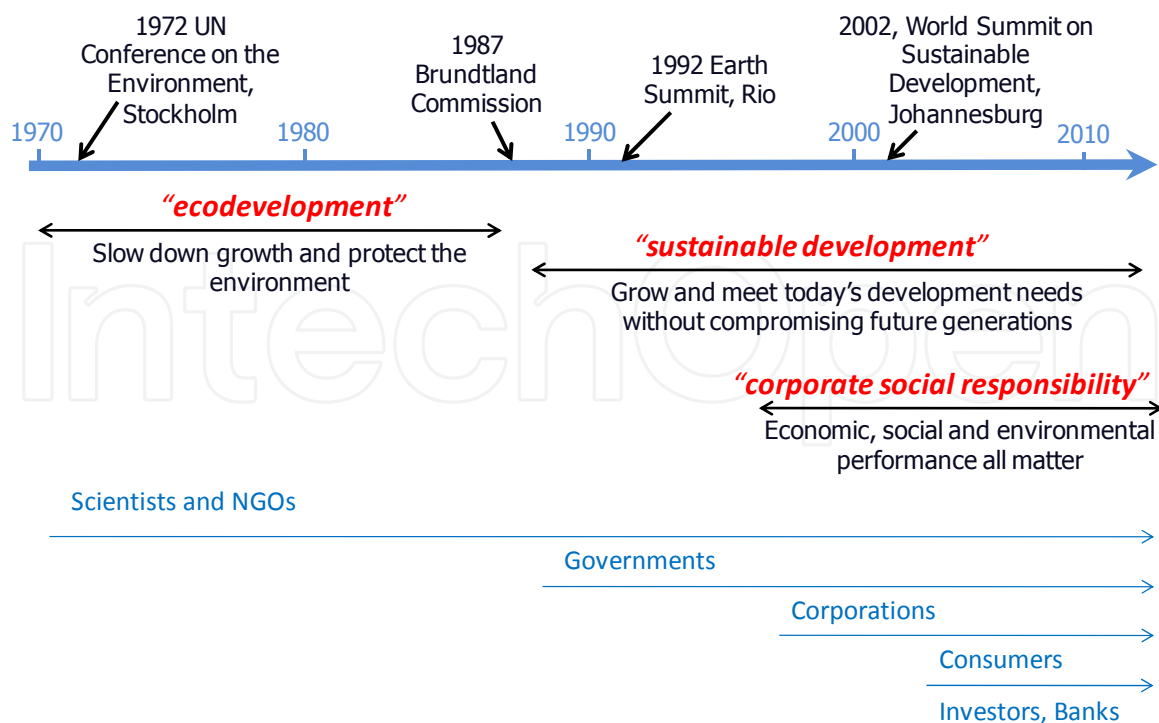


Fig. 1. Evolution of understanding of sustainability and sustainable development.

The term “sustainable development” came from the 1987 Brundtland Commission, which defined it as development that “meets the needs of the present without compromising the ability of future generations to meet their own needs” (United Nations 1987). An important embedded concept is inter- and intra-generational equity, meaning that those within the same generation as well as those who will inherit the world from us get equal opportunities to gain the benefits of natural resources without bearing unfair and inequitably distributed costs.

In the last few decades, corporate social responsibility has received increasing attention and at this point in time is almost business-as-usual for modern corporations. It broadens consideration of corporate performance beyond financial to also encompass social and environmental, often expressed as the “triple bottom line” or “people-planet-profit”.

Consumers and investors have increasingly found avenues to promote their interest in sustainability through green choice schemes, sustainability certification schemes, and socially responsible investment indices and offerings. In the finance sector, many commercial banks have signed up to the Equator Principles, which commits them to ensure sustainability expectations are met by any loan recipients.

Looking forward, Rio+20 is to be held in 2012, with a focus on the “green economy”. A green economy is defined by the United Nations Environment Programme (UNEP) as one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities¹. In its simplest expression, a green economy can be thought of as one which is **low carbon, resource efficient** and **socially inclusive**.

¹ UNEP (2010) *Green Economy Report: A Preview*.

<http://www.unep.org/GreenEconomy/LinkClick.aspx?fileticket=JvDFtjopXsA%3d&tabid=1350&language=en-US> United Nations Environment Programme. Retrieved 1 September 2011.

Practically speaking, a green economy is one whose growth in income and employment is driven by public and private investments that reduce carbon emissions and pollution, enhance energy and resource efficiency, and prevent the loss of biodiversity and ecosystem services.

Alongside these trends, there is international recognition that climate change presents one of the world's greatest sustainability challenges. If sustainability considerations address how we act now to ensure viability of our societies and their functions in the future, then climate change is inherently part of this discussion. The Kyoto Protocol, the 1997 international agreement linked to the United Nations Framework Convention on Climate Change (UNFCCC), set targets for reducing greenhouse gas (GHG) emissions². The Intergovernmental Panel on Climate Change (IPCC) was set up to provide the world with a clear scientific view on the current state of knowledge in climate change and its potential environmental and socio-economic impacts³. UNFCCC conferences subsequent to the Kyoto Convention, based on information arising from IPCC reports, have raised the global imperatives of both mitigating and adapting to climate change. This has influenced thinking on hydropower as part of the climate change solution. This has been thoroughly examined in the hydropower chapter of the IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation (Kumar et al 2011).

In summary, "sustainable hydropower" is considered to have three critical components:

1. The long-term viability of a hydropower project;
2. The contribution of the project to sustainable development; and
3. The integrated consideration of the different sustainability dimensions (social, environmental, financial/economic, technical, governance).

3. Sustainability issues in the international hydropower sector

Sustainable development requires attention to a wide range of social and environmental objectives. These are captured well by the Millennium Development Goals (MDGs)⁴. The MDGs are eight international development goals that all 193 United Nations member states and at least 23 international organizations have agreed to achieve by the year 2015:

1. Eradicate extreme poverty and hunger
2. Achieve universal primary education
3. Promote gender equality and empower women
4. Reduce child mortality rates
5. Improve maternal health
6. Combat HIV/Aids, malaria and other diseases
7. Ensure environmental sustainability
8. Develop a global partnership for development.

Whilst significant progress has been made on these goals, challenges still remain, particularly with respect to addressing disparities between rural and urban areas, supporting the most vulnerable, and advancing sustainable development (UN 2011).

² http://unfccc.int/kyoto_protocol/items/2830.php, Retrieved 1 September 2011.

³ <http://www.ipcc.ch/index.htm>, Retrieved 1 September 2011.

⁴ <http://www.un.org/millenniumgoals/bkgd.shtml>, Retrieved 1 September 2011.

Sustainable hydropower, perhaps well beyond other potential sources of electricity, has significant potential to support progress towards the MDGs. Hydropower is the largest source of renewable energy in the electricity sector, contributing 16% of worldwide electricity supply as of the end of 2008 (Kumar et al 2011). Hydropower is a mature and long-lived technology, with some projects in operation for more than a century. Some parts of the world, such as Quebec, Tasmania and Norway, have built their economies around hydropower, and have a long history of development and management of hydropower operations. Other parts of the world are seeking to utilise their considerable hydropower resources as a major vehicle to advance their economic development (e.g. Lao PDR, Nepal, Sarawak). There are still large opportunities for continued hydropower development worldwide, particularly in Africa, Asia and Latin America. For example, as much as 92% of the technical potential for hydropower remains undeveloped in Africa. There is also considerable potential to upgrade and modernise existing hydropower facilities, or to add hydropower generation to water storages (Kumar et al 2011).

Unlike other forms of electricity, hydropower can provide both energy and water solutions, and consequently can promote economic and social development. Hydropower can be developed at many scales, and to fit many electricity supply needs. Large hydropower projects can have important multiplier effects, and multipurpose hydropower projects may provide the financial means to deliver water services beyond just electricity generation. As a water management measure, hydropower can help address drinking water, irrigation, flood control and navigation services needs. Additionally, hydropower offers significant potential for carbon emissions reductions (Kumar et al 2011).

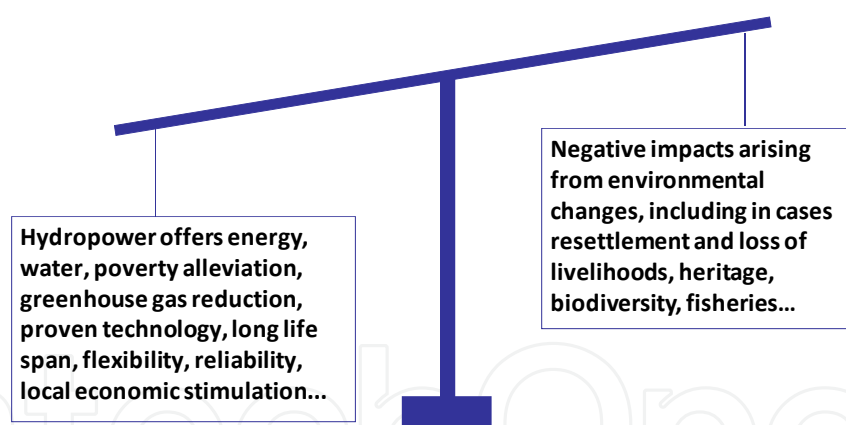


Fig. 2. Sustainable hydropower – ensuring benefits outweigh costs.

The degree to which hydropower can advance sustainable development objectives depends on careful planning, and attention to optimising the positive and minimising the negative in project development and operation. Because hydropower can fundamentally alter landscapes and regions, considerable care must be taken in planning for a development. With careful planning, hydropower projects can help address poverty eradication and regional development needs through provision of electricity and water supply. There is also the potential to leverage additional benefits such as clean water, sanitation, transport, health and educational facilities, other industries, and local capacity building. Without careful assessment and planning, hydropower may undermine sustainable development objectives through negative effects on natural habitats and river flows as well as on project-affected

communities, livelihoods and living standards. The extent of both positive and negative impacts can be managed through choices around project siting and design, and attention paid to recognising and addressing social and environmental issues from the outset. The intent is to ensure that benefits are maximised and negative impacts avoided, minimised, mitigated and compensated (see Figure 2).

Sustainability issues relating to hydropower cover all aspects of the triple bottom line. Important environmental issues encompass habitats, biodiversity, invasive species, water quality, erosion, reservoir sedimentation, and downstream flow regimes. Reservoir sedimentation can greatly limit the life of a hydropower project, and can be exacerbated by catchment practices beyond the control of the hydropower facility. Passage of aquatic species past the physical barrier presented by dams has been a challenge for the hydropower industry. Increasingly with climate change, reliability of the water resource and avoidance of greenhouse gas emissions from reservoirs need careful consideration. Important social issues include livelihoods and living standards of project-affected communities, physical and economic displacement, indigenous communities and vulnerable social groups, public health, safety, labour and working conditions, and cultural heritage. Particular areas of concern for both environmental and social issues have related to failure of mitigation measures, lack of adequate compensation or follow-up, and cumulative impacts. Increasingly, the need for community engagement and acceptance, and a “social licence to operate”, are recognised as important for successful developments, and attention to human rights. With economic issues, the major concerns have been with delivery of expected benefits, and distribution of costs and benefits; because of these concerns, the concept of “benefit-sharing” has received increasing focus with hydropower developments. Local capacity building is also an important economic issue relating to hydropower sustainability. Alongside these environmental, social and economic issues are issues relating to technical considerations (e.g. infrastructure safety, asset reliability and efficiency) and governance (e.g. institutional capacities, the policy context, and ethical practices).

An important over-arching framework for sustainable hydropower development is Integrated Water Resource Management (IWRM) and basin development planning. Many hydropower projects are evaluated in isolation of an overall basin planning framework, and issues arise due to competing or conflicting needs and uses of the basin resources. IWRM has a focus on understanding and rationalising use of and impacts on basin resources. With respect to hydropower, this may result in measures to ensure maintenance of ecosystem services (e.g. fish passage or sediment through-flow); protection of undeveloped river reaches; more coordinated operation of different hydropower facilities to achieve better water resource efficiencies; delivery of environmental flow regimes; and/or increased multi-purpose hydropower facilities to offer a variety of services such as navigation, irrigation, water supply, aquaculture or recreation.

Transboundary issues can represent a particular challenge for hydropower projects, particularly where the benefits of the project accrue to one country with costs borne by downstream countries in terms of hydrological changes and their environmental and social consequences. Considerable attention has been paid globally to the creation and effective functioning of transboundary river commissions (e.g. the Danube, Zambezi, Nile, and Mekong rivers) with the purpose of enabling information exchange and better transboundary cooperation with water infrastructure development and operation. These issues may be

	ADVANTAGES	DISADVANTAGES
ECONOMIC ASPECTS	Provides low operating and maintenance costs Provides long life span (50 to 100 years and more) Meets load flexibly (i.e hydro with reservoir) Provides reliable service Includes proven technology Can instigate and foster regional development Provides highest energy efficiency rate (payback ratio and conversion process) Can generate revenues to sustain other water uses Creates employment opportunities Saves fuel Can provide energy independence by exploiting national resources Optimizes power supply of other generating options (thermal and intermittent renewables)	High upfront investment Precipitation dependent In some cases, the storage capacity of reservoirs may decrease due to sedimentation Requires long-term planning Requires long-term agreements Requires multidisciplinary involvement Often requires foreign contractors and funding
SOCIAL ASPECTS	Leaves water available for other uses Often provides flood protection May enhance navigation conditions Often enhances recreational facilities Enhances accessibility of the territory and its resources (access roads and ramps, bridges) Provides opportunities for construction and operation with a high percentage of local manpower Improves living conditions Sustains livelihoods (freshwater, food supply)	May involve resettlement May restrict navigation Local land use patterns will be modified Waterborne disease vectors may occur Requires management of competing water uses Effects on impacted peoples' livelihoods need to be addressed, with particular attention to vulnerable social groups Effects on cultural heritage may need to be addressed
ENVIRONMENTAL ASPECTS	Produces no atmospheric pollutants Neither consumes nor pollutes the water it uses for electricity generation purposes Produces no waste Avoids depleting non-renewable fuel resources (i.e., coal, gas, oil) Very few greenhouse gas emissions relative to other large-scale energy options Can create new freshwater ecosystems with increased productivity Enhances knowledge and improves management of valued species due to study results Can result in increased attention to existing environmental issues in the affected area.	Inundation of terrestrial habitat Modification of hydrological regimes Modification of aquatic habitats Water quality needs to be monitored/managed Greenhouse gas emissions can arise under certain conditions in tropical reservoirs Temporary introduction of methylmercury into the food chain needs to be monitored/managed Species activities and populations need to be monitored/managed Barriers for fish migration, fish entrainment Sediment composition and transport may need to be monitored/managed, including measures to limit reservoir sedimentation Introduction of pest species needs to be monitored/managed

Table 1. Economic, social and environmental advantages and disadvantages of hydropower.

between upstream and downstream countries, or those that have the same river as a national border. Itaipu Binacional is a classic example of a hydropower development bridging two

countries, in this case Paraguay and Brazil. In such cases well-designed cooperative agreements are essential, as well as ongoing processes to anticipate and address any emerging issues and maintain harmony.

After more than a century of experience, hydropower’s strengths and weaknesses are well understood. Whilst not all negative impacts of hydropower can be eliminated, much can be done to mitigate them. A summary of economic, social and environmental aspects of hydropower is provided in the Table 1, taken from the Sustainable Hydropower Website⁵:

4. International initiatives relating to sustainable hydropower challenges

4.1 Overview of major international initiatives

Figure 3 provides a timeline of major international initiatives influential in shaping the global understanding of hydropower sustainability. Increasingly through the 1990s, attention at a global level was directed at the sustainability issues relating to dams development broadly, and hydropower specifically. One of the first international level initiatives to better define these issues and mitigation measures to address them was through the International Energy Agency’s (IEA) Implementing Agreement on Hydropower Technologies. A major and intensive focus was cast on the dams sector globally through the World Commission on Dams between 1998 and 2000, and its follow-up the UNEP Dams and Development Project. In the last decade, the most far-reaching and influential initiatives addressing sustainability in the hydropower sector have been driven by the International Hydropower Association. These are expanded on in the following sections.

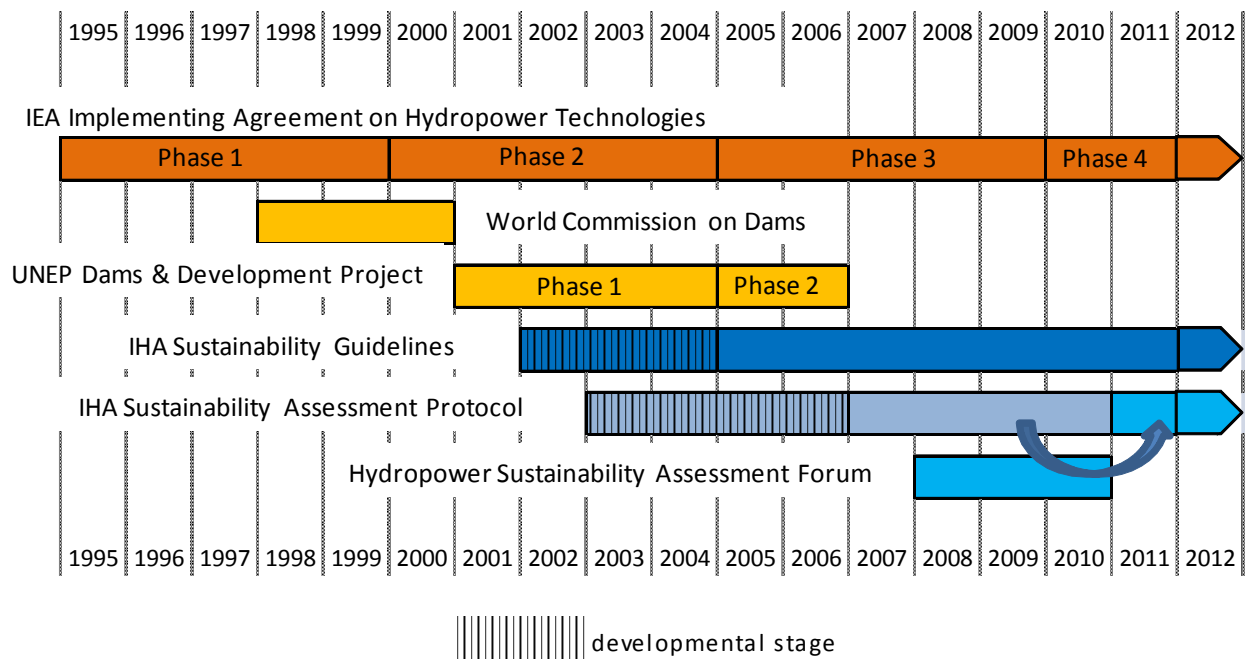


Fig. 3. International initiatives addressing hydropower sustainability issues.

⁵ www.sustainablehydropower.org. Retrieved 1 September 2011

4.2 International Energy Agency Implementing Agreement on hydropower technologies

The IEA is an autonomous organisation which works to ensure reliable, affordable and clean energy for its 28 member countries and beyond⁶. The Hydropower Implementing Agreement⁷ is a working group of IEA member countries and others that have a common interest in advancing hydropower worldwide. The Implementing Agreement's programme is carried out by task forces called Annexes. Two annexes have been particularly relevant to sustainable hydropower: Annex III - Environmental and Social Impacts of Hydropower, and Annex VIII - Hydropower Good Practices.

Reports from the Task Force on Environmental and Social Impacts⁸ examined the positive and negative environmental and social impacts of hydropower (IEA 2000a), the effectiveness of mitigation measures (IEA 2000b), and issued guidelines in relation to the above (IEA 2000c). Annex VIII documented successful mitigation measures for ten key issues in the design and operation of hydropower projects, which included sixty extensively documented Case Histories collected from 20 countries (IEA 2006). These initiatives have provided an important foundation upon which other international initiatives have drawn.

4.3 World Commission on Dams

The World Commission on Dams was a highly intensive review of the global dams sector undertaken between 1998 and 2000, with two objectives:

- To review the development effectiveness of large dams and assess alternatives for water resources and energy development; and
- To develop internationally acceptable criteria, guidelines and standards, where appropriate, for the planning, design, appraisal, construction, operation, monitoring and decommissioning of dams.

Key findings documented both the benefits and the costs of dams, and prompted a significant focus on the need to make concerted efforts to address sustainability issues. Important conclusions capturing these concerns were that *"Dams have made an important and significant contribution to human development, and the benefits derived from them have been considerable. In too many cases an unacceptable and often unnecessary price has been paid to secure those benefits, especially in social and environmental terms, by people displaced, by communities downstream, by taxpayers and by the natural environment"* (WCD 2001).

The WCD report set out a series of strategic priorities, policy principles, criteria and guidelines. The seven strategic priorities are:

1. Gaining public acceptance
2. Comprehensive options assessment
3. Addressing existing dams

⁶ <http://www.iea.org/about/index.asp>. Retrieved 1 September 2011.

⁷ http://www.ieahydro.org/IEA_Hydropower_Agreement.html. Retrieved 1 September 2011.

⁸ International Energy Agency (IEA) Implementing Agreement for Hydropower Technologies & Programs: Technical Reports. 1995-2009. <http://www.ieahydro.org/agreement.htm>. Retrieved 1 September 2011.

4. Sustaining rivers and livelihoods
5. Recognising entitlements and sharing benefits
6. Ensuring compliance
7. Sharing rivers for peace, development and security.

Responses to the WCD report ranged from acceptance to rejection across nations and institutions. Unfortunately, even ten years later, positions on the outcomes remain divisive. One of the challenges was its complexity. With three grounding Global Norms, five Core Values, five key Decision Points, seven Strategic Priorities, 33 associated Policy Principles, and 26 Guidelines, converting these into operational practices has proven to be a difficult. Most institutions and stakeholders broadly accepted the core principles and Strategic Priorities, but have had polarised views on the guidelines (Moore et al 2010).

The WCD has been the focus of considerable review and evaluation (e.g. Dubash et al 2001; Fujikura & Nakayama 2009). The Water Alternatives journal issued a special edition ten years post-WCD to reflect on what had progressed or changed as the result of this process. Critical themes identified from the review of the WCD ten years on (Moore et al 2010) include:

- Diverse perceptions: Perspectives differ on the impact of the WCD Report and process
- Changing drivers:
 - Water and energy demands continue to rise and drive dam development
 - Climate change is now a greater driver of hydropower expansion
 - New financiers are changing the loci and framework for decision-making processes
- Environment and social justice: Negative consequences of dams on the environment and livelihoods of dam-affected communities remain critical issues
- New assessment tools: The quest for new decision-making tools and approaches continues, from assessment protocols to economic analysis
- Advances in participation and accountability: How can participation, compliance, accountability, and performance be ensured?
- Negotiation: Multi-stakeholder platforms continue to show promise for informing and shaping negotiated agreements that result in better sharing of the resources, benefits, and costs associated with dams.

4.4 International Hydropower Association sustainability initiatives

The International Hydropower Association (IHA) addresses the role of hydropower in meeting the world's growing water and energy needs as a clean, renewable and sustainable technology. With members active in more than 80 countries, IHA is a non-governmental, mutual association of organisations and individuals. Its membership is open to all those involved in hydropower. IHA was formed under the auspices of UNESCO in 1995, as a forum to promote and disseminate good practice and further knowledge about hydropower. IHA's mission is to advance sustainable hydropower's role in meeting the world's water and energy needs. It has 85 corporate members spanning six continents.

In 2004 IHA adopted Sustainability Guidelines (IHA 2004), providing a framework for good practice to which IHA committed to work towards in cooperation with government, business, civil society, consumers and individuals. In 2006 IHA adopted its Sustainability

Assessment Protocol (IHA 2006) after having internally trialed a previous five versions. The Protocol's purpose was to evaluate performance of hydropower projects against the IHA Sustainability Guidelines. Also in 2006, IHA launched the Sustainable Hydropower Website (www.sustainablehydropower.org), a joint initiative with the International Energy Agency to demonstrate projects that have successfully implemented sustainability measures on specific sustainability issues.

The IHA initiative which has had the most momentum has been the IHA Sustainability Assessment Protocol (IHA 2006). This was developed as an industry self-assessment tool, and provides a framework for projects to rate their performance on a number of sustainability aspects covering economic, social, environmental issues on a scale of 1 to 5. Scores are for each aspect, not an overall project score, so areas of strength and weakness, and opportunities for improvement, can be clearly identified.

4.5 Hydropower Sustainability Assessment Forum

The Hydropower Sustainability Assessment Forum was a cross-sector collaboration that reviewed the IHA Sustainability Assessment Protocol (IHA 2006) between 2008 and 2010. The Forum involved developing and developed world governments, commercial and development banks, social and environmental NGOs, and the hydropower industry. The mission was to develop a consensus product reflecting common views of the important issues and criteria for a sustainability assessment of a hydropower project at its different life cycle stages. The process involved global consultation (see Arup 2009) and a major trialling program for the draft Protocol (IHA 2009). Reference groups to the Forum members and open global consultation periods were built into the process to obtain views beyond the immediate Forum membership. The Forum's objective was to agree on a measurement tool that is practical, objective, and able to be implemented globally across a range of contexts. The aim was to facilitate objective decision-making on critical hydropower sustainability issues. It was hoped that the thorough and inclusive process would result in commitment by the hydropower sector and endorsement by external organizations.

Identified opportunities in the work of the Forum included:

- Broader endorsement outside of the hydropower sector to see wider promotion and application;
- Greater harmonisation of the Protocol with other standards;
- Improvements on emerging concepts;
- Increased objectivity; and
- Improved support information e.g. technical guidance notes.

After 9 meetings, 10 webinars, 2 global consultation phases, and trialling of Draft Protocol on 6 continents, the Forum recommended the updated Hydropower Sustainability Assessment Protocol to IHA in September 2010. It was formally adopted by IHA in November 2010, and internationally launched, along with an independent and multi-stakeholder governance council, in June 2011.

A fundamental premise of the work of the Forum was that an industry driven and owned initiative has far-reaching potential to influence performance in the hydropower sector. The lack of adoption by industry of the WCD guidelines was a disappointing outcome at the end

of such an investment in time, money, stakeholder input and analysis. If an industry owned tool incorporates much of the outcomes embedded in WCD and other standards, disparate approaches start to converge. Locher et al (2010) provides more detail on the relationship of the Forum process with WCD, points of commonality and departure, and the work undertaken by the Forum to embed WCD outcomes into the Protocol. Significantly, the Hydropower Sustainability Assessment Protocol (IHA 2011) benefits from many developments beyond WCD that have been happening in the area of project and corporate sustainability performance. These include but are not limited to the Equator Principles, International Finance Corporation Performance Standards, multi-national development bank safeguards policies (e.g. the World Bank Group, and the Asian Development Bank), the Global Reporting Initiative, Social Responsible Investment assessment tools (e.g. Dow Jones Sustainability Index, FTSE4Good), best practice experiences in the hydropower sector, and corporate experiences with annual sustainability assessment and reporting approaches. The Protocol also incorporates the latest experience in addressing governance issues at the national, sectoral, institutional and project levels.

5. Sustainability assessment tools and approaches for hydropower

5.1 Sustainability assessment

Sustainability assessment tools and approaches are increasingly being recognised and used to ensure more comprehensive consideration of a broad range of criteria (e.g. Gibson et al 2005). Project-level assessments have traditionally been based on Environmental Impact Assessments (EIAs), then increasingly accompanied by Social Impact Assessments (SIAs) either within or alongside the EIA. An integrated impact assessment might be called a Social & Environmental Impact Assessment (SEIA), or some equivalent labelling, but a true sustainability assessment is likely to go beyond this to incorporate economic, financial, governance and technical considerations.

The following sections focus on tools beyond EIA and SIA and government regulatory processes that are applied to hydropower developments to reflect international level standards and expectations. The most recent effort, the Hydropower Sustainability Assessment Protocol (IHA 2011), is explained in some detail since it is the outcome of a collaborative process drawing on other approaches. Development bank safeguards policies such as those of the World Bank, and International Finance Corporation Performance Standards used by the Equator Principles Financial Institutions (the “Equator Banks”), are also briefly described. Also described briefly is a regional initiative assessing the sustainability of river basins in which hydropower is a predominant activity, modelled on the Hydropower Sustainability Assessment Protocol and ultimately aspiring to be a useful interactive tool with the Protocol.

5.2 Hydropower Sustainability Assessment Protocol

The Hydropower Sustainability Assessment Protocol (IHA 2011) is a sustainability assessment framework for hydropower development and operation. It enables the production of a sustainability profile for a project through the assessment of performance within important sustainability topics.

Assessments rely on objective evidence to support a score for each topic that is factual, reproducible, objective and verifiable. The Protocol is designed for, and best used with, repeated application, and is likely to be highly effective if it can be embedded into business systems and processes. If used early in a particular project stage, it can be a gap analysis and can guide further activities. Used at the end of a project stage may help inform decisions to progress to the next stage, or in the case of the Operations tool to guide continuous improvement measures. Assessment results may be used to inform decisions, to prioritize future work and/or to assist in external dialogue.

To reflect the different stages of hydropower development, the Protocol includes four assessment tools – Early Stage, Preparation, Implementation, Operation - which have been designed to be used as stand alone documents.

Through an evaluation of basic and advanced expectations, the Early Stage tool may be used for risk assessment and dialogue prior to advancing into detailed planning. The Early Stage assessment tool includes key topics relating to the strategic environment; first reviewing existing needs, options and policies, then looking at the political situation and institutional capacities, followed by an assessment of the technical, social, environmental and economic risks (Table 2). This tool is not a scoring tool, unlike the other three Protocol assessment documents. It is a guide to consideration of important Early Stage issues, recognising that this project stage may be characterised by limited information and the need for a certain degree of commercial confidentiality.

Assessment of the Project’s Strategic Context	Assessment of the Project Issues and Risks
Demonstrated need Options assessment Policies & plans Political risks Institutional capacity	Technical issues and risks Social issues and risks Environmental issues and risks Economic and financial issues and risks

Table 2. Protocol Early Stage Topics.

Integrative perspective	Environmental perspective	Social perspective	Technical perspective	Economic & financial perspective
Demonstrated need & strategic fit Communications & consultation Governance Integrated project management Environmental & social issues management	Downstream flows Erosion & sedimentation Water quality Biodiversity & invasive species Noise, dust & waste management	Project affected communities & livelihoods Resettlement Indigenous peoples Cultural heritage Public health Labour & working conditions	Siting & design Hydrological resource Asset reliability & efficiency Reservoir planning, filling and management Infrastructure safety	Economic viability Financial viability Project benefits Procurement

Table 3. Protocol Preparation, Implementation and Operation Stage Topics and Content.

Communications & Consultation	This topic addresses the identification and engagement with project stakeholders, both within the company as well as between the company and external stakeholders (e.g. affected communities, governments, key institutions, partners, contractors, catchment residents, etc). The intent is that project stakeholders are identified and engaged in the issues of interest to them, and communication and consultation processes establish a foundation for good stakeholder relations throughout the project life.
Governance	This topic addresses corporate and external governance considerations for the project. The intent is that the developer has sound corporate business structures, policies and practices; addresses transparency, integrity and accountability issues; can manage external governance issues (e.g. institutional capacity shortfalls, political risks including transboundary issues, public sector corruption risks); and can ensure compliance.
Demonstrated Need & Strategic Fit	This addresses the contribution of the project in meeting demonstrated needs for water and energy services, as identified through broadly agreed local, national and regional development objectives and in national and regional policies and plans. The intent is that the project can demonstrate its strategic fit with development objectives and relevant policies and plans can be demonstrated, and that the project is a priority option to meet identified needs for water and energy services.
Siting & Design	This addresses the evaluation and determination of project siting and design options, including the dam, power house, reservoir and associated infrastructure. The intent is that siting and design are optimised as a result of an iterative and consultative process that has taken into account technical, economic, financial, environmental and social considerations.
Environmental & Social Impact Assessment & Management	This addresses the assessment and planning processes for environmental and social impacts associated with project implementation and operation throughout the area of impact of the project. The intent is that environmental and social impacts are identified and assessed, and avoidance, minimisation, mitigation, compensation and enhancement measures designed and implemented.
Integrated Project Management	This addresses the developer’s capacity to coordinate and manage all project components, taking into account project construction and future operation activities at all project-affected areas. The intent is that the project meets milestones across all components, delays in any component can be managed, and one component does not progress at the expense of another.
Hydrological Resource	This addresses the level of understanding of the hydrological resource availability and reliability to the project, and the planning for generation operations based on these available water inflows. The intent is that the project’s planned power generation takes into account a good understanding of the hydrological resource availability and reliability in the short- and long-term, taking into account other needs, issues or requirements for the inflows and outflows as well as likely future trends (including climate change) that could affect the project.
Infrastructure Safety	This addresses planning for dam and other infrastructure safety during project preparation, implementation and operation. The intent is that life, property and the environment are protected from the consequences of dam failure and other infrastructure safety risks.

Financial Viability	This addresses both access to finance, and the ability of a project to generate the required financial returns to meet project funding requirements, including funding of measures aimed at ensuring project sustainability. Access to carbon finance may be important to this. The intent is that the project proceeds with a sound financial basis that covers all project funding requirements including social and environmental measures, financing for resettlement and livelihood enhancement, delivery of project benefits, and commitments to shareholders/investors.
Project Benefits	This addresses the additional benefits that can arise from a hydropower project, and the sharing of benefits beyond one-time compensation payments or resettlement support for project affected communities. The intent is that opportunities for additional benefits and benefit sharing are evaluated and implemented, in dialogue with affected communities, so that benefits are delivered to communities affected by the project.
Economic Viability	This addresses the net economic viability of the project. The intent is that there is a net benefit from the project once all economic, social and environmental costs and benefits are factored in.
Procurement	This addresses all project-related procurement including works, goods and services. The intent is that procurement processes are equitable, transparent and accountable; support achievement of project timeline, quality and budgetary milestones; support developer and contractor environmental, social and ethical performance; and promote opportunities for local industries.
Project-Affected Communities & Livelihoods	This addresses impacts of the project on project affected communities, including economic displacement, impacts on livelihoods and living standards, and impacts to rights, risks and opportunities of those affected by the project. The intent is that livelihoods and living standards impacted by the project are improved relative to pre-project conditions for project affected communities with the aim of self-sufficiency in the long-term, and that commitments to project affected communities are fully delivered over an appropriate period of time.
Resettlement	This addresses physical displacement arising from the hydropower project development. The intent is that the dignity and human rights of those physically displaced are respected; that these matters are dealt with in a fair and equitable manner; and that livelihoods and standards of living for resettlees and host communities are improved.
Indigenous Peoples	This addresses the rights, risks and opportunities of indigenous peoples with respect to the project, recognising that as social groups with identities distinct from dominant groups in national societies, they are often the most marginalized and vulnerable segments of the population. The intent is that the project respects the dignity, human rights, aspirations, culture, lands, knowledge, practices and natural resource-based livelihoods of indigenous peoples in an ongoing manner throughout the project life.
Labour & Working Conditions	This addresses labour and working conditions, including employee and contractor opportunity, equity, diversity, health and safety. The intent is that workers are treated fairly and protected.

Cultural Heritage	This addresses cultural heritage, with specific reference to physical cultural resources, at risk of damage or loss by the hydropower project and associated infrastructure impacts (e.g. new roads, transmission lines). The intent is that physical cultural resources are identified, their importance is understood, and measures are in place to address those identified to be of high importance.
Public Health	This addresses public health issues associated with the hydropower project. The intent is that the project does not create or exacerbate any public health issues, and that improvements in public health can be achieved through the project in project-affected areas where there are significant pre-existing public health issues.
Biodiversity & Invasive Species	This addresses ecosystem values, habitat and specific issues such as threatened species and fish passage in the catchment, reservoir and downstream areas, as well as potential impacts arising from pest and invasive species associated with the planned project. The intent is that there are healthy, functional and viable aquatic and terrestrial ecosystems in the project-affected area that are sustainable over the long-term, and that biodiversity impacts arising from project activities are managed responsibly.
Erosion & Sedimentation	This addresses the management of erosion and sedimentation issues associated with the project. The intent is that erosion and sedimentation caused by the project is managed responsibly and does not present problems with respect to other social, environmental and economic objectives, and that external erosion or sedimentation occurrences which may have impacts on the project are recognised and managed.
Water Quality	This addresses the management of water quality issues associated with the project. The intent is that water quality caused by the project is managed responsibly and does not present problems with respect to other social, environmental and economic objectives, and that external water quality occurrences which may have impacts on the project are recognised and managed.
Reservoir Planning	This addresses the planning for management of environmental, social and economic issues within the reservoir area during project implementation and operation. The intent is that the reservoir will be well managed taking into account power generation operations, environmental and social management requirements, and multi-purpose uses where relevant.
Downstream Flow Regimes	This addresses the flow regimes downstream of hydropower project infrastructure in relation to environmental, social and economic impacts and benefits. The intent is that flow regimes downstream of hydropower project infrastructure are planned and delivered with an awareness of and measures incorporated to address environmental, social and economic objectives affected by those flows.

Table 4. Sustainability topics in the Protocol’s Preparation Assessment Tool.

The remaining three assessment tools, Preparation, Implementation and Operation, set out a graded spectrum of practice calibrated against statements of basic good practice and proven best practice. The graded performance within each sustainability topic provides the opportunity to promote structured and continuous improvement. Each project stage assessment tool has in the order of twenty topics that cover the range shown in Table 3.

Each topic is scored with respect to criteria which may include assessment, management, stakeholder engagement, stakeholder support, conformance and compliance, and outcomes. Within the scoring statements for these topics, a number of important cross-cutting issues are represented, encompassing human rights, climate change, transboundary issues, transparency, gender, and integrated water resources management.

To provide greater insight beyond the labels, Table 4 provides more detail on what the sustainability topics in the Preparation assessment tool address, and what their intent is. This table well-illustrates the comprehensiveness of the Protocol content with respect to critical hydropower sustainability issues.

5.3 Development bank safeguards policies

The World Bank Safeguard Policies apply to all World Bank lending – they establish a range of social and environmental obligations that must be met by recipients of World Bank project finance, and formalise the World Bank's own commitments in relation to related areas such as transparency and consultation. The World Bank Safeguard Policies are designed to help staff promote socially and environmentally sustainable approaches to development as well as to ensure that Bank operations do not harm people and the environment. The World Bank conducts Environmental Assessments (EA) of each proposed investment loan to determine the appropriate extent and type of environmental impact analysis to be undertaken, and whether or not the project may trigger other safeguard policies. Compliance with the safeguards policies is the expected standard, in addition to compliance with applicable local, national, and international laws.⁹

There are eight environmental and social safeguard policies that are used for investment lending:

- OP/BP 4.01 Environmental Assessment
- OP/BP 4.04 Natural Habitats
- OP/BP 4.09 Pest Management
- OP/BP 4.10 Indigenous Peoples
- OP/BP 4.11 Physical Cultural Resources
- OP/BP 4.12 Involuntary Resettlement
- OP/BP 4.36 Forests
- OP/BP 4.37 Dam Safety

The policies include tests relating to the level of social/environmental risk associated with a project, so that whilst the policies are generally applicable the specific requirements vary depending on the assessed level of risk for a particular project. Funding recipients must meet the requirements prior to receiving World Bank finance, and/or must agree to implement the requirements over the project implementation period. There is considerable supporting information provided by the World Bank for many of these policies, for example the World Bank Source Book on Resettlement. Governance of the Safeguard Policies is the responsibility of the World Bank.

⁹ <http://search.worldbank.org/all?qterm=safeguards%20policies>

5.4 International Finance Corporation Performance Standards

The Equator Principles Financial Institutions (EPFIs) are commercial banks who have committed to only provide loans to projects where the borrower complies with the social and environmental policies and procedures that implement the Equator Principles. The Equator Principles were developed by private sector banks – led by Citigroup, ABN AMRO, Barclays and WestLB – and were launched in June 2003. The banks chose to model the Equator Principles on the environmental standards of the World Bank and the social policies of the International Finance Corporation (IFC). Seventy-two financial institutions have adopted the Equator Principles, which have become the de facto standard for banks and investors on how to assess major development projects around the world. In July 2006, the Equator Principles were revised, increasing their scope and strengthening their processes.

The IFC Performance Standards are equivalent to the World Bank Safeguard Policies but are implemented by the IFC, the member of the World Bank Group responsible for private sector lending. They apply to lending to private sector companies rather than government entities. The IFC Performance Standards apply both to IFC's own lending as well as its lending in consortia together with private sector banks.

The eight IFC Performance Standards incorporate essentially the same risk assessment approach as the World Bank:

- PS 1: Social and Environmental Assessment and Management Systems
- PS 2: Labor and Working Conditions
- PS 3: Pollution Prevention and Abatement
- PS 4: Community Health, Safety and Security
- PS 5: Land Acquisition and Involuntary Resettlement
- PS 6: Biodiversity Conservation and Sustainable Natural Resource Management
- PS 7: Indigenous Peoples
- PS 8: Cultural Heritage

These are supported by Guidance Notes. Companies must meet, or agree to meet, the requirements of the Performance Standards in order to receive IFC financing. Governance of the Performance Standards is the responsibility of the IFC.

The Equator Principles are closely linked to the IFC Performance Standards. The Equator Principles are a voluntary framework adopted by a number of private sector banks referred to as the Equator Principles Financial Institutions (EPFI), or the "Equator Banks". These principles specify a common due diligence framework, underpinned for application in emerging economies by the IFC Performance Standards. In signing up to the Equator Principles, the Equator Banks agree to apply such policies to any project lending over US\$10 million in value. As for the World Bank Safeguards and the IFC Performance Standards, the application of the policy is based on a risk assessment. Governance of the Equator Principles as a system is the responsibility of the Equator Principles Association, an association of the EPFIs.

Whilst the IFC Performance Standards are accompanied by sector specific guidelines, there are no such guidelines at present for the hydropower sector. This was one factor that led to the participation by the Equator Banks in the Hydropower Sustainability Assessment Forum.

5.5 Rapid Basin-wide Hydropower Sustainability Assessment Tool

The sustainability assessment approaches outlined above are applied at the hydropower project level. A limitation for hydropower sustainability is that issues can arise due to cumulative impacts and poor integrated basin development planning and management.

In the Mekong River basin where there are ambitious hydropower development agendas, work has been undertaken during the past few years on a basin sustainability assessment tool that is designed to address the types of sustainability issues that arise with an accumulation of hydropower developments. The Rapid Basin-wide Hydropower Sustainability Assessment Tool (RSAT)¹⁰ is a basin / sub-basin assessment and dialogue tool that brings together the major actors in a river basin to undertake a structured analysis of sustainability issues. The RSAT was designed to replicate the structured and comprehensive approach of the Protocol, within a graded spectrum promoting continuous improvement, and hence can serve as a complementary tool to the Protocol. RSAT application in a basin can be enhanced if hydropower projects within that basin have applied the Protocol, and these could potentially be applied in an iterative manner to progressively improve basin outcomes.

The RSAT is a product of several years of conceptualization, preparation, and stakeholder engagement in the Mekong region under the partnership initiative called the Environment Criteria for Sustainable Hydropower (ECSHD). ECSHD partners are the Asian Development Bank (ADB), Mekong River Commission (MRC) and the World Wide Fund for Nature (WWF). The ECSHD was formalised in 2006 as a platform to develop tools that will assist decision-making for sustainable hydropower development in the Mekong River Basin.

The RSAT is currently being trialed in the four lower Mekong River basin countries – Cambodia, Lao PDR, Thailand and Vietnam. It is planned to have an updated tool at the end of 2011.

6. Moving forward

Each of the major initiatives outlined in Section 4 and the diversity of tools and approaches outlined in Section 5 have played a role in building an understanding of and addressing hydropower sustainability. The work of the IEA established a foundation of knowledge that was hydropower specific. The World Commission on Dams (WCD) process brought together a diversity of sectors and captured their knowledge and views on dam development and operation. The initiatives of IHA have been important steps for the hydropower industry to digest the findings and outcomes of earlier processes, and interpret this and other information into tools that industry members can understand and apply. The Hydropower Sustainability Assessment Forum brought the IHA initiatives, and a broader set of tools and approaches used by governments and banks, together to build a cross-sectoral consensus on a structured view of hydropower sustainability.

The review of the WCD process (Moore et al 2010) concluded that controversy around dams has not gone away. It is apparent, however, that the framework surrounding dam controversies has shifted due to changing regional development pressures, due to evolution

¹⁰ <http://www.mrcmekong.org/ISH/sustainability-assesment-tool.htm>. Retrieved 1 September 2011.

of international norms and processes relating to sustainability in general, and due to particular sustainability issues such as climate change. Of interest has been a swing in international NGOs towards cautious support of hydropower provided sustainability principles (such as those underlying the Protocol) are strongly embedded in its development and operation.

An example of this swing can be seen in the work of M-Power (the Mekong Programme for Water, Environment & Resilience) which is actively supporting more sustainable hydropower governance through its project activities. M-Power is introducing and building capacity for the utilisation of new governance tools, such as the Protocol¹¹ in response to rapid advancement of hydropower agendas in the Mekong Region, and growing concerns of a range of stakeholders in the potential for adverse social and environmental impacts. M-Power's work seeks to influence the way hydropower is designed, developed and managed, through facilitating constructive engagement with stakeholders (civil society, government, developers and banks) about hydropower development issues in the Mekong Region. M-Power also aims to work with major hydropower companies operating in the region to make demonstrable gains in corporate social and environmental responsibility.

The Protocol is an evolutionary tool, and not the final answer on sustainable hydropower. It is an important consensus product of a rigorous 2½ year process that establishes a platform from which further steps can be taken. The scoring system, the structure, the method of application, the content and detail on the sustainability topics and criteria will all benefit from testing. Understanding of issues such as environmental flows, benefit sharing, and climate change is continuously improving. Learning from experience will be equally important for some long-term and highly sensitive issues such as stakeholder engagement, indigenous peoples, human rights, transboundary issues, corruption and legacy issues. All of these are challenges for many sectors beyond hydropower. The Protocol provides a framework for sharing of good practice amongst hydropower sector practitioners. This is already demonstrated by the IHA's formation of a Sustainability Network with sub-groups on key issues such as Indigenous Peoples.

It is necessary to be clear on what the Protocol is not. The Protocol is not an international standard specifying essential performance requirements or the basis for gaining a sustainability label or stamp of certified sustainability for a hydropower project; these may be developed in the future building on the platform provided by the Protocol. The Protocol is not a replacement for regulatory processes, although it is able to guide governments' understanding of sustainability issues and how these can be addressed. The Protocol does not make decisions on hydropower projects; decisions are always made by those authorities mandated with this responsibility and will be made based on their criteria, but may be better informed by application of the Protocol. The Protocol is not the "solution" to achieving hydropower sustainability; it is a voluntary industry support tool, and sustainability will best be achieved where all actors work in support of this objective. Sustainability outcomes can be well achieved if Protocol application to individual projects is alongside government attention to the context for sustainable hydropower development, e.g. through energy master planning, water development planning, basin development

¹¹ http://www.mpowernetwork.org/Major_Projects/Hydropower_Sustainability/index.html, Retrieved 1 September 2011.

planning and integrated water resource management, needs and options assessments incorporating sustainability considerations.

An important legacy of the Forum experience has been a recognised need to demonstrate the further evolution and application of the Protocol is not an industry-controlled process. An independent Hydropower Sustainability Assessment Council (HSAC), chaired by WWF, governs the use, application, quality control and any future reviews of the Protocol, and its official use must comply with Terms & Conditions of Use (see www.hydrosustainability.org). Credibility in application is also a very important objective. Work is underway on the development of Protocol assessor accreditation courses that will be overseen by the HSAC. IHA, as the Protocol's management entity under the Council Charter, has formed IHA Sustainability Partnerships¹² with a diversity of global institutions to offer formalised training, capacity building and supported application of the Protocol so that it can be used in a consistent manner.

Evolution of the Protocol into future versions is alongside evolution of the other sustainability assessment tools reviewed in this paper. The World Bank has reengaged with hydropower as an important vehicle for sustainable development (World Bank 2009); it was an observer and in-kind contributor to the Forum process, has expressed its support for the Protocol, and continues to act as observer to the HSAC. The World Bank announced in March 2011 that it has embarked on a two year process of updating and consolidating its environmental and social safeguard policies into an integrated environmental and social policy framework¹³. IFC is presently in the midst of a two year review process for the standards, with revised standards expected to become operational in 2012¹⁴. Future work is being planned to take the Rapid Basin-wide Hydropower Sustainability Assessment Tool through an international testing process to provide a globally applicable tool to support river basin planning and management.

7. Conclusion

This paper captures numerous important and complex issues that must be taken into account, and the potential sustainable development benefits that can be realised, if sustainable hydropower projects are implemented. Increased scrutiny of the dam sector and sustainability issues with hydropower projects in the 1990s caused some organisations to turn away from support for this industry. The last decade has seen a renewed interest, particularly with respect to the role hydropower can play in helping to address climate change. This renewed interest is now accompanied by the ability to access tools to guide sustainable hydropower development. There is also a high degree of convergence across sectors in terms of expectations for sustainable hydropower projects.

Basic good practice for hydropower requires good environmental and social impact assessments, and effective mitigation and self-sustaining compensation measures. Attention needs to focus on values-based downstream flow regimes, equitable distribution of project

¹² <http://www.hydrosustainability.org/Sustainability-Partners.aspx>. Retrieved 1 September 2011.

¹³ <http://web.worldbank.org/WBSITE/EXTERNAL/PROJECTS/EXTPOLICIES/EXTSAFEPOL/0,,contentMDK:22849125~pagePK:64168445~piPK:64168309~theSitePK:584435,00.html>. Retrieved 1 September 2011.

¹⁴ <http://www.ifc.org/ifcext/policyreview.nsf/Content/Process>. Retrieved 1 September 2011.

costs and benefits, adaptive management, genuine stakeholder engagement processes, and local capacity building.

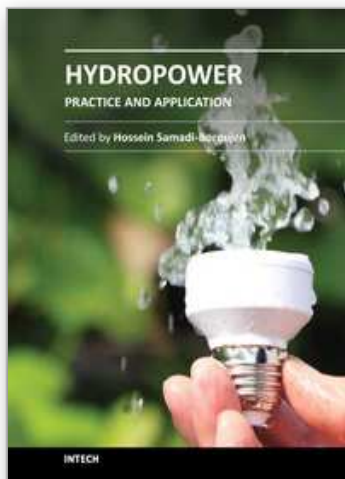
Sustainable development of hydropower is not simple. Tools and approaches are increasingly available to guide and advance sustainable hydropower. These need to be accompanied by awareness-raising, education, incentives, open dialogue, and willingness. In the end, sustainable hydropower will only be successful where there is genuine commitment.

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Hydropower - Practice and Application

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Hydroelectric energy is the most widely used form of renewable energy, accounting for 16 percent of global electricity consumption. This book is primarily based on theoretical and applied results obtained by the authors during a long time of practice devoted to problems in the design and operation of a significant number of hydroelectric power plants in different countries. It was preferred to edit this book with the intention that it may partly serve as a supplementary textbook for students on hydropower plants. The subjects being mentioned comprise all the main components of a hydro power plant, from the upstream end, with the basin for water intake, to the downstream end of the water flow outlet.

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