Dams: An Essential Component of Development

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Abstract: Dams have become an integral part of basic infrastructure by offering indispensable benefits like irrigation, hydropower, domestic and industrial water supply, flood control, drought mitigation, navigation, fish farming, and recreation. As controversial as they have been during the last decades due to negative social and environmental impacts, the limited and uneven distribution of water at the global level has made the world realize that more dams, mostly large dams, are needed if development is to be promoted and if basic human needs are to be covered. Overall, it has been global dynamics in terms of water, energy (including trade aspects), food, and climate securities that has recasted the role of dams triggering massive investment on construction and modernization of multiple projects all over the world. It is thus fundamental to continue improving project planning and implementation to avoid unnecessary social and environmental costs. This paper discusses the role of dams on development, hydropower as the main source of renewable energy, the potential it holds to promote regional development, resettlement as the most critical factor still facing construction of large dams, and the role an entirely new group of actors are having in investment of dam projects at the national, regional, and global levels. **DOI: 10.1061/(ASCE)HE.1943-5584.0000919.**

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Introduction

Throughout history, water has been considered to be a critical natural resource on which mankind's very survival has depended. In order to ensure water availability for domestic and agricultural purposes and also for protection against floods, retaining structures have been built for thousands of years. As science and technology have advanced, larger and more complex infrastructures have been built to support ever-increasing human activities in the domestic, agricultural, and industrial sectors (for a historical review of hydrological development, see Biswas 1970).

Dams, many of them large dams, have become essential requirements for continuing economic and social development. According to the International Commission for Large Dams (ICOLD), large dams are those higher than 15 m; higher than 10 m but with more than 500 m crest length; more than 1 million m^3 storage capacity; or more than 2,000 m^3/s spilling capacity. Their benefits in terms of irrigation, hydropower, domestic and industrial water supply, flood control, drought mitigation, fisheries, and recreation are well known (Berga et al. 2006; ICOLD et al. 2000), as are the negative economic, social, and environmental impacts that have resulted from poor project planning and implementation.

Increasing water demands due to population growth, higher requirements for energy, food and biofuels, and concerns related to carbon emissions and their potential impacts to climate change, have contributed to the resurgence of the interest in large dams in many countries. In the specific case of hydropower dams, it has been the increasing demands of electricity in a highly competitive world that have triggered massive investments for their construction as well as modernization of existing projects. As the only economic mass storage available for energy and also the largest renewable energy source, hydropower generation is thus the focus of most dam projects that are now under construction, even when projects are multipurpose. It is also hydropower benefits that justify their costs.

Regarding social and environmental impacts of dams, societies all over the world are looking for better quality of life and are expecting governments, international organizations, private sector groups, and nongovernmental organizations (NGOs) to work towards this end. Governments and developers are now aware that the global society expects them to make social and environmental considerations an integral part of project planning and implementation. This has made them pay attention more closely to numerous concerns and improve the projects, many times significantly, with positive results. Opponents are also conscious that society expects them to collaborate rather than mostly oppose. Many groups are thus willing to work jointly with the governments so that dam projects are planned, constructed, and operated within an overall framework for development and not only looking to short-term economic goals often with limited concern for social and environmental considerations.

This paper analyzes the role of dams as an essential component of development. The role of hydropower dams for renewable energy generation and promotion of regional development is also discussed with emphasis on growing energy trade mostly in Asia. Impacts of large dams, both real and perceived, are also presented. Finally, the role of the different actors in decision-making in development, including the *new* actors in dam construction at the national and international levels, is put forward for discussion of the water and development communities.

Large Dams and Their Impacts on Development

The primary objectives of every water development project in the developing world should include poverty alleviation, improvement in the standard of living of the populations, regional income

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redistribution, economic efficiency, and protection of the environment. All of these issues have to be assessed against the backdrop of considerable costs (both financial and human) that go into the planning, design, and construction of any project. In addition to the classical criteria of technical, economic, and financial feasibility, large development projects such as dams, have to satisfy a fourth and increasingly stringent criterion, namely social, environmental, and political acceptance (Berga et al. 2006; Bhalla and Mookerjee 2001; Biswas et al. 2004; Rangachari 2006; Scudder 2005; Tortajada et al. 2012; World Bank 2009).

In spite of the unquestionable social and economic benefits that could accrue from properly planned and managed dam projects, those that have been poorly planned and executed have resulted in reduced economic benefits as well as significant social and environmental costs that have been both unnecessary and also unacceptable (Scudder 2005, 2012). This has turned many environmental and social groups against dams, with the national and international media and civil society questioning the benefits of large-scale irrigation and hydropower development projects in many parts of the world. According to the World Bank (2009) environmental, social, and financial constraints resulted in a decade of stagnant investment in the 1990s.

Large dams, because of the size of the areas they cover and inundate, have become the lightning rods for opposition by various social and environment activist groups, not always without biases. One of the demands of the opposition groups has been, and rightly so, the improved social and environmental performance of the governments, lending institutions, and private sector groups that are involved in the planning and construction of dams. The increasing pressure exerted by these groups at the national and international levels has had many positive impacts as the concerned institutions have been forced to improve the processes leading to the construction of dams and their subsequent management. Two important benefits have been increased: participation of local stakeholders and better treatment of project-affected people (PAP). At the same time, construction of projects has also been delayed or stopped for no other reasons than ideological ones (Jagadeesan and Kumar 2013). A vast literature has been published on these topics (e.g., Aditjondro and Kowalewski 1994; Balon 1978; Bandyopadhyay 1995; Bharti 1991; Carter 1966; D'Souza 2002; Fullbrook 2008; Gadgil and Guha 1994; Li et al. 2001; Lin 2007; McCully 2001; Mohanti 2005; Rothman and Oliver 1999; Scudder 2005, 2012). Activities of national and international social and environmental movements against dams are also well known [e.g., International Rivers (earlier International River Networks) and the International Anti-Dam movement, http://www.internationalrivers.org/, and Narmada Bachao Andolan, unofficial website, http://narmada.org/].

In the case of irrigation projects, there are compelling reasons to improve the management and the efficiency of irrigation schemes, irrespective of the pressures from environmental and social groups. Changes in land uses as a result of irrigation have sometimes resulted in extensive waterlogging, salinization, deforestation, and soil erosion. Rapid expansion of irrigated areas, without major changes in the present management practices, can contribute to environmental degradation and negative impacts on the projects unless appropriate countermeasures are taken (Tortajada et al. 2012). Nonetheless, the discussions in the international arena have also often gone out of proportion. What has been demanded by national and international NGOs in many cases is that no dams be constructed, irrespective of their overall total benefits to the society. Although some of these groups represent the interests of the populations affected, many others represent only their own views and own agendas. In their genuine or faked concern for the people and the environment, basic needs and the rights of the low-income majority of the population of the developing world have many times been ignored (Scudder 2012).

The validity of the arguments for and against dams by governmental institutions and NGOs cannot be resolved one way or the other because of the lack of past and present post-project evaluations of the economic, social, and environmental impacts (both positive and negative) of large dams from different parts of the world. Hence, mostly anecdotal information can be used to justify or refute the arguments made by the proponents or the opponents of large dams. Some of the several recent efforts in this regard include the work by Nakayama et al. (2009), Nakayama and Fuyikura (2013), Scudder (2005, 2012), Tortajada (2000), Tortajada et al. (2012).

As mentioned by Duflo and Pande (2007) systematic empirical evidence on the impact of large dams mostly in terms of welfare is missing for the most part in policy debates. This emphasizes the critical importance to assess the impacts, both positive and negative, of dam construction (e.g., Biswas et al. 2004; Rangachari 2006; Shah and Kumar 2008; Tortajada et al. 2012).

The contributions of the now extinct World Commission on Dams (WCD 2000) on promoting a global policy dialogue on large dams and their impacts are very controversial. Although many parties supported the report of the Commission, many others seriously questioned the procedure to establish the commission, the transparency of their processes and methodologies, and also the biases of the final report (for information on both views about the World Commission on Dams, see Asmal 2001; Bird and Wallace 2001; Dingwerth 2005; Hemmati 2002; ICOLD et al. 2000; Iyer 2001; Rangachari 2005; Sengupta 2001; Thornton 2001). As mentioned by Rangachari (2005), "The setting up of the World Commission on Dams and its Report—that came out in 2000—did not result in a balanced review but only accentuated the controversies. The WCD report, in fact, questioned the very utility of dams and generated acrimonious debates regarding their impacts. ... In some cases, the individual reports elaborated for the Commission were not considered as objective research studies but rather as an attempt at propaganda against all large dams in general."

Ultimately, and after some years of having disappeared, the impacts of the WCD are perceived as mixed. There are comments in the sense that they have been modest not only in the dam-building countries, but also on the international funding institutions financing dams (Biswas 2004, 2012), and also comments that stress their importance (Scudder 2001, 2005; Thornton 2001). The fact is, for example, that the World Bank's support to infrastructural development has doubled from approximately 20% in 2000 to some 40% in 2008. In the case of water projects, including dams, financing increased almost 3.5 times in six years, from $1.8 billion in 2003 to $6.2 billion in 2009.

During the 21st century, the debate on dams has become less polarized. Concerns over social and environmental impacts from large projects, and their political consequences, have resulted in most countries adopting more open processes on dam construction. Planning and implementation of compensation plans have improved in many cases, and many international NGOs are not demanding the *no* construction of dams in all the cases. Most important, populations in both urban and rural areas in most places in the world are better informed at present, more aware of their rights, and thus more likely to demand more transparent processes.

With the increasing construction of large dams as a response of the expanding demands for water and energy, it is inevitable that there will be increasing involuntary resettlement. Because of the importance of resettlement, serious assessment of past experiences and human and environmental costs should have been analyzed in depth, but this is unfortunately not the case. In one of the

few assessments available, Scudder (2005) has carried out a comparative survey of dam-induced resettlement in 50 cases. Scudder stresses the lack of information provided by project authorities and governments on dam-induced resettlement as the main handicap to assess the related outcomes. In his survey, where he considers both quantitative and qualitative analysis, Scudder documents "the unsatisfactory and unacceptable impact of large dams on those who must involuntary resettle from future reservoir basins" (p. 85). Clearly, much more efforts need to be done in this regard.

Resettlement is a very complex process that goes far beyond the formulation of laws and regulations. Even the implementation of the most appropriate laws is often inadequate because of economic, social, institutional, and cultural constraints, as well as from issues like lack of vision, coordination, inefficiency, and lack of political will. Properly implemented, resettlement programs can be an element of a nation's strategy to promote development and reduce poverty. However, this requires not only sound policies and adequate resources, but also major changes in the mind-sets of the officers concerned, to ensure that the resettlers receive their fair shares of the benefits from the projects that are directly responsible for their displacement (Scudder 2005, 2012).

Involvement of local leadership and constructive NGOs is a basic requirement to improve resettlement operations. In many cases, the contributions of the NGOs have been substantial and beneficial including conducting baseline socioeconomic surveys, organizing resettlers' participation, intervening at the grassroots level, and calling the attention of national and international agencies to problems emerging due to improper resettlement operations, especially when resettlement practices are inadequate (Scudder 2005). Nonetheless, evaluations of involuntary resettlement of major case studies have also shown that NGOs' involvement is not always productive or even positive (Bhalla and Mookerjee 2001; Mallaby 2004; Patel 2001; Picciotto et al. 2001; Verghese 2001). Therefore, each case has to be analyzed individually. Impacts of NGOs' involvement can also be limited because of the lack of interest of the governments or because of their own lack of interest, because of adversarial relationships with authorities, because their individual agendas do not always coincide with those of the affected populations, single cause advocacy, and also due to limited availability of technical knowledge and support.

Improvement should thus be on the side of all parties involved, not only the government, private sector, and international organizations but also NGOs. Although there are resettlement programs where there is not enough constructive NGO involvement, some other programs tend to fail due to confrontational relationships between NGOs and resettlement agencies, affecting negatively the PAP, because in many cases, NGOs even refuse to establish a dialogue (Picciotto et al. 2001).

It is essential that there are both practical and moral reasons to ensure that all affected people participate in the decision-making process, and that they are fully compensated and properly rehabilitated. All parties lose when projects are designed without the input of local knowledge and experience, when basic civil and human rights are threatened or violated, and when the projects are delayed as a result of resistance and protests from PAP because they may have been unfairly treated. Unless the difficult issues associated with the water development projects are considered properly, opposition to them could accelerate in the future as a result of which consideration of large dams as a solution to the water and energy constraints may become more difficult. The challenges, then, are to improve the relationships among dam planners, dam-affected communities, and human rights and environmental activists, to find jointly the best procedures and reduce environmental and social costs, and also to formulate and implement policies sensitive to economic development, social acceptability, and environmental protection (Fisher 2001).

Renewable Energy Generation

In a world with increasing water demands, growing energy needs, and economic constraints in energy investment, as well as climate change concerns, the fundamental role hydropower dams can play is increasingly recognized.

The key drivers behind the energy demand have been, and will continue to be, population and income growth. According to several estimates, world population is projected to reach 8.3 billion by 2030, and world income to roughly double the 2011 level in real terms by the same year, with the corresponding stress in the energy systems worldwide. Low and medium income non-OECD economies will account for over 90% of population growth. They are also expected to contribute 70% of the global GDP growth and over 90% of the global energy demand increase due to their rapid industrialization, urbanization, and motorization [British Petroleum (BP 2013)].

Clearly, the energy needs for the world as a whole continue to increase significantly and, with it the associated water requirements. According to the USEIA (2011), the global marketed energy consumption will increase by 53% from 2008 to 2035. Fossil fuels will continue supplying much of the energy used worldwide, but renewable energy will witness the fastest growth, increasing from 10% of total energy use in 2008 to 14% in 2035. For energy production, only in 2010, water withdrawals were in the order of 580 billion cubic meters (bcm) of which 70 bcm were consumed, with the power sector accounting for over 90% of the total amount [International Energy Agency (IEA 2012)]. This shows the strong dependence between water and energy.

If the current rate of 5–8% in annual increase in electricity consumption is to be maintained in many developing countries for the indefinite future, water requirements for the energy sector need to be carefully assessed, and be explicitly factored into national water policies (Biswas and Tortajada 2009). Already, in countries like France, the major user of water is the electricity-generating industry, and not the agricultural or industrial sectors. In the United States, thermoelectric generation represented 41% of freshwater withdrawals in 2005, slightly ahead of irrigation (Barber 2009; NETL 2010; According to the U.S. Geological Survey's National Water-Use Information Program, data availability for 2010 is not expected until late 2014, http://water.usgs.gov/watuse/). Overall, thermoelectric power plants withdraw approximately 94 liters of water for each kWh of electricity generated, primarily for cooling. Because thermoelectric generating capacity in the country is expected to increase by nearly 15% between 2008 and 2035 depending on the technology used, water consumption is expected to increase from 28 to nearly 50% on a national basis resulting in increasing competition for water resources (Feeley et al. 2008; NETL 2010).

In terms of renewable sources of energy, hydropower represents at present the largest renewable source for power generation in the world. Currently utilized by 160 countries, the global installed hydropower capacity in 2008 was around 874 GW, excluding pumped-storage schemes (WEC 2010). It produced 3,431 TWh in 2010, also meeting approximately 16% of global electricity needs the same year. Almost 90% of the increase in production has been, and is expected to be the case between 2010 and 2035, in non-OECD countries, where the remaining potential is higher than in OECD countries and where electricity demand growth is strongest (IEA 2012).

Table 1. Distribution of Installed Hydropower Capacity at the End of 2008 (World Energy Council 2010, Used by Permission of the World Energy Council, London, www.worldenergy.org)

Country	Hydropower capacity (%)
China	20
Brazil	9
United States	9
Canada	8
Russian Federation	6
India	4
Norway	3
Japan	3
France	2
Italy	2
Sweden	2
Spain	2
Venezuela	2
Turkey	2
Switzerland	2
Mexico	1
Rest of the world	24

While China has taken the lead, Europe, United States, and Canada continue to develop substantial hydropower capacity. On the contrary, Africa still has the poorest ratio of development of hydropower potential (WEC 2010; Tables 1 and 2).

Hydroelectricity consumption of selected countries is shown in Table 3. The countries with the highest consumption in 2011 were China, Brazil, Canada, and United States, with 157, 97.2, 82.2, and 74.3 mtoe respective.

Global hydropower capacity is expected to increase from 1,067 GW in 2011 to more than 1,680 GW in 2035, representing more than 50% of renewable-based electricity by 2035 mostly in China and India in Asia, and Brazil in Latin America [the rest will be a combination of wind (25%), bioenergy (13%), and solar energy (7.5%)]. Also by 2035, it is estimated that China's total installed capacity (420 GW) will be almost that of the entire OECD countries in 2011. The increase in India's capacity from 42 GW is calculated to reach 115 GW and that of Brazil and Africa to over 130 GW from 89 GW for the same years (IEA 2012).

In the case of Himachal Pradesh in India, 2.5% of total project cost of hydropower dams has to be earmarked for catchment area treatment activities.

The United States is focusing on modernization of existing hydropower infrastructure, increasing efficiency, and reducing environmental impacts of hydropower projects rather than constructing new projects. The country has approximately 25,000 dams that provide 70 GW of conventional energy and 22 GW of pumped-storage hydropower. There are also more than 80,000 nonpowered dams (dams that do not produce electricity and whose purposes are water supply and inland navigation purposes or NPD) with very large potential for clean energy production. The U.S. Department of Energy has carried out an assessment to determine the hydropower potential for the 54,391 most feasible projects. For this assessment, it considered that all water passing the facilities would be available for conversion and that hydraulic head at the facility would remain constant. It did not include economic feasibility of developing each unpowered facility or the environmental, socioeconomic, and electric power infrastructure that would allow estimating site feasibility and development cost in addition to potential.

Table 2. Current Installed Hydropower Capacity by Region (World Energy Council 2010, Used by Permission of the World Energy Council, London, www.worldenergy.org)

Region	GW	Hydropower capacity by region (%)
Asia	307	35
Europe	221	25
North America	168	19
South America	132	15
Africa	22	3
Oceania	14	2
Middle East	11	1

Table 3. Hydroelectricity Consumption, 2011 (Adapted from BP 2013)

Million tons oil equivalent (mtoe)	2011	Change 2011 over 2010 (%)	2011 share of total (%)
China	157.0	–3.9	19.8
Brazil	97.2	6.5	12.3
Canada	85.2	7.3	10.8
United States	74.3	24.9	9.4
Russian Federation	37.3	–2.1	4.7
India	29.8	18.9	3.8
Norway	27.6	3.5	3.5
Japan	19.2	–6.7	2.4
Venezuela	18.9	9.0	2.4
Sweden	15.0	–0.6	1.9
Turkey	11.8	1.1	1.5
Colombia	10.9	19.7	1.4
France	10.3	–27.5	1.3
Italy	10.1	–12.1	1.3
Total world	971.5	1.6	100
of which: OECD	315.1	2.5	39.8
Non-OECD	476.4	1.1	60.2
European Union	69.6	–16.2	8.8
Former Soviet Union	54.6	–2.4	6.9

Note: Only countries with a consumption higher than 10 mtoe have been considered. The primary energy value of hydroelectricity generation has been estimated by calculating the equivalent amount of fossil fuel required to generate the same volume of electricity in a thermal power station, assuming a conversion efficiency of 38% (the average for OECD thermal power generation). Data is based on gross primary hydroelectricity generation and does not consider cross border electricity supply.

The results of the study show that the NPDs have the potential to produce 12 GW of new renewable capacity, a potential that is equivalent to increasing the existing conventional hydropower capacity by 15% (Hadjerioua et al. 2012). The summary of the assessment by hydrologic regions is in Table 4. It shows that the largest potential generation is in Ohio, Upper Mississippi, Arkansas-White-Red, and South Atlantic Gulf regions. According to the study, the hydropower potential within the first three regions is located at navigation locks and dams in relatively big rivers. Further evaluations on how to increase hydropower production at these several NPDs is still necessary (Hadjerioua et al. 2012).

The Energy Department has also launched an initiative to optimize the performance of the country's hydropower infrastructure within the Recovery Act. Within this program, Boulder, Colorado, has received $1.18 million toward a total estimated project cost of $5.155 million to modernize the Boulder Canyon Hydroelectric Plant. It is estimated that the modernized project will provide 583,000 MWh of energy, which will provide electricity to about 1,000 homes each year (for more information, see City of Boulder, Colorado, http://www.bouldercolorado.gov/index.php?option=com_content&view=article&id=12679&Itemid=4608).

Table 4. Summary of NPD Assessment by Hydrologic Regions Totaling 12 GW of Potential (Hadjerioua et al. 2012)

Hydrologic regions (HUC02)	Potential capacity (MW)	Potential generation (TWh/year)	Hydrologic regions (HUC02)	Potential capacity (MW)	Potential generation (MWh/year)
1. New England	243	1.110	10. Missouri	258	0.865
2. Mid-Atlantic	479	1.997	11. Arkansas-White-Red	1,898	5.960
3. South Atlantic-Gulf	1618	3.778	12. Texas-Gulf	608	1.308
4. Great Lakes	156	0.903	13. Rio Grande	98	0.241
5. Ohio	3236	13.603	14. Upper Colorado	53	0.145
6. Tennessee	53	0.197	15. Lower Colorado	124	0.370
7. Upper Mississippi	2027	9.943	16. Great Basin	29	0.080
8. Lower Mississippi	743	2.802	17. Pacific Northwest	225	0.871
9. Souris-Red-Rainy	58	0.239	18. California	156	0.586

Brazil is planning to achieve almost 80% of total installed capacity of renewable development by 2020 largely with hydropower, but also with wind power and biomass (10 Year Plan for Energy Expansion, http://www.epe.gov.br/PDEE/Forms/EPEEstudo.aspx).

Africa continues to have the lowest ratio of development of hydropower potential. In 2010, the continent had 27 GW of installed hydropower capacity generating 105 TWh, which supplied only 16% of the continent's electricity.

Technical potential, calculated at about 1,800 TWh, is predominantly located in the Republic of Congo, Ethiopia, and Cameroon, but plans for development are progressing in the continent. In Uganda, the 900 million Bujigali hydropower scheme began operation in early 2012, although its output depends on water availability (Hydropower & Dams 2012a). The African Development Bank has approved a $35 million loan and a $3 million standing facility to Itezhi-Tezhi Power Corporation and a concessional loan of 18 million to the Zambian Government to develop the Itezhi-Tezhi. This project will support the energy sector in the country, including the growth in the mining industry (Hydropower & Dams 2012b). In spite of the growth in the hydropower sector in the continent, there are serious reservations regarding financial, funding, managerial, social, and environmental considerations (WEC 2010). An example is the Inga I and Inga II projects in the Republic of Congo (Nevin 2008).

In Europe, the Union Climate Change Committee (CCC) is looking to harmonize the approval process for large hydro projects among member states to regulate sustainability aspects and ensure that environmental considerations follow international criteria. The objective is to avoid differences in transaction costs and achieve clarity and legal certainty in the carbon trading market, so that projects from any member state receive equal treatment (De Brauw Blackstone Westbroek 2008). Although this is a welcome step toward making carbon credits available from large hydro projects, it is not abiding. Each EU member state has the discretionary power when assessing the admissibility of project-based credits.

As the use of renewable energy increases for financial, energy, and also climate reasons, the importance of the role of hydropower will increase as well. A fundamental consideration is that policies to develop hydropower tend to favor projects that have the minimum land-to-power ratio. The caveat is the stress this imposes in the system as the absence of storage introduces additional variability and uncertainty (WEC 2010).

The hydropower sector has been working on sustainability issues for more than a decade. This has been perhaps out of necessity, but considering that the growth of the sector is likely to continue due to economic and energy considerations, all attempts to make it more sustainable should be supported. The International Hydropower Association (IHA) has been leading this effort. In collaboration with governments, financial institutions, industries, and social and environmental NGOs, the different parties have engaged in reviewing a hydropower sustainability assessment protocol. The objective of this protocol is to assess the performance of hydro projects based on their planning, design, optimization, construction, and operation. This includes consideration of downstream sustainability flows and physical and economic resettlement. It is expected that the process, and the protocol itself, will contribute to establish sustainability standards for hydropower in the longer term (IHA 2011; WEC 2010).

A steady increase in hydropower, and the rapid expansion of wind and solar power, have paved the road to position renewable energy as an indispensable component of the global energy mix. Nonetheless, it is very important to learn from past experiences and keep in mind that the successful expansion of large hydropower development is dependent on social, economic, and environmental issues which, if not solved, will not only hold back its potential contribution to development, but will be counterproductive to the development processes.

Regional Development

The potential benefits of properly planned and managed water development projects to regional development have been acknowledged and are receiving increasing support (Biswas et al. 2004; Tortajada et al. 2012). Within a framework of regional development, in the case of hydropower, energy can be sold and bought with multiple economic, social, environmental, and security benefits, if planned and managed properly within a long-term framework of development (Nakayama and Maekawa 2012).

Bhutan is one of the best examples that show that water development within a framework of cooperation plays a very important role for economic growth and regional development. Bhutan is a country with 38,394 km^2, and altitude that ranges from 100 to 7500 masl and a population of roughly 700,000 people. Contrary to its agricultural potential that is very limited, it has an enormous hydropower potential calculated at about 30,000 MW with 23,760 MW viable both technically and economically. Bhutan's development is based in the premise that water development is not an end by itself but a means to an end, the end being to improve the lifestyle of the population (Biswas 2004).

According to the Tenth Five Year Plan (Royal Government of Bhutan 2009), hydropower, together with sunrise industries such as tourism, cultural industries, and information and communication technology have become the most economic productive sectors for the country. Hydropower is by far the primary source of energy for domestic use and local industrial consumption, and major export and revenue carrier for the last two decades. The sector drives

the economy and contributes to almost 25% of GDP and around 40% of total national revenue.

The country has an installed capacity of 1,489 MW. This has translated into the highest per capita consumption of electricity in South Asia. Several more hydropower plants are under construction for a total of 3,046 MW, and financing is in progress for an additional 4,610 MW (Rinzin 2012).

The impacts of hydropower for regional development, under the Indo-Bhutan Agreement for the long-term development of hydropower, have been overwhelmingly positive. Under the agreement, a minimum of 5,000 MW should be developed for exports by 2020. Even though this goal requires a massive capacity addition of more than 400 MW per year, and very large funding for it, the Royal Government has set a target of 10,000 MW by 2020 in the main three river basins of the country (IMF 2010).

Hydropower projects are mostly run-of-the-river, which virtually do not result in displacement of communities or significant inundation. The sustained growth of the hydropower sector thus depends on the good state of the environment in addition to the management practices at the river basin level. Environmental protection can be a challenge for the country with such a large hydropower development. Nonetheless, the protection of the environment is very important for overall socioeconomic development, and it is in itself an economic rationale for the long-term utilization of hydropower resources.

The IMF considers that some of Bhutan's hydropower projects could be considered for carbon credit gains since their green exports help to offset industrial pollution in the region (IMF 2010). An important caveat is that, since most of the funds are provided by the Government of India, this has made imperative for Bhutan to strengthen local ownership and equity issues. As in most of the development projects, social and environmental considerations have been a challenge for the government. So far, however, outcomes have been positive for the country and its people (Rinzin 2012).

Another country with the potential to become a net energy exporter to its neighbors is Laos. The so-called power trade between Laos and Thailand is said to be positive for both countries: for Laos because it will allow it to exploit its hydropower potential to meet its domestic demands and also earn significant export revenues to Thailand, and for Thailand because it will allow it to assure the much needed energy resources. Cooperation between the two countries is under a Memorandum of Understanding where Thailand is committed to buy 5 GW of hydropower by 2015. Thus far, some 1.9 GW have been supplied to Thailand from four hydropower plants: Theun Hinboun, Houay Ho, NamThuen 2, and Nam Ngum 2 (Watcharejyothin and Shrestha 2009). Laos's enormous hydropower potential provides the country with the opportunity to export electricity also to Vietnam and Cambodia. Although the benefits for Laos would be very positive from the economic point of view, there should be a great deal of caution regarding social and environmental impacts of the large development projects so that they are not counterproductive on the long term (Smits and Bush 2010; Souksavath and Maekawa 2013; Souksavath and Nakayama 2013; World Bank 2012).

Involvement of New Actors and Development of New Partnerships

The involvement of new actors in the water sector other than the traditional ones has transformed water resources development at the global level. Participation of nonstate actors has become unprecedented in number and type as it originates in several countries concurrently and it has become global in reach. It also has the potential to influence decision-making in any issue, any situation, and any country anywhere in the world.

Both affected and globally interested actors now interact through partnerships that do not recognize national boundaries due to the possibilities provided by communication technologies. The emergence of social media has also revolutionized the who, how, and where of the discussions. This has substantially increased the number and type of actors, although discussions are not necessarily rich in content. Even when virtual stakeholders do not always assume responsibility or accountability for their roles, they are often able to exert pressure on specific issues that are of their interest but on which they may have limited knowledge or even information (Tortajada 2014).

Dialogues have thus become more inclusive out of necessity because of the multiplicity of actors that participate in decision-making. The current challenge is how to include multiple interests within overall policies. The value of these inclusive dialogues is that water resources decision-making has shifted from being primarily in the hands of governments to include multiple parties and views. For example, at the international level, the public sectors do not seem to be any more in charge of setting the international agendas, at least with reference to water and environmental issues. Additionally, the pressure from nongovernmental groups has been so intense that it has resulted in more accountability and transparency of the government and private sector actors, although not necessarily from the nongovernmental groups.

A fundamental fact in the effective implementation of social and environmental guidelines in dam projects is the role played by national and international financial groups. Regional banks that traditionally had supported construction of dams and had established social and environmental guidelines hoping that the dams would have mostly positive impacts, have gradually lost their weight in global decision-making giving way to new actors, especially during the post-2000 period.

A relevant new set of actors playing an increasingly important role in the water sector at the global level is represented by donors that are otherwise not the traditional ones, such as China, India, Turkey, and Brazil. The importance of these emerging donors is not so much the amount of aid they are disbursing, but the new roles they are playing as donors as developing countries. This is challenging the current traditional architecture of international aid, breaking the North-South aid flow stream and broadening it to South-South cooperation based on mutual national interests. This emerging architecture is modifying the sphere of influence of donor countries and is also challenging the rules under which aid is normally provided.

The most important emerging donor that has acted more proactively, aggressively, and intensively all over the world has been China. Aid of China to Africa, Latin America, and Southeast Asia has increased from less than $1 billion in 2002 to an estimated $25 billion in 2007 (Lum et al. 2009). It is argued that China's aid in Africa and Latin America serves its long-term economic objectives via infrastructure, public works, and natural resource development, whereas those in southeast Asia reflect longer-term diplomatic and strategic objectives.

Overall, it is China that has been investing more heavily in the water sector through its support for large infrastructure in the several countries, mostly in terms of dams. At present, the country far outweighs the support of all the development banks (including the World Bank) in aids to development of water infrastructure. In 2008, Chinese companies were involved in 97 dam projects in 39 countries. By 2011, the country was supporting the development of 251 dams in 68 countries (Tanaka 2011). Some examples include

financial support of $448 million to help finalize the Neelum Jhelum project in Pakistan by China Exim Bank (Hydropower & Dams 2012b). In Nepal, the 750 MW West Seti hydro project in Nepal will be developed by CWE Investment Corporation, a subsidiary of Three Gorges Corporation. In Nigeria, there are two hydropower stations with a total capacity of 3,750 MW with China's Sino hydro corporation and Gezhouba Group Company, and the 3,050 MW Mambilla plant and the 700 MW Zungeru plant—85% financed by China's Export-Import Bank with the balance being financed by Nigeria and private equity funds. In Cambodia, the first-scale hydropower project of the country, a 194 MW Kamchay storage project with a 100-m high dam and two power plants built by Sinohydro Corporation, is a 400-MW storage hydropower project—a joint project by Cambodian, Chinese, and Vietnamese companies, and there are four more projects with a combined capacity of more than 900 MW by Chinese companies (Hydropower & Dams 2012a; http://eng.sinohydro.com/).

A valid concern at the international level is that economic, social, and environmental considerations may not be an important part of dam construction guidelines when funds come from China. This could be very different compared with financial support from development banks with stringent requirements. Nevertheless, these are decisions that correspond to the governments concerned only.

China claims that its assistance to other developing countries, with no political strings attached, indicates its desire to fulfill its obligations with the international community. (See the white paper on China's foreign aid, published by China Daily on April 22, 2011, available at http://www.chinadaily.com.cn/cndy/2011-04/22/content_12373944.htm.) It also states that foreign aid should be mutually beneficial between developing countries, should focus on practical aspects, accommodate recipient countries' interests, and promote friendly bilateral relations through economic and technical cooperation. Nevertheless, as it has been the case for aid provided in the past, perceived economic and political self interests remain important considerations for all donors. In the case of China, engagement with developing countries at such a massive scale could be considered to be part of an overall national strategy for acquisition of the much needed resources to sustain its economic growth. Whatever may be China's ultimate objectives, it is a fact that the country is rewriting the terms and conditions of development aid, and the rest of the world is having to take notice of the plans of this new major actor.

With the increasing needs for water, energy, and food, construction of dams to provide much needed services can only continue in the foreseeable future. Therefore, policies and politics as well as management of financial, human, natural, and other resources need to be reassessed continuously as part of the evolving development frameworks and societal needs of the countries concerned in order to make the best of infrastructural development.

It is important to keep in mind that infrastructural development alone will not solve the problems arising from increasing water, energy, and food needs along with climate change concerns. Water, energy, and food securities, both traditional and nontraditional, are very complex and require holistic long-term futuristic visions and timely coordinate actions to implement those visions. Only then the countries are likely to navigate successfully in the path to development.

Final Remarks

The importance of large water storage for the socioeconomic development of countries and their population cannot be denied. It is more so for semiarid and arid countries and regions within countries. It has contributed significantly to economic and social growth of entire countries in the past, and it is becoming even more important due to the fundamental role it can play in the search for water, food, energy, and climate securities at the national, regional, and global levels. In terms of hydropower, the abundant potential in developing countries calculated in excess of 1,900 GW, has still not been exploited (World Bank 2009) and can contribute toward this goal. Implemented within a framework for development and efficient water management where construction is not the goal and alternative options are considered, dams represent an important alternative for socioeconomic development.

Equally, there are many important issues that can no longer be ignored. These include negative social and environmental impacts that can be avoided, and should be avoided, given the present knowledge and experience on planning and management practices of dam projects. Awareness at the national and international levels on the importance of social and environmental considerations of dams from governmental organizations, but mostly from NGOs (not always without biases), has been an important factor that has contributed to improved performance and better management practices of public and private institutions. Nevertheless, because water and energy needs for the future will only increase, national policies and programs that involve hydropower need to be revised and improved whenever necessary in order to ensure that their positive impacts are maximized and their negative impacts are minimized. Development is about people, and this should be kept in mind by all parties involved in dam projects.

A very important factor in the implementation (or lack of it) of social and environmental guidelines in dam projects is the role played by national and international financial groups. Regional banks that traditionally had supported construction of dams and had established social and environmental guidelines hoping that the dams would have mostly positive impacts, have gradually lost their weight in global decision-making, giving way to new actors, especially during the post-2000 period.

A concern at the international level has been that social and environmental considerations may not be an important aspect of dam construction guidelines when funding comes from some of the new actors. Nevertheless, one would argue that as the countries develop, these are, and should have always been, the responsibility of the countries concerned irrespective of the financial institutions involved. If necessary, the role of third parties should be only advisory in nature, but it is in the interest of the respective countries and policymakers to improve their sectoral policies, improve the lifestyles of their populations, and protect their environment.

Finally, to provide much needed services, dam construction can only continue in the foreseeable future. Therefore, policies and politics as well as management of financial, human, natural, and other resources need to be reassessed continuously as part of the evolving development frameworks and societal needs of the countries concerned. In spite of its fundamental importance, infrastructural development alone will not solve the problems arising from increasing water, energy, and food needs along with climate change concerns. Water, energy, and food securities are very complex and require holistic long-term futuristic visions and timely coordinate actions to implement those visions. Only then the countries are likely to navigate successfully in the path to development in a changing global environment.

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