Executive Summary

Project on "Water and Security in South Asia" (WASSA)

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Project on "Water and Security in South Asia" (WASSA)

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  *The views expressed herein do not necessarily represent those of the U. S. Government.

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PREFACE

More than 1.3 billion people live in South Asia. Almost half of these depend on river systems for their water needs. Many of these major rivers, some of which are amongst the world's largest, flow across national borders and have been a source of tension in the region. At times, when the snow melts in the Himalayas, or during the monsoon, there is too much water, and frequent floods. At other times, there is too little water available, and intense competition for it arises between countries, and between upstream and downstream provinces or states even within the same country.

In the western part of the sub-continent, the waters of the Indus basin are shared by Pakistan and India. In the North and Northeast, the basins of the Ganges, Brahmaputra, and Meghna are shared by India, Nepal, Bhutan, and Bangladesh, and in some areas by China. Although some arrangements presently exist to share the waters between the respective countries, their implementation has not always been satisfactory, and there is a widespread perception that these arrangements could be inadequate in times of increased water scarcity.

There are also disputes within India and within Pakistan regarding the equitable distribution of water between the states or provinces. As the populations of the countries increase, and water availability declines, tensions over water rights are likely to increase as well.

The project on "Water and Security in South Asia" focuses on the critical issues mentioned above. It has several goals:

- Identification of the key issues regarding water resources in the subcontinent;

- An examination of the provisions of the Indus Water Treaty of 1960 between India and Pakistan, and the other water Treaties or Agreements critical to the region;
- Identifying approaches to water conflict issues within and between the countries of South Asia that could be used throughout the region;
- Examining some of the climate change and investment aspects of water availability that could affect the future availability of water in the region.

The Carnegie Corporation of New York has identified water availability as a priority area for its Program. In his report to the Board of the Corporation, President Vartan Gregorian has pointed out that ”Much less heed is being given to the most basic human need ---- water. In 1996, the United Nations Development Programme reported that there were ten countries in the world, largely in Africa, where more than half the population did not have access to potable water. The sharing of water resources has the potential of bringing rival nations together in common cause, just as the manipulation of the water supply by those who control it can lead to conflict and violence, as we already see in the Middle East and could witness in Asia and Africa”. In keeping with this priority, the Carnegie Corporation of New York provided the funding for the WASSA project.

Issues relating to a resource as critical as water can obviously only be negotiated by the various governments themselves. Projects like WASSA could make several important contributions such as:

- Highlight the issues through a regional prism;
- Offer constructive alternatives to conflict in addressing the critical issue of water, whereas governments in the subcontinent have largely tended to focus on these issues in the shadow of conflict;

- Create a joint stake in the solution of issues relating to water through creative thinking on future actions by experts who understand the political world that shapes decisions;
- Deal with questions of trust which influences the entire range of water as well as other important issues in South Asia;
- Create conditions for cooperation through the development of a network of technical experts placed to make a difference with their respective governments.

Teams consisting of persons from Bangladesh, India, Nepal, and Pakistan have prepared the reports of the WASSA project. Consultants based in South Asia, Japan and the USA have provided additional input. The participants met several times during the project in working groups as well as in Workshops for the whole team.

The project work has been carried out under the following themes:

- Gaps between water demand and supply;
- Approaches to meeting the gaps;
- Water sharing conflicts within countries and possible solutions;
- Water sharing conflicts between countries and possible solutions;
- Possible impacts of global climate change on water availability;
- Investment requirements for enhancing water supply.

Participants from each of the following organizations (and in one case, two eminent consultants) have taken the lead on one of the above topics, and have provided input in other areas:

- Bangladesh Unnayan Parishad (BUP);
- Economic Development Consultants (EDC), Pakistan;
- Jalsrot Vikas Sanstha (JVS), Nepal;
- Nepal Water Conservation Foundation (NWCF);

- Pakistan Institute for Environment-Development Action Research (PIEDAR);
- Trust for Water, Environment and Development Studies (TWEDS), Bangladesh;
- Water and Power Consultancy Services (I) (WAPCOS), India;
- Dr. M. S. Reddy and Mr. N. V. V. Char, India.

Dr. James E. Nickum (TJK College, Japan), Dr. Murari Lal (India), Dr. Amir Muhammed (Pakistan), Mr. P. B. Shrestha and Dr. H. M. Shrestha (Nepal), and Mr. George Verghese (India) have made valuable contributions to individual volumes.

Although we have listed the participating organizations above, the views expressed in this and other reports of the WASSA project are those of the individual authors, and not necessarily those of their organizations. In most cases, the views expressed in the Reports reflect those of all the authors of that Report. In a few cases, the authors had differing opinions that have been identified as such.

Distinguished persons with close links to policymakers in the four countries are serving as Policy Advisors for the project. They are:

- Major-General Mahmud Durrani (Pakistan), former Chairman, Pakistan Ordnance Factories Board;
- Mr. Salman Haidar (India), former Foreign Secretary, Government of India;
- Mr. Farooq Sobhan (Bangladesh), former Foreign Secretary, Bangladesh;
- Ambassador Bhekh Thapa (Nepal), Ambassador of Nepal to India.

The Policy Advisors have given generously of their time and provided valuable input. The authors of the project reports have incorporated this input in the Final

Reports. These are being printed in three volumes, covering the following major themes:

Water Demand-Supply Gaps and Approaches to Closing the Gaps;
Water Conflicts *within* Countries, and Approaches to resolving them;
Water Conflicts *between* Countries, and Approaches to resolving them;

The Final Drafts of the volumes were reviewed by water resource specialists not associated with the WASSA project. Input received from them, as well as from the project Conferences held in Islamabad in February 2003 and in New Delhi in September 2003, has been incorporated in the Final Reports. Some of the individual reports can be downloaded from the GEE-21 web site at <www.gee-21.org>.

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Project Coordinators
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1. INTRODUCTION

Water is a renewable resource, but a finite one. Only about 3% of the world's total water resource is fresh (not saline) water, of which roughly one-third is inaccessible. The rest is unevenly distributed. In many areas, the existing water resources are increasingly contaminated with wastes and pollution from industrial, agricultural and domestic sources. Over the years, rising population, growing industrialization, and expanding agriculture have led to a rising demand for water.

South Asia is one of the most densely populated regions of the world. It houses roughly one-fifth of the world's population, and this share is likely to increase to one-fourth of the total world population by the year 2025. The region is emerging as the poorest, the least literate, and the most malnourished region of the world. The per capita income in South Asia is lower than that of any other region, with only a 1.3% share of the global income. The region has 40% of the poorest people in the world.

Several social indicators illustrate the economic backwardness of the area. The level of education is one such indicator. With an adult literacy rate of 48%, nearly half of the world's illiterate population lives in South Asia. Despite the significant economic growth during the last few decades, including increases in food grain production, the region has the greatest number of malnourished children.

The economies of the countries in the region are heavily dependent on agriculture, which contributes about 40-50% of the Gross Domestic Product (GDP) and provides nearly 70% of the rural employment. A large proportion of the food grain production comes from irrigated agriculture, and irrigation is the major user of fresh water supplies in the region.

The main limitation to increasing the food production in the region is the availability of water. In the monsoon-dependent climate of the region, the amount of utilizable water for year round activities depends on the inter-seasonal transfer of water through storage above the ground as well as underground. Of the various measures necessary for economic development, water resources development is one of the most important. Cooperation between various countries of the region could greatly help in the sustainable development of critical water resources.

The project on "Water and Security in South Asia" (WASSA), which covers the countries of Bangladesh, India, Nepal and Pakistan, focuses on the security aspects of the region that are related to water. Security is defined in its broader context, including food availability, economic development, and long - term sustainability.

Protecting individuals and communities from the consequences of environmental decline is also a security issue. Water has been, and remains, one of the most persistent sources of tension at both the international and national levels. As an example, in view of the increasing gravity of the problems associated with water during a recent revision of the 1987 National Water Policy, India recognized water security as an over-riding national objective not only with regard to food security but also in its own right (MOWR, NWP, 2002).

India has also recognized that the community is the rightful custodian of water, and exclusive control by the government machinery would not help the cause of the community management of water resources. The National Water Management Plan (NWMP) of Bangladesh, an offshoot of the National Water Policy approved in 1988, has been formulated with food security as the top priority for a medium term strategy (WARPO, 2001).

Nepal is considered to be one of the least developed countries (LDCs) of the world. If managed properly, the abundant water resources potential of Nepal can alleviate poverty and contribute substantially to economic development, ensuring food security and the health of the country's population, as well as preserving vital ecosystems.

Pakistan is basically an agricultural country, most of which has an arid climate. Only 7 percent of its area has adequate rainfall, mainly in the form of monsoon rain during the three summer months of the year. As such, a densely settled Pakistan relies on rivers and groundwater for most of its water needs. Around 18 million hectares are irrigated by various sources, mainly canals and tube wells (GoP, Economic Survey, 2001).

From the above perspectives, an important element of the WASSA project's approach to identifying water security problems and needs is the estimation of demand-supply gaps and the elaboration of strategies to address these gaps. Large gaps, present or looming, are a clear indicator of water insecurity and, possibly, of a growing need to negotiate across sectors or hydrological or administrative boundaries for possible solutions.

2. CURRENT AND FUTURE WATER AVAILABILITY

In assessing the availability of water resources in the countries of the region, there are a number of data problems, including inconsistency in historical data because of changes in the technology of data collection, lack of access to some official data, wild guesses made in water use (both surface and ground water), and wide seasonal variations in the region's rainfall. Keeping all these factors in view, assessments of water availability have been made for countries of the region under study. The approximate water availability (surface water and ground water), in the four countries of the region is summarized in Table 1.

Table 1. Present availability of water in South Asia

Country	**Area (million ha)**	**Population (Million, 1998)**	**Average Annual Precipitation (mm)**	**Average annual water potential (Internal renewable resource) BCM**	**Average Annual Utilizable potential Surface water BCM**	**Total Ground water Resources potential BCM**	**Total utilizable ground water Resources potential BCM**	**Total Utilizable surface and ground water potential BCM**
Bangladesh	14.8	126	2,360	[@]373	[+]1,160	23	23	[+]1,183
India	329.0	980	1,170	1,870	690	432	396	1,086
Nepal	14.7	23	1,530	237	225	124-685	6-12	237
Pakistan	79.6	132	494	236[#]	180	56	56	236
Total	**438.1 (3.26%)**	**1,261 (21%)**	**[wa] 1,099**	**2,716 (6.8)**	**2,255**			**2,742**
World	**13,422.3**	**6,005**	**820**	**40,000**				

@ Excludes 1010 BCM of cross border flows and 340 BCM generated by local surface flows and 23 BCM by ground water flows; + includes cross border flows

 # Does not include 170.3 BCM of cross border surface flow from Afghanistan, China and India of Western Rivers of Indus, Chenab and Jhelum.

Figures in bracket show the percentage vis-à-vis the world totals

[wa] *Weighted average for WASSA Region*

Sources: GWP - SASTAC VISION documents; FAO Country papers; NCIWRDP report of India; World Bank, & WASSA Country Paper Drafts.

The deficiency or otherwise of water availability in different basins/regions is defined in the following way:

- Basins with fresh water resources of 1000 to 1600 cubic meters per capita per year are considered water stress zones with major problems occurring in drought years;
- Basins with renewable water resources of less than 1000 cubic meters per capita per year are deemed water scarce basins. In this threshold, water availability is considered a severe constraint on socio-economic development and environmental quality.
- Basins with renewable water resources of less than 500 cubic meters per capita are considered as absolute scarcity basins.

The per capita availability of water in the region is reducing progressively due to the increasing population in all countries of the region. The present situation in the four countries of the region for different population figures and projections for 2025 are illustrated in **Figure 1**.

Thus, considering each country as a whole, the total precipitation, the surface flows and dynamic groundwater, three of the countries ---Bangladesh, Nepal and India, are endowed with enough water that provides for a comfortable balance between “resource” and “requirement”, whereas Pakistan already has a water scarcity situation. Even for the other three countries, the total water availability numbers provides a somewhat distorted picture. In the case of Bangladesh and Nepal, the shortage is acutely felt in the lean season flows, particularly in the month of March. In the case of India, the shortages are felt in six river basins that are already water scarce or water stressed. This is shown in **Figure 2**.

Even in some of the basins in India where the availability of water is adequate, the rising population and food requirements are likely to lead to water scarcity by 2025. The water use and demand projections for various uses in India are shown

in **Figure 3**. The figure also shows the projected population and food requirement for the country in 2025.

The water demand supply gap by 2025 for each of the four countries is shown in Table 2.

Table 2. Projected water "Requirements" and Gaps (in billion cubic meters per year) in the four countries in 2025.

Country	**Total Water Required**	**Projected Water Availability**	**Projected Water Surplus /deficit (Gap)**
India	1,060	1,086	(+) 26
Pakistan	335	236	(-)102*
Bangladesh	48	1,181	(+)1,133
Nepal	40	232	(+)192

** includes flows at rim stations*

3. APPROACHES TO MEETING WATER SHORTAGES

There is a general tendency to overestimate future demand. This is a natural reflection of a "no regret" syndrome typical of most planners. Nonetheless, some river basins in India are clearly headed towards a gap between "demand" and "resource" in the next two decades unless action is taken. This is directly attributable to the large spatial variation in rainfall across the country. The temporal variation further exacerbates the gap in some of these basins. However, the situation is manageable if surface and ground water are handled as a unitary resource and managed scientifically.

In Pakistan, which is experiencing the fastest rate of population growth among the countries of South Asia and is also the most water-stressed country among them, renewable water resources have been exploited to the limit while remaining a largely agrarian economy. The country will have to adapt to water scarcity in the coming decades. Technical innovations in the water sector and related innovations in governance are essential for meeting the needs of the people and ensuring the security of their livelihoods. These innovations could also ease the transition to a sustainable industrial economy.

Given the above context, what is really critical is the "gap" between "demand" and "supply" at the consumer level. This gap has more to do with administering water than with its availability as a natural resource, at least in the WASSA time frame (up to 2025). The reasons for the supply-demand gap in the region are summarized below:

- Irrigated agriculture continues to be the dominant user of water, though demand for the other sectors is increasing;
- Greater food production is required to meet growing population needs;
- There is over - irrigation in some areas and under - irrigation in other areas in India and Pakistan.

- Presently the use of ground water and surface water is disjointed. These two resources are a unitary reserve and need to be managed accordingly;
- There is a gap in terms of quality as well as quantity, particularly for drinking water and sanitation;
- Even with enough water in the Ganges and Brahmaputra, its non-availability during the lean season is evident in India, Nepal and Bangladesh;
- The development of hydropower in Nepal, which could make a major contribution to economic development in the region, is still very low;
- The human element is a principal factor in the inefficiency in all sectors of water use, although it is hard to quantify;
- Property and use rights are often unclear, which may place obstacles in the way of water user organizations and the financial self-sufficiency of water distributors. Related gaps exist in governance and institutional reform, including greater participation of the public;
- The delay in the settlement of interstate and inter-provincial disputes on water sharing is also a cause for gaps, as in India and Pakistan.

The specific approaches towards reduction of these gaps could be broadly categorized under a four level strategy envisaged to achieve sustainable development. These are discussed below:

1. Increasing the efficiency of water use in all sectors, particularly irrigated agriculture and domestic & Industrial water supply, including technology improvements and participatory management. These would be at the micro- (farmed field, household), meso- (distributary, watercourse) and macro- (river basin, canal command, and urban district) scales. Measures to improve efficiency include: Introducing economic incentives, Operation and Maintenance (O&M) funding and related policies, revenue generation, storages (Surface water - major & minor, Ground water),

Diversion schemes, Renovation and Modernization of Projects, and the conjunctive use of surface and ground water;

2. Knowledge of innovations that enable the institutional reforms to happen such as sprinkler and drip irrigation, and Interbasin water transfers;
3. Reinforcement of the values for conservation and for community rights and responsibilities that drive the acquisition and application of knowledge, such as watershed management, catchment area treatment and soil conservation, and defined systems of water rights;
4. Governance & Institutional innovations that enable the new technologies to be widely adopted and applied - Integrated Water Resource Management (IWRM), private sector participation, and investments.

These options are discussed in detail in volume 1 of the WASSA Reports.

4. WATER SHARING CONFLICTS WITHIN COUNTRIES

4.1. Introduction

Water and Security are both subjects that have been studied a great deal. However the relationship between the two has not been explored as extensively. In this Section, we focus on water sharing conflicts within each of the four South Asian countries that are part of the WASSA project. The aim is to understand how laws, rights, administrative procedures, and customary practices for water sharing within Bangladesh, India, Nepal and Pakistan have enhanced or retarded the livelihoods and security of water users in various economic sectors across the States, Provinces, or regions of these countries, and what might be undertaken to improve the situation.

Water security in South Asia involves far more than rivers and aquifers flowing across national boundaries, although that is commonly where the discourse on security stops. In this report we argue that security begins at home, or at least on the farm, and that an investigation of the problems of water sharing within countries, at all scales, sheds light on and in many ways directly impacts transnational water sharing issues. It does so in at least two ways – directly and, we hypothesize, by resonating in a "fractal" way – problems and their solutions tend to replicate themselves at different levels of scale.

Directly, interstate or inter-provincial conflicts and differences in interest may play an important role in international conflict negotiation. For example, the 1996 agreement between Bangladesh and India over the sharing of the waters of the Ganges (Ganga) resulted in anxious protests from Uttar Pradesh and Bihar. There was a feeling that some kind of embargo would be imposed on the States in the future to restrict lean season utilization in their jurisdictions in order to maintain a certain minimum flow at Farraka. Similarly, what may seem a wholly internal conflict between Punjab and Sindh in Pakistan, exacerbated by the

recent droughts, takes place against a backdrop of accusation that the Indus Waters Treaty of 1960 favored the Punjab against Sindh.

Because of the salience of water issues between the States or Provinces and the consequent availability of information on them, local conflicts may receive less attention. However, conflicts are common at community scales between users and sectors. Case studies from Bangladesh and Nepal that are discussed in volume 2 of the WASSA Reports illustrate some of the many kinds of local water-related livelihood issues. Insight into the conditions that have led either to constructive engagement and resolution, or to an impasse, could be applied to similar situations that occur across South Asia.

Our other argument, more tentative but if true more profound, is that conflicts are fractal (similar in character at all levels), and that solving local conflicts may in many cases be a more meaningful approach to security than focusing on the international scene. Even if human and water security problems at the local level are not absolutely fractal, addressing them may be the most effective way to reduce tension at higher levels. Indeed, conflicts between larger political entities may often be a way of displacing, denying and projecting more embedded internal differences of interest and power. Conflicts, whether latent or overt, whether of interest, words, or arms, exist between neighbors, no matter how small or big they are. Differences exist, of course – indeed, it seems that conflicts are more likely to be intractable, and even to lead to the shedding of blood, at the local level.

For example, inequities in water availability within watercourses between head, middle and tail end farmers are more acute than imbalances in water supply at provincial or state and canal scales. Subsidized water prices and unaccountable top-down delivery systems make farmers dependent on state irrigation officials, leading to a cycle of bribery, unintended and deliberately induced uncertainty in water supplies, and a further need for individual irrigators to seek special favors

from departmental officials. Many maladies, such as application of excessive water to the fields of those with access and excessive investment in private facilities such as deep tube wells, can be attributed to this problem. Water theft, an indicator and cause of conflict [and subsequent litigation or threat of it], takes up considerable time and energy of irrigation farmers.

It may be, as some say, that the State is too large a unit to do well the little things (be responsive to local conditions) and too small to do well the big things (river basin management or macroeconomic guidance in a global economy). Therefore new methods of governance are called for, at both small and large scales, to allow the state to focus on those areas that it can and must do, remove itself from other arenas, and establish mutually productive linkages with other actors such as civil society and river basin organizations.

4.2. Key Conflicts at State or Provincial Levels

The elements of the key conflicts between the States in India or Provinces in Pakistan key have been extracted from the Case Studies analyzed for the WASSA project. These are shown in Table 3.

Table 3: Water Sharing Conflicts between States or Provinces

Basin or Dam	**Parties to the Conflict**	**Nature of Conflict**	**Current Status/ Mediators**
1. Indus – Pakistan	Punjab, Sindh, Balochistan, NWFP, AKJ, and NA	Water sharing	Continuing. IRSA and CE secretariat
2. Indus (Eastern Rivers) – India: Ravi-Beas	Haryana, Punjab, Rajasthan, Delhi	Water sharing	Continuing. Ravi-Beas Tribunal
3. Ganga Sub - Basins:			
3.1 Yamuna	Delhi, Haryana, Himachal, Rajasthan, Uttaranchal	Water sharing	Agreement, May 1994, but conflict continues. Upper Yamuna Board
3.2 Sone	Bihar, Madhya Pradesh, Uttar Pradesh	Timing of releases from dam to meet power and irrigation requirements; assessment of basin yields	Conflict continues. Bansagar Board; Sone River Commission
3.3 Damodar	Jharkhand, West Bengal, Union Government	Submergence of uplands and coal mining areas; flood control benefit not fully realized	Impasse to further development, partial operations. Damodar Valley Corporation.
3.4 Upper Ganga including Ramaganga	Uttaranchal and Uttar Pradesh	Potential conflict on storage dam projects owing to the submergence and irrigated tracts in now different States	Ganga Management Organization to be controlled by Union Government is yet to be set up.
4. Brahmaputra	North-eastern States	No disputes, but	Benefit sharing yet to

		mega projects scaled down or re-designed owing submergence issues	be established.
5. Barak	Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura	No progress on multipurpose project, owing to divergence in submergence costs and benefits	-
6. Narmada	Gujarat, Maharashtra, Madhya Pradesh, Rajasthan	Conflict between affected people and States	In public interest litigation filed by NGO, Supreme Court (Oct. 2000) has allowed construction of dam, subject to provisos.
7. Godavari	Andhra Pradesh, Karnataka, Orissa, Madhya Pradesh, Maharashtra	Conflict resolved in 1980 after twenty plus years	Mutual negotiations, bilateral and trilateral agreements among the five parties, ratified by Tribunal.
8. Krishna	Andhra, Karnataka, Maharashtra	Almatti Dam, Telugu Ganga Project, water investments aimed at establishing claims	Tribunal award expired, issue in court, new Tribunal inevitable after court decision.
9. Cauvery	Karnataka, Kerala, Pondicherry, Tamil Nadu	Established prescriptive rights of early developer versus "justice"	Cauvery Authority has been set up and is functioning. The final award of the Tribunal is awaited.
10. Pennar	Andhra Pradesh, Karnataka	1892 Agreement reopened on grounds of improvement to tanks, unauthorized diversions	Legal recourse initiated by a State.
11. Brahmani-Baitarani	Jharkhand, Orissa, Madhya Pradesh	No conflicts owing surplus water flows	-

12. Subernarekha	Bihar, Jharkand, Orissa, West Bengal	Inter State water agreements negotiated since 1964	-
13. Mahi	Gujarat, Madhya Pradesh, Rajasthan	-	Project specific agreements have worked well.
14. Tapi	Gujarat, Maharashtra, Madhya Pradesh	-	Project agreements and Inter-state Control Board has worked to common benefit.
15. Mulla Periyar Dam	Kerala, Tamil Nadu	Dam safety, submergence of reserve forest land and wildlife sanctuary	Supreme Court has directed establishment of Experts Committee.

The river basins discussed in the Table above are shown in **Figures 4 & 5**.

Even from the summary presented in Table 3, it is apparent that what goes under the title of "Water sharing conflicts" in fact encompasses a range of issues in addition to the allocation of water. These include:

- Conflicts over data --- for example, the Government of Sindh has recently decided to send its inspectors to Chashma reservoir to validate the discharge data provided by WAPDA (a federal agency);
- Conflicts over interest --- for example, between timing of releases from the Rihand Dam for hydropower needs in UP and for irrigation in Bihar;
- Conflicts over values --- for example, over reserve forest lands and wildlife sanctuaries in Kerala that could be submerged with the full operation of a dam; and

- Conflicts over relationships --- for example, over costs of submergence in Uttaranchal, and benefits from irrigation in UP, now that the two are separate States.

Another feature is the variety of instruments used for conflict resolution, ranging across judicial, semi-judicial, administrative, semi-autonomous and political branches of government, and comprising of regular courts, special tribunals, control boards, river basin authorities, development corporations, ministerial and expert committees and sub-committees, and meetings of apex political leadership. A common factor in these conflicts is their long duration.

4.3. Local Conflicts between Sectors and Users

Water security can be as crucial an issue at the local level as at the regional and international scales, even though narratives of water conflicts between countries and provinces tend to get more publicity. First, there are the multiple impacts of large development projects. Inter-basin transfers of water, for example, affects household security, village security and valley security. Second, the inter-play between 'street-level' bureaucrats, markets, and social solidarity, may bear fruit in a constructive engagement or lead to unnecessary violence. Case studies of local and sub-regional conflicts between sectors and users in Bangladesh and Nepal prepared for the WASSA project have been included in the summary shown in Table 4.

Table 4. Examples of Local and Sub-regional Conflicts

Country, Area	Stakeholders	Nature of Conflict	Status
Pakistan, Irrigated Indus Basin	Head, middle and tail end farmers on *Sirkari* watercourses	Warabandi (water turn); Water theft (obstruction, breaches, pipes, *moga* tampering, and so on)	Pervasive.
Pakistan, Manchhar Lake	Fishers, upstream rice	Saline effluent from outfall drain has	Project to extend outfall drain to the sea

	farmers, government	damaged lake and fisheries	may mitigate the damage.
India: Alwar district, Rajasthan	Tarun Bharat Sangh, a NGO & 500 villages communities; Government	Rights over dried up river that was revived by community investment in 2500 rainwater harvesting structures	On-going: "River parliament" of riparians has established rules & regulations for river management.
Bangladesh: Sylhet haors, Kawadighi Haor	Farmers, irrigation and flood protection managers, fishermen	Reduction in fish habitats, populations, and diversity owing to conversion of wetlands to farmlands. Need for rapid drainage of water at start of winter rice cultivation	Constructive engagement. Experimental fish pass allows fish migration and breeding. Potential for scaling up under the National Water Management Plan.
Bangladesh: Coastal Cox's Bazar	Shrimp industry, rice farmers	Land and water use conflicts as powerful shrimp industry inundates coastal ponds with saline water and aggravates soil salinity, delaying drainage and farmers' access to rice seedling beds	Impasse; Unless industry shifts to fresh water prawns, which also have an export market and which can be farmed in rotation with winter rice, and land use zoning is enforced.
Nepal, Melamchi river basin and Kathmandu	Rural and Urban users, Municipalities, Development Bank	Project to augment city water supply by inter-basin transfer via 27 km long tunnel through mountains has environmental impacts	Melamchi project under progress with ADB assistance. No major project in hand to reduce leakages that equal 40% of city water supply.
Nepal: Chitwan valley, Khageri Irrigation Project and Baghmara Forest community on the edge of Chiltan National Park	Managers of community owned irrigation systems, Community forest groups as eco-tourism operators	Proposal for lift irrigation that would dry up the local stream used for lucrative canoe rides and deplete biodiversity	Constructive engagement with potential for conservation and development – slightly longer irrigation canal from main river that maintains flows in stream.

The river basins of Bangladesh and Nepal are shown in **Figures 6 and 7** respectively.

Examples of insecurities generated by water conflicts at sub-national scales are summarized in Table 5 below, and grouped according to a hierarchy of human needs for security.

Table 5. Sub-National Water Sharing Related Insecurities

Hierarchy of Needs (Security Needs)	**Recent Examples of the Means of Insecurity**
Basic Needs (Livelihoods)	Disruption of rice farmers livelihoods by salinization of coastal ghers at Cox's Bazar by shrimp industry (Bangladesh)
Security Needs (Physical Security)	Submergence of homes (shelter) in the head ponds of Tehri and Narmada dams, (India)
Social Needs (Network Security)	Severance of human settlements by irrigation infrastructure in the Chashma Right Bank Canal Command, Pakistan (2001)
Ego Needs (Identity Security)	Protests by politicians and farmers associations in Sindh against planned Thal Canal, Punjab, Pakistan (2002)

4.4. Recommendations

The water crisis in South Asia is mainly a crisis of governance, and not mainly one of scarcity. The project team recommends policy reform and institutional development. There is also scope for innovation and its diffusion, but such technical changes should take place within a rights-based approach that seeks to include rather than further marginalize the poor.

a) Get Ahead of the "Crisis Curve" within Countries

Procrastination in settling water disputes does not pay. The challenge for South Asian countries is to get ahead of the crisis curve, to develop institutional capacity and a culture of cooperation among central and provincial governments, sectors and users in advance of costly, time-consuming crises that in turn threaten livelihoods, economic stability and ecosystem integrity.

In all four countries, getting ahead of the crisis curve entails de-politicizing water conflicts, taking advantage of the strengths of democratic institutions, while containing their weaknesses. There are several routes to achieving institutionalized cooperation:

- Strengthening existing institutions and conflict resolution mechanisms;
- Establishing bargaining arenas for settlement of disputes between state or provincial governments and for subsequent management of water resources;
- Establishing integrated river basin (sub-basin) management; and
- Establishing economic cooperation forums for water negotiations and management.

The four routes, like the channels of a braided river, are not mutually exclusive but distinct. The choice or blend that is appropriate depends as much on the vision of the leadership in each country as on the traditions and past forms of governance and management culture.

Strengthening Existing Institutions and Mechanisms

The existing institutions in South Asia for settlements of water disputes consist largely of courts, special tribunals, river control boards and water development authorities, other forms of departmental administration, and political caucus. The instruments are judicial and semi-judicial awards, administrative decisions, and inter-governmental accords. They are basically various types of hierarchical organizational structures characterized by conventional top-down decision-making. As such, this route may be called the continued centralization model.

Such a top-down approach is proving less and less acceptable as a means of providing solutions for river water sharing, for example, in India. Currently, even the Tribunal Awards, which have the backing of the Constitution, are floundering

in the face of interminable interpretations and legal court battles. Still, given the country's present political system, adjudication by Tribunals appears to be the best mechanism for solving inter-state water sharing conflicts.

In Pakistan, the Balochistan Ground Water Rights Administration Ordinance (1978) is another top-down legislation that empowers the Governor or Chief Minister of the province as the sole authority to give permission for sinking a new tube well. This concentration of sanctioning authority has not acted as a restraint to groundwater mining in this water-scarce province. In fact, giving the permission to bore a new tube well has become a form of political patronage.

Establishing Bargaining Arenas

The essence of the Bargaining Arena (BA) model is that it represents a compromise between the extreme of top-down decision-making mentioned above and the other extreme of bottom-up voluntary cooperation, as illustrated by the Alwar villagers' "river parliament". The model consists of two types of actors: the central authority and interest groups represented in the bargaining arena. There are important differences between direct government regulatory intervention, voluntary cooperation and the bargaining arena model. In the first case, there is only a direct link between the controlling authority and each stakeholder; in the second case, there is no outside controlling authority. In the BA model, the central authority has enforcement power that is needed at different stages, to get the stakeholders to make plans and to implement them. In the case of lapse or default, the controlling authority has binding powers. The controlling authority uses the BA model instead of direct regulation, because the stakeholders know more about the situation on ground, and in order to minimize bureaucracy and political decision-making.

In Pakistan, the Indus River System Authority (IRSA) was set up in 1992 as a bargaining arena between provinces to implement the Water Accord of 1991. It has had a turbulent history only because on three separate occasions, the

controlling authority decided to over rule or by-pass IRSA for short-term reasons. The fact that IRSA has survived its first decade through periods of political expediency and emergency related to drought conditions, however, speaks for the basically robust nature of such an arrangement.

Similarly, some of the local level conflicts in Nepal, such as those brought to the fore with the revival of traditional systems, can be managed at the local level through decentralization or devolution. Higher-level State institutions can be maintained as courts of last resorts rather than parties to the conflict.

Establishing Integrated River Basin (Sub-Basin) Management

There are two archetypes of river basin management, the authority model and the coordinative model. The authority model has the same features of hierarchical top-down decision-making as discussed in the first approach above. The coordinative model reverses the bargaining arena concept. A cooperative body of Federal and provincial governments is established at the apex to set policy, while an authority or commission supports and executes the council's decisions. In so far as it is the operational aspects of river basin management that require quick decision-making, this arrangement makes sense. The Murray-Darling model is an example of a consultative ministerial council with oversight of a commission with executive authority. However, to work well, such a river basin governance model requires a mature and serious political culture.

In India, even though the River Board Act is a statute, its use for the purpose of Basin planning of Inter-state Rivers has not materialized due to the very nature of the Act being advisory. Even after the water allocations among or between the States for Inter-state rivers are made, the planning process for integrated development of the river basin with due regard to all sectors of water needs has not matured. Several recommendations in this regard need to be acted upon.

River Basin Organizations (RBO) should be set up for ensuring integrated development of River Basins. This could be better done under a separate Act in consonance with the revision of the ISWD Act, which shall take cognizance of the Stakeholders' participation.

A Framework for a River Basin Organization is given in **Figure 8**, which envisages a phased process to achieve integrated basin development. These phases comprise a legal and regulatory framework, State level and Inter-state organizations, and implementation and monitoring. Such RBOs could also be involved with negotiation of Inter-state water disputes, before the dispute is referred to the Tribunal for adjudication. There could be no bar on the Union Government setting up multi-disciplinary RBOs by an executive order. To start with, RBOs may collect and analyze data and prepare plans for Integrated River Basin Development for optimal utilization of the water with appropriate sectoral allocations. In the next phase, RBOs could assist the tribunals, and finally, they could be authorized to monitor the implementation of development plans by the State RBOs.

Establishing Economic Cooperation Fora For Water Negotiations And Management

Crow (1998) has argued that the valuation of water resources enables a simpler, more open assessment of international exchanges than is possible with the existing forms of diplomatic 'barter'. The arguments for including new actors from the private sector and for creating new spaces for water agreements holds with equal force at state, provincial, and local levels. While negotiations on water sharing are limited to cases where there is a double coincidence of wants, benefit sharing on a monetized basis can extend cooperation to include unevenly represented interests.

The approach may be illustrated with a case from Pakistan. Ahmed and Kutcher (1992) argue that water can be profitably traded between water surplus and

water short agro-ecological zones in Punjab and Sindh, now that the Water Accord has established the shares of the provinces.

Ground water, according to Indian Law, is defined in terms of the Indian Easements Act (GOI, 1882), under which the ownership of land carries with it the ownership of the ground water under it. As a result, this huge resource is not regulated due to political problems and the legal problem of easement rights. The Supreme Court has directed the Ministry of Environment and Forests to set up the Central Ground Water Authority and frame rules for the regulation of ground water. The Authority has been set up and the draft "Environment Protection Rules for Development and Protection of Ground Water" have been framed and circulated to the States for immediate action.

State Governments need to act expeditiously on the Rules. Legal remedies have to be found for priority allocation of ground water to meet drinking water needs, and to prevent over - extraction for other uses. In a fast changing scenario, where the committed irrigation releases may have to be diverted to different needs like drinking water, industry, environment, etc., with better economic value and opportunity costs, the existing user may be given a 'limited legal right' to the transfer of such right, temporarily or permanently, to another user who may be prepared to pay more for such use.

b) Get More Crop Per Drop

There is still considerable scope worldwide, and especially in South Asia, for producing more grain with less water. The International Water Management Institute (Molden et al., 2001) applies water accounting procedures to bear on the productivity of various uses of water in a basin. The strategy is to realize real water savings and to produce more agriculture output with the same amount of available water. As against (a fairly optimistic) base scenario that requires a 29% increase in the world’s irrigated area and a yield increase of 38% over a 30-year

period (1995-2025), the more crop per drop scenario envisages a 76% yield increase to meet the world's food and nutrition requirements.

In the specific case of India, an approximate doubling of yields from 2.7 t/ha to 4.7 t/ha would eliminate the need to divert or draw up more water for irrigation than at present. The key measures include changing to new crop varieties, switching from high water – consuming crops to crops with higher economic productivity per unit water, precision irrigation that reduces non-beneficial evaporation, better timing of supplies to reduce crop stress, and improved non-water inputs that work in association with irrigation (Molden 2001).

Pakistan, with wheat yields averaging 2.3 t/ha, can go a long way to improving yields per unit land and water by rationalizing water allocations across canal commands within provinces according to (Hussain et al., 2000). Irrigated wheat yields vary from 0.5 t/ha to 5.4 t/ha across a random sample of 1,220 farms located in 14 canal commands of the lower Indus Basin in Sindh. The authors argue that shortage of irrigation water in some canal commands and poor land quality in others are the two fundamental constraints. The marginal productivity of irrigation water varies significantly and immediate productivity gains could be achieved by effective reallocation of water across canal commands.

Another way to improve water productivity is to shift emphasis from large-scale development of water resources to more local-centered management of existing supplies. In principle, lining distributaries and watercourses could save about 10 MAF. Experiences in lining watercourses with bricks over the past few years have not proven effective, however, as they leak. New lining materials may show more promise, but only if they are accepted and installed by the community.

Much water can be saved through the modest leveling of farms and change in irrigation practice from flood to furrow irrigation. Tube well irrigation could be combined with low-head sprinkler and trickle systems. Investment in farmer

education for water saving would almost certainly yield high returns, especially if combined with improvements in conveyance systems to ensure timely and predictable deliveries. To be fully effective, a number of these improvements, especially those that bring water to the farm, require organization and mobilization of the irrigation community.

Sugar cane is a water intensive crop. Is it the right crop for largely arid and semi-arid Pakistan, especially when sugar can be imported at lower prices from countries with climates more conducive to higher productivity? This is a question that the economic and agriculture sector policy makers need to address.

c) Focus on the End-user

Apply empowering technologies

Local reservoirs and village tanks are an integral part of some irrigated South Asian landscapes. They are an essential part of the survival strategy for farmers and households in semi-arid rain-fed regions. Surface and ground reservoirs can increase the options for irrigation and drinking water for farmers and households in perennial canal irrigated zones with suitable soil and groundwater conditions. Unlike large reservoirs on rivers that will inevitably silt up over time, local ponds can be de-silted and groundwater recharged and used in perpetuity. A vision of dispersed and reliable local surface and underground storages needs to replace the dream of large dams and reservoirs.

Modern communication technologies also show much promise for improving the quality of information to communities as well as to system operators. For example, the installation of automatic gauges with computerized telecommunication linkages at critical locations such as reservoirs, barrages and points of release along major canals can enable monitoring of real-time data. The widespread use of satellite communication systems and relatively inexpensive reception systems can also allow this information to be shared with

parties throughout the command area, allowing them to provide superior mass supervision of water releasers, and to make wiser cropping and watering decisions.

d) Build Capacities of Water Users Organizations

South Asia has at least three decades of experience with single - purpose water user associations. The results have not been to the level of initial expectations. We suggest that the problem is with the approach adopted.

Until the Mona experiments by Lowdermilk et al. (1978), Pakistani national policy makers were not aware that watercourse losses far exceeded the total amount of water stored at the just completed Tarbela dam. The low cost physical solution was brick lining of the watercourses. A notional level of farmer involvement was sought, mainly to reduce the burden on the provincial exchequer, and to make the program more palatable to donors. The watercourses of influential farmers in single Biradari situations were targeted. After three decades of effort, the head sections of around one-third of the watercourses in the Indus Basin have been lined. Already, the cracks in the brick lining and a dried under-bed have meant that losses in many watercourses have reverted to the situation before lining.

The large farmers have often found that they could not exclude the cattle of the poor from wallowing in the watercourse and damaging the berms. Without social cohesion, farmers in their individual interest are also prone to making unauthorized outlets at night, further destroying the lining.

Direct assistance to the target communities had the charm of tangible results in a defined time frame. However, it led to the common error of a one-sided focus on project objectives. It meant that not enough attention was given to the requirements of the implementing community, and to its operational context. The risk that project results would not be sustained was naturally high.

It is argued that attention should shift to building the capacities of the involved farmers' organizations, to strengthening the relations between local organizations, and embedding of specific project activities within these organizations. In addition to specific programs and projects, intermediate development support organizations would also become a focus of such an approach.

Some elements of capacity building for local irrigation management are:

- Enhancing the skills of individual farmers in water measurement, record keeping, and communications, perhaps changing their passive and defeatist attitudes in the process of empowering them with such skills;
- Irrigation farmers may be profit-maximizing individuals, but they are not necessarily bound together in an organization for the management of a common water supply. Strengthening farmers' organizations through the discipline of regular meetings, emerging rules and guidelines for governance, and rising savings for water management, is a strategic investment. Key tools include problem visualization and conflict resolution skills. Community animators with these skills should be identified and empowered;
- Finally, it is essential to create networks of co-operation between different farmers' organizations, and enhance co-ordination among their activities in order to scale up water management programs and to sustain their impacts.

Human and institutional development efforts should also focus on intermediate organizations, such as local government, co-operatives, industry and professional associations, training institutes, intermediating NGOs, community organizations and interest groups that provide support to farmers' organizations.

e) Address Inequities of landholding

Some regions of South Asia have experienced effective land reforms, while others have not. Equity in access to land, water and other natural resources is important for sustainable use. It is also necessary for successful innovation diffusion, as the following example from Pakistan demonstrates.

In NWFP, where most of the clientele of the On-Farm Water Management Program are small owner-farmers, it has been possible to collect up-front the farmers' contribution for the renovation of common watercourses and 96 per cent of the amount due has been recovered. On the other hand, in Sindh, with skewed landholdings, large farmers have captured the program and only 20 per cent of the amounts due have been recovered (Halcrow, 1996).

A one-time land reform may not be enough if economic processes cause sharp inequities to emerge again. In Bangladesh, the conflict in water sharing between farmers and fishermen can be addressed through policies of social equity, enforcement of committed programs, and genuine participation of people at the grassroots level. A clarification of farmers' rights and community empowerment for their enforcement is a prerequisite for effective land use zoning control of shrimp cultivation in the Southwestern coastal zones.

f) Reduce Subsidies

Subsidies, resource capture by the elites, the decay of government departments and local conflicts owing to actual and perceived inequities in resource allocations and the application of rules, are interlinked phenomena. As Mustafa (2001) has shown for Sidhnai in Pakistani Punjab, *tawan* (collective fine) for stealing irrigation water is seldom enforced in the tracts of land dominated by large landlords, who already enjoy highly subsidized canal water supplies. The first step in departmental reforms and rules - based water management should be to phase out subsidies. It is necessary to collect at least enough to cover the O&M costs of service delivery. Proper pricing will generate the consumer demand for departmental reform and reductions in unnecessary overhead costs.

g) Provide a Responsive Delivery System

Improved metering systems can make volumetric charges for water more feasible, while providing reassurance to irrigators that they are receiving their water in appropriate quantities at the right time. Communications systems combined with adequate metering and charging systems, should also facilitate wider adoption of demand-driven water release systems. In all of these ways, new technologies linked to information systems can help more clearly define enforceable rights and improve trust. It is important, however, to avoid as much as possible the appropriation of new information systems by rent seekers and to span the digital divide. It is also necessary to promote the adoption of simple technologies that empower irrigators, even those who are semi-literate.

h) Ensure the Participation of End Users

User participation is a mantra often repeated, and equally often forgotten. In fact, user participation is essential from the beginning, such as in the design phase of projects. It is equally important for project implementers to be sensitive to variations in local conditions.

Agitated NGOs have asked for an inspection under Asian Development Bank rules of the Chashma Right Bank Canal project in Dera Ghazi Khan, Pakistan, owing to the alleged violation of the Bank's rules for the re-settlement of displaced persons. In fact, flooding and displacement would not have arisen as issues if the designers had consulted the local farmers on the alignment of the canal. A feasible alignment cutting through slightly higher ground would have saved a tract of land west of the canal from being flooded and causing loss of life in the first year of its operation.

Establish a Rights-Based Approach

A clear and enforceable specification of water rights will, in principle, improve water use efficiency by creating strong incentives aligning the generation of surplus with its distribution. Because of pervasive rent seeking, built up over time, there is likely to be resistance to clarity of water rights, especially at the lower levels, but that is precisely where the efficiency gains (and therefore the reduction of conflict at both lower and higher levels) are likely to be achieved. To be fully effective, water rights must include transferability.

Three countries in this Study struggle with the rigidities of the colonial 1873 Act that emphasizes central ownership, a top-down approach, and non-transferability. The only doctrine of the major ones that allows transferability is appropriationist or historical rights. Clearly, transferability (marketability) requires the costly commitment of resources – e.g., to improved metering, monitoring, registration and enforcement mechanisms – as well as the overcoming of asymmetric power relations between zamindars (land owners), corrupt local officials, and already entitled but under-served end users.

Water resources development has been seen in the past decades as a state-led venture, where many of the losers (oustees, people whose water would be transferred to urban areas etc.) had their rights forcibly taken away by the State using its right of acquisition for what it claimed was the greater good. Often the level of state compensation was seen as grossly unfair. In many cases, a market-based solution (with the state acting as a fair adjudicator) would alleviate many of the conflicts, for two reasons. One, a market-negotiated compensation is less coercive than state acquisition. Two, preserving the State as an adjudicator instead of an adversary in acquisition, keeps the hope alive that a fair deal can be achieved, and hence prevents conflicts from acquiring the status of an impasse.

Build Capacity by Providing Information and Building Trust

Data are not just a source but a major category of conflict. Much of the distrust in water conflicts stems from distrust of institutions that collect data, especially if these institutions themselves are a party to the conflict. Issues of pollution or demand forecasting or other aspects of "data" could become resources for the resolution of conflicts if they have been sufficiently "pluralized", i.e. they are collected and verified by multiple actors (which is also good science) at various scales. Only consensus generated through such a process, rather than from single-mission outfits using monopoly power, will inspire faith in their veracity. This applies to local as well as inter-state conflicts.

Even with disclosure, it may be difficult to generate trust. Water users tend to consider first their own “needs,” defined in terms of recent use or future plans Sometimes this can be part of competitive status seeking, such as among the Zamindars (landlords) of Sindh cited in IBRD 1996. Consideration of the rights of others requires agreement on what the basis of the rights is, and to accept the legitimacy of formal rights systems as opposed to informal ones.

Despite all these problems of information, more open information would appear to be a necessary condition for improved trust, by leading to improvements in the quality of both further information and the nature of the discourse among stakeholders. Hence, mechanisms need to be worked out that can work with imperfect information and uncertainty while reducing the possibility of opportunism by all parties.

Make greater use of non-governmental approaches

The Alwar, Rajasthan river parliament is an exceptional example of voluntary cooperation that spans 500 villages. Smaller examples of such cooperation can be found at a number of places in South Asia. We do not think that such heroic arrangements are durable or that they could be replicated widely. Yet, it is

important to recognize and even develop such social capital that may contest issues and then cooperate with government in better water management. The alternative to water rights and rules established after contest is not "no conflict", but hidden conflict.

Give safe drinking water top priority

More than a hundred million people in South Asia – all poor and the majority of them women and girls - lack access to safe drinking water. Several hundred million lack access to sanitation. As a result, millions suffer illness and premature death from water borne diseases each year. All four countries face formidable financing challenges in raising resources for meeting the Millennium Development Goal (MDG) for safe water and none appear to be on target so far.

Meeting the MDG and WSSD goals for access to safe water and sanitation will require accurate assessments of regional and local situations of water and of the poor; sound strategies for preventive and promotional hygiene education; enhanced capacities for extension of appropriate technologies; and engagement of the private sector in hardware provision at affordable prices. Above all, meeting the goals requires vision, political will and national, provincial, corporate and community leadership.

In Bangladesh, in recognition of arsenic as a major threat in the water sector, urgent rethinking is essential for the supply of safe domestic water throughout the country. While waiting for detailed analytical studies, options should be explored for alternate or mitigating actions like cheaper arsenic removal kits, boiling surface water from ponds, rainwater harvesting or extracting groundwater from deeper aquifers. A long-term sustainable strategy for conjunctive use of surface water and groundwater will have to be worked out.

5. WATER SHARING CONFLICTS BETWEEN COUNTRIES

5.1. Introduction

Many of the major rivers of South Asia flow across more than one country. In the western part of the sub-continent, the waters of the Indus basin are shared by Pakistan and India. In the North and Northeast, the basins of the Ganges, Brahmaputra, and Meghna are shared by India, Nepal, Bhutan, and Bangladesh, and in some areas by China. Although some arrangements presently exist to share the waters between the respective countries, their implementation has not always been satisfactory, and there is a widespread perception that these arrangements would be inadequate in times of increased water scarcity.

This summary focuses on the Indus river system shared by Pakistan and India, and on the Ganges river system shared by Nepal, India, and Bangladesh through the following international water treaties:

- Pakistan - India — Indus Water Treaty (1960);
- India - Bangladesh — Ganges treaty (1996);
- Nepal - India — Sarada Agreement (1920), Koshi Agreement (1954), Gandak Agreement (1959), and Mahakali Treaty (1996).

Pakistan - India

The Indus river system, which is the lifeline of Pakistan and western India, comprises the river Indus and its five main tributaries namely the Jhelum, Chenab, Ravi, Beas and Sutlej. The partitioning of India in 1947 created a new international boundary, which cut across the Indus river system unevenly. After years of mounting tension, India and Pakistan signed the Indus Water Treaty for sharing the waters of the Indus river system between them. Under the provisions

of this treaty, in general, the waters of the western rivers (Indus, Jhelum and Beas) are available to Pakistan, while those of the eastern rivers (Sutlej, Ravi and Beas) are available for unrestricted use by India. A map of the Indus river system is shown earlier in Figure 4.

India-Bangladesh

The initiation of construction of a barrage across the river Ganges by India in 1957 at Farakka, about 18 km upstream of the western boarder of Bangladesh (at that time East Pakistan), led to a water sharing conflict between the two countries. The objective of the barrage was to divert 40,000 cusecs of Ganges water to Bhagirathi – Hooghly. The construction of barrage was completed in 1970 without any agreed understanding between the two countries. After a serious of negotiations between India and Bangladesh, the Ganges water sharing treaty was signed in 1996. Prior to this treaty, both countries had several short-term agreements for sharing the water of the Ganges since 1977.

The Ganges Treaty of 1996 specifies that the quantum of water to be released by India to Bangladesh shall be in compliance with the formula presented in Table 6. The sharing of the Ganges waters at Farakka between India and Bangladesh is based on 10-day periods, during the dry season, starting from 1 January to 31 May every year.

Table 6. Formula for sharing the Ganges waters between India and Bangladesh

Availability at Farakka	Share of India	Share of Bangladesh
70,000 cusecs or less	50 per cent	50 per cent
70,000-75,000 cusecs	Balance of flow	35,000 cusecs
75,000 cusecs or more	40,000 cusecs	Balance of flow

1 cusec = 1 cubic foot per second.

India and Bangladesh are each guaranteed to receive 35,000 cusecs of water in alternate three 10-day periods from March 11 to May 10. Bangladesh shall

receive the guaranteed amount of water during March 11-20, April 1-10 and April 21-30, while India shall receive the same amount during the periods March 21-31, April 11-20 and May 1-10.

India-Nepal

Since the beginning of the last century Nepal and India have entered into several agreements on the Trans-boundary Rivers with the objective of sharing benefits from them including the Sarada, Gandak and Koshi Agreements. These agreements allowed India to construct barrages at her own expense on the Trans-boundary rivers, which in turn allowed Nepal to draw a fixed share of water and hydroelectric power (where applicable) from these projects. India's shares of water and other benefits are, however, not specified.

In 1983, India unilaterally started construction of the Tanakpur barrage on the Mahakali River (which is a boarder river) at about 20 km upstream of the Sarada barrage, to divert all the dry season flow to generate 120 MW of hydropower for her use. This led to a water related conflict between the two countries, and subsequently led to the Mahakali Integrated Development Treaty of 1996. The Mahakali Treaty encompasses the Sarada Agreement of 1920, and includes the Sarada barrage, the Tanakpur barrage, and the proposed Pancheshwar multipurpose project. The last named aims to develop a 250-300 m high dam to regulate 6,560 million cu m of water for irrigation, and to generate 4,000 – 6,000 MW of hydropower.

The 1996 Mahakali Treaty has two scenarios: pre- Pancheshwar and post-Pancheshwar. The pre- Pancheshwar scenario of the Mahakali Treaty allowed Nepal to draw fixed shares of water from both the Sarada and Tanakpur barrages and a fixed share of hydropower from the Tanakpur barrage. India's share of water and power from these barrages are, however, not specified.

In the post- Pancheshwar scenario of the Mahakali Treaty, both countries have equal entitlement to the utilization of the water from the Mahakali River without prejudice to their existing consumptive uses. The basic principles ensure that both sides design and operate the project as a single, integrated scheme to yield the maximum total net benefit, with costs borne by both parties in proportion to the benefits accruing to them. The Mahakali Treaty is a framework treaty, and intends to establish a framework for all future mutual water development by Nepal and India.

5.2 Categorization of the water treaties

Depending on the context, the South Asian treaties mentioned in the preceding section can be grouped into three categories. Accordingly, the nature of the conflicts and possible solutions for further cooperation in the region vary considerably. Table 7 presents the categorization of the South Asian water treaties based on their objectives.

Table 7: Categorization of the South Asian water treaties

Water Treaties	Objective
India -Bangladesh: Ganges Treaty	Concentrates on water sharing: Water sharing treaty
Nepal - India: Mahakali Treaty	Concentrate on sharing the benefits: Benefit sharing treaty
Pakistan - India: Indus Treaty	Partitioned the rivers: River sharing treaty

Table 7 suggests that, unlike the India-Bangladesh and Nepal-India treaties, the Indus Water treaty is neither water sharing nor a benefit sharing treaty. It is a treaty that simply partitions the rivers between the two countries. Thus, the Indus Treaty is a river sharing treaty according to which the waters of three western rivers (Indus, Jhelum and Chenab) are for the use of Pakistan, while those of the three eastern rivers (Rabi, Beas and Sutlej) are for the use of India.

This characteristic of the Indus Water treaty, which simply partitioned the rivers between the two countries, is considered to be an important element for the success of the treaty. As a result, both India and Pakistan are independent of one another in managing water supplies in their part of the Indus river system. In contrast, the India-Bangladesh and Nepal-India treaties do not create a situation of independence in implementing their provisions, which are influenced by several hydraulic and institutional externalities. As a result, several issues concerning interpretation and implementation of these treaties continue to emerge. Some of these issues are discussed in the next section.

5.3 Public perceptions of equity

Perspectives from Bangladesh

Considerable differences exit within Bangladesh about Bangladesh's share of water as allocated by the Ganges treaty. Some feel that the 1996 treaty has overlooked the concerns of the Bangladeshi people, and believe that Bangladesh should have received more water than that stipulated by the 1996 treaty. Many in India, particularly in West Bengal, feel that it is they who are receiving less than their share of the Ganges waters.

What is the basis for the dissatisfaction in Bangladesh with the 1996 Ganges treaty? An analysis of flow data suggests that during the period 1997 to 2000, the gap between the flows released to India and Bangladesh narrowed considerably compared to the period 1978 to 1987 (**Figure 9**). This implies that the 1996 treaty provided less water to Bangladesh when compared to the 1977 agreements.

This reduction in Bangladesh's share of water as provisioned by the 1996 treaty compared to that of earlier agreements seems to have caused dissatisfaction among in Bangladesh. The lack of governing principles in sharing water may have caused this ad hoc reduction in Bangladesh's water share. In this context,

many in Bangladesh feel that historical use rights and ecological considerations should be the basic governing principles for sharing international waters.

Perspectives from Nepal

Similarly, many people in Nepal are dissatisfied with the India-Nepal Agreements on the Sarada, Koshi, and Gandak Rivers. The large differences between Nepal's share (about 2.6 % of available flow) and India's share of water from these barrages are in part some of the reason for such dissatisfaction (Table 8). As a result, the people of Nepal feel that they have not been treated equitably in the past. This aspect has led to increased resentment in Nepal.

Table 8. Water sharing provisions in Indo-Nepal treaties

Name of treaty	Average annual river flow (m^3/sec)	Percentage of available flow	
		India's share (As per canal capacity)	Nepal's share (as per treaty)
Sarada	725	50.5	3.7
Koshi	1550	40.6	1.3
Gandak.	1590	56.0	2.1

Perspectives from India

The Indian perspective is somewhat different. In the case of the Indo-Bangladesh treaty, India feels that the apportionment of water made under the Treaty gives Bangladesh a generous share, taking all relevant parameters such as population, arable area, rainfall and the Ganges dependant area into account. As Bangladesh has not sought to invoke a review of the treaty, the deadline of which was December 2001 (as per treaty), India argues that despite periodical protestations, on the whole the treaty constitutes a fair settlement, with each side sharing the shortage.

The stipulated flows are being released below Farakka, but cannot fully enter the Gorai in SW Bangladesh. The Gorai resuscitation program (capital dredging of the Gorai outfall, with assistance from the Netherlands) has not provided a

complete answer, and no decision has yet been made on the contemplated Ganges barrage at Pangsha. Discussion on the sharing of the Teesta, Brahmaputra and other common rivers continues alongside the search for augmenting the lean season flows of the Ganges.

In the case of the Nepal-India treaties, India feels that the percentage of water delivered to Nepal from these barrages should be looked at from a geographical perspective, especially from the perspective of the availability of irrigable land. In this context, India also feels that the help provided by India to Nepal in developing several other water resource projects that were not stipulated by the Treaty should also be taken into account.

Looking to the future

There are several other arguments raised by each country in relation to its share of the water. What is lacking, however, is the principle that governs the sharing of water and other benefits between countries. The usual upstream-downstream tensions, the unequal size of the countries, and several other geo-political aspects may all have contributed to such ad hoc arrangements for the sharing of water.

There is thus a need to define governing principles regarding the sharing of water, the costs of the water resource development projects, and benefits derived by them, through a framework treaty based on a regional approach.

5.4 An issue of downstream benefits between Nepal and India

Construction of any storage project in Nepal will augment lean season flows of the river and moderate floods. As irrigable land in Nepal is limited, this will ultimately benefit India. Nepal has been demanding that India should give due consideration to such downstream benefits, and would like to account for it based on certain principles. India, however, is reluctant to account for such benefits, with the view that Nepal is asking for such benefits based on the latter's

ownership rights to flowing water. In this context, India feels that no one can claim ownership of natural waters -- it is yours if you use it.

5.5 An issue of flow augmentation: India – Bangladesh conflict

As the Ganges dry season flow at Farakka is not enough to meet the increasing water need of both countries, serious water security concerns have emerged. As a result, all the past Indo-Bangladesh treaties and agreements recognized the need of augmentation of the Ganges lean season flow. Despite this recognition, the augmentation proposal is not yet finalized due to differences of opinion between the two countries. As a result, the issue of flow augmentation is a major source of tension between India and Bangladesh.

Perspectives from Bangladesh

Regarding the augmentation of the river flow, the position of Bangladesh is that the total water requirements of the entire Ganges basin could be met from the resources available within the basin itself. Bangladesh has therefore proposed augmentation through harnessing and developing the enormous monsoon flows of the Ganges in the upper catchment regions of Nepal and India. This proposal, put forward by Bangladesh, was unacceptable to India since it required the participation of Nepal. India has consistently shown its preference for bilateral arrangements rather than regional ones.

Perspectives from India

India proposed the augmentation of the Ganges from the river Brahmaputra, which contains surplus water with an advantageous lag of two months over the lean season flows of the Ganges. Considering GBM (Ganges, Brahmaputra, and Meghna Rivers) as a single river basin, India therefore forwarded several proposals. These included the transfer of about 100,000 cusecs of water from the Brahmaputra River by constructing a 324 km long link canal to the Ganges, and diversion of waters from some of the north bank tributaries (Manas, Sunkus

Raidak, and Torsa) to Tista and further down to Ganges above Farakka. There are several proposals being considered. However, these proposals were not acceptable to Bangladesh.

A joint DPR of the Sapta Kosi High Dam in Nepal is to be initiated soon. If this project is carried out, it could be a promising source for augmenting the lean season flow of the Ganges.

Differences of opinion between the two countries

Regarding Bangladesh's proposal of augmenting the Ganges lean season flow, India argues that she has been negotiating with Nepal over the past 25 years and continues to do so even today for the development of said storage projects for her own use. India feels that Nepal has its own perspectives and priorities with regard to water resource development. Therefore the notion that Nepal would readily allow its development planning to be determined by extraneous considerations remains a gross simplification of ground realities. Further, India feels that in a situation where the bilateral cooperation is not really encouraging, the expectation that a multilateral framework will work magic is quite unrealistic.

Bangladesh views the Indian augmentation proposal as based on the concept of mass transfer of water from one basin to another (from Brahmaputra to Ganges). Bangladesh feels that such a mass transfer of water across a basin would be against the internationally accepted principles initiated by the International Commission on Irrigation and Drainage (ICID). Further, Bangladesh is of the opinion that all the lean season flows of the Brahmaputra River basin are required in the Brahmaputra-dependent areas to maintain the ecological balance of the river, and to meet irrigation demand in the lower Brahmaputra area.

Looking to the future

The foregoing discussion raises a question: why could a consensus not be reached between the two countries for augmenting the Ganges lean season flow

despite all the provisions made repeatedly by the Indo-Bangladesh treaties and agreements? There could be several reasons for this, only a few of which are mentioned here.

First, the desire to implement any provision made by the treaty depends on the extent of its need for both the countries. For India, the need to arrive at an early settlement of an augmentation proposal does not seem that great. For Bangladesh, augmentation is urgently needed. Thus, differences in the level of urgencies between the two countries may have delayed finalization of augmentation proposals. This suggests that for implementing any provision made by the treaty, the urgency of its need for both the countries should be similar.

Second, a lack of general principles for sharing costs and benefits in developing Trans-boundary rivers has also been a reason for delays in the finalization of augmentation proposals.

Third, the success story of the Pakistan - India Indus Water treaty suggests that the involvement of an outside institution for mediation, and the availability of financial resources, is the key to arriving at an early settlement of any conflict between two countries. Lack of such a mediator and of financial resources may have contributed to the disagreement between India and Bangladesh concerning the augmentation proposal.

5.6 Issues in sharing benefits in implementing the Mahakali Treaty

As noted earlier, the Mahakali Treaty of 1996 between Nepal and India aims to construct a 250-300 m high dam at Panceshwar in the Mahakali River in order to regulate 6,560 million cum of water for irrigation and to generate 4,000-6,000 MW of hydropower. To achieve these objectives the treaty lays down the following principles:

- Both countries have equal entitlement to the utilization of the water from the Mahakali River without prejudice to their existing consumptive uses.

- The power benefits from the Pancheshwar shall be assessed on the basis of, inter-alia, saving in costs to the beneficiaries as compared to the relevant alternatives available.
- The Pancheshwar Project would be developed on the basis of mutual costs and benefit principles to be outlined in a Detailed Project Report (DPR) that is to be jointly prepared.

Due to the differences in opinions in interpreting the provisions laid down in the above principles, serious issues have emerged in implementing Mahakali Treaty. These include:

Existing consumptive uses:

Although the treaty stipulates Nepal's existing consumptive uses, it fails to define such uses in India. However, the above-mentioned principle of sharing the costs and benefits made it necessary to identify existing consumptive uses in India in order to arrive at a consensus about the actual benefit that India would receive from the project. In this regard, India claimed that the existing use right of the Lower Sarada Project located about 160 km downstream of the Indo-Nepal border should be considered.

India's claim on the existing consumptive uses of waters in the Lower Sarada Project seems to be based on the Helsinki Rules and the UN convention on the non-navigational uses of International Waters. Nepal, however, claims that such rules are not applicable because the condition of applicability of existing consumptive uses is well defined by the treaty itself. Quoting the words of the treaty, Nepal claims that the provision of the existing consumptive uses is applicable only to the waters of the Mahakali River, which is defined as a border

river. The present controversy on preparation of the DPR primarily relates to this issue of existing consumptive use.

Assessment of electric power benefits

Article 3(4) of the Mahakali Treaty states: "A portion of Nepal's share of energy shall be sold to India. The quantum of such energy and its price shall be mutually agreed upon by the parties". It is to be noted that the Pancheshwar dam is to be designed for peaking power. In this context, Nepal feels that for peaking power a separate tariff based on the costs of alternative energy needs to be worked out. In contrast, India believes that while peaking power may command higher time-of-day price, it cannot enjoy too high premium in an increasingly competitive market. This is due to the strengthening of several power grids and load dispatch centers within India, which make it possible to transfer substantial and increasing blocks of power, whether from more distance hydro-power plants or giant pithead power stations in the coal-belt area across large distance over extra high voltage transmission lines.

Location of re-regulating dam

A re-regulating dam is necessary to hold the water released from the main dam (Pancheshwar dam). Earlier, two sites namely Rupali Gad and Poornagiri were proposed for the study. A difficulty has arisen since the Rupali Gad, Nepal's preferred site for a re-regulating dam, is found to be technically infeasible. India believes that the next site, that is Poornagiri, should be considered for the re-regulating dam. But, Nepal is reluctant to go ahead with Poornagiri on account of the required higher displacement of people and other political sensitivities. The question about siting is holding up the completion of the joint DPR, on which further progress depends.

Looking ahead

The earlier discussion suggests that serious concerns have emerged in implementing provisions made by the Indo-Nepal Mahakali Treaty. In this context, certain basic principles have to be asserted. These are:

- Water rights should not be confused with ownership of flowing waters;
- India should accept that prior appropriation is not an absolute principle.
- Paying a larger proportion of capital costs as a one-time royalty by India for the dam could be one of the alternatives.

In the case of re-regulating a dam, if a satisfactory intermediate site cannot be found for the diurnal storage of waters passing through the Pancheshwar, the overall project parameters may need to be recast. One way or the other, delay cannot be in anybody's interest. Thus, there is a need for both countries to discuss these issues to arrive at a consensus for their mutual benefit.

This suggests that for the successful development of bilateral or regional cooperation in the field of water resources:

- Each country should show a willingness to agree to ideas put forward by the other country, and
- The treaties and agreements reached between the countries should be honored and implemented in a true spirit by all the concerned countries.

5.7 Lessons learned from the Indus Water Treaty

Factors contributing to the success of Indus Treaty

The Indus Waters Treaty is the only agreement that has been faithfully implemented and upheld by both India and Pakistan. Although its negotiation was often arduous and frustrating, the final outcome is considered by many to

have been a success. The following factors were important for the success of the Indus Treaty.

- The characteristic of the Indus treaty, which made both India and Pakistan independent of one another in managing their water supplies in their part of the river system;
- The involvement of funding institutions and outside mediators was helpful in resolving outstanding conflicts and formulating treaties;
- Both India and Pakistan were successful in detaching the functional aspects of water related issues from political, historical and traditional considerations.
- The need for treaty was urgent for both countries.

Even though the Indus Waters Treaty has been successful for over forty years, the increasing needs for water and power in India and Pakistan are beginning to subject the Treaty to tensions. Pakistan believes that the 450 MW Baglihar Hydropower project by India on the Chenab river is a violation of the Treaty. Its request for a visit by Pakistan's Commissioner for the Indus Waters to visit the site has not been granted, and it may invoke Article IX(2)(a) of the Treaty for the appointment of a Neutral Expert to resolve the problem. This would be the first time in 43 years that a dispute on the river waters would be referred to a Neutral Expert.

Water security in South Asia, especially in Pakistan

A stark reality is that the population in the South Asian countries is increasing at an average annual rate of about two percent, which will greatly influence water demand in the region. Thus, the region will see an increase in the demand for water, thereby creating pressures to increase withdrawals from international rivers. In this context, regional cooperation has become imperative, involving all co-riparian countries in order to manage the increasing demands for water resources.

Further, volume two of this study suggests that the water situation in Pakistan is already serious, when compared to the other south Asian countries. Although, until recently, the Indus Treaty allowed both India and Pakistan to act independently in safeguarding issues concerning their water security, they cannot continue to do so in the future. This is because Pakistan is already a water - stressed country and requires utilizing the full potential of the Indus River system in an integrated basin approach. This cannot take place without further cooperation between India and Pakistan. It is therefore necessary to think ahead and conceptualize a follow-up agreement to the 1960 Indus Water Traety. One can, for example, envisage storage on the upper Indus, Jhelum and Chenab, over and above what is presently permitted by the current Treaty. Due to the hostility between the two countries, the idea may appear remote at the present time. But the very exercise of looking ahead would reveal the opportunity costs of non-cooperation and confrontation.

5.8 Recommendations

The Indus, Ganges and Brahmaputra River basins (IGB basins) offer unique opportunities for optimal water resource development through cooperative efforts. With the signing of the Ganges Waters Treaty between Bangladesh and India and the Treaty on the Mahakali River between Nepal and India, both during 1996, there is a desire to create an atmosphere of confidence. The Male declaration (1997) and the Colombo Declaration (1998) of the SAARC summit were a boost to regional cooperation by endorsing the idea of two or more countries cooperating in project-based development works within the SAARC framework. Thus the countries of the IGB basins can now look ahead to collaborative approaches in harnessing the region's water resources. This Report would like to make the following recommendations:

- It is essential to establish governing principles for sharing international waters among the riparian countries in a river basin through a framework treaty.

Defining the principles for sharing the costs and benefits of water resource development projects within each river basin would be highly desirable for reducing tensions between countries.

- Effective institutional mechanisms with adequate authority to guide, instruct, and monitor the implementation of each treaty are necessary for successful implementation. Mechanisms for the joint operation of control structures, and provisions for the settlement of disputes according to international practice are essential for the successful implementation of the treaties. A joint river basin commission to deal with a specific river and treaty, or a joint country commission to deal with several water related treaties, would be the most appropriate form of institutional arrangements. Similarly, a Tribunal, well-versed in internal water law and management, whose decisions would be binding for all the parties concerned, would be the most appropriate mechanism for dispute settlement.

- The involvement of funding institutions and outside mediators could be very helpful in formulating water-related treaties and resolving outstanding conflicts in sharing international waters.

- Water related disputes have a greater likelihood of being solved if the functional aspects of disagreement are negotiated separately from political, historical and traditional considerations.

- The willingness to agree, to accept ideas put forward by other parties, and to change positions when necessary, are vital for the successful implementation of any water sharing treaty. These considerations are more likely to be met when the urgency of the water sharing treaty is equally great for both the parties.

- For the successful development of regional cooperation in the field of water resources, the treaties and agreements reached between the countries need to be honored and implemented in the true spirit in which the concerned countries signed them.

- Understanding the compulsion of the other party is essential for the success of regional or bilateral cooperation.

- Cooperation between the countries in the region is more likely when the benefits of the agreement are substantial and pressing enough to overcome the political difficulties that frequently exist.

- The South Asian countries need to agree to respect the principles of international law to consult with each other before initiating projects that utilize or manage international waters.

6. IMPACTS OF CLIMATE CHANGE ON WATER AVAILABILITY

6.1. Introduction

The enhanced greenhouse effect and global warming are attributed to a human-induced increase in atmospheric concentrations of greenhouse gases (GHG) with radiative properties. A worldwide increase in cumulative emissions of GHGs has caused changes in atmospheric concentrations of these gases, including carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and halocarbons (hydrofluorocarbons - HFC). As a consequence of global warming, a number of changes are likely to occur in the atmospheric, terrestrial, and oceanic systems around the globe.

Based on the ranges of climate sensitivities and the plausible ranges of GHG and sulfur dioxide (SO_2) emissions reported by the Intergovernmental Panel on Climate Change (IPCC), climate models project that global mean surface temperature could increase by about 1.5 to 6.0 degrees Celsius by 2100. Precipitation is likely to increase though projections vary by region. In central areas of continental masses, the frequency and severity of droughts could increase with drier summers and lower precipitation overall as the result. The scientific community has projected a continued decline in glacier mass, snow cover, and sea-ice, especially in the northern hemisphere. A wide range of possible sea level rise is also anticipated, which could affect coastal activities severely.

There is a growing scientific consensus on the likelihood of significant climate change and the potential for large adverse impacts worldwide in the future. In general, changes in water supply and quality, along with temperature change, will impact agricultural production patterns, human settlements, and human health, as well as biodiversity and migratory patterns. In addition to the scientific community, policy makers worldwide are also committed to face the challenges

of climate change. There is a growing concern that the poorer countries are likely to be the worst victims of adverse impacts caused by climate change. Not only are the poorer countries less prepared to address various anticipated adverse impacts, but in many cases their development efforts will be offset significantly by the projected losses.

The likely responses of the global community to face the challenges of global climate change are grouped in two categories: (a) *mitigation*, by which countries will reduce their GHG emissions, and (b) *adaptation*, by which adversely impacted communities will try to moderate the threats and maintain livelihood under changed circumstances. The industrialized countries will be the major actors in mitigation, as identified by the United Nations Framework Convention on Climate Change. Since the per capita GHG emissions of most of the developing countries are small, their initial role in mitigation will be on a voluntary basis. On the other hand, as the victims most likely to be affected by global climate change, their role in adaptation will be large and necessary.

The South Asia region constitutes only of developing countries, and some are counted amongst the Least Developed Countries (LDCs). These countries are characterized by high population and low per capita resource endowment, endemic poverty, poor state of governance, and low Human Development Indices (HDI). These will be most severely affected under climate change, but their responsibility to the historical loading of GHGs in the atmosphere is insignificant. Moreover, they lack financial and technological resources in order to prepare in terms of long-term adaptation.

The livelihoods of the large population in the region depend predominantly on the availability of adequate quantities of water. Maintaining their livelihood has become difficult in recent years due to increases in population and variable availability of water. Climate change and its associated adverse impacts will cause increased hardships for the people of the region.

This Section summarizes some of the findings in a Discussion Paper of the WASSA project, which assesses how the water resource sector of Bangladesh, India, Nepal and Pakistan may be adversely affected, and how these societies will be impacted by climate change. It also indicates what policy directions will have to be considered in order to counteract the adverse impacts of climate change in the South Asian countries.

6.2. Climate Change Scenarios

According to the Inter-governmental Panel on Climate Change the climate forcing of greenhouse gases will result in significant changes in mean climate, its inter- as well as intra-seasonal and inter-annual variability, in South Asia. Building a climate scenario for the region as a whole has been made possible by the introduction of state-of-the-art climate change models, but there is only limited confidence in their projections of future regional climate. In this Summary document, it is only possible to provide examples of the output of such models. Details are given in the Discussion Paper.

The regional GCM experiments reveal that, over the land regions of the Indian Sub-continent the area-averaged annual mean surface temperature rise is projected to range between 3.5 and 5.5°C (footnote) by the end of 21st Century. The results are summarized in Table 7. It is found that the projected surface warming is more pronounced during winter than during the summer monsoon season.

Table 7. Plausible changes in temperature over Indian Sub-continent

Time frame	Seasonal Distribution	Temperature change (°C)			
		A1	A2	B1	B2
2020s	Annual	1.18	1.00	1.32	1.41
	Winter	1.19	1.08	1.37	1.54
	Summer	1.04	0.87	1.12	1.17
2050s	Annual	2.87	2.63	2.23	2.73
	Winter	3.18	2.83	2.54	3.00
	Summer	2.37	2.23	1.81	2.25
2080s	Annual	5.09	5.55	3.53	4.16
	Winter	5.88	6.31	4.14	4.78
	Summer	4.23	4.62	2.91	3.47

Note: Based on CCSR/NIES Model Experiments; Area-averaged for land regions only.

The modeling results for South Asia for the winter months of 2050 are shown in **Figure 10**. The plausible changes in precipitation are shown in Table 8.

Table 8. Plausible changes in precipitation over South Asia

Time frame	Seasonal Distribution	Precipitation Change (%)			
		A1	A2	B1	B2
2020s	Annual	2.29	2.16	4.15	5.97
	Winter	0.39	-1.95	4.36	3.64
	Summer	1.81	2.37	3.83	5.10
2050s	Annual	9.34	5.36	6.86	7.18
	Winter	3.22	-9.22	3.82	3.29
	Summer	10.52	7.18	7.20	8.03
2080s	Annual	9.90	9.07	7.48	7.62
	Winter	-19.97	-24.83	-4.50	-10.36
	Summer	14.96	15.18	11.12	10.10

Note: Based on CCSR/NIES Model Experiments; Area-averaged for land regions only.

6.3. Some Implications of Climate Change Scenarios

The vulnerability of any resource or sector of any area or region to climate change induced effects can only be understood keeping the physical, economic and societal circumstances in perspective. The existing key risk factors often give indications on potential risks in the future. The inability of the society impacted by the changed circumstances to mitigate the adverse impacts translates into elements of vulnerability. A summation of the latter gives the vulnerability profile of that area or location. The South Asia region, in general, is quite vulnerable to extreme climate events such as droughts, floods, riverbank erosion, and cyclones. A changed climate could exacerbate these vulnerabilities in terms of both extent and frequency. The country-specific elements of risks posed by climate change, translated into possible impacts, are discussed in detail in the WASSA Discussion Paper.

6.4. Recommendations for Addressing Climate Change

In terms of global emissions of GHGs, the countries of South Asia make a relatively small contribution. Like other developing countries, they are exempt from any time-bound forced emission reduction targets under the Kyoto Protocol. However, India is already the fifth largest emitter of carbon dioxide, the gas that makes the most contribution to climate change. The current United States Administration has indicated that it will not ratify the Kyoto Protocol. Amongst the reasons cited for this stand are the adverse economic implication for the USA, and the likelihood that major developing countries such as China and India are not required to limit GHG emissions.

Starting from lower bases, the emissions of developing countries are increasing at a rapid rate. Asia's total emissions of carbon dioxide, the principal greenhouse gas, from the use of fossil fuels already exceed those from any other continent, as shown in **Figure 11**. On a per capita basis, of course, the emissions of carbon

dioxide from energy use in the developing countries are only a small fraction of those from the industrialized countries, as shown in **Figure 12.** As South Asia modernizes, such emissions are likely to increase considerably, but still remain much smaller than those from the OECD countries.

The South Asian countries, along with many other developing countries, are taking voluntary measures to abate GHG emissions while ensuring sustainable development pathways. It is expected that these countries will continue to develop in the coming decades, while reducing the rate of increase in their future emissions of greenhouse gases.

The IPCC suggests that there exists a number of ways to adapt to the changed climate conditions in order to partially avoid the adverse impacts of climate change. It may not be possible to completely avoid the adverse impacts of climate change on the water resources sector of the South Asian countries, but a number of measures may be considered to modify the threats and to increase the social and institutional resilience of these countries. Some of these measures are summarized below.

- **Flood management**. The major water-related problem in the Eastern Himalayan region is recurring floods, while that in the Western Himalayan region is drought. The best adaptation against floods is to increase the capacity of each country to forecast floods and implement early warning systems. To enhance flood-forecasting capacities of the countries in the GBM region, further development of a basin-wide flood forecasting mechanism is imperative.
- **Agricultural Practices.** Since agriculture is the single most important livelihood activity of the majority of the people in the South Asian countries, it is necessary to devise actions to minimize damages to agriculture. There is a need to develop crop varieties that are high yielding, but flood-, drought-, and salinity- tolerant. Application of

biotechnological interventions should be promoted towards development of such crop varieties. Research should be adequately followed up by farmer level demonstration and training, otherwise the new developments will not be accepted at the grassroots.

- **Institutional Changes**. Currently, water resource planning and implementation practices in the South Asian countries are oriented towards centrally managed systems that are often large and largely ineffective. Such management often fails due to the inability to reflect local-level needs and problems, poor operation and maintenance, lack of initiative by the local people to operate and maintain the schemes etc. Sub-basin level integrated water resource management practices should be considered with local level planning and implementation. Priority should be given to involving local people at every stage of implementation of the schemes. Their collective efforts should be institutionalized by encouraging them to formulate local-level Water Users' Associations (WUA). It is expected that the needs of various interest groups will be best served by involving the local people in the decision-making and implementation stages. Some of the required measures are shown in Table 9.

Table 9. Adaptation to climate change for crop cultivation

Measures	Actors	Requirements	Comment
Bear loss (no adaptation) - Loss of production - Loss of assets	- Individual farmers and farming communities		Hypothetical, highly unlikely to take place.
Share losses - Crop insurance - Cooperative management - Governmental subsidies	- Individual farmers and insurance companies - Farming communities - Farming communities and state	Additional investment in terms of premium. Agreement for sharing the output. State allocation for offering subsidies. Adequate legal and institutional framework.	Provisions to be made. Political motivation is required.
Modify the threats - Preparedness (early warning) - Awareness and training - Investment for structural measures	- Research community and farmers - Local government institutions, NGOs and farmers - Central and local governments	- Research & extension - Extension, media campaign - Investments (anticipatory) - Crop calendar adjustment - Opting for less susceptible crops	Farmers are already practicing it, based on ancestral behaviour/ knowledge. Manifold opportunities are plausible, barrier removal and implementation could be less costlier. High priority option.
Prevent adverse effects - Structural measures	- Government institutions - Farming cooperatives	- Large investment - Political motivation - Long-term planning	Investment intensive option. Financial constraints might hinder implementation process.
Change land use - Alternative cropping - Abandon crop agriculture	- Researchers, extension workers, farmers - Individual farmers	- Innovation through research, investment - Means of survival, skills for alternative employment	Unless alternative employment opportunities are created, it is not likely to be accepted socially.
Change location - Relocate to less vulnerable places	- Individual farmers and farming communities	- Free cultivable land	Heavily constrained due to unavailability of fallow cropland.

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