Adaptation to Climate Change Impacts and Regional Cooperation on Water and Hazards in the Himalayan Region

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Abstract

Water should be allocated efficiently taking advantage of externalities in the upstream-downstream framework. Its public-good characteristics means 'free-rider' opportunities need to be factored in. The Himalayan river basins will be impacted due to rapid glacier melting and temperature rise. The need for cross-border co-operation is more urgent now than the conventional rationale might suggest. A review of treaties among riparian nations on international rivers in the Himalayan region and their poor implementation, however, does not seem to reflect a good prospect. This paper suggests the perspective of regional economic framework to expedite the implementation of cross-border cooperation with a central focus around cross-border economic exchange, primarily trade in water as a commodity, source of energy and ecosystem services.

Keywords; Himalayan river basins, riparian nations, water trade, cross-border cooperation, Nepal.

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I. Introduction

The rapid retreat of the Himalayan glaciers has consequences for water-related hazards, such as glacier lake outburst floods, and for water stress, as a result of the decline in fresh water supplies during the lean season. Thus, there is a need to think and act seriously about cooperation among the countries in the Himalayan region for managing water resources and water-related hazards. According to the Fourth Assessment report of the Intergovernmental Panel on Climate Change (IPCC), the incidence and intensity of floods in the Himalayan region are expected to increase as a result of an increase in precipitation during the monsoon season and glacial retreat, both following from global warming. This poses a challenge for reducing the vulnerability of the more than 1.3 billion people living in the major river basins downstream from the Hindu Kush-Himalayan region. The overriding importance of climate change as a driver of environmental change makes it important to address disaster-reduction and water-management concerns in a holistic manner at the river basin level. Such an approach is considered by the IPCC to be an adaptive measure for climate change impacts.

The economics of water resources management also suggests the need to take advantage of externalities while planning water management, that is the production externalities reflected in the upstream-downstream linkages, whether it is for communities, districts, and provinces within national borders, or across international boundaries. While holistic basin-wide water resources management is an approach currently being promoted by water scientists and economists alike, in the Himalayan region the problem lies in the implementation of such a strategy, because most of the Himalayan rivers are international rivers and involve transboundary water management.

It has been suggested recently that regional cooperation on water and hazards can be facilitated by a perspective of regional economic cooperation that goes beyond the focus on water alone. This perspective would be based on water as a natural resource of central focus, around which cross-border economic exchange, primarily trade, and the development of infrastructure to facilitate it, take place. The present paper looks at these issues under three sections covering: a) conflict and co-operation, b) climate change impacts and regional cooperation on water-related hazards, and c) basin wide regional economic cooperation.

II. Conflict and Cooperation

This section presents an overview of the fundamental factors leading to cross-border water-related conflicts and likely avenues for cooperation and discusses them using examples drawn from the greater Himalayan region. The basic regional statistics related to the major rivers and river basins are summarised in Table 1.

Table 1: Principal Rivers of the Greater Himalayan region – Basic Statistics

	Area, sq km	Mean discharge (m^3/s)	% of Glacier melt in river flow	Population x1000	Population density	Water availability per person m3/year
Indus	1,081,718	5,533	44.8	178,483	165	978
Ganges	1,016,124	18,691	9.1	407,466	401	1,447

Brahmaputra	651,335	19,824	12.3	118,543	182	5,274
Irrawaddy	413,710	13,565	Small	32,683	79	13,089
Salween	271,914	1,494	8.8	5,982	22	7,876
Mekong	805,604	11,048	6.6	57,198	71	6,091
Yangtze	1,722,193	34,000	18.5	368,549	214	2,909
Yellow	944,970	1,365	1.3	147,415	156	292
Tarim	1,152,448	146	40.2	8,067	7	571
Total				1,324,386		

Source: Jianchu Xu *et al*. 2007

Factors leading to cross-border water-related conflicts - Some of the critical indicators of vulnerability to conflict among nations related to water availability are the per capita water availability, the level of water withdrawals for annual use in relation to its availability, and the extent of dependence on water resources that flow in from the borders. Table 2 shows the per capita water availability by country in 2000 and 2005.

Table 2. Per capita water availability in 2000 and 2005 (cubic metres/person/ year)

Country	Basin Name	Population, Thousands	Per Capita Water Availability* 2000	Per Capita Water Availability* 2005
Afghanistan	Indus, Tarim	24,926	2,986	2,610
Bangladesh	GBM**	149,664	8,809	8,090
Bhutan	GBM	2,325	45,564	40,860
China	GBM, Indus, Tarim	1,320,892	2,259	2,140
India	GBM, Indus	1,081,229	1,880	1,750
Myanmar	GBM	50,101	21,898	20,870

Nepal	GBM	25,725	9,122	8,170
Pakistan	Indus, Tarim	157, 315	2,961	1,420

Source: FAO's AQUASTAT 2005

*Water Availability: Total Actual Renewable Water Resources

** Ganges-Brahmaputra-Meghana

The critical stress level of water availability, that is the level at which users start to feel the shortage of water, has been given as 1700 cubic meters per person per year. Some hydrologists have estimated 1000 cubic meters per person per year as the minimum water requirement for a moderately industrialized nation that uses water efficiently. In the region (Table 2), the annual water availability for Pakistan was already below the critical stress level in 2005, and judging from the rate at which it declined between 2000 and 2005, it may soon fall below the minimum level. The data shows that India, China, and Afghanistan are also water-limited nations in the region, where the annual water availability is quickly approaching the critical stress level.

Just as population growth could adversely affect the demand side, climate change may have a serious effect on the supply side of water resources management. Table 3 shows the ratio of annual water withdrawals (demand) to annual renewable water availability (supply) by country. Among the countries in the region, the level of water demand is about three-quarters of the level of supply in Pakistan. This would suggest that there might be a water shortage, if the water supply decreases due to adverse consequences of climate change. Normally, levels of demand greater than one-third of supply are considered risky. On the other end, the ratio is less than 5% in Myanmar and Nepal, which is an indicator of the vast potential of underutilized water resources that these countries might be able to tap without harming the riparian nations.

Table 3. Ratio of Water Demand to Supply by Country

Country	Basin	Water Withdrawals* as a Percentage of Renewable Supply**
Afghanistan	Indus, Tarim	36
Bangladesh	GBM	7
Bhutan	GBM	NA
China	GBM, Indus, Tarim	NA

India	GBM, Indus	34
Myanmar	GBM	3
Nepal	GBM	5
Pakistan	Indus, Tarim	76

Source: FAO's AQUASTAT 2005

*Water Withdrawals: Total Use

**Renewable Supply: Total Actual Renewable Water Resources.

Since the countries in the Himalayan region fall within the three major river basins of the Indus, Ganges-Brahmaputra-Meghana (GBM), and Tarim, the extent to which water resources are shared would be an important indicator of vulnerability to competing interests among the nations in the region. Table 4 presents data on the fraction of the total water supply of the countries that originates outside their borders and that flows across their borders to other nations. Both Bangladesh and Pakistan receive more than three-quarters of their surface water supply from across their borders, mainly from India. Furthermore, although only about one-third of water supply to India originates outside its borders, almost three-quarters of the surface water during the dry season in the fertile and high population density, Ganges basin flows from Nepal. These interrelationships between Bangladesh, India, Nepal, and Pakistan in the Indus and the GBM basins may give rise to frictions and tensions over water in the region.

Table 4. Dependence on Imported Surface Water

Country	Basin	Percent of Total River Flow Originating Outside of Border
Afghanistan	Indus, Tarim	15
Bangladesh	GBM	91
Bhutan	GBM	0.4
China	GBM, Indus, Tarim	1
India	GBM,	34

	Indus	
Myanmar	GBM	16
Nepal	GBM	6
Pakistan	Indus, Tarim	76

Source: FAO's AQUASTAT 2005

A. Potential Areas for Regional Cooperation on Water

The literature suggests that although cooperation can occur when mutual benefits are possible, existence of potential benefits is not sufficient for cooperation to take place. There is a need to ask three questions: (a) are there truly potential mutual benefits, or is it a situation where only one party can benefit at the cost of the other, (b) if the latter, can the situation be redefined to transform it to one of potential mutual benefit, and (c) what are the impediments to actually achieving mutual benefits (Crow and Singh, 2000). Cooperation between India and Pakistan in the Indus river basin is considered as a good example of the situation being redefined to transform it into one of potential mutual benefit by enlarging the size of the pie rather than just dividing it.

The principal potential benefits of cooperation in water resources are: (a) sharing information for flood forecasting and early warning, (b) storing water in upstream river basins for flood moderation, (c) storing water resources for increasing flow in dry seasons, (d) storing water for inland water transport, (e) harnessing water resources to generate hydroelectricity, and (f) managing watersheds to help increase the quality and quantity of water available for irrigation and drinking water by downstream users.

The type of exchange of benefits between countries may be: (a) bilateral barter, which is subject to the need to find a "double coincidence of wants", or (b) a financial transaction based on the payment of a mutually-agreed upon monetary value for the environmental services delivered. Table 5 lists what the governments of Bhutan, India, and Nepal have sought from each other to benefit mutually from the development of water resources in the GBM basin.

Table 5. A simple framework to study potential water-related international transactions between Bhutan, India, and Nepal

Potential parties	Good or service	Type of exchange anticipated
Bhutan to India	Supply of hydroelectric power#	Monetized
Bhutan to India	Supply of water storage benefits*	Barter exchange
India to Bhutan	Navigation and transit#	Barter exchange

India to Bhutan	Provision of finance and engineering for construction#	Partly monetized
Nepal to India	Supply of hydroelectric power*	Monetized
Nepal to India	Supply of water storage benefits*	Barter exchange
India to Nepal	Navigation and transit#,*	Barter exchange
India to Nepal	Provision of finance for construction*	Monetized
India to Nepal	Provision of engineering expertise*	Probably monetized

Source: Crow and Singh (2000)

#: occurring to some extent

*: discussed

**: suggested

B. A Simple Example of Cooperation

The opportunities for cross-border cooperation between India and its neighbours, Bhutan and Nepal, on hydroelectricity were enhanced by two major developments in India related to the power sector, one physical and the other institutional. At the physical level, hydroelectric power-grid interconnections in India evolved from the local level in the 1950s to the provincial level in the 1960s, and then on to the regional level in the 1970s and finally to the national level in the 1990s. For the development of transmission and power-grid interconnections, the Power Grid Corporation was given responsibility for: (a) the development of the national grid by interconnecting the five regional grids, (b) establishing the national load dispatch center, and (c) modernizing the regional and provincial load dispatch centers.

At the institutional level, India promoted the establishment of trading companies, such as the government-supported Power Trading Corporation (PTC), to promote the power market. As these physical and institutional setups succeeded within its borders in India, they started exploring cross-border sources of power for interconnections and trading. From India's perspective, as the PTC sees it, the rationale for long-term cooperation in energy are: (a) to take advantage of the potential for economies of scale as a result of large cross-border projects set up primarily to address opportunities provided by India's shortage situation; and (b) to use cross-border renewable energy sources for environmental and conservation benefits, among others. They have identified the major constraints to cross-border power trading as: (a) transmission infrastructure and wheeling facilities within the boundaries, (b) inter-grid synchronization for cross-border interconnections, and (c) electricity pricing.

Worldwide, cross-border grid interconnections are on the rise. Interconnections already exist in North America, Europe, and Southern Africa, including the Nord Pool (Denmark, Finland, Norway and Sweden), and the South African Power Pool (12 countries). India intends to use its recent domestic experience in regional grid interconnections for expanding to cross-border grid interconnections. India's existing major cross-border interconnections are with Bhutan: Chukha hydroelectric project (336 MW) interconnected at Birpara in India, and Tala hydroelectric project (1020 MW), at Silguri in India.

For electricity pricing, the power trading companies act as "market makers" negotiating prices separately with the producers (generators) and distributors, and thus taking the "market risk", which they tend to diversify by dealing with a large number of buyers and sellers, in what is a suppliers' market as of now. The trades are largely short term, duration less than one year, although efforts are being made to increase the long term ones, towards a seventy-thirty short-term to long-term mix.

However, such cooperation in hydroelectric power can take place only after the necessary legal provisions are agreed upon by the two countries. The India-Nepal Power Trade Agreement signed on June 5, 1997, but yet to be ratified by the Nepalese legislature, is an umbrella agreement for power trading between the two nations. It goes a step ahead of the agreements between Bhutan and India dedicated to the specific hydroelectric projects. The India-Nepal agreement provides unlimited marker access for power trading. Any party in India or Nepal may enter into a power trade agreement: government, semi-governmental, or private enterprise (see, Article1). It also makes a provision for the market mechanism to decide on the price and the quantity of electricity to be delivered at a mutually agreed-upon destination, without any form of government intervention (see, Article 2). In some form, the agreement has already been used as a basis for the power trading agreement between the Power Trading Corporation of India and the Snowy Mountain Engineering Corporation (SMEC) for the sale of power to be generated at the 750 MW West Seti project in Nepal. Once it is brought to full practice, it may be a best practice example of cooperation in power trade between riparian countries. To realize such opportunities for cooperation in hydropower generation, however, it may be increasingly necessary to take adaptation measures to face potential glacier lake outburst floods in the region.

III. Climate change impacts and regional cooperation

Climate change has introduced a new dimension to the potential benefits of cooperation in the context of upstream-downstream linkages. Temperature changes in the Himalayas have been much higher than the global average. In Nepal, an increase has been recorded of 0.6 degrees centigrade every 10 years between 1977 and 1999 (Shrestha, *et al*, 1999). Warming in Tibet has also been progressively greater with elevation (Liu and Chen, 2000). The glaciers of the Himalayas, especially in the eastern and central regions, have been shrinking at an accelerated rate in recent decades, although this drastic reduction in ice cover has not been observed in the north-western Himalayas, Karakorum, Hindu-Kush, or Pamirs (Xu, *et al*, 2007). However, these observations have to be evaluated carefully as they have been largely based on limited case studies.

Climate change may lead to an increase in the frequency and magnitude of glacier lake outburst floods (GLOFs) and flood-related disasters. Scientists have estimated that if the present trend continues, most valley glacier trunks and small glaciers will disappear by 2050. As glaciers retreat, glacial lakes are often formed especially in locations above 4,500 meters. Subsequently, glacier lake outburst flood (GLOF) events may occur as the amounts of melt-water in these lakes increase and the moraine deposits give way. There have been at least 35 GLOF events in Bhutan, China, and Nepal in the past. 204 potentially dangerous lakes have been identified in the Hindu Kush-Himalaya region. In addition, high relief, steep slopes, complex geological structures with active tectonic processes and continued seismic activities, and a climate characterized by great seasonality in rainfall, all combine to make water-induced disasters a common phenomena in the Himalayan region. Floods and droughts are likely to increase further both due to the decline in glaciated area of the basin causing reduced hydrological modulation and due to an increase in extreme precipitation events.

A Simple Example of Regional Impact of Potential GLOFs

To demonstrate the increasing need for regional cooperation in the context of global warming, an example of upstream-downstream linkages related to potential GLOFs and hydropower stations in the Himalayan region is presented here for the Dudh-kosi sub-basin in the gbm's koshi basin, 54% of whose catchment area falls in china (Tibet) and 46% in Nepal.

The dudh kosi sub-basin is home to about 36 valley glaciers. These glaciers have retreated at rates of between 10 and 74 meters per year. For example, the rate of retreat for the Imja glacier near Mt. Everest, the one retreating fastest, has increased from 41 meters per year from 1962 -2001 to 74 meters per year from 2001-2006. This sub-basin contains 12 "potentially dangerous" glacier lakes, all moraine dammed, including Imja and Dig tso. The basin has experienced glof events in 1977, 1985, 1998 and 2001, including the Dig tso event. The Dig tso glof event on 4 august 1985 caused a 10 to 15 meter high surge of water and debris to flood down the Bhote kosi and Dudh kosi rivers for 90 kilometers. At its peak, the discharge was 5,613 cubic meters per second, two to four times the magnitude of maximum monsoon flood levels (Shrestha, et al, 2006). The flood began in early afternoon and lasted for about six hours. The resulting damage included the complete destruction of the almost-completed hydropower project at Thame near Namche in the everest region, built at an estimated cost of 45 million rupees. To minimize the adverse impacts of such events, it is necessary: (a) to monitor and assess the status of glacier lakes, (b) to install early warning systems, (c) to implement mitigation measures, and (d) to develop estimates of flow-regime changes in different catchments under various likely climate change scenarios, in order to develop a scientific basis for cost-effective adaptation measures (Bajracharya, Mool and Shrestha, 2007).

It is clear from detailed GIS mapping of the Kosi Basin, that GLOFs in China (Tibet AR) and Nepal could have serious consequences for the existing and planned hydropower stations in Nepal (see Figure 1).

Figure 1: Potentially dangerous glacier lakes and hydropower stations in the Kosi basin

The location of the cross-border potentially dangerous glacial lakes in the catchment of the Arun River, on which the Upper Arun (335 MW), Arun III (402 MW), and Lower Arun (308 MW) hydroelectric power stations are planned, is noteworthy. The location of such lakes in the catchment of the Dudh-Kosi River, on which a storage hydropower project (300 MW) is being planned, also deserves special attention. Further to the west, the Tso Rolpa glacial lake is situated in the catchment that can affect the tailrace part of the existing Khimti-Khola hydropower station (60 MW). This is also one of the cases in which mitigation measures have been carried out and early warning systems established by the government, with donor support. Further west of the Dudh-Kosi River is the Tama-Kosi River, on whose catchment several potentially dangerous glacier lakes have been identified across the border in China (Tibet). These examples demonstrate that regional cooperation on managing GLOF risks is essential to reducing project risk, which is vital to raising funds at a reasonable cost of capital, for generating hydroelectricity in Nepal to sell in the Indian market at competitive prices.

Specific areas of action to be considered for regional cooperation include the following:

a) The Himalayan region is considered to be a data 'white spot' (data gap) in the global climate map of the 4AR of the UN's Intergovernmental Panel on Climate Change (IPCC) due to the paucity of data on hydrology and meteorology. There is a need for regional cooperation among the countries in the Himalayan region to gather and share information for assessing and monitoring climate change and its consequences for water resources management.
b) National Adaptation Plans of Action (NAPAs) are currently being prepared by the national governments of the Himalayan region on the initiative of the UN Framework Convention on Climate Change (UNFCCC). These NAPAs need to suggest plans of action to simultaneously utilize satellite-based techniques supported by field-based techniques for monitoring glacier retreat as well as for assessments of the potential impact downstream of glacial lake outburst floods.
c) The principle of integrated water resource management at the basin level, or IWRM, has already been accepted by scientists and policymakers alike. It is considered by the IPCC to be an adaptive measure for climate change impacts. The concern currently is how to implement this approach by incorporating water governance within the framework of national governance. As the national governments of the Himalayan region make preparations to implement IWRM, it is necessary to consider regional cooperation for adaptation to the events occurring in the catchments that lie across the borders. For example, as described above, glacial lake outburst floods in China could affect hydropower stations in Nepal.

Furthermore, the concept of IWRM at the basin level follows an eco-system based framework. Water is considered to be a life-line or blood supply line of the entire ecology, climate, and broader environment. The inherent nature of the geo-morphological make-up of the catchments of the river and the connecting sub-rivers determines the potential of natural siltation. The human induced changes and infrastructure development combined with the regional and global climate change impacts indicate the aggravated nature of hazards that can trigger water-induced disasters. The concept of IWRM at the basin level can promote an integrated management of land, water, and plant resources involving the people within the catchments. Such an approach has already been practiced worldwide including the Tennessee Valley Authority (TVA) and to some extent in the Mekong river basin.

IV. Basinwide regional economic cooperation

The state of international cooperation on water is limited by the fact that governments tend to negotiate agreements on benefit-sharing in very specific areas of cooperation, such as hydroelectric power trade, without considering the holistic approach. While it is a step in the right direction for developing physical and institutional mechanisms for cooperation on water, the limitation of such cooperation is that it does not clearly address the factors leading to cross-border conflicts on water, such as the declining per capita water availability due to increasing demand in both the domestic and industrial sectors, depleting supply, and population growth in urban centres, all increasing the gap between supply and demand.

Treaties on international rivers do not seem to reflect the concerns that the scientific and economic principles discussed above suggest. In an analysis of 145 international treaties related to water, 39 percent included benefit-sharing in hydroelectricity. In only about a third of the cases was the quantum of water allocation considered, with flood control accounting for 9 percent (UNDP, 2006).

There is also a preference among riparian nations to opt for bilateral negotiations, even in river basins shared by more than two countries. Out of the 263 international river basins, 106 have water institutions, and two-thirds of these have three or more riparian nations. However, less than a fifth of the accompanying agreements are multilateral, showing the preference by riparian countries for bilateral agreements (UNDP, 2006). Furthermore, third party mediation is also discouraged, even when there are asymmetries of power between the countries involved. Here the main issues appear to be those related to property rights and externalities. The fact that international river water is a common property with a high `free rider' tendency by the lower riparian countries, it has limited exclusion potential, especially the economically weaker parties.

Many international river basins have shown interest to follow an approach of cooperation at the basin level. Such cooperation may be in the form of (a) coordination of activities, such as sharing information; (b) collaboration among the nations, such as developing adaptable plans; or (c) common action among the riparian countries, such as developing infrastructure facilities jointly. Nepal's statement at the U.N General Assembly Meeting in September 1998 probably sums up the interests of both the upstream and downstream nations in the Himalayan region (UN General Assembly Statement of Nepal, 1998):

> "Mr. President: On our march towards a democratic and just society, we face many challenges, such as pervasive poverty, mass illiteracy, environmental degradation, population explosion and, above all, gender inequality. We believe that many problems related to economic development can be more effectively tackled through regional or sub-regional cooperation among nations. Tremendous opportunities are available for sub-regional cooperation in our part of the world among the countries in the Ganga-Brahmaputra-Meghna basin. These opportunities include water resources development, flood control, energy supply, forestry management and environmental protection, among others. Development efforts in water resources, for example, would help irrigate the fertile fields in the plains of India, improve the waterways so vital for the transportation sector of Bangladesh, and generate hydropower in Nepal to meet the energy needs of the region as a whole. Such a development strategy may be the key to future prosperity in the region."

The issue is how we could create an environment conducive to optimal utilization of water resources at the basin level. While IWRM is an approach currently being promoted by water scientists, donors, and economists alike, the overriding importance of climate change as a driver of environmental change makes it even more important to address disaster-reduction and water-management concerns in a holistic manner. However, the problem is in the implementation of such a strategy.

Interestingly enough, such an environment may be feasible only if we can also consider within the basket of benefits resulting from cooperation, indirect economic benefits 'beyond water', although water will be the natural resource of main focus. Table 7 presents a simple framework on the basket of benefits resulting from cooperation among nations in the basin. This framework has adapted the classification of the benefits into four types: political, environmental, direct economic, and indirect economic benefits. All four are defined and illustrated in Table 7 (Sadoff and Grey, 2002). The table shows how the domain of treaties may expand from those based on (a) the conventional practice of water-sharing; to (b) the optimum utilization of water resources in the basin through IWRM; and finally to (c) regional economic cooperation through the integration of regional infrastructure, trade, and markets.

The success of all these treaties, however, will depend on the strength of the institutional mechanisms the riparian nations in the basin adopt for water governance. It appears to us that, in the changing context of regional integration for trade and investment among nations, institutional mechanisms for regional economic cooperation with a focus on water may have the highest probability of success.

The Greater Mekong Sub-basin (GMS) program in the Mekong basin may be a good example of adopting an institutional mechanism towards regional economic integration. The basin is shared by the six nations of Cambodia, China, Laos, Myanmar, Thailand, and Vietnam. Along the lines of the classification in the framework on Table 7, while there have been major disputes in the region 'because of the Mekong', significant benefits have also been derived 'from the Mekong' through the lower basin's cooperative management. Furthermore, sharing these benefits has not only been an important stabilizing factor in the lower basin, but it has also brought substantial benefits 'beyond the river', both directly and indirectly. These benefits 'beyond the river' include the hydroelectric power trade between Laos and Thailand, even during the periods of conflict, and natural gas purchase by Thailand from Myanmar, creating ties that bind the countries in a web of mutual dependency (Sadoff and Grey, 2002).

Table 7. A simple framework on the benefits of cooperation

Taxonomy of benefits	Definitions	Examples	Domain of treaties	Probability of success
Political benefits	Reducing costs because of the river	Policy shift to cooperation and development away from conflicts	Conventional practice of water-sharing	Low to medium, e.g., Indus Waters Treaty
Environmental benefits	Increasing benefits *to* the river	Improved water quality, river flow characteristics, soil conservation, biodiversity	Based on the principles of integrated water resources management (IWRM)	Medium, e.g., Mekong River Basin Agreement
Direct economic benefits	Increasing benefits *from* the river	Improved water resources management for drinking-water, irrigation, navigation, and hydropower; for the conservation of freshwater ecosystems; and for risk-management of water-related disasters	Based on the principles of integrated water resources management (IWRM)	Medium, e.g., Mekong River Basin Agreement
Indirect economic benefits	Increasing benefits *beyond* the river	Integration of regional infrastructure, markets, and trade	Based on the principles of regional economic cooperation	Medium to high, e.g., Greater Mekong Subregion Program

An Example of basin wide cooperation on the Mekong River

The Mekong River Basin Agreement of 1995 is an example of a treaty that emphasizes IWRM. The purpose of the Agreement is to support (a) the sustainable development and management of the Mekong River basin's water and related resources, and (b) institutional, financial and management issues relating to the mechanism of coordination between the member countries. Prior to the signing of the 1995 Mekong River Agreement, the MRC's forerunner, the Interim Mekong Committee examined legal and institutional structures in other river basins (Mekong Secretariat, 1994). In particular, there was a direct input from the Murray-Darling Basin Commission in Australia, the MRC's counterpart organization in the Murray-Darling River basin, to the development of the 1995 Mekong River Basin Agreement. The final institutional structures adopted in the Mekong basin contain many similarities to those of the Murray-Darling Basin, with membership, frequency of meetings, and decision-making structures of the three permanent bodies being similar.

Four of the basin countries, Cambodia, Laos, Thailand, and Vietnam, have cooperated in their management of the basin by establishing the Mekong River Commission (MRC), created by the 1995 Agreement on the cooperation for the sustainable development of the Mekong River Basin. The MRC consists of three permanent bodies. In addition, as outlined in the Agreement, there are National Mekong Committees in each of the participant countries which act as liaison bodies between the MRC Secretariat and the national organizations. The three permanent bodies are as follow;

1. The Ministerial Council is the senior body which is made up of one member from each participating country at the Ministerial or cabinet level, who is authorized to make policy decisions on behalf of their government (MRC, 1995, Article 15).

2. The Joint Committee consists of country representatives from relevant government ministries at the Head of Department level (MRC, 1995, Article 23). It is expected to be much more active in the day-to-day running of the organization than the Council.
3. The MRC Secretariat, based in Phnom Penh in Cambodia, provides technical and administrative services to the Council and the Joint Committee, according to the direction of the Joint Committee (MRC, 1995, Article 28).

Based on the experiences gained in sub-Saharan Africa, Southeast Asia and South Asia, the constraints to the management of such regional basin organizations have been identified as (a) constrained autonomy; (b) weak institutional capacity; (c) insufficient financing; (d) the inability of the institutions to enforce agreements; (e) the lack of expertise for the technical, social, and environmental analyses required to formulate regional water resource development plans; (f) the unavailability of financial resources to provide appropriate levels of support for planning studies and to manage and operate the river basin organizations; (g) the lack of institutional concentration on project implementation due to the pressure of vested interest groups as opposed to regional development planning; and (h) the limited authority vested by the national governments in the regional basin organizations to implement policies and programs within its mandate (Gould and Zobrist, 1989; Salman and Uprety, 2002).

However, the greatest constraint is often the non-participation of some of the important basin countries in the basin initiatives. In the case of the MRC, for example, the absence of China and Myanmar has prevented basin-wide management. Nevertheless, these countries have joined with the MRC countries in the Greater Mekong Sub-region (GMS) program, which is envisaged from the perspective of regional economic cooperation. Such a perspective of regional economic cooperation goes beyond the focus on water alone, but would be based on water as a natural resource of central focus, around which cross-border economic exchange, primarily trade, and the development of infrastructure to facilitate it, take place.

All the six nations in the Mekong river basin, known as the Greater Mekong Sub-region (GMS) nations, have agreed to promote trade and investment in the region. The Asian Development Bank, through the GMS program, has supported regional cooperation for strengthening cross-border physical connectivity. The key activities of the GMS include development of economic corridors, focusing on road investments to improve access; institutional and policy changes for trade facilitation; and transit policy harmonization to reduce logistics costs across the sub-region. Five economic corridors have been identified and several road investments are under way in these corridors, while feasibility studies are addressing prospective improvements in railway networks. In addition to hard infrastructure facilities, ADB has also focused on cooperation through trade and transit harmonization (Kuroda, 2006).

V. Lessons learned for regional cooperation

In the changing context of the regional co-operation scenario brought about by climate change and economic globalization and their consequences for water stress and water-related hazards, the importance of wise management of transboundary rivers cannot be overemphasised. The international protocols and conventions as well as best practices and experiences discussed in this paper provide good models to conceptualize, design, and promote future cross border co-operation. Based on the analysis of this paper, the following policy implications and conclusions can be drawn.

1. Comprehensive ecosystems framework: We need a comprehensive ecosystem framework for the development and management of water resources in the Himalayas.
2. Adaptation to climate change impacts: The impacts of climate change could be a major problem. We need to focus holistically on the river basins and act fast; this may mean working across boundaries. In the context of upstream-downstream linkages, it is necessary to consider the benefits of transboundary cooperation for coping with the events occurring in the catchments that lie across the borders. (Glacial lake outburst floods in China, for instance, could affect hydropower stations in Nepal.) There is also a need for transboundary cooperation among the countries in the Himalayan region to gather and share information related to water-related hazards. To this end, an institutional mechanism for sharing data through a regional inter-governmental institution needs to be strengthened; such an institution already exists in the form of the International Centre for Integrated Mountain Development (ICIMOD).
3. Regional cooperation in water should be made part of the total regional economic cooperation and infrastructure development strategy. The establishment of power grid networks and the proliferation of power trading companies in India have helped develop the physical and institutional mechanisms necessary for trans-boundary trade in electricity. The imperatives of globalization and climate change are also strongly driving countries to embark on regional cooperation encompassing trade, commerce, and other economic exchanges along with regional sustainable development strategies. The perspective of regional economic cooperation may help to expedite the implementation of institutional mechanisms for regional cooperation on water and hazards for which good potentials exist in the Himalayan region.

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