DAM-BUILDING IN INDIA AND CHINA – LESSONS LEARNT

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Executive summary

The utility of dams cannot be ignored as an effective tool of water resource management. There is not any single standard that can be suggested to apply in constructing dams because geography, climate and socio-economic conditions vary from country to country. The proponents of large dams argue in favour of dams for poverty alleviation and economic growth at national levels. The critics oppose construction of large dams on grounds of environmental hazards and socio-economic losses for the affected communities resulting due to mass-displacements and modification of river flows.

Building dams is capital-intensive not only in construction terms but also in terms of financing environmental assessments and social resettlement costs. It was not until the 19th century that the indigenous and tribal communities affected by dam-construction were recognized as 'involuntary resettlers.' In the post-World War-II period, the cost-benefit analysis of dam-building began involving many of the aspects related to environment, ecology, resettlement and rehabilitation, riparian relations and water quality. Contemporary world additionally focuses on two important implications of dam-building: 1) cumulative impacts of dams and 2) climate change impacts on water resources.

The regions under study are densely populated. The population is growing fast in the Indus, Ganges-Brahmaputra-Meghna (GBM) and Yangtze basins. The population growth rate recorded for the Indus Basin is highest as compared to other regional basins under study (Table 1). This has led to an overarching pressure for continuous water supply to meet ongoing development needs (in India and China) and to begin addressing development challenges (in the case of Pakistan). The three countries are commonly vulnerable to floods and landslide hazards besides facing quality deterioration problem in their

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respective river basins. Equal is the state of governance systems in India, Pakistan and China, which lack transparency over issues of water development and management. In terms of economic growth, the three countries differ from each other remarkably and this stands out as the biggest factor in planning water resources development. Based on the purchasing power parity, China with US$ 8, 390 has the highest rate of gross national income (GNI) per capita in the region followed by India with US$3,590 GNI and Pakistan standing third with only US$2, 870 GNI for the year 2011.[(1)]

Table 1

Population density and annual population growth in study regions

Regions	River Basins	Shared by number of countries	Basin Population (millions)	Basin Annual Population growth (1995-2005)
South Asia	GBM	5	630	2.02 %
South Asia	Indus	4	300	2.83 %
China	Yellow River	1	185.3	0.87 %
	Yangtze	1	378.4	0. 58%
	Pearl	3	92.5	1.23 %
	Red	3	27.8	1.59 %

Sources: AQUASTAT – FAO,[(2)] Olli Varis, et.al.[(3)]

Dam-building in the Himalayas faces high risks of environmental hazards including catastrophic failures and glacial lake outburst floods as the region is located in an active seismic zone.[(4)] China and India are two big neighbouring countries of Pakistan involved in ambitiously planning and constructing new water reservoirs in their territories. In spite of the opposition of local, regional and international environmentalists, the two emerging economies are fully set to address the domestic energy and water supply shortages by constructing a series of dams. The 12th Five Year Plan (2011-2015) of China proposes to add an additional 140 gigawatts (GWs) to the current 230 GWs of hydropower capacity. China has embarked upon a hydropower development programme as a renewable source of energy to meet commitments of cutting carbon emissions by up to 45 per cent by 2020.[(5)] However, according to the environmentalists, sedimentation in the reservoirs is itself a big cause for greenhouse gas emissions.

The paper seeks to evaluate the characteristics of dam-building drive in India and China by reviewing their respective policies and practices. It focuses on some important questions: How varied is the response of the two countries with respect to ecological and socio-environmental impacts of dams? Do the development benefits of dam outweigh its social and environmental costs? What are the lessons that Pakistan can learn from the Indian and Chinese commitment to reservoir planning and construction? The paper is a non-technical attempt to learn lessons from the emerging socio-economic merits and demerits as well as environmental implications of dam-building in India and China. The purpose of this study is to suggest a departure from history by highlighting alternative

approaches in dam construction and investment decisions for the planners and policymakers of Pakistan. The study recognizes important hydrological facts for the Indus Basin and emphasises informed risk assessments in constructing some of the proposed dams in Pakistan. It also stresses the need to encourage well-informed water management decisions with few socio-environmental risks.

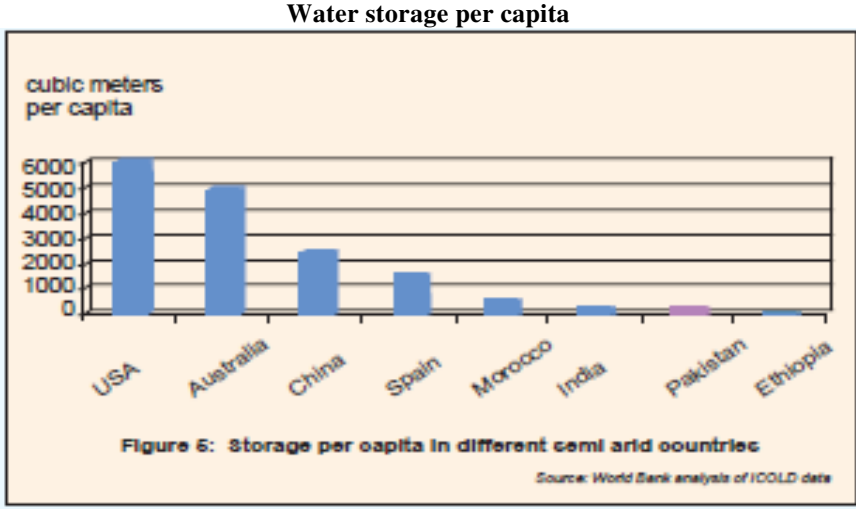
Introduction

India and China are two most active countries in the world in terms of the number of dams in operation, under-construction and planned. The primary objectives of dam-building include irrigation, flood control and hydropower generation. However, the principal motivation behind mega-dam projects in both India and China is the push for economic development which they equate with large water reservoirs and high level of hydropower generation. This is simply following in the footsteps of America and Europe where similar level of mega-engineering took place in the first part of the 20th century.

China has the per capita water storage of more than 2,000 cubic metres through dams. India has a per capita storage of only 200 cubic metres per annum while the figures for Pakistan are even much lower. (Figure 1).[6] China and India both are heavily criticised by the environmentalists and human rights defenders within as well as outside the region for ecological losses and large human displacements that the dam construction activity involves. China with 22,000 large dams[7] is the top dam-building nation in the world whereas India is a distant third in the row with over 4,000 large dams only after the United States having 6,390 large dams.[8] According to the National Energy Statistics, China's 230 GW of installed hydropower capacity make it the world's largest hydropower user.[9] Four countries — China, India, the United States and Pakistan — account for more than 50 per cent of the world's total irrigated area (Figure 2).[10] China and India account for the largest number of people displaced due to dam construction.[11]

Figure 1

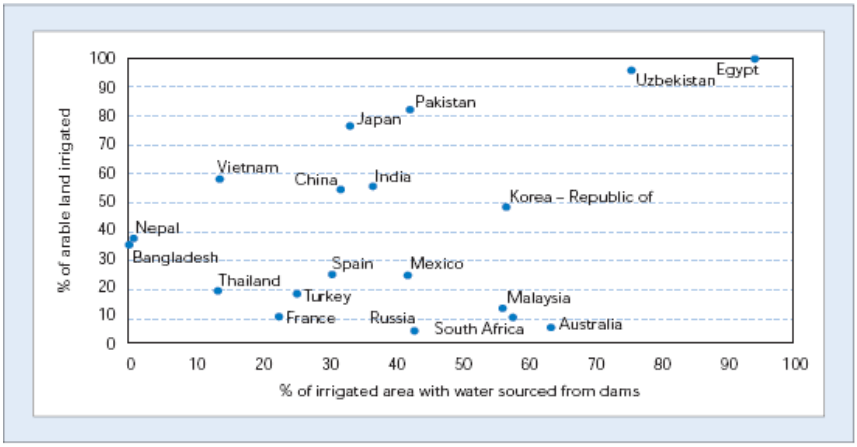
Water storage per capita



Source: World Bank, 2006.[12]

Figure 2

Percentage of dam-irrigated area



Source: World Commission on Dams, 2000.[13]

Construction of water reservoirs, especially large dams,* became the central source of industrial and agricultural development worldwide in the last

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There are a number of definitions of large dams. The International Commission on Large Dams (ICLOD) uses the criterion of 'height' as defining a small, medium or large dam. A dam higher than 15m is classified as a large dam. Many others refer to the gross Storage capacity of a dam and foundation design as a basis for the classification of the dams. The ICLOD definition is used worldwide to define the size of a dam. For a detailed report on the

century. According to the World Commission Report on Dams, besides domestic and industrial benefits of dams, some 30-40 per cent of irrigated land worldwide now relies on dams and that dams generate 19 per cent of world electricity.(14) However, higher temperatures and receding snowlines are increasingly reducing flows in the world basins. Less available water means declined capacity for irrigation, energy generation and domestic consumption. Climate change is challenging mega-dam projects. Scientists have begun questioning the utility of big dams with such weather extremes as flood in one year followed by drought the next year. The rate of evaporation of water stored in reservoirs is also predicted to increase with the warming up of global climate. It is not only environment that pays the price for mega water projects. Mass human displacements, loss of ecological habitat, huge investments and riparian conflicts are some of the major costs of dam-building. It has recently become an important consideration in developing countries including India and China to mitigate these costs at least at the national level. Genuine concerns for cross-border or international implications of dam-building have a low priority in both the countries. One of the most important lessons that the two case studies provide to Pakistan is that in order to achieve sustainable water resource development, dam-building should become only a part of an integrated water management policy.

Pakistan has a poor economy. As a single basin country with fast growing population, its water needs for domestic, industrial and irrigation purposes are multiplying every year with huge pressure on limited water resources. The Indus Basin is well-known for its flow dependency on rain and glacial-melt water. New scientific investigations have indicated vast differences in glacial change behaviour across the Himalayas. While glaciers for many of the Indian and Chinese river basins are retreating fast, contributing to rapid seasonal flows, glaciers feeding the Upper Indus Basin are in fact expanding in mass under climate change influence. The dearth of information and research on changing flow trends in the Indus Basin warrants careful planning in proposing and constructing any new storage reservoirs. Dam-building is not only about investment and engineering options, operational issues such as reservoir safety, emergency preparedness and seasonal management call for well-informed decision-making.

Dams and development: A case study of China

China has nine river basins (Figure 3) with varied hydrological quantity and quality. China is not a water-scarce country but water availability per capita is increasingly falling from 2,195 m^3 (cubic metres) in 2000 to estimated projections of 1,760 m^3 in 2030.(15)

China has long been facing the problem of water imbalances in the form of an arid North and flooded South. The country has faced worst floods in

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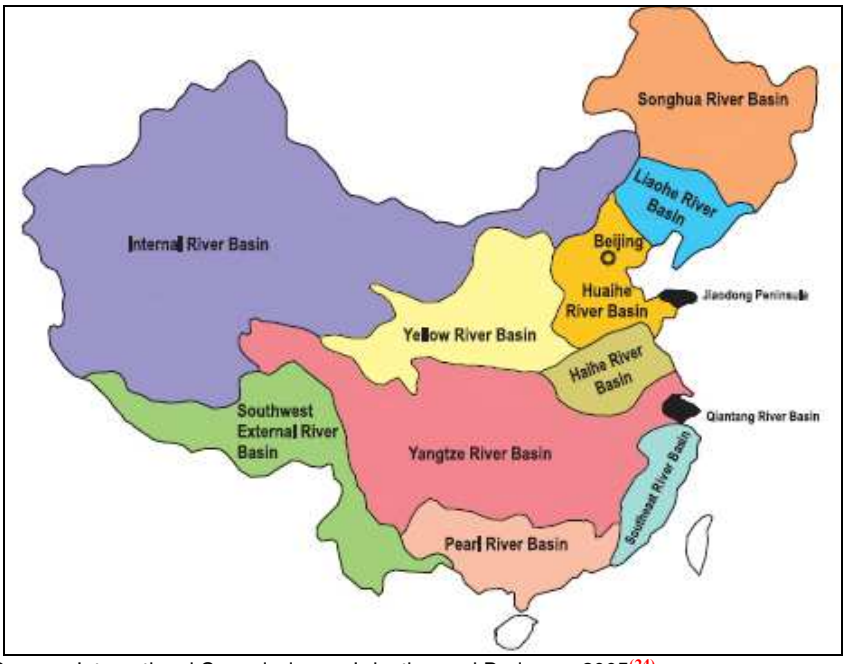
definition of large dams, see Shah and Dinesh Kumar. “In the Midst of the Large Dam Controversy: Objectives, Criteria for Assessing Large Water Storages in the Developing World,” *Water Resource Management*, 2008, No. 22, pp. 1799–1824.

the past including the floods in 1930, 1939 and 1959 that respectively claimed 3.7 million, half a million and 2 million lives across the nation.[16] The extensive drought episodes in northern China have affected economic growth and food security to a large extent. According to Zhang Jiatuan, of China's State Flood Control and Drought Relief Agency, since the 1990s, losses from drought have been equivalent to 1.1 per cent of China's average annual gross domestic product (GDP), or about 300 billion yuan (US$41 billion).[17] Over-pumping of groundwater with a combination of reduced rainfall has also led to water scarcity in the relatively water-rich areas of the country. In 2007, a severe drought left over a million people short of drinking water in southern China.[18] Climate change is making the matters worse. Many of Chinese rivers depend upon glacial melt and rainfall for their annual flows which are threatened by a rise in temperatures. According to the Ministry of Water Resources of China, the country suffers from a shortfall of nearly 40 billion cubic metres of water a year, largely because of global climate change. Rainfall in northern China is decreasing and resources in the watersheds surrounding the Yellow River, Huai He and Liao He (rivers) has dropped by 12 per cent over the past decade.[19] Large-scale urbanization and expanding infrastructure need sustainable water supply in China. Indeed it is the growing Chinese economy that has been the driving force behind dam-building initiatives on a large scale.

It is in this background that central governments in China stick to water conservation policies through mega dams and water transfer projects. The Ministry of Water Resources[20] identifies three problems/reasons for the greater need to protect/conserve national water resources. These include: 1) floods and waterlogging, 2) drought and water shortage, and 3) water environment deterioration. These problems provide a good raison d'être for the Chinese Government to upgrade and build water infrastructure in the country. China's hydropower expansion is an essential part of its strategy to reduce carbon emissions from energy generation sources. China is the world's largest CO_2 emitter due to its heavy reliance on coal, which is a very carbon-intensive fuel and constituted 76.5 per cent of total energy production in the country in 2010. The ratio of hydropower composition to the total energy production remained 9.4 per cent for the same year.[21] China wants to increase the share of non-fossil sources in the energy mix. To serve the dual purpose of increasing power supply and reducing carbon emissions, China has announced an increase in non-fossil sources to 15 per cent of the energy mix by 2020, to 20 per cent by 2030 and to one-third by 2050.[22] China leads the world with 212 GW of installed hydroelectric capacity, followed by Brazil (82.2 GW), the United States (79 GW), Canada (76.4 GW) and Russia (46 GW).[23] Mega-dam projects are planned basins wide to achieve this objective.

Figure 3

River basins of China



Source: International Commission on Irrigation and Drainage, 2005[24]

History of dam-building in China: From past to present

China has 2000 years of history in dam-building. One of the oldest dams constructed in southwest China 2200 years ago is the Dujiangyan, which is in operation to date for flood control and irrigation.[25]

Before 1949, there were only 22 large dams in China. Dam-building has gained momentum since the 1950s[26] to meet the irrigation, energy and water supply needs of the growing population. During 1958-1960, the Communist Party of China actively promoted dam construction as a national campaign. This campaign equated the goal of *harnessing water* with *harnessing people*, which resulted in a nation-wide enterprise for reservoirs construction.[27] At the height of the Great Leap Forward, central authorities used the motto of collective development at all costs to advocate a nationwide dam-building campaign. By 1985, the state-organized campaigns for electricity, irrigation, and flood control succeeded in building 70,000 dams and 80,000 reservoirs. By 1992, when the Three Gorges Project was approved for construction, China already had 369 large reservoirs.[28]

In the Yangtze River basin, more than 45,700 dams with 220.0 billion m^3 of total capacity have been constructed.[29] According to the statistics, by 2002 nearly 34 large reservoirs had been built or were under construction on the upper reaches of the Yangtze River (URYR), and more than 30 large reservoirs had been designed and set up with a total storage capacity of about 200 billion

m^3. By 2020, the layout of major reservoirs will be basically completed in the Yangtze River basin. With the gradual implementation of hydropower planning, total reservoir storage capacity in the URYR (upper reaches of the Yangtze River or referring to the Jinsha River — Yichang section) will be 61 per cent of the total river runoff. According to the plans, most rivers in the area of mainstream of the upper Yangtze reaches will be covered by reservoirs.[30] Sharing the large untapped water resources of the Mekong with its south-east neighbours (Cambodia, Laos, Thailand, Myanmar and Vietnam) China has 17-19 hydropower projects in operation, under-construction or under-consideration in the upper Mekong.[31] A large number of the dams recently built or planned are multipurpose in nature and have capacity for flood control and energy generation.

The installed hydropower capacity accounts for about 24 per cent of the total power capacity with annual generation making up 14.8 per cent of the total. According to the China Electricity Council, the country's hydropower investment reached 44.4 billion yuan ($7 billion) in the first five months of the year 2012, up nearly 50 per cent year-on-year.[32] Earlier reports said China is working on hydropower units with a record capacity of more than 1 million kW, expected to be put into service by 2020.[33] China's 230 GW of installed hydropower capacity make it the world's largest hydroelectric power user, according to statistics released by the National Energy Administration in April.[34]

Rural hydropower development has recently become an important focus for policymakers. As of the end of 2011, there were some 45,151 hydropower projects with 62 GW of installed capacity operating in China's rural areas. To improve the management system of the hydropower industry, 120 rural hydropower associations were set up in the country, among which nine are at provincial level, and 111 at city or county level. Computer technology has also been applied in the construction of rural hydropower stations, as automatic operation was realized in 752 unattended hydropower stations. Equal attention has been paid to the small-scale hydropower industry in China half of which is located in Yunnan, Sichuan, Guangdong and Fujian provinces.[35]

Known/assessed impacts of dam-building in China

Several dams built in China in the past are socially and environmentally unsuccessful. Recently, the government started focusing more on environmental aspects of dam-building. Three tasks have been identified by the Communist Party, i.e. building dams with more economic and energy benefits while protecting environment and relocating people more successfully.

Environmental impacts

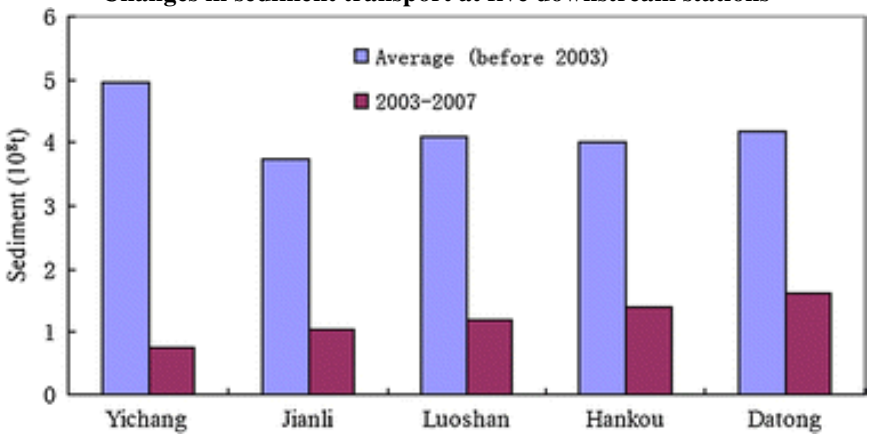
On the one hand, the Three Gorges Dam (TGD) reduced the frequency of major floods downstream and on the other hand its operation began to affect hydrological processes downstream. Several studies have found a relationship

between sediment decrease and reservoirs construction on major rivers of China including the Pearl River,[36] Yellow River[37] and Yangtze River.[38]

When the TGD started operating in 2003, the Yangtze downstream entered a stage of sediment reduction. During the first two years of impoundment (2003–2004), sediment discharge at Yichang (first station downstream the dam) decreased by 164 million tons.[39] Figure 4 presents the changes of sediment transport compared with that before the operation of the TGD at five major monitoring stations downstream the dam from 2003 to 2007.[40]

Figure 4

Changes in sediment transport at five downstream stations



Source: Zhandong Sun, et.al., 2012.[41]

Another major impact investigated in the TGD downstream area is the effect on ecological habitat due to the seasonal reduction of water levels for the period 2006-2010. The serious droughts that hit downstream Dongting Lake wetlands have been attributed to prolonged periods of extreme low water levels.[42] The project has also increased the earthquake and landslide risks in the region.[43]

On 18 May 2011, Wen Jiabao, Premier of the State Council of the People's Republic of China, passed the "Three Gorges Post-Project Plan" and "Water Pollution Control Plan for the Middle and Lower Reaches of the Yangtze River." The first plan recognises that while the project has brought multi-purpose benefits including to hydropower, flood control and shipping, it has given rise to numerous problems including resettlement, environmental and geological hazards, negative impacts on irrigation and water supply in the middle and lower reaches of the Yangtze River. The Three Gorges Post-Project Plan seeks to mitigate project's socio-economic and environmental hazards in the basin area.[44]

A number of environmental impacts are also investigated for the South-North Water Transfer Project (SNWT) of China. Some of the potential impacts studied in the Western route area include reduction in power generation capacity

for the downstream hydropower dams, the disruption of ecological integrity in the headwaters regions of the Yangtze, Yellow and other rivers involved in the diversion project and finally the seismic and landslide hazards. Wastewater treatment is an important concern along the diversion channels in SNWT. For the two other Eastern and Central routes, potential effect of industrial and agriculture run-off on water quality has been the most significant concern.[45] Dam construction by China in the Mekong Basin has also altered the natural fish migration patterns. Of the eight cascade dams, the Mengsong Dam, in planning, is considered the biggest threat to migratory fish from the Lower Mekong.[46] This will not only change the ecological environment of the Mekong region but will negatively affect the economic structure of the society as fishing is a significant source of livelihood in the Mekong region. The Pearl basin, covered by the third longest river of China, has been studied widely for a decrease in sediment flux due to deposition in the reservoirs.[47] China is known for most dam-break failures in the world with 2900 dam-breaks occurring in the country since 1954.[48] Dam-break failures including natural landslides and manmade breakouts have resulted in huge human and animal casualties and loss of infrastructure facilities.

Socio-economic impacts

Social impact analysis doesn't get much attention in feasibility reports on Chinese dams. Like many other projects, the Three Gorges Project also remains focused on resettlement and livelihood programme — building houses for the migrants and providing them compensations to begin a new life. However, the potential social impacts such as loss of cultural heritages, gender imbalances, problem of harmonization with other ethnic communities, change in socio-economic status due to migration, loss of employment have not been given specific consideration by the dam-building authorities.[49] The Project's 185-metre dam and 600-sq km reservoir have forced the relocation of at least 1.3 million residents.[50] However, the project besides generating large units of hydroelectricity has also increased water flow levels, easing the severe shortages in rice-growing areas downstream.[51]

The rural economies of China are paying huge socio-economic costs for the hydropower stations constructed and being planned on free-flowing rivers. One of the examples is the Manwan Dam (1500 MW) constructed by China on the Upper Mekong River in 1996. Among the significant impacts of Manwan Dam for the village communities are a decline in agriculture productivity and animal husbandry, shortages of water for irrigation, increasing costs for electricity, and depletion of forest resources.[52] The 21-GW (gigawatts) Three Gorges Project alone led to the displacement of over 1.3 million people in the reservoir area. This number will continue to increase due to the risk of landslides caused by the gigantic hydropower project.[53]

For the Central route of the SNWT project of China, relocation of more than 300,000 people has become an important socio-economic issue.[54] According to the Chinese environmentalist Yu Xiaogang, to mitigate social impacts of dam-building, affected people could be made shareholders in the dam

company. Their participation will contribute to local development with reduced social impact.[55]

International impacts

About 112 international rivers and lakes cross China involving 17 riparian countries. Yet the country does not have any single agreement with co-riparian countries on water regulation, sharing or management. Out of the 15 most important international rivers crossing the country, 12 originate in China making it the most important upstream country in Asia and the world.[56] The last decade showed a growing debate on the China's unprecedented hydropower development on international rivers and their environmental impact in downstream countries.

Cross-border water conflicts have begun surfacing over China's relations with neighbouring countries in relation to water sharing in the Mekong, Irrawaddy, Salween and Paunglaung[57] and Brahmaputra rivers. With a cascade of dams planned and being constructed by China in Upper Mekong (UM) from where 30 per cent of dry season flows originate,[58] hydrological alterations by the reservoirs will result in serious social, economic and ecological hazards for the 60 million people living downstream along the Lower Mekong (LM). The Chinese dams in UM are also projected to affect the operation of 12 proposed dams in LM. According to the scientific statistics, more than 50 per cent of total basin sediment load in the Mekong will be trapped annually by the construction of eight Chinese dams upstream.[59]

The Mekong's hydrological regime has been significantly altered by the Lancang-Jiang cascade. The dry season hydrological changes are significant in all downstream gauging stations as far as Cambodia. The Lancang-Jiang series of dams (including the construction of eight dams on the mainstream of Upper Mekong Basin) by China may significantly alter the socio-economic status of people living downstream as far as Cambodia where the major livelihood source is fish and agriculture. Any major change in water quality or quantity is intrinsically linked to the lifecycle of ecological habitat with positive and negative effects for human beings.[60]

The fact that one or more dams with multi-season regulating capacity reservoirs in lower Mekong-Lancang, Yangtze and Salween rivers raised downstream concerns regarding changes in flow regimes led China to construct the last dam on the Yunnan cascade, Ganlanba, as a counter-regulating dam between large upstream dams and downstream water users. However, according to reports, the Ganlanba has improved navigation as the only downstream benefit.[61] India has been much furious since the revelation of Chinese plans to build hydropower reservoirs on the Brahmaputra River.

China's international policy regarding water management is discreet and self-guarded. With Mekong countries, China's relationship is limited to less sensitive issues. On the inter-governmental Mekong River Commission (MRC), China maintains only the observer status. With Kazakhstan, China has signed an agreement on water quality in Irtysh River in February 2011.[62] China also has a joint project on the Tumen River Economic Development Programme with

South Korea, Mongolia and Russia. China's selective level of engagement with neighbouring riparian countries and continued secrecy regarding data sharing on flow volumes, sediment transport, etc., have not only reinforced the perception about China's 'go it alone' policy[63] on major international rivers but have also strengthened the suspicion that China lacks the spirit behind widely shared sub-regional goals on poverty alleviation, increased access to reliable energy supply and sustainable environmental development.

Policy response by China

Resettlement Policy and pollution control are the two biggest areas addressed by the Chinese Government in an attempt to reduce environmental and socio-economic hazards resulting from dam-building spree in the country.

The government has started showing increased interest in understanding the environmental impacts of water resources conservation in domestic as well as in international river basins. As for example, to maintain water quality in the central channel of South-North Water Transfer Project, several measures have been undertaken to ensure that the Danjiangkou reservoir will be "a reservoir of clean water to send to Beijing" by constructing an ecological forest preserve of some 356,667 ha (881,342 acres) around the reservoir; establishing erosion control measures in the area surrounding the reservoir; and shutting down more than 800 small but heavily polluting businesses in the area.[64]

A number of scientific studies have also been supported by the government on water resources development in international rivers. Some of these include "Integrated Allocation of Trans-boundary Water Resources in Lancang River Basin", "Reasonable Allocation of Sharing Water Resources in Northwest China", and "Foreign Policies of International Rivers in China."[65] Besides supporting academic research on water resources, the Chinese government is also active in capacity-building for engineers, practitioners and researchers in the field of water resource development and management.

In 1981, the country's Reservoir Resettlement Law was promulgated which created a "reservoir maintenance fund" to divert money from the hydropower industry for poverty relief among many of the displaced people in the countryside. Under this law, hydropower stations were required to allocate 0.001 yuan per kilowatt hour of electricity they generated for funding projects designed to improve the living conditions of reservoir resettlers. The widely popular policy of the Chinese government promoted by the early 1990s in reservoirs areas was the introduction of developmental resettlement policy. This policy incorporated local economic development into resettlement plans. Specifically, the approval of construction funds is made contingent upon plans made by project administrators and local governments to utilize part of the resettlement investment to improve economic conditions in reservoir areas or at resettlement sites elsewhere.[66] People get monetary compensation from the dam-building companies and relocate. The government provides social security to all those who lose their livelihoods as a result of relocation. But the major issue for people relocating to other areas is the loss of their social and economic

capital including culture, natural resources, traditional bonds and their forefathers' lands. To date, people are paying the price for China's growing water economy needs. It will take another decade to measure the benefits of national economic development for the public at grass-root levels.

The dam-building industry in China suffers from lack of integration between various sectors for water demand management. China is located in a geographical zone seriously affected by climate change impacts. Huge investments in mega-dam projects are able to prevent floods, reduce carbon emissions besides generating energy for the massively growing industries of China but the question of sustainability arises in the wake of visible climate changes. This is a question mark that how long could the dam-industry of China support the fast-melting glaciers on the one hand and extreme dry spells on the other? Water conservation through massive financial investments needs to be well supported by water preservation policies in order to integrate the whole water management industry.

Dams and development: A case study of India

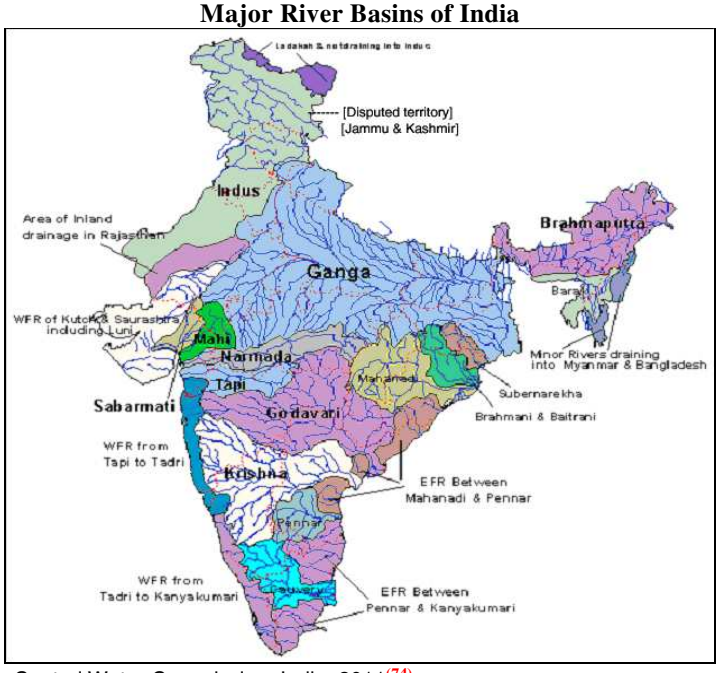
India has 12 major and 46 medium river basins (Figure 5).[67] However the country is water-stressed due to the progressive reduction in per capita water availability, which was estimated at 1545 cubic metres in the 2011 census.[68] The live storage capacity of India is 253 billion cubic metres (BCM) and per capita water storage capacity is 209m^3.[69] Due to spatial and seasonal variations in river flows, floods and droughts are a common phenomenon in the country. India has long been facing weather extremes with rainfall as low as 150mm per year in Rajasthan to as high as 10,000 mm in the northeast hills.[70] Nearly 12 per cent of the total geographical area of the country is flood prone while 16 per cent is drought prone.[71] The Indus, Mahi and Sabarmati basins are physically water scarce whereas those of the Brahmaputra, Ganga, Meghna and Barak are rich in water resources. Food security has become an important concern given the growing population of the country. However like China, there is a growing competition in India between irrigation and industry in increasing water demands.

India ranks fourth in the world after China, the USA and Russia in building the greatest number of dams. The rising economy of India requires water for growing irrigation, power for expanding industries and infrastructure for flood control. Like China, the drive for national development has been the main factor behind dam-building in India. This is reflected through the statements of Indian leaders as speaking to those displaced by Hirakud Dam in 1948, the then prime minister, Jawaharlal Nehru, resonated, "If you are to suffer, you should suffer in the interest of the country." According to the estimates of the year 2012, India has a total storage capacity of 225.14 BCM. Storages for 63.89 BCM are under construction and storages for another 107.54 BCM are under consideration. The expected storage capacity after the completion of planned projects is 396.57 BCM against the total availability of 1869.35 BCM of water in the river basins of India.[72]

The two main sources of freshwater in India are rainfall and glacial melt which are erratic in terms of space and timing. It is for this reason that the National Water Policy, 2002, recognised inter-basin transfer of waters as one of the important non-conventional ideas to augment the availability of water for growing needs. A revised version of the National Water Policy (June 2012) elucidating the importance of climate change recognizes the need for an evaluation of economic, social and environmental impacts of inter-basin transfers.[73]

Figure 5

Major River Basins of India



Source: Central Water Commission, India, 2011[74]

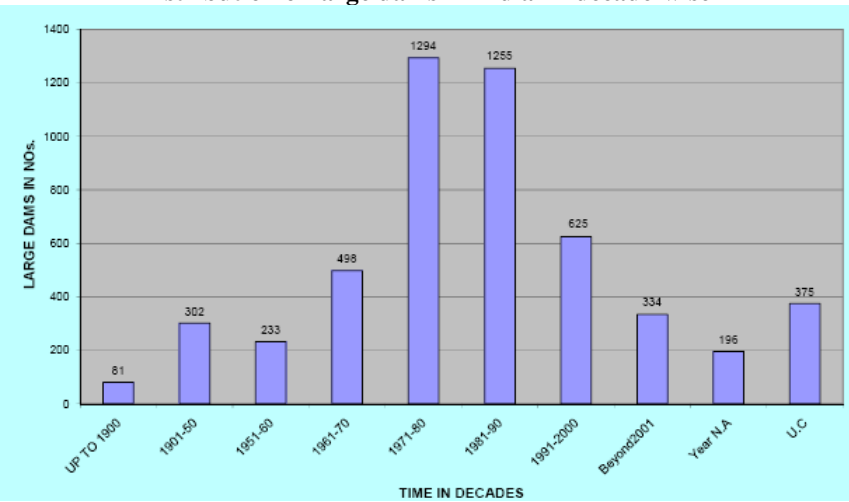
History of dam-building in India: From past to present

Up to 1900, India had only 81 large dams. This number grew to 496 by 1970. The largest number of dams, i.e. 1294, was built between 1970 and 1980 (Figure 6). By 2012, India completed 4,818 large dams in the country. Those which are under construction number 375.[75] This figure is exclusive of medium and small dams under construction in different basins in the country. In the Brahmaputra basin alone, India is reportedly constructing 200 large and small dams in the state of Arunachal Pradesh.[76] Before independence in 1947, India had only 30 dams exceeding 30 metres as most dams were less than 15-20 metres high.[77] The construction of high dams especially for hydropower generation began in the post-independence period including the Hirakud, Gandhi

Sagar, Bhakra Nangal, Pong and Damodar Valley dams as massive projects of the government of India. Dams with a height between 100 and 200m are 20 in number. Only the Bhakra-Nangal Project in Punjab and Tehri Dam in Uttaranchal state are above 200 m. The Indira Sagar Project in Madhya Pradesh state, completed in 2006, is the largest dam built in India to date. Only the Sardar Sarovar dam is going to be the next in terms of size.[78] This was only in the last decade that the government embarked upon an ambitious plan of adding 50,000MW of hydropower to the national energy sector by 2025. The Central Electricity Authority of India has proposed 168 large hydroelectric projects with a total installed capacity of 63,328MW in the Northeast alone.[79]

Figure 6

Distribution of large dams in India — decade-wise



Source: National Register of Large Dams, India, 2012.[80]

Until the last decade, dams in India were mainly planned and built to serve the major purpose of irrigation. Even for the multipurpose projects, irrigation was the main consideration. Hydropower and flood control were largely the secondary but related objectives. However, recently a number of dam projects have begun surfacing in Indian policy planning particularly for energy generation. About two-thirds of the installed hydropower capacity in the country is attributed to storage-backed schemes (i.e., dams) and one-third comes from run-of-the-river schemes.[81] According to the estimates of the Indian Ministry of Water Resources, out of the estimated 84,000MW potential of hydroelectric power, the current installed capacity is about 13,000 MW. Nearly 6,000MW projects are under construction and 3,000MW is expected from the projects already cleared. This will provide India 22,000MW of hydroelectric power once the projects under consideration and under construction are completed.[82] The 50,000MW initiative of the government announced in 2003 envisages the

construction of 162 new hydropower schemes by 2017. This will be followed by adding another 67,000 MW of hydropower in the next 10 years.[83]

Dams have contributed to the development and modernization of irrigated agriculture in India. The Bhakra Dam alone added an irrigated area of 6.8 million hectares over 35 years.[84] By 2000, dam-irrigated area in the country accounted for 35 per cent of total irrigated area.[85] A fourfold increase in the gross irrigated area from 1951 to 1997 has been estimated due to dam-based canal irrigation. However, the actual contribution of dams to food production in this period is less than 10 per cent.[86] Critics of large dams attribute surplus food production in India to many other factors including the use of better fertilizers and chemicals, multi-cropping, improved quality of seeds, etc. However, it cannot be denied that a number of the dam projects in India have positively contributed to irrigation and flood control objectives. Multipurpose reservoirs such as Damodar Valley Dams (Tilaiya Dam 1953, Maithon Dam 1957 and Panchet Dam 1959), Beas, Hirakud, Ukai, Bhakra, Chambal and Nagarjunsagar dams have played a role in resolving flood problem downstream.[87]

Climate change is worsening the water security situation in India. A study by the Kathmandu-based International Centre for Integrated Mountain Development (ICIMOD) says the frequency of floods and flashfloods in the state of Arunachal Pradesh has increased in the last 20 years. Arunachal Pradesh, through which the Brahmaputra flows and where many of Assam's major rivers originate, received 22 per cent excess rain in 2012. This flood situation was in sharp contrast to the previous year's (2011) rainfall deficit in the state.[88]

Known/assessed impacts of dam-building in India

The history of reservoir construction in India is replete with poor water governance, lack of environmental concerns, massive human displacements and inter- and intra-state disputes. The National Water Policy, 2012, recognises that "water resources projects are being planned and implemented in a fragmented manner without giving due consideration to optimum utilization, environmental sustainability and holistic benefit to the people."[89] It is for this reason that integrated water resources development and management has recently become the primary focus of the national water mission in the country.

Socio-economic impacts

Initially dams were mainly aimed at supporting irrigation. The Bhakra Dam constructed on the Sutlej in India in 1963 is as famous as the Tarbela Dam on the Indus in Pakistan for heralding green revolution in the divided subcontinent. According to the National Council of Applied Economic Research, India, "The Bhakra Dam alone added an irrigated area of 6.8 million hectares over 35 years. The production of rice and wheat in the Bhakra command area during 1996-97 was 8 times" the figure for 1960-61.[90]

Other than that of human displacements, social impacts of dams in India are largely underreported. One major social and environmental impact recognised by a study on dams in Northeast India is the loss of resources under common use such as pasture land.(91) Some important downstream impacts of the dams investigated in Northeast India include loss of fisheries; changes in wetland ecology in the floodplains; impacts on agriculture in riverine islands and tracts; impacts on various other livelihoods due to blockage of rivers by dams (for example, driftwood collection, sand, and gravel mining); increased flood vulnerability due to massive boulder extraction from riverbeds for dam construction and sudden water releases from reservoirs in the monsoons and dam safety and associated risks in this geologically fragile and seismically active region.(92) The influx of economic migrants* for dam construction activities disturbing the socio-economic and political balance of the culturally rich regions such as Sikkim is reportedly one major impact of dam-building in Northeast India.(93)

In India, displacement has another face affecting the lives of those who are already marginalized in society. They include women, Dalits (Scheduled Castes) and Scheduled Tribes. Protest movements against big dams have a strong history in India. One of the longest anti-dam struggles in India is known as Narmada Bachao Andolan –NBA (Save the Narmada Movement) which has been using public pressure to force policymakers to abandon plans for damming the Narmada basin.+ These anti-dam movements have played a great role in raising awareness about socio-economic vulnerabilities of those displaced by reservoir construction.

It is largely due to lack of planning and failure of impact evaluation agencies that at times people have to be resettled twice as a result of dam-building. The case of Tehri dam (2005) is an example where people were uprooted from their lands twice owing to the submergence of the old town of Tehri by the reservoir. However, the resettlement and rehabilitation programme was largely successful in the case of Tehri dam where a whole new city of Tehri was created for 110 displaced villages. Some of the positive socio-economic impacts of Tehri Dam include the creation of new infrastructure facilities, improving status of women in the relocated rural communities, better access to education and water and energy outputs. The negative socio-economic impacts of the dam included few employment opportunities, problem with rehabilitation

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* To protect culture and resources of the State, the Sikkim Government prohibits the settlement of non-indigenous people in the Dzongu areas, inhabited by the old Lepcha community.

+ This is the fifth largest river in India. The government of India plans to build 31 large, 135 medium and 3,000 small dams in the Narmada Basin. The idea of damming the Narmada dates back to 1947-48. The basin is shared by three states of India - Gujarat, Maharashtra and Madhya Pradesh. Full development of the basin was envisaged to secure irrigation and drinking water and electricity for the dry and energy-short regions in three riparian and one non-riparian state, i.e. Rajasthan. “Large Dams on the Narmada River,” *Friends of River Narmada*. <http://www.narmada.org/index.html>

choices* and loss of religious and cultural connectivity.(94) Likewise, for the Sardar Sarovar Project (also known as the Narmada Valley Project), issues arose regarding the treatment with project oustees. The rehabilitation package gave rise to new disputes as many displaced people preferred cash to land and there were also allegations against the state of Madhya Pradesh over not providing land in compensation in compliance with the Narmada Water Disputes Tribunal (NWDT) Award.(95) In fact the major issue that appeared during the legal battles between the NBA and the state authorities in the Supreme Court of India was the false claim by the state of Maharashtra over land availability for rehabilitation of affected families by adding 5 metres to the height of the Sardar Sarovar Dam. The planned height of the dam is 138 metres and the legal battle surrounds the debate that given the unavailability of land for rehabilitation of families affected with the current height of 90 metres, the number of people displaced with the planned height will be 320,000, making rehabilitation impossible due to the non-availability of land.(96)

A review of literature on impacts of water development projects record in India shows that the largest socio-economic impact of dam-building in the country has been in terms of delayed rehabilitation and disgruntled resettlers. Conditioned by the bureaucratic and muddled system of governance, the project authorities always seemed to be interested in physical transfer of people from the project location to another land without due concern for their livelihood and welfare.(97) A large number of the people thus displaced include tribal or indigenous (*Adivasi*) communities.(98) Their main source of livelihood consists of forests, pasture lands and common property resources which were submerged by reservoirs such as Tehri, Sardar Sarovar and Narmada Sagar dams, to name a few. Even with cash compensations, most of these tribal people were marginalized due to lack of professional skills and few livelihood choices. Another major problem mentioned in the literature on economic impacts of dam-building in the country is the loss of economic survival opportunities for landless people in the post-displacement period.(99) The rehabilitation policy of the Indian Government recognizes compensation only for the loss of asset/land. Therefore the landless people become real destitute by losing their earlier economic activity in the process of relocation.

Environmental impacts

Nearly all the dam projects have negative environmental and ecological effects by submerging forests, grazing lands and by reducing fisheries in the naturally flowing rivers. This is a case like environment versus development. The Damodar River (also known as "River of Sorrow") was the first basin selected by the government of India as early as 1947 for flood control projects

* The rehabilitation package consisted of cash or land in lieu of displacement. On the one hand, people in many cases were not satisfied with the compensation packages. The government on the other hand recorded that more and more people filed claims for compensation for their displacement on one pretext or the other. See, *Impact of Tehri Dam*: *Lessons Learnt*, Water for Welfare Secretariat, Indian Institute of Technology, Roorkee, February 2008, p.10.

considering its seasonal flooding. The five reservoirs (four were constructed during 1953-1959 and one in 1978) built on the Damodar and its tributaries tangibly moderated the flood flows to the extent of 53 to 80 per cent in the high flood years.[100] However, these reservoirs have created a more worsening flood situation downstream in the lower valley of the Damodar as due to the decrease in channel capacity,* even a lower-level flood is anticipated as a big problem in the lower Damodar River.[101]

The diverted flow of Ranganadi River by the construction of 405MW Rangandai hydropower project (RHEP), Stage I, in Arunachal Pradesh has affected the aquatic life and tourism downstream. Mining and pollution due to dam-construction activities are also serious threats to the ecology of regions like Sikkim and Arunachal Pradesh which are rich in biodiversity.[102] The Brahmaputra carries the second largest sediment yield in the world and traverses through the regions identified for seismic activities. The gigantic plans for the construction of dams/run-of-the-river projects in basins such as the Brahmaputra carry environmental risks not only for development projects such as glacial lake outburst floods and landslides but are also a recipe for ecological disaster by disturbing the natural water balance and releasing environmentally dangerous gases such as methane. Flow fluctuations in the Brahmaputra tributaries such as the Subansiri, Siang, Lohit and Dibang rivers through a series of dams will reportedly impact breeding grounds of important flora fauna species in the large forest area of the region. Besides, it would negatively affect the biodiversity of national parks such as Dibru-Saikhowa and Kaziranga in Northeast India.[103] Mega-dams in Northeast India, which is proposed to serve as the powerhouse of the country, are promoted to seek carbon credits. However, most mega-dam projects in India have been criticized at national and international levels for lack of compliance with environmental standards. According to report of the World Commission on Dams, instead of environmental impact studies being done before approval of the projects under the Sardar Sarovar Project, "they were done concurrently with construction, an approach that undermines the very basis of environmental planning."[104] The construction of Nathpa Jhakri's India, largest hydropower station with 1,500MW capacity on the Satluj, faced repeated halts (from 1993 to 2004) by the Ministry of Forest and Environment due to project authorities' continuous violation of the Forest Conservation Act and the Environment Act. The project was approved by the World Bank much before the actual environmental appraisal.[105]

The earlier culture of lack of consultation with the dam oustees is really changing with people's movements raising environmental awareness at national, regional and international levels against ill-conceived development projects. Some of these movements have been successful while others failed to achieve the desired results. The Silent Valley Hydroelectric Project (1973), proposed to be constructed on the Kuntipuzha River of Kerala's Palghat district, home to an evergreen rainforest, was abandoned due to massive public protests to save the

* The Lower Damodar in general and its lower section in particular has risen owing to increase in siltation and encroachments on the riverbed. This has reduced the carrying capacity of the channel downstream.

world's richest biological and generic heritages in the valley.[106] Forced by the persistent opposition of the indigenous communities in the state of Sikkim to the proposed dams on the Teesta River, the state government has cancelled the construction of 10 dams, with the recent four cancelled as recently as June 2012.[107]

The Tehri hydroelectric project (1978) was opposed by environmentalists both for its negative socio-economic and environmental impacts* on the region. However, even after 17 years (1978-1995) of legal and emotional battle with the government, the popular movements failed to halt the Tehri Dam project. The Polavaram Project in the Godavari Basin in the state of Andhra Pradesh was delayed for a number of years on environmental accounts. The project has the potential to irrigate large tracts of land, provide drinking water to 3 million people and supply 23,500 million cubic feet of water to industries. However, its estimated submergence of nearly 10,000 acres of forestland and threat to the flora and fauna in Andhra Pradesh, Chhattisgarh and Orissa [108] became primary reasons for public opposition and protests against its construction.

In recent years, the Narmada Valley Project has become famous for mass public protests against the negative environmental and ecological effects of damming the sacred river of Narmada. Proposed to be completed by 2040, the project would rank as the largest irrigation project ever planned and implemented as a single unit anywhere in the world.[109] However, the project poses serious environmental dangers as it seeks to submerge a vast area of forestland. The state of Madhya Pradesh has lost 32 sq km of forest cover due to dams especially on the Narmada River. The state boasts the largest forest cover in India.[110] Nearly all environmental clearances of the development projects undertaking deforestation require appropriate afforestation compensation. But the implementation of such legal environmental requirements often remains a challenge even after the commissioning of the project.

Whether successful or failed, mass movements have historically influenced the legal and policy aspects of environment and development. It is for this reason that today all the dam projects need to get environmental clearance before proceeding ahead with any construction activity. But there is no denying the fact that environmental assessment for development projects is still in a nascent state in India.

International impacts

According to the *International River Basin Register*, of Oregon State University, India shares 7 international river basins in the world.[111] India shares a greater number of rivers with Bangladesh than with any other country in the region. More than 140 common water systems have been identified for the two countries and are grouped under three international river basins — the Fenney, the Ganges-Brahmaputra-Meghna, and the Karnaphuli.[112] Therefore, widespread economic, environmental and political impacts are natural in the

* The region of Tehri is vulnerable to earthquakes and landslides.

region due to India's construction of mega-dams in massive numbers. India has a number of agreements on sharing and regulation of common water resources with its riparian neighbours. Still, the damming of common rivers has resulted in large-scale regional opposition. Pakistan and Bangladesh are the two regional riparian countries that have shown much resistance to Indian dams upstream their river tributaries due to the negative downstream effects on irrigation, local livelihoods, ecology and overall environment. Pakistan has sought legal adjudication for two — Baglihar and Kishanganga — out of several disputes on India's construction of dams on shared tributaries of the Indus River. With more than 33 projects at various stages of completion[(113)] and nearly 190 hydropower schemes identified[(114)] by India on various tributaries of the Indus Basin, Pakistan being a lower riparian is apprehensive of their cumulative impacts on the seasonal and timely flows for its own irrigation and energy projects. India's proposed dams on the Teesta River have been a sore point in its bilateral relations with Bangladesh. More than 30 dams, barrages and diversions constructed upstream in India, Nepal and Bhutan have reduced dry-season flows in Bangladesh up to 60 per cent.[(115)] The construction of the Tipaimukh dam on Barak River in Manipur (100 km from the border of Bangladesh) is contested between the two for its ecological and reduced flow effects on irrigation, fisheries, drinking water supply, navigation, and groundwater levels in bordering villages of Bangladesh.[(116)] India has recently assured Bangladesh of not undertaking any project upstream that may have negative downstream effects for Bangladesh.[(117)]

Nepal, although an upper riparian neighbour, is equally disturbed owing to the bad effects of the dams built by India on common rivers in the past. Dams built by India on tributaries of Mahakali, Gandak and Kosi have raised inundation issues on the Nepalese side. Even many non-concrete dams including Bagmati, Khurdlotan, Mahalisagar, and Laxmanpur are said to have resulted in waterlogging, submergence of agriculture lands and displacement of people in border areas of Nepal.[(118)] Many other big projects proposed by India in Nepal have long been delayed due to internal opposition in Nepal against selling out national interests to the co-riparian. Acute dissatisfaction exists in Nepal for India's past record of unilateral decisions and actions to build structures on the common rivers of the Ganges-Brahmaputra Basin. The major concern of the Nepalese government is to get an assured equitable share in perceived benefits (energy generation, irrigation, flood control) of dam-building with minimized losses upstream.

The Indian project of river interlinking (IRL) — proposed in 1980 and revised recurrently with the recent drive in 2012 — in the Ganges and the Brahmaputra basins has invited much regional uproar as neither Bangladesh nor Bhutan and Nepal were formally consulted as lower and upper riparian countries, respectively. The plan to transfer surplus or flooded waters of the Ganges and Brahmaputra envisages construction of several large dams and structures in Nepal and Bhutan. These structures, if built, would have the potential to cause several environmental effects such as increasing inundation problems in the southern lowlands of Nepal and submergence of land in areas of

Nepal bordering India.[119] Bangladesh as a lower riparian country is afraid of reduced water flows. The proposed IRL project through the diversion of water by 12 upstream Indian dams may also result in increased sedimentation in downstream rivers of Bangladesh.[120] Moreover, 72 dams proposed to be built in Northeast India gave rise to due concerns in Bangladesh for their ecological, environmental and economic consequences on the Meghna River Basin which is an important source for fisheries, tea gardens, irrigation and wetlands in Bangladesh.[121]

It is only Bhutan that has kept silent to date about the negative environmental and ecological effects of the IRL project largely because of two reasons. One, due to India's heavy involvement in developing Bhutan's water resources and investing in large hydropower structures on the latter's territory; and two, Bhutan's large revenues earned from hydroelectricity being sold to India.

India has always been opposed to trilateral or regional approach to water management. The historical record of Indian dam-building on international rivers shows that India has adopted opposite attitudes with its upstream and downstream riparian neighbours. With upstream riparian neighbours — China, Bhutan and Nepal — India has been following the negotiating policy of 'equitable water security' while with downstream riparian neighbours — Pakistan and Bangladesh — it has been resorting to the doctrine of 'necessity" in proposing major dam projects. There is also a small power- big power aspect to the debate of dam-building on international rivers. With relatively weak upstream riparian neighbours (Bhutan and Nepal), India, as a big regional power, has been forging bilateral water security relationships by investing in water infrastructures across the borders. Whereas with China, a powerful upstream riparian, India is critical of its dam-building impacts on the ecology and environment of the shared rivers. For the small riparian neighbours, India advocates the policy of bilateralism to maintain its supremacy over shared river waters; and for the big riparian neighbour, India has now started talking about waters in Tibet as a 'commons'[122] to build affected countries alliance against China. This should be noted here that instead of a multilateral treaty there are two different bilateral treaties vis-à-vis the Ganges River for which India, Bangladesh and Nepal are co-riparian countries. China is the only left-out riparian of the Ganges River having no treaty with co-riparian countries. India is both an upper and lower riparian for the Ganges River but for the same river waters, India has concluded two agreements — the Mahakali Treaty with Nepal and the Ganges Treaty with Bangladesh. The lack of basin-wide approach to water management issues in South Asia only leads to the complicated and artificial crisis of shared water resources.

Policy response by India

In recent years, two aspects of dam-building have started widely influencing public policy regarding any new dam project in India. These include socio-economic constancy (balance between rehabilitation costs and project benefits) and environmental concerns. With almost 60 million people displaced

since 1947, India has the highest number of human displacement for development projects in the world. However, only a third of these people were resettled in a planned manner.[123] The National Resettlement and Rehabilitation Policy (2007) requires any new project to go through Social Impact Assessment (SIA) before its commencement.[124] The provision of SIA has also been introduced as an important part of the Land Acquisition Bill 2012.[125] Through the process of decentralization, the rehabilitation policies have been adopted by many states in India. The state of Gujarat has further liberalised its policies by purchasing the land identified by the dam oustee and allotting it to him/her.[126] However, there is still no economic and social recovery assessment practice regarding the resettled people post-rehabilitation, a factor seriously undermining the success of mega-projects proposals in India.

Water has been a state-subject in India but in recent decades, the Centre's ability to influence the planning and implementation of projects has been increased to some extent under several laws and policy frameworks introduced. These include Environment Protection Act, 1986, Forest Conservation Act, 1980, Wild Life (Protection) Act, 1972, and the Water (Prevention and Control of Pollution) Act, 1974. The states' proposed dam projects need to get clearances from the Central Government under all these Acts and this has strengthened public power against many of the large dam projects with massive socio-environmental impacts. The rise of public interest litigation has become an important legal tool for the project-affected people.

Another important change in recent years is the wide acceptance of the concept of impact-mitigation to become a part of project planning and construction activity in India. The issue of rehabilitation has become more pronounced as compared to the old focus on mere resettlement of the people displaced by dams. In some of the recent dam projects, more comprehensive rehabilitation packages were introduced. For example, the Tribunal established under the Inter-State Water Disputes Act for the Sardar Sarovar Dam decided land-for-land compensation to the displaced. There has also been an emphasized focus in National Water Policy drafts of 2002 and 2012 on people's participation in project planning and development. However, what is lacking on ground is the issue of sustainability with regard to the management of water resources. Both the National Water Policies, 2002,[127] and 2012 have been criticized for their inherent deficiencies regarding sustainability of water resource policies. These policies also suffer from lack of institutionalization of multi-sectoral cooperation over water use.

The importance of basin-wide (or sub-basin) planning was recognized as early as the 1950s with the Central Water Commission's assessment of resources and identification of storage sites in different basins of the country. The River Boards Act was introduced in 1956 in order to set up advisory river boards for regulation or development of water resources in a given river basin. It was formally acknowledged through the 1987 National Water Policy document. Bhakra Nangal, Sradar Sarovar and Gandhi Sagar dams are some of the examples for projects undertaken through basin-wide planning. However, inter-disciplinary management of a basin or sub-basin inclusive of development in all

sectors ranging from mega-projects, micro-watershed development, environmental, ecological, economic and social development still lacks implementation in India.[128] Similar concerns need to be integrated for planning development on international river basins.

Climate change has recently begun to get a prominent place in national policy documents dealing with the proposals and planning of water reservoirs. In order to avoid large-scale submergence and devastation to fragile ecological areas, most hydropower projects are proposed as run-of-the-river plants. However, a policy response is missing in India regarding the cumulative impacts of run-of-the-river plants on the hydrology of different river basins. Recently, the High Court of the state of Karnataka halted the implementation of a number of mini- and micro-hydel projects in the Western Ghats region of the state pending a cumulative impact assessment.[129] These legal standards however remain missing for nation-wide or region-wide cumulative impacts of dams on river basins in India.

Lessons learned and policy options for Pakistan

Similar to worldwide practice, the regulation of river waters by construction of dams and reservoirs in India and China have primarily been motivated for the provision of hydropower, irrigation, domestic and industrial supply and flood and drought control. By fulfilling these objectives, dams contribute to positive economic gains and national development at the cost of massive negative socio-environmental impacts. For China, social impacts of dams are reported and evaluated scarcely due to the system of governance perceived as less transparent. However, huge criticism exists for the potential environmental consequences of dams-led development within and outside China. This has led to the adoption of policies at the State level for the concurrent mitigation of negative socio-environmental impacts. India has been more open in terms of reporting the negative socio-economic and environmental impacts of dams-led development in the country. In the previous section, the negative and positive outcomes of dams have been described and analysed in detail for India and China. The major objective was to evaluate the approach, attributes and pitfalls in the dam-building inspiration of the two case studies. The development of water conservation projects and management of their negative impacts in India and China share a number of differences and similarities (Table 4). The present section evaluates a number of issues pertinent to reservoir construction in the two countries in an attempt to draw lessons for a developing country like Pakistan.

First of all, domestic circumstances (such as large population, regional imbalance in water distribution, climate change threats, energy shortage and growing water scarcity, etc.) in India and China are similar with respect to the need for greater number of water conservation projects. However, a number of factors vary considerably in the two countries as regards to dam building. Two major factors include the contrasting systems of governance and divergence in infrastructure resources. All dam projects need to be approved by the Central Government in China whereas in India water is a state subject and the centre

gets involved only in mega-projects. The per capita gross domestic product (GDP) of China is two times greater than India's. China is also home to the world's second-largest highway network,[130] an essential resource to support dam-building industry in any country.

The second major issue is of finance. China is a much larger economy than India and most of the dams built in China are being largely funded by revenues from the power industry. More than half of the cost for the Three Gorges Project, world's largest hydroelectric plant till date, was financed by the Chinese government through the principle of equity.* Other sources of funding include massive domestic debt, indirect foreign loans and issuance of domestic as well as international bonds by the government. Due to the controversial nature of the project, foreign direct funding was limited to 5-6 per cent of the total project costs.[131] India is also following in the footsteps of China by depending upon domestic sources to fund mega-projects such as Sardar Sarovar and Maheshwar dams after being denied foreign loans from World Bank and other international contractors in 1990s[132] on socio-environmental grounds. Large economy and diverse financial resources have allowed China to not only fund the rehabilitation process but also to invest in ecological restoration and reforestation projects.

The third issue is related to environmental policies and regulations for dam construction and resettlement issues. The Chinese Government has a strict policy for protecting cultivated land in order to control the total amount and percentage of land used for construction to curb the unjustified appropriation of farmland.[133] A number of policy plans and projects (e.g. National Plan for Sand Prevention and Control (2005-2010), water and soil conservation projects, water pollution control projects, National Programme for Wetland Protection Engineering (2002-2030) and Action Plan for Biodiversity Conservation)[134] are underway in China to mitigate the negative impacts of dam and other projects on environment and ecology in the country elsewhere. The central government spent 233.2 billion yuan (more than 30 billion US dollars) on the 27.7 million hectares of new forests planted from 1999 to 2009.[135] The total output value of China's environment industry in 2010 was equivalent to about 139.7 billion US dollars[136] against Chinese investment worth 54.75 billion US dollars in water conservation projects in 2011.[137] In India, besides many individual states' policies on water and environment, a number of central government laws regulate dam-related issues including River Boards Act, 1956, Inter-State River Water Disputes Act, 1956, Water (Prevention and Control of Pollution) Act, 1974, National Water Policy, 2002, National Wildlife Action Plan (2002-2016), National Environment Policy, 2006, National Resettlement and Rehabilitation Policy, 2007, National Action Plan on Climate Change, 2008, etc. Both India and China are, however, increasingly facing the issues of implementation in compliance with international standards on environment and water management.

The fourth issue is of resettlement and rehabilitation work. Both India and China are highly focused on mitigating the negative socio-environmental

* Equity was realized through a nation-wide levy on the electricity price, contributions from several budgets and profit from the Gezhouba power plant.

effects on dam-displaced population. China has been providing 600 Yuan ($96.55) a year as a follow-up subsidy to each reservoir resettlement migrant since 1 July 2006. The subsidy is set to last 20 years.[138] The decentralized system of rehabilitation and compensation payments in India is marred by gross inequalities and complicated legal issues regarding land allotments between various states. Differences between states' policies concerning mode of compensation for dam oustees have delayed rehabilitation in many dam projects in India.

Fifthly, India and China are identified as major global hotspots for climate change worst implications for water resources. Climate change threats for these two countries include shortage of water, sea level rise, extreme weather events, increase in natural disasters and shrinkage of arable land. China has been working to reduce the risk of decreasing grain harvests caused by global warming in the coming decades.[139] China has done far better than India in the Clean Development Mechanism (CDM) scheme and has overtaken India in 2007 as the world's biggest beneficiary of CDM. Till late August 2011, India had 719 CDM projects having been registered by the CDM EB, accounting for about 21 per cent of the world's total 3,427 projects registered with the CDM EB, following China with 46 per cent.[140] In 2007, China made more money than any other country out of rich-world polluters — $5.4 billion, or 73 per cent of the total. India, which, along with Brazil came second, made $445m — 6 per cent of the total.[141] India and China are competitors in better focusing their national policies vis-à-vis climate change programme.

Table 2

A comparative assessment for dam building in India and China

Similarities	Differences
Chronic imbalance between population density and water availability in different regions of both countries.	Centralization of water resource management in China, while in India water management is a state subject.
Both suffer from frequent floods and droughts.	India has signed a number of water treaties with its riparian neighbours. China has no water treaty with any of its riparian neighbours.
Reduced per capita water availability.	Dam-building in India is vulnerable to NGOs opposition and public protests on socio-environmental grounds. China is less transparent and open both for dam-building plans and to public opposition.
Dismal record with rehabilitation issues for the displaced people.	As compared to India, China is more successful in financing the resettlement costs.[142]
China and India both have outstanding disputes with their lower and upper riparian neighbours for reservoir construction on shared river basins.	China is not only self-financing the construction of dams within the country but also serves as a major funder for dam-building around the world. India largely relies on foreign loans to finance its dam projects.
Shortage of electricity — therefore both have an increased focus on augmenting hydropower.	
New water policies of the two countries are	

better focused on addressing social and environmental concerns regarding dams under construction and dams awaiting pre- feasibility studies.	
No stakeholder consultation takes place in either country for a dam project.	
Increased water pollution.	
Lack of integration between various water sectors within the dam-building industry.	
Increased role for private sector in financing and constructing dam projects.	
Unsatisfactory environmental impact assessments (EIAs) by the agencies concerned.	
Time and cost overruns for large projects.	
Climate change impacts in terms of glacial melt and GLOFs are equally established for the water resources of the two countries.	

Sources: International Rivers Network, HRI China (hrichina.org), AQUASTAT FAO, World Bank and earlier cited literature in the case studies.

Lessons for Pakistan

Pakistan shares a number of similarities with India and China in terms of water scarcity, population increase, energy shortage, and weather extremes. However, unlike India and China, Pakistan has only one river basin, which is shared by India under the Indus Waters Treaty, 1960. Any massive future uses by Afghanistan on the Kabul River, a tributary of the Indus basin, will also affect the availability of water for proposed mega-projects in Pakistan.

Besides learning some of the good practices from India and China, Pakistan needs to take cognizance of the fact that the geological and climatic responses to the hydrological resources of Pakistan vary considerably from that of these two countries. In contrast to many of the Himalayan glaciers feeding the river basins of India and China, where there is significant evidence of glacial retreat[(143)] (and upcoming threats of reduced flows), glaciers of the Upper Indus Basin (UIB) are not retreating and many in the Karakorams are in fact increasing in mass.[(144)] Most of the glacial melt-waters in the Indus Basin actually go to the sea because of timing — coinciding with the monsoons. Therefore, it makes good sense to store the glacier waters behind dams for multiple uses throughout the year by effectively dealing with the expenses, dangers and inefficiencies involved in dams' construction.* Since runoff trends in the Indus basin vary spatially and seasonally, seasonal flow assessments, besides comparative evaluation of runoff trends at different stations, will be of substantial value[(145)] in planning and designing reservoirs with better response to climate change variability.

The case studies done above provide the following significant lessons for Pakistan:

* Email conversation on 12 January 2013 with Kenneth Hewitt, a glaciologist associated with Wilfrid Laurier University, Canada.

- Building a dam with uncertain climate change implications and natural disaster risks, is like a case "Damned (or dammed!) if you do and damned if you don't."[+] Urgent considerations should be given in Pakistan to new storages both at micro — and macro-levels besides improving water use efficiency by managing the demand side. With a population growth rate of 2.05 per cent and an annual addition of 3 million persons,[(146)] there will be an inevitable rise in water demand in Pakistan in the coming years. A huge supply crisis is predicted for the drought years with the current storage capacity of Pakistan too scanty to even support the existing irrigation needs of the country.
- Renovation of old projects such as the Mangla Dam Raising Project and Tarbela 4th Extension Project is currently underway with the financial assistance of the World Bank. The Chinese experts have rejected the option of de-silting the Tarbela reservoir to increase its storage capacity. According to the feasibility study, massive financing required to remove silt and rock deposits from the dam is almost equal to the cost of a new dam.[(147)] The Tarbela Dam will itself complete its lifespan of 50 years by 2029. After the completion of 1,450MW Ghazi Barotha project in 2004, a gap of nine years is tremendous enough to demonstrate the lack of efforts for new reservoir projects in Pakistan. It takes more than a decade between a final decision for dam construction and its coming into operation. In order to increase the per capita storage capacity, new dams are necessary to be planned on fast-track basis.
- Maximum funds should be generated from within the country to support the renovation of old reservoirs and construction of new ones. Additional levies should be placed on irrigation and energy sectors to increase the revenue for infrastructure purposes. The Chinese model of self-financing the resettlement costs should be especially exemplary for policymakers in Pakistan. To meet this objective, primary consideration must be given to stakeholder consultation, community participation and partnership with the private sector. Moreover, delays in projects like that in the Neelum-Jhelum hydropower project. cause huge cost overruns (Rs15 billion in 1989 to Rs333 billion in 2011).[(148)] Planning based on domestic funds and resources could solve such issues in the future.
- Legal framework and regulations on dam-related issues are scant in Pakistan. The draft prepared for national resettlement

[+] Email conversation (on 10 January 2013) with David Archer, a hydrologist based at New Castle University, USA

policy in March 2002 has never been approved and the old Land Acquisition Act, 1894, has been the most commonly used law for development projects which does not cover resettlement and rehabilitation issues. The practical record of compensation payments, relocation and rehabilitation of dam-displaced communities is also poor in Pakistan. People displaced by the two large reservoir projects — of the country -Tarbela and Mangla dams — still recall the stories of broken promises and socio-economic impacts of displacement. There is an urgent need to formulate updated versions of national resettlement policy and land acquisition act in Pakistan in view of the much desired water resources development/management.

- Environmental impact assessments (EIAs) and safety measurements for dam-burst events and earthquake risks should become an important part of any proposed dam project. Both India and China have been unsuccessful in the actual implementation of EIAs for their reservoir development plans. This has led to domestic and international opposition for many of the projects in the two countries following with the withdrawal of multilateral funding and construction companies from some of the projects as well as cancellation of others on environmental grounds. The proposed site for the Diamer-Bhasha dam in Pakistan is reportedly seismically active. Significant concerns should be raised in the country about the geo-hazard questions regarding infrastructure as well as preparedness and the safety of people in Gilgit-Baltistan. Recently, more than 340 large landslides have been identified along the Indus streams in the Karakoram, Hindu Kush and northwest Himalayan ranges.[149] This calls for a careful approach and perhaps revision of the proposed construction of dams in high mountains (Diamer-Bhasha) due to the geo-hazards involved.
- Like China, Pakistan could increasingly focus on run-of-the-river (ROR) hydropower plants with few submergence and displacement issues. The Ghazi Barotha Hydropower Project on the Indus, completed in 2004 with loans from Japan and the World Bank, is a good example with relocation of only 1,000 families.[150] However, the cumulative effect of many ROR projects on a single river may result in drying up for longer spells during the time of diversions. Therefore these projects may also cause significant environmental harm if undertaken without an independent environmental assessment.
- Another important lesson is to improve coordination between various water sectors. The current water stress in Pakistan is related to both demand and supply management. Climate

change has replaced the past slogan of water resource development with water resource management and this warrants local adaptation initiatives in areas ranging from household consumption and irrigation to industrial uses. To meet the water demands for irrigation, energy, environment and industry, a broader strategy of water-environment relationship is required. Restraining the demand side by an increase in water usage efficiency is equally important besides supply projects for water conservation. Therefore alternative water conservation strategies should be pursued simultaneously and huge water structures should only be opted as a last resort* through an integrated water policy.

- The Tribunal established under the Inter-State Water Disputes Act for the Sardar Sarovar Dam in India presents a test case for the controversial Kalabagh dam in Pakistan which has been delayed for more than 25 years due to the water-sharing disputes between the provinces. The Pakistan Water Apportionment Accord was promulgated in 1991 to apportion the share of water to the four provinces from canal supplies. The accord does not deal with any water conflicts arising between the provinces which is a major hindrance to new development projects in the country. It also lacks enforcement mechanism to distribute water share as per the 1991 Agreement.(151) A legal framework on inter-provincial water disputes is earnestly desired in Pakistan with the power of judicial tribunals to resolve such inter-provincial differences as the one between Punjab, supporting the construction of Kalabagh dam, and the rest of the provinces opposing the construction of the proposed dam.
- Other lessons learned include the possibility to reduce the socio-environmental impacts to manageable levels through practical measures such as community consultation, rigorous evaluation of alternatives (including dam design, funding sources, technology required, land acquisition, compensation methods, etc.), stakeholder/beneficiary involvement in financing the project, awareness raising, reforestation and re-plantation, promoting good water use practices as demand management.

Conclusions

Dam-building stands as an important national water development strategy around the world. While the benefits of dam construction are realized at national scale, most of their costs including loss of livelihoods, problems in

* Personal conversation with Ramaswami Iyer, a Delhi-based writer and former secretary, Water Resources, Government of India.

cultural adaptation, gender imbalances due to relocation of the residents, reduced water flows for irrigation, depreciated water quality and loss of ecological habitat are borne by people living in the reservoir area. In the case of international rivers, geo-political tensions are some of the negative impacts associated with dam-building. Dam debate is not merely about good or bad, small or large, but it is all about planning and management.

The downstream impacts of dams range from dam-break floods and reduced seasonal flows to quality deterioration of water. There have been regional level demands in India for completing the cumulative impact study in advance for projects proposed on the Teesta River and Brahmaputra floodplains.(152) Recently, geological concerns have begun to emerge regarding building of dams in seismic- and landslide-prone areas. In China, such concerns have been expressed for dams on the Nu River (known as the Salween River when enters Myanmar), for dams on Brahmaputra River in Northeast India and for the Diamer-Bhasha Dam on the Indus River in Pakistan. Global warming is also affecting the glacial mass and rain patterns. Modern sciences have found a relationship between large reservoirs and an increase in rainfall intensifying the flood season. Investigating the rain patterns around water bodies in Chile, scientists found that rains were much higher there than in similar areas without them.(153) The "lake effect" could be measured for the reservoirs built without taking the evaporation factor into consideration. To date, no serious study has been undertaken in the Himalayan or Tibet region for socio-economic impacts of large dams under climate change.

Funding for dams has been a major issue in developing countries. China has self-financed the world's largest hydropower project – the Three Gorges Dam (1850 MW) — as in Chinese view, the project would have cost 10 times more with foreign loans. The primary claim of generating cheap electricity by building mega-dams is thus practically achieved by China. This spirit of nationalism needs to be sought through in Pakistan before embarking upon large water development projects.

While India, Pakistan and China face similar kind of challenges with regard to development needs and associated environmental, political and socio-economic costs of dam-building, the three countries remarkably differ from each other in terms of economic growth and water governance institutions. India has a much progressive history in adopting resettlement policy. Maharashtra, which has the largest number of dams in the country, was the first state in India to formulate a resettlement policy in 1976.(154) However there have been gaps in implementing the policy on the ground nationwide. The record of resettlement and rehabilitation is relatively poor in India than that in China. There are three main lessons that policy sections in Pakistan must learn and adapt accordingly in planning and constructing any large reservoir in the country.

- Consultation with the affected people/stakeholders of the project.
- Short- and long-term policy implementation plan for the effective resettlement and rehabilitation of the people displaced.

- Pre-proposal advanced level studies to anticipate and mitigate environmental impacts of a given project and disbursement of data.

The biggest irony is that local communities are seldom consulted during the planning and feasibility study of a proposed reservoir. The bureaucratic culture of hiding facts and lack of consultation with the stakeholders in the developing countries largely affects an integrated development plan for water resources.

The scientific basis for planning development of the river basins is equally poor in India, Pakistan and China. In India and Pakistan, water management is done through sector- wise administrations/ministries which have conflicting interests. Without giving due consideration to the impacts of these inter-linkages between multiple water sectors, it would be naïve to fully estimate the costs and benefits of dam projects. In the developed world, mega-dams are beginning to be seen as obsolete solutions for water management problems. The raising of the Tarbela Dam is a good example as the topographical constraints limit the possibility of having good storage sites. Therefore it is important to preserve the live storage capacity of the existing reservoirs as much as possible.[155]

There is a limit to which the hydropower or multipurpose dams could be built on a river basin. This is true that environment and culture become remote considerations when questions of sustenance and survival come in. But there is no end to alternative methods of development. The need is to better understand the interrelationships between population, resources, environment and development through quantitative and qualitative models of assessment.[156] As the illuminating new book *Energise*, by James Woudhuysen and James Kaplinsky, points out, dams are what we make of them. Loss of wildlife, the generation of greenhouse gases and even resettlement are a small price to pay compared with the benefits of a dam – if they are well planned and run.[157]

Any statement unconditionally supporting or opposing the construction of dams need to be based on ground realities. Dam-building can only become an essential part of large developmental goals by having due respect for ecological, social, economic and political ethos in a given society. Dams should only be built by considering the integrity of a river basin and various water sectors at the national level and legitimate needs of the riparian states. A basin-wide approach must be the basis of any water management or development policy.

Notes and References

1. *Data for GNI per capita PPP*, Washington: The World Bank, 2011. <http://data.worldbank.org/indicator/NY.GNP.PCAP.PP.CD>, (accessed on 14 February 2013).
2. FAO-Aquastat, Indus River Basin, Food and Agricultural Organisation of the United Nations, 2011. <http://www.fao.org/nr/water/aquastat/basins/indus/index.stm>, (accessed on 10 March 2013).
3. Olli Varis, Matti Kummu, Aura Salmivaara, "Ten major rivers in monsoon Asia-Pacific: An assessment of vulnerability," *Applied Geography*, No.32, 2012, pp.441-454.
4. Shripad Dharmadhikary, *Mountains of Concrete*, International Rivers: California, 2008, p.3.
5. "China sets first targets to curb world's largest carbon footprint," *The Guardian*, 26 November 2009. <http://www.guardian.co.uk/environment/2009/nov/26/china-targets-cut-carbon-footprint>.
6. World Bank, *Better Management of Indus Basin Waters: Strategic Issues and Challenges*. South Asia Region, Agriculture and Rural Development Unit, Washington DC, 2005.
7. China is the country with the largest number of reservoirs in the world. However, the estimates vary from regional to international organisations. According to Chinese National Committee on Large Dams, China has built 87,000 reservoirs, all types, by the end of 2006, of which more than 500 are large reservoirs, more than 3,200 medium-sized reservoirs, and about 83,300 small reservoirs. Zhao Chun, Jia Jinsheng, Zheng Cuiying, Xia Lianqiang, Wenpeng, *Management System Development of Dangerous Reservoirs in China & Preliminary Statistics Analysis of Distress Causes*, Beijing: Chinese National Committee on Large Dams (CHINCOLD), (accessed on 26 March 2012) The World Commission on Dams Report, 2000, estimates the total number of dams in China at 22,000.
8. World Commission on Dams, *Dams and Development: A New Framework for Decision Making*, London: Earthscan Publications Ltd, 2000, p.9.
9. "China sets 2012 hydropower target for rural areas," *Interfax China*, 7 June 2012. <http://www.interfax.cn/news/20356>, (accessed on 19 November 2012)
10. World Commission on Dams, op.cit., (ref.8), p.13.
11. Ibid., p.17.
12. *Better Management of Indus Basin Waters — Strategic Issues and Challenges*, Islamabad, World Bank, 2006. <http://siteresources.worldbank.org/INTPAKISTAN/Data%20and%20Reference/20805819/Brief-Indus-Basin-Water.pdf>, (accessed on 8 March 2013)
13. World Commission on Dams, op.cit., (ref.8), p.13.
14. Ibid., p.xxix.
15. China: Lower water availability and uneven distribution of water. *Global Water Partnership China*, <http://www.gwp.org/en/gwp-in-action/China/>, (accessed on 08 December 2012).
16. Peter H. Gleick, "China and Water," in Peter H. Gleick, Heather Colley, Michael J. Cohen, Mari Morikawa, Jason Morrison and Meena Palaniappan, (ed.), *The World's Water 2008-2009: The Biennial Report on Freshwater Resources,* Washingon DC: The Pacific Institute for Studies in Development, Environment and Security: 2009, pp. 84-85. <http://www.worldwater.org/data20082009/ch05.pdf>, (accessed on 10 December 2012).
17. Wang Ying, "Drought nationwide problem now," *China Daily*, Beijing, 21 December 2007. <http://www.chinadaily.com.cn/china/2007-12/21/content_6337847.htm>, (accessed on 22 September 2012)

18. "Flooded China warns of heat, drought — and snow?," *China Daily*, 2 August 2007. <http://www.chinadaily.com.cn/china/2007-08/02/content_5447658.htm>, (accessed on 22 September 2012)
19. Xie Chuanjiao, "Warming Takes toll on water resources," *China Daily*, 11 May 2007. <http://www.chinadaily.com.cn/china/2007-11/05/content_6229698.htm>, (accessed on 22 September 2012).
20. "Conserving and Protecting Water Resources," *Ministry of Water Resources*, The People's Republic of China. <http://www.mwr.gov.cn/english/cpws.html>, (accessed on 26 March 2012).
21. "Total Production of energy and its composition," *China Statistical Year Book, 2011*, <http://www.stats.gov.cn/tjsj/ndsj/2011/indexeh.htm>, (accessed on 19 August 2012)
22. Gang Chen, *China's Climate Policy*, Volume 24 of China Policy Series, New York: Routledge, 2012, p.61.
23. "Report says worldwide development of hydroelectric power slow in 2011," *Hydroworld.com*, Washington DC, 13 February 2013. <http://www.hydroworld.com/articles/2013/02/reports-says-worldwide-development-of-hydroelectric-power-slow-i.html>, (accessed on 15 February 2013).
24. "Water Resources Assessment of Qiantang River Basin," China: Country Policy Support Programme (CPSP), New Delhi: International Commission on Irrigation and Drainage, 2005, p. 2. <http://www.icid.org/cpsp_report5_web.pdf>, (accessed on 20 October 2012).
25. Bryan Tilt, Yvonne Braun, Daming He, "Social Impacts of Large Dam Project: A comparison of international case studies and implications for best practice," *Journal of Environmental Management*, Volume 90, July 2009, p.S253. <http://oregonstate.edu/cla/anthropology/sites/default/files/pdf/faculty/tilt/tilt_et_al_sia_dams.pdf>, (accessed on 27 November 2012).
26. Zhang Lubiao, "Social Impacts of Large Dams: The China Case," Thematic Review 1.1, Working paper of the World Commission on Dams. <http://www2.wii.gov.in/eianew/eia/dams%20and%20development/kbase/contrib/opt124.pdf>, (accessed on 27 March 2012).
27. Shui Fu, *A Profile of Dams in China*, 24 October 2007, International Rivers: Berkeley. <http://www.internationalrivers.org/files/attached-files/a_profile_of_dams_in_china.pdf>, (accessed on 10 November 2012).
28. Jin Jung, "Displacement, Resettlement, Rehabilitation, Reparation and Development," China Report, Thematic Review I.3, *World Commission on Dams*, South Africa, 1999, p.4.
29. Zhandong Sun, Qun Huang, Christian Opp, Thomas Hennig and Ulf Marold, "Impacts and Implications of Major Changes Caused by the Three Gorges Dam in the Middle Reaches of the Yangtze River, China, *Water Resources Management*, Springer online, 30 May 2012.
30. Nan Zhang, Hong Mou He, Shao Feng Zhang, Xiao Hui Jiang, Zi Qiang Xia and Feng Huang, "Influence of Reservoir Operation in the Upper Reaches of the Yangtze River (China) on the Inflow and Outflow Regime of the TGR-based on the Improved SWAT Model, *Water Resources Management*, Springer online, November 2011.
31. R Edward Grumbine, John Dore, and Jianchu Xu, "Mekong hydropower: Drivers of change and governance challenges," *Frontiers in Ecological Environment* 2012, Volume 10, No.2, p.91. <http://www.esa.org/pdfs/Grumbine.pdf>, (accessed on 27 November 2012).
32. Liu Yiyu, "Alstom boosts hydropower investment in China," *China Daily*, 02 August 2012. <http://www.chinadaily.com.cn/business/2012-08/02/content_15640371.htm>, (accessed on 19 February 2012).
33. "China completes world's largest hydropower unit," *China Daily*, 13 July 2012. <http://www.chinadaily.com.cn/business/2012-07/13/content_15578435.htm>.
34. "China sets 2012 hydro targets for rural areas," *Interfax China,* 7 June 2012. <http://www.interfax.cn/news/20356>, (accessed on 19 August 2012).

35. *Annual Report, 2007-2008*, Ministry of Water Resources, People's Republic of China, p.29. <http://www.mwr.gov.cn/english/Publications.html>, (accessed on 19 November 2012).
36. Shurong Zhang, Xi Xi Lu, David L. Higgitt, Chen-Tung Arthur Chen, Jingtai Han, Huiguo Sun, "Recent changes of water discharge and sediment load in the Zhujiang (Pearl River) Basin, China," *Global and Planetary Change,* 60, 2008, pp. 365–380. <http://www.mgac.nsysu.edu.tw/ctchen/Publications/A/226.pdf>, (accessed on 20 November 2012).
37. Tao Yang, Qiang Zhang, Yongqin David Chen, Xin Tao, Chong-yu Xu, Xi Chen, "A spatial assessment of hydrologic alteration caused by dam construction in the middle and lower Yellow River, China," *Hydrological Processes*, Volume 22, Issue 18, 30 August 2008, pp.3829–3843.
38. Qiang Zhang, Vijay P. Singh, Xiaohong Chen, "Influence of Three Gorges Dam on stream flow and sediment load of the middle Yangtze River, China," *Stochastic Environmental Research and Risk Assessment*, May 2012, Volume 26, Issue 4, pp.569-579.
39. Kehui Xu, John D. Milliman, "Seasonal Variations of Sediment Discharge from the Yangtze River before and after impoundment of the Three Gorges Dam," *Geomorphology* No. 104, 2009, p.277. <http://ww2.coastal.edu/kxu/Geomorphology09.pdf>, (accessed on 2 July 2012)
40. Zhandong Sun, et al., op.cit., (ref.29), 2012.
41. Ibid.
42. Ibid.
43. "China declares Three Gorges hydro project complete," Reuters, 4 July 2012. <http://www.reuters.com/article/2012/07/04/china-threegorges-idUSL3E8I42ZW20120704>, (accessed on 11 March 2013).
44. The State Council Executive Meeting Discusses and Passes the "Three Gorges Post-Project Plan", Translated by *Probe International*, 18 May 2011. <http://laep.ced.berkeley.edu/3gd/docs/StateCouncil_Mea%20Culpa_2011.pdf>, (accessed on 26 November 2012).
45. Darrin Magee, "Moving the River? China's South–North Water Transfer Project," in Brunn, Stanley D. (Ed.), *Engineering Earth: The Impacts of Mega-engineering Projects*, Netherlands: Springer, 2011, p.1508-1510.
46. Bin Kang, Lisa Perrett, Yungang Li, Daming He, "Are the fish of the upper and lower Mekong interconnected?," *Chinese Journal of Oceanology and Limnology*, Volume 27, Issue 2, May 2009, pp.400-407. <http://lancang-mekong.org/Asian_en/Asian_show_cn.asp?ID=339&classID=131>, (accessed on 17 December 2012).
47. S.B. Dai, S.L. Yang, A.M. Ca, "Impacts of dams on the sediment flux of the Pearl River, southern China," *Catena*, Volume 76, Issue 1, 15 December 2008, pp.36–43. <http://dx.doi.org/10.1016/j.catena.2008.08.004>, (accessed on 7 December 2012).
48. Cui Peng, Han Yongshun, Dang Chao and Chen Xiaoqing, "Formation and Treatment of Landslide Dams Emplaced During the 2008 Wenchuan Earthquake, Sichuan, China," in *Natural and Artificial Rockslide Dams*, Volume 133 of Lecture Notes in Earth Sciences, Berlin: Springer, pp.295-321.
49. Ubiao Zhang, "Social Impacts of Large Dams: The China Case," Thematic Review Paper for Report on Dams and Development, Thematic Review I.1; "Social impact of large dams: Equity and distributional issues," World Commission on Dams, South Africa, 1999, pp.xi-xiii. <http://www.docin.com/p-415031944.html>, (accessed on 4 July 2012).
50. "China declares Three Gorges hydro project complete, op.cit., (ref.43).
51. "Three Gorges Dam determined to rectify financial problems," *China Daily*, 24 May 2011. <http://www.chinadaily.com.cn/cndy/2011-05/24/content_12564883.htm>.
52. Tilt, et.al., op.cit., (ref.25), p.S254.

53. "Three Gorges dam to displace 20,000," Reuters, 18 April 2012. <http://www.iol.co.za/business/international/three-gorges-dam-to-displace-20-000-1.1279105>, (accessed on 27 November 2012).
54. Darrin Magee, op.cit., (ref 45), pp.1508-1510.
55. Prime Sarmiento, "Environment — China: What Makes A Good Dam?," interview with the Chinese environmentalist Yu Xiaogang, *Inter press Service*, 7 September 2009. <www.ipsnews.net/2009/9/>, (accessed on 27 November 2012).
56. He Daming, Zhao Wenjuan, Feng Yan, "Research Progress of International Rivers in China," *Journal of Geographical Sciences*, Volume 14, Issue 1, July 2004, p.22.
57. Panchali Saikia, "China's Longjiang Dam: Concerns for Myanmar," *Eurasia Review and Analysis*, 15 January 2011. <http://www.eurasiareview.com/15012011-china%e2%80%99s-longjiang-dam-concerns-for-myanmar/>, (accessed on 26 November 2012).
58. Grumbine, et.al., op.cit., (ref.31).
59. Matti Kummu, X.X. Lu, J.J. Wang, and Olli Varis, "Basin-wide sediment trapping efficiency of emerging reservoirs along the Mekong," *Geomorphology*, Issue 119, 2010, p.181. <http://www.academia.edu/2289839/Basin-wide_sediment_trapping_efficiency_of_emerging_reservoirs_along_the_Mekong>, (accessed on 28 November 2012).
60. Timo A. Räsänen, Jorma Koponen, Hannu Lauri, Matti Kummu, "Downstream Hydrological Impacts of Hydropower Development in the Upper Mekong Basin, *Water Resources Management*, September 2012, Volume 26, Issue 12, Springer, p.3495.
61. Darrin Magee, "The Dragon Upstream: China's Role in Lancang-Mekong Development," in Joakim Öjendal, Stina Hansson, Sofie Hellberg, (Eds.) *Politics and Development in a Transboundary Watershed: The Case of the Lower Mekong Basin*, The Netherlands: Springer, 2012, p.6.
62. "Parting the Waters," *China Economic Review*, Hong Kong, 1 April 2012. <http://www.chinaeconomicreview.com/node/56995>, (accessed on 10 December 2012).
63. Magee, op.cit, (ref.61), p.21.
64. Ibid., p.1510.
65. He Daming, Zhao Wenjuan, Feng Yan, "Research Progress on International Rivers in China," *Journal of Geographical Sciences*, Volume 14, Issue 1, July 2004, p.25.
66. Jun Jing, "Displacement, Resettlement, Rehabilitation, Reparation and Development — China Report," *Thematic Review I.3*, South Africa: World Commission on Dams, 1999, p.6.
67. "India, Country Paper on Water Security," Central Water Commission, Ministry of Water Resources, Government of India, New Delhi, June 2011, p.1. <http://www.indiaenvironmentportal.org.in/files/file/Water%20Report%20-INDIA.pdf>, (accessed on 10 January 2013).
68. "Per capita water availability," Press Information Bureau, Ministry of Water Resources, Government of India. <http://pib.nic.in/newsite/erelease.aspx?relid=82676>, (accessed on 10 January 2013).
69. "Water Storage Capacity," Press Information Bureau, Ministry of Water Resources, Government of India. <http://pib.nic.in/newsite/erelease.aspx?relid=83836>, (accessed on 10 January 2013).
70. India, AQUASTAT — Food and Agricultural Organisation, "Water Report 37, 2012", <http://www.fao.org/nr/water/aquastat/countries_regions/IND/index.stm>, (accessed on 18 August 2012).
71. "India: Country Paper…," op.cit., (ref.67), p.1.
72. Water and Related Statistics, Chapter 5, *Integrated Hydrological Data book*, Central Water Commission, New Delhi, March 2012, p.45. <http://www.cwc.nic.in/main/webpages/HBA.pdf>, (accessed on 16 February 2013).

73. National Water, Policy, 2002 and National Water Policy 2012, Ministry of Water Resources, Government of India, <http://wrmin.nic.in>, (accessed on 16 February 2013).
74. "India, Country Paper…," op.cit., (ref.67).
75. State-wise distribution of large dams — Abstract, *National Register of Large Dams*, Government of India, 2012. <http://www.indiaenvironmentportal.org.in/files/file/National%20Register%20of%20Large%20Dams%202012.pdf>, (accessed on 27 December 2012).
76. "India speeds up work on 200 dams," *The Asian Age*, New Delhi, 12 February 2013.
77. Ravi Hemadri and Harsh Mander, "Dams, Displacement, Policy and Law in India," Thematic Review 1.3: *Displacement, Resettlement, rehabilitation, reparation and development*, 2000, Cape Town: World Commission on Dams, <http://unpan1.un.org/intradoc/groups/public/documents/APCITY/UNPAN021311.pdf>, (accessed on 22 December 2012).
78. Mukuteswara Gopalakrishnan, "Resettlement and Rehabilitation: Lessons from India," In C. Tortajada, et al., (ed.) *Impacts of Large Dams: A Global Assessment*, Water Resources Development and Management, 2012, p.358.
79. Neeraj Vagholikar, "Dams and Environmental Governance in North-east India," in *India Infrastructure Report 2011*. IDFC-Infrastructure Finance Company, Investment Banking and India Infrastructure Development, p.360.
80. State-wise distribution of Large Dams, op.cit., (ref.75).
81. R. Rangachari, Nirmal Sengupta, Ramaswamy R. Iyer, Pranab Banerji, and Shekhar Singh, "Some Agreed Conclusions – Large Dams in India, draft paper for The World Commission on Dams, 2000." (accessed by requesting one of the authors).
82. "Hydroelectric Power," Ministry of Water Resources, Government of India. <http://wrmin.nic.in/index2.asp?sublinkid=407&langid=1&slid=313>, (accessed on 16 February 2013).
83. *Mountains of Concrete: Dam-Building in the Himalayas*, International Rivers, USA, 2008, p.7.
84. "Report on Economic Impact of Interlinking of Rivers Programme," *National Council of Applied Economic Research*, India, April 2008, p.xiii. <http://www.indiaenvironmentportal.org.in/files/99.pdf>, (accessed on 11 July 2011).
85. Esther Duflo and Rohini Pande, "Dams, Centre Discussion Paper No.923," August 2005, Yale University USA: *Economic Growth centre*, p.3. <http://www.econ.yale.edu/growth_pdf/cdp923.pdf>, (accessed on 29 December 2012).
86. Himanshu Thakkar, "Contribution of Large Dams in Food Production, Food Security in India," SANDRP Paper, March 2000, Delhi: South Asia Network on Dams, Rivers and People, <http://www.sandrp.in/irrigation/lrg_dam_contri.pdf>, (accessed on 27 December 2012).
87. Swati Mollah, "Flood Control Policies In India — How Far We Are?," *Golden Research Thoughts*, Volume 2, Issue, 1 July 2012, p.2. <www.aygrt.net>, (accessed on 20 December 2012).
88. Naresh Mitra, "Excessive rain, melting glaciers causing deluge," *The Times of India*, 11 July 2012.
89. *Draft National Water Policy, 2012*, Ministry of Water Resources, Government of India. <http://mowr.gov.in/writereaddata/linkimages/DraftNWP2012_English9353289094.pdf>, (accessed on 16 February 2013).
90. *Report on Economic Impact of Interlinking of Rivers Programme*, National Council of Applied Economic Research, India, April 2008, p. xiii. <http://www.indiaenvironmentportal.org.in/files/99.pdf>, (accessed on 11 July 2011)
91. Neeraj Vagholikar, op.cit., (ref.79), p.363.
92. Ibid., p.365.

93. Jiten Yumnam, *An Assessment of Dams in India's Northeast: Seeking Carbon Credits from Clean Development Mechanism of the United Nations Framework Convention on Climate Change*, Manipur: Citizen's Concerns for Dams and Development, February 2012.
94. Jason Newton, "Displacement and Development: The paradoxes of India's Tehri Dam," *The Geographical Bulletin*, No. 49, Gamma Theta Upsilon, 2008, pp.19-32.
95. MJ Peterson, "Narmada Dams Controversy – Case Summary," *International Dimensions of Ethics Education in Science and Engineering*, Case Study Series, Version 1; September 2010. <http://scholarworks.umass.edu/cgi/viewcontent.cgi?article=1015&context=edethicsinscience>, (accessed on 16 February 2013).
96. Clause IV (6) of the Narmada Water Disputes Tribunal Award states that "in no event shall any areas in Madhya Pradesh and Maharashtra be submerged under the Sardar Sarovar Project unless all payments of compensation and costs are made for acquisition of land and arrangements are made for rehabilitation." This clause has served as the centerpiece for litigation by the Narmada Bachao Andolan (NBA); *The Narmada Valley Project*, Center of Excellence in Environmental Economics, Madras School of Economics, Ministry of Environment and Forests, India. <http://coe.mse.ac.in/nm.htm>, (accessed on 20 February 2013).
97. Hemadri and Mander, op.cit., (ref.77).
98. Neeraj Vagholikar, op.cit., (ref.79).
99. Hemadri and Mander, op.cit., (ref.77).
100. Suresh Chandra, India: Flood Management — Damodar River Basin, *Global Water Partnership* — Associated Programme on Flood Management, December 2003. <http://www.apfm.info/pdf/case_studies/india.pdf>, (accessed on 19 February 2013).
101. Kumkum Bhattacharyya, *The Lower Damodar River, India*, New York: Springer, 2011, pp.120-121.
102. *Mountains of Concrete: Dam-Building in the Himalayas*, International Rivers, USA, 2008, pp.24-27.
103. Neeraj Vagholikar and Patha J. Das, "Damming Northeast India," India Environment Portal, 2010, pp.6-9. <http://www.indiaenvironmentportal.org.in/files/Damming%20Northeast%20India_%20Kalpavriksh_%20Aaranyak_ActionAid%20India_2010.pdf>, (accessed on 18 February 2013).
104. Barry Sadler, Iara Verocai and Frank Vanclay, *Environmental and Social Impact Assessment for Large Dams*, World Commission on Dams, South Africa, November 2000, p.24. <http://www.agsci.utas.edu.au/WCDreportEIA%26dams.pdf>, (accessed on 19 February 2013).
105. Ann Kathrin Schneider, *SJVN: well equipped to develop the Rampur project*? International Rivers Network, USA, July 2005. <http://www.internationalrivers.org/files/attached-files/nathpa_jhakri_rampur.pdf>, (accessed on 20 February 2013).
106. *The Silent Valley River Project*, Centre of Excellence in Environmental Economics, Madras School of Economics, Ministry of Environment and Forests, India. <http://coe.mse.ac.in/si.htm>, (accessed on 20 February 2013).
107. *Teesta River*, International Rivers, USA. <http://www.internationalrivers.org/campaigns/teesta-river>, (accessed on 24 February 2013).
108. "Indira Sagar Polavaram Project Back in the limelight," Projects Monitor, India, 19 July 2011. <http://www.projectsmonitor.com/IRRIGATION/indira-sagar-polavaram-project-back-in-the-limelight>, (accessed on 21 February 2013).
109. *The Narmada Valley Project*, op.cit., (ref.96).
110. "MP: 32 Sq Km Forest Cover Lost Due to Narmada Dam," *Outlook*, India, 17 December 2010.
111. International River Basin Register, Table of Basins, Institute for Water and Watersheds, Oregon State University, updated August 2012. <http://www.transboundarywaters.orst.edu/publications/register/tables/IRB_asia.html>, (accessed on 26 February 2013).

112. Aaron T. Wolf, Jeffrey A. Natharius, Jeffrey, J. Danielson, Brian S. Ward, Jan K. Pender, "International River Basins of the World," *International Journal of Water Resources Development*, Vol.15 No.4, December 1999. <http://www.transboundarywaters.orst.edu/publications/register/register_paper.html>, (accessed on 26 February 2013).
113. *"Avoiding Water Wars: Water Scarcity and Central Asia's Growing Importance for Stability in Afghanistan and Pakistan*," A Majority Staff Report, Committee on Foreign Relations, United States Senate, Washington, 112th Congress First Session, 22 February 2011.
114. *"Hydro Development Plan for 12th Five-Year Plan (2012-2017)*," Central Electricity Authority- Hydro planning and Investigation Division, Government of India, New Delhi, September 2008, <http://www.cea.nic.in/reports/hydro/hydro_develop_12th_plan.pdf>, (accessed on 2 July 2011).
115. United Nations Environment Programme, *Global International Waters Assessment - Challenges to Regional Waters: Regional Assessments in a Global Perspective*, UNEP, Kenya, 2006, p.25.
116. "Tipaimukh High Dam," *International Rivers*, USA. <http://www.internationalrivers.org/resources/tipaimukh-high-dam-3499>, (accessed on 27 February 2013).
117. Khurshid expects resolution of Teesta issue in 7 months, *The Financial Express*, Dhaka, 18 February 2013.
118. Dr. Shastra D. Pant, "Nepal: India's Alarming Harassments through embankment construction," *Telegraph Nepal*, 15 August 2012. <http://www.telegraphnepal.com/national/2012-08-15/nepal:-indias-alarming-harassments-through-embankment-construction>, (accessed on 26 February 2013).
119. Hari Man Shrestha, "River-Linking Concept of India Viewed from the Nepalese Perspective," in Dwarika Nath Dhungel, Santa B. Pun (ed.), *The Nepal-India Water Resources Relationship: Challenges,* New York: Springer, 2009, pp.227-231.
120. Md. Khalequzzaman, *The Indian River-linking Project: A Geologic, Ecological, and Socio-economic Perspective*, Blogs — Water Resources Engineering Forum (WRE), 28 July 2012. <http://wreforum.org/khaleq/blog/4971>, (accessed on 24 February 2013) Also see Md. Khalequzzaman, *Upstream Control of Waters in the G-B-M Basin and potential Impacts on Bangladesh*, Lock Haven University, USA, 2006. <http://www.lhup.edu/mkhalequ/research/IndianRiverLinking_IFC_2006.pdf>, (accessed on 24 February 2013).
121. Md. Khalequzzaman, *Large Dams in NE India and Implications for Bangladesh*, Lock Haven University, USA. <http://www.lhup.edu/mkhalequ/research/Dams%20in% 20NE%20India-Implications%20for%20Bangladesh.pdf>, (accessed on 24 February 2013).
122. According to the report , "India needs to raise global awareness on why the waters in the Tibet region matter to the almost 2 billion lower riparian people living in the Subcontinent and the Southeast Asia region in terms of livelihood and survivability, thereby underlining water resources as a 'commons' and not just for the consumptive use of China." *Water Security for India: The External Dynamics,* IDSA Task Force Report, Institute for Defence Studies and Analyses, New Delhi, 2010, p.50.
123. Mihir Shah, "Bill for land gives true value," *The Hindu*, 13 September 2012.
124. *Social Impact Assessment - National Resettlement and Rehabilitation Policy, 2007*, Section 4.1, Department of Land Resources, Ministry of Rural Development, Government of India, New Delhi, <http://dolr.nic.in/dolr/actandrule.asp>, (accessed on 4 March 2013)
125. Mihir Shah, Bill for land gives true value, *The Hindu*, 13 September 2012.
126. "SC to take final decision on Narmada rehabilitation," *The Times of India*, 11 March 2008.

127. Ramaswami R. Iyer, *Water Perspectives, Issues, Concerns*, New Delhi: Sage publications, 2003, pp.66-68.
128. Ibid., pp.71-72.
129. Samir Mehta, "India's Dam Boom: Small Not Always Beautiful," *International Rivers,* Berkeley, 18 July 2011. <http://www.internationalrivers.org/blogs/257/india-s-dam-boom-small-not-always-beautiful>, (accessed on 9 March 2013).
130. *China 2030- Building a Modern, Harmonious and Creative High-Income Society*, Conference Edition, The World Bank Development Research Center of the State Council, the People's Republic of China, Washington: The World Bank, 2012, p.4, <http://www.worldbank.org/content/dam/Worldbank/document/China-2030-complete.pdf>, (accessed on 4 July 2012).
131. Jan Willem van Gelder, Frank van der Valk, Jan Maarten Dros, Janette Worm, *The Impacts and Financing of Large Dams*, WWF International - Living Waters Programme, November 2002. <http://awsassets.panda.org/downloads/aidenvdamfinancereport.pdf>, (accessed on 11 March 2013).
132. Ibid.
133. "Ecological Protection and Construction, White Paper on Environmental Protection in China (1996-2005)," *China News and Report*, June 2006. <http://www.china.org.cn/english/2006/Jun/170355.htm>, (accessed on 12 March 2013).
134. Ibid.
135. China to spend US$30 bln more on afforestation by 2021, *China News and Report*, 18 August 2010 <http://www.china.org.cn/environment/2010-08/18/content_20739051.htm>.
136. Gov't invests big in water pollution control, *China News and Report*, 29 February 2012. <http://www.china.org.cn/environment/2012-02/29/content_24758528.htm>.
137. "China invests heavily in water conservation," *China News and Report*, 31 January 2012. <http://www.china.org.cn/environment/2012-01/31/content_24515269.htm>, (accessed on 12 March 2013).
138. China's subsidies to reservoir migrants hits $15.84b, Xinhua News Agency, 7 November 2012. <http://china-wire.org/?p=24742>, (accessed on 14 March 2013).
139. "Govt plans for output losses due to climate change," *China Daily*, 28 December 2010.
140. Xiaoyi Jiang, *Legal Issues for Implementing the Clean Development Mechanism in China*, New York: Springer, 31 May 2012, p.207.
141. "China, India and climate change: Melting Asia," *The Economist*, London, June 2008.
142. From the 1980s, China started practicing the policy of allocating a percentage of revenue from the sale of electricity not just for financing resettlement costs but also to address previous resettlement issues. Thayer Scudder, *The Future of Large Dams: Dealing with Social, Environmental, Institutional and Political Costs*, London: Earthscan, 2005.
143. M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson (eds.), "The Himalayan Glaciers," *IPCC Fourth Assessment Report: Climate Change 2007*: Working Group II: Impacts, Adaptation and Vulnerability, Cambridge University Press, Cambridge, United Kingdom and New York, USA.
144. Dirk Scherler, Bodo Bookhagen and Manfred R. Strecker, "Spatially variable response of Himalayan glaciers to climate change affected by debris cover," *Nature Geoscience*, 23 January 2011. <http://www.nature.com/ngeo/journal/v4/n3/full/ngeo1068.html>, (accessed on 16 March 2013). Also see Kenneth Hewitt, "Glacier Change, Concentration, and Elevation Effects in the Karakoram Himalaya, upper Indus Basin," *Mountain Research and Development*, June 2011.
145. M. Sharif, D.R. Archer, H.J. Fowler, and N.Forsythe, "Trends in timing and magnitude of flow in the Upper Indus Basin," *Hydrology and Earth System Sciences Discussions*, 9, 9931–9966, 2012.

146. *Annual Plan, 2011-2012*, Planning Commission, Government of Pakistan, Islamabad, p.147.
147. "Tarbela desilting to be costlier than new dam," *Dawn*, 7 January 2013.
148. Power Issues: Government willing to hook up with India, *The Express Tribune*, Islamabad, 2 November 2011.
149. Kenneth Hewitt, "Gifts and Perils of Landslides," *American Scientist*, Volume 98, 2010, pp.410-419.
150. Resettlement in the Pakistan Ghazi-Barotha Hydropower Project, The World Bank, Washington, D.C. (publication date unavailable). <http://siteresources.worldbank.org/INTINVRES/214574-1115363218432/20480138/ResettlementPakistanGhaziBarothaHydropowerProjectCaseStudy.pdf>, (accessed on 16 March 2013).
151. Dr. Shahid Ahmad, *Pakistan Water Apportionment Accord for Resolving Inter-Provincial Water Conflicts — Policy Issues and Options*, International Union for Conservation of Nature and Natural Resources, IUCN Pakistan, Karachi, 2010, p.8. <http://cmsdata.iucn.org/downloads/pk_ulr_d4.pdf>, (accessed on 18 March 2013)
152. Neeraj Vagholikar, op.cit., (ref.79), pp.367-368.
153. Matt McGrath, "Reservoirs can make local flooding worse, says study," BBC News, 14 December 2012. <http://www.bbc.co.uk/news/science-environment-20663875>, (accessed on 22 December 2012).
154. Amrita Patwardhan, "Dams and tribal people in India," Paper prepared for *Thematic Review 1.2*, World Commission on Dams, South Africa, 2000, p.10.
155. M.K. Goel, Sharad K. Jain, and P.K. Agarwal, "Assessment of Sediment deposition rate in Bargi Reservoir using digital image processing," *Hydrological Sciences Journal*, 47(S) August 2002, p.82.
156. Jack D. Ives and Bruno Messerli, *The Himalayan Dilemma — Reconciling Development and Conservation,* The United Nations University, New York: Routledge, 1989.
157. Kirk Leech, "The Narmada dambusters are wrong," *The Guardian*, London, 3 March 2009. <http://www.guardian.co.uk/commentisfree/2009/mar/03/india-narmada-dams>, (accessed on 21 February 2013).