Climate Change, Adaptation and Adaptive Governance in Water Sector in South Asia

Monirul Mirza
Adaptation and Impacts Research Division (AIRD)
Environment Canada
C/o-Department of Physical and Environmental Sciences
University of Toronto at Scarborough
1265 Military Trail, Toronto, Ontario M1C 1A4
Canada
Email: monirul.mirza@ec.gc.ca; monirul.mirza@utoronto.ca

ABSTRACT

South Asia is the home of almost one-fourth of world population. Economies of the countries of South Asia are highly dependent on agriculture. More than 80 per cent of withdrawn water is used in the agriculture sector. Failure of monsoon heavily affects agriculture sector. For example, in 2003, due to late arrival of monsoon and reduced water supplies, overall economic growth of India reduced to 4% from the previous three years average of 8%. Floods also affect economies by reducing crop yield, infrastructure damage and leave a footprint in the livelihoods of the poor people in the society. Field survey results from an Asia-Pacific Network (APN) funded project found that people demonstrated partial resilience by adapting to recurrent onslaught of natural hazards and disasters but a large section of people unable to cope with. Institutional capacities and their governance of hazards are inadequate. Studies carried out on the implications of climate change on water indicate increased frequency of both floods and droughts in South Asia. Therefore, economic and social damage in South Asia may increase in future. The hardships of people could be reduced by increasing their adaptive capacities through institutional supports at various levels. This paper discusses the current status of adaptation and coping mechanisms in water sector in South Asia, future implications of climate change and how institutional adaptive governance will reduce vulnerability and increase adaptive capacity. Mechanisms include climate focus development, mainstreaming of climate change into development planning and institutional reform.

1.0 CLIMATE CHANGE AND WATER: WHY SHOULD SOUTH ASIA BE CONCERNED?

1.1 Climate Change and Sea Level Rise: Global and South Asian Regional Context

"Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global mean sea level." This is one of the major conclusions drawn in the recently released fourth Assessment Report[1] of Working Group I (WGI) of the Intergovernmental Panel on Climate Change (IPCC) (IPCC, 2007a) in the backdrop of eleven of the last twelve years rank among the 12 warmest years in the instrumental record of global surface temperature since 1850.

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[1] Note that the report "*Climate Change 2007:The Physical Science Basis*" assesses the current scientific knowledge of the natural and human drivers of climate change, observed changes in climate, the ability of science to attribute changes to different causes, and projections for future climate change. The report was produced by some 600 authors from 40 countries. Over 620 expert reviewers and a large number of government reviewers also participated throughout the assessment process.

The updated 100-year linear trend (1906-2005) of 0.74°C was found to be larger than the corresponding trend of 0.6°C for 1901-2000 calculated in the Third Assessment Report (TAR) released in 2001. The report further concluded that most of the observed increase in globally averaged temperatures since the mid-20th century was *very likely* due to the increase in anthropogenic greenhouse gas concentrations. This statement is an advance from the conclusion drawn regarding 'anthropogenic' contribution to global warming in the TAR.

The Report concluded that continued GHG emissions at or above current rates would cause further warming and induce many changes in the global climate system during the 21st century that would *very likely* be larger than those observed in the 20th century. Advances in climate change modeling now enable best estimates and likely assessed uncertainty ranges to be given for projected warming for different emission scenarios. The best estimate for the low scenario (B1) is 1.8°C (likely range is 1.1°C to 2.9°C), and the best estimate for the high scenario (A1FI) is 4.0°C (likely range is 2.4°C to 6.4°C). Although these projections are broadly consistent with the span quoted in the TAR, they are not directly comparable (IPCC, 2007a).

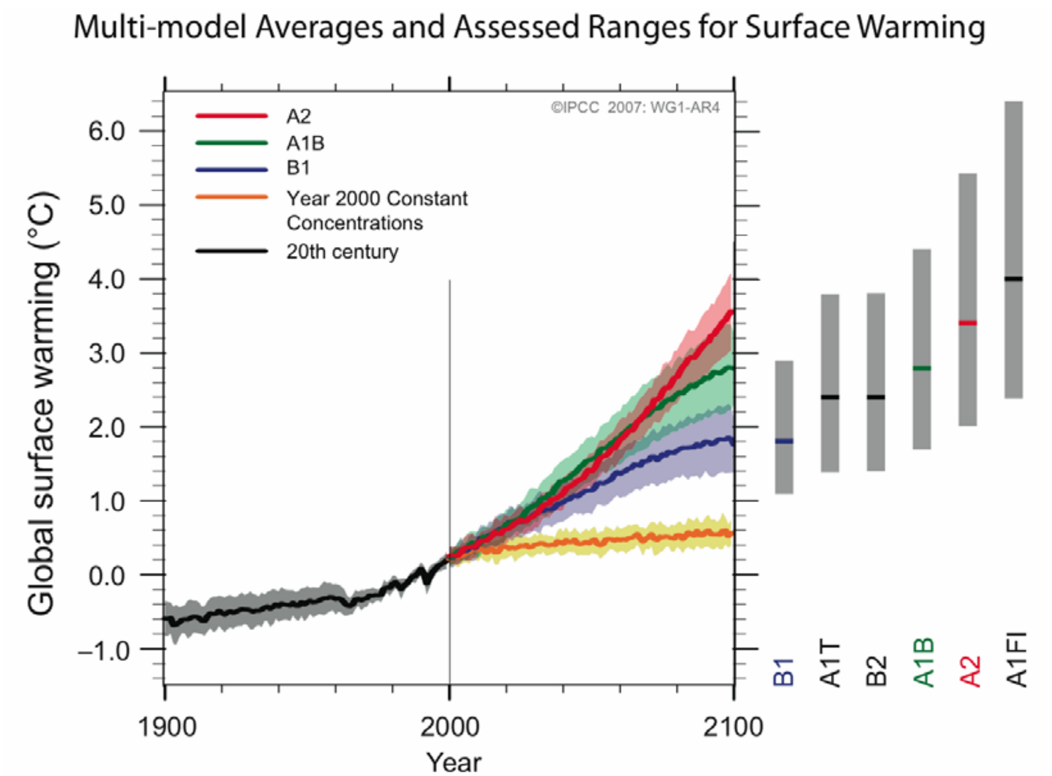

Figure 1: Solid lines are multi-model global averages of surface warming (relative to 1980-99) for the scenarios A2, A1B and B1, shown as continuations of the 20th century simulations. Shading denotes the plus/minus one standard deviation range of individual model annual averages. The orange line is for the experiment where concentrations were held constant at year 2000 values. The gray bars at right indicate the best estimate (solid line within each bar) and the *likely* range assessed for the six SRES marker scenarios. The assessment of the best estimate and *likely* ranges in the gray bars includes the AOGCMs in the left part of the figure, as well as results from a hierarchy of independent models and observational constraints (IPCC, 2007a).

Model-based projections of global average sea level rise at the end of 21st century (2090-2099) are also variable depending on the emission scenario. For example, for B1 scenario, sea level rise is projected to be 0.18-0.38 m. In case of A1FI scenario, it could be 0.26-0.59 m. Note that the model-based range excludes future rapid dynamical changes in ice flow. The ranges are narrower than in the TAR (0.13-0.88 m) mainly because of improved information about some uncertainties in the projected contributions. The anthropogenic warming and sea level rise would continue for centuries due to the timescales associated with climate processes and feedbacks, even if greenhouse gas concentrations were to be stabilized.

How much climate change and sea level rise are expected to occur in South Asia? Projections of temperature and precipitation for A1FI and B1 scenarios[2] are included in the 'Asia' regional chapter of the recently released IPCC WGII report. Projections of sea level rise have not been included.

Table 1. Projected changes in surface air temperature and precipitation for South Asia under SRES A1FI and B1 (highest and the lowest future emission trajectory, respectively) pathways for three time slices, namely 2020s, 2050s and 2080s.

Region	Season	2010-2039				2040-2069				2070-2099			
		Temp. (°C)		Precip. (%)		Temp. (°C)		Precip. (%)		Temp. (°C)		Precip. (%)	
		A1FI	B1	A1FI	B1	A1FI	B1	A1FI	B1	A1FI	B1	A1FI	B1
South Asia	DJF	1.17	1.11	-3	4	3.16	1.97	0	0	5.44	2.93	-16	-6
	MAM	1.18	1.07	7	8	2.97	1.81	26	24	5.22	2.71	31	20
	JJA	0.54	0.55	5	7	1.71	0.88	13	11	3.14	1.56	26	15
	SON	0.78	0.83	1	3	2.41	1.49	8	6	4.19	2.17	26	10

Source: IPCC, 2007c.

The climate model projections show very high seasonal differences in temperature change. Winter (DJF) would likely to be warmer than the other seasons followed by the summer (MAM). Under the A1FI, temperature change would exceed the IPCC business-as-usual scenario best estimate value (4°C). Most of the monsoon temperature increase would be lowest among four seasons. Country specific temperature change scenarios are not available in the IPCC WGII report. For *Bangladesh*, climate models project a steady rise in temperature (Agrawala *et al.*, 2003). Winter season may be warmer than the summer; the trend is similar to the regional trend in temperature increase. CICERO (2000) has estimated 0.9°C increase in temperature by 2020 for *Pakistan*, doubling to 1.8°C by 2050. For *Nepal*, the constructed scenarios demonstrate a significant and consistent increase in temperature for the years 2030, 2050 and 2100 across the various models. Increases in temperature are projected to larger in the winter season than for the summer. This is consistent with the climate scenarios with Bangladesh showing an upstream-downstream similarity (Agrawala *et al.*, 2003).

Seasonal precipitation changes do not show a consistent pattern. For example, under the A1FI scenario first and third time-slices demonstrate decrease in precipitation for the winter months (**Table 1**). Most of the climate models estimate that precipitation will increase during the summer because the air over land will get warmer compared to air over oceans in the summer. The highest

[2] A1FI is a fossil intensive scenario with high economic growth and rapid introduction of new and more efficient technologies. On the other hand, B1 storyline emphasizes on global solutions to economic, social and environmental sustainability, including improved equity, but without additional climate initiatives.

precipitation change (in per cent) is projected for the summer months followed by most of the monsoon. Implications of monsoon precipitation could be substantial on the key economic sectors although it is expected to be smaller than that of summer as more than 80% of the annual precipitation in South Asia occurs in the monsoon. For B2 scenario, a strong monsoon is expected for Bangladesh (Agrawala *et al*., 2003). With the aid of ECHAM4 and HadCM3 models, Kumar *et al.* (2003) constructed precipitation scenarios for 30-year time slices centered around 2020s, 2050s and 2080s relative to 1960-1990 climate. The simulations show increase in the rainfall over a large area of land and ocean which covers the core monsoon region in *India*. For *Nepal*, precipitation in the summer monsoon months are expected to be more pronounced than the winter months. No information on seasonal changes in precipitation is available but CICERO (2000) mentioned about high uncertainty around annual precipitation, which may change by ±3% by 2020, and 6% by 2050.

1.2 Future Climate Impacts on Water Resources: Why Should South Asia be Concerned?

Future climate change will significantly impact monsoon and winter precipitation dynamics, increasing the vulnerability of water resources by increasing the frequency and magnitude of floods and droughts and by changing quality of water in South Asia. This section addresses some of the “reasons for concern” for water sector in South Asia which are briefly discussed below:

- *The relationship between global mean temperature increase and damage to or irreparable loss of unique and threatened water systems*: Some unique and threatened water resources systems such as glacial lakes, Himalayan snow and glaciers and coastal and inland wetlands may be irreparably harmed by changes in climate beyond certain thresholds. However, recently released IPCC Working Group II (IPCC, 2007b) report mentioned enlargement and increased numbers of glacial lakes due to melting of glaciers in the high mountains due to increases in temperature.

Himalayan glacial snowfields store about 12,000 km^3 of freshwater. About 15,000 Himalayan glaciers form a unique reservoir which supports perennial rivers such as the Indus, Ganga and Brahmaputra which, in turn, are the lifeline of millions of people in South Asian Countries (Pakistan, Nepal, Bhutan, India and Bangladesh) (IPCC, 2007b). The Himalayan Rivers supply an estimated 8500 km^3 of water annually. Roughly about 10 percent of this volume of water comes from the melt water contribution which is very vital for the dry season flows. The remaining amount is generated from rainfall. The glaciers act as buffers and regulate the runoff water supply from high mountains to the plains during both dry and wet spells (Bahadur, 1998).

Recession of the Glaciers: Himalayan glaciers that feed the Ganges River appear to be retreating at a fast rate (**Table 2**). The estimated retreat of the Dokriani glacier in 1998 was 20 metres compared to an annual average of 16.5 metres over 1993-1998 (Down to Earth, 1999). Dokriani is just one of the several hundred glaciers that feed the Ganges. The 30.2 km long Gangotri glacier has been receding alarmingly in recent years **(Figure 2)**. Hasnain (2002) reported that between 1842 and 1935, the glacier was receding at an average of 7.3m every year; however, the average rate of recession between 1985 and 2001 is about 23 m per year indicating a three-fold increase.

IPCC (2007b) has mentioned that if the present rate of melting continues, there is a likelihood that many of the glaciers will be disappearing by the year 2035 and perhaps sooner is very high if the Earth keeps getting warmer at the current rate. Its total area will likely shrink from the present 500,000 to 100,000 km^2 by the year 2035. Global warming and glacier retreat in the Himalayas will have four broader implications. First, in the short run, in the process of continued retreat, more water will be supplied in the glacier dependent perennial rivers in the Himalayas (Singh, 1998). This may generate positive effects on dry season water availability. Second, chances of glacial lake outburst flood (GLOF) may increase (IPCC, 2007b). It is estimated that out of the 2,315 glacial lakes in the Nepalese Himalayas, 20 are potentially dangerous (ICIMOD/UNEP, 2001). Since 1935 Nepal has experienced more than 15 such GLOF events, which has become even more frequent in recent times. Besides human population developmental infrastructures such as hydropower, irrigation and drinking water supply projects are particularly vulnerable to such events (Shrestha, 2006).Third, in the long-run, dry season flow in the Himalayan rivers could be greatly reduced, posing serious eco-environmental problems (Hasnain, 1999). Note that with increase in population, water demand will likely be higher in the long-run. Therefore the gap between the demand and supply will be wider. Fourth, in the short-run, with increase in dry season flow, sediment supply in the rivers may increase. This may pose a threat to existing dams and reservoirs in the region.

Table 2. Record of retreat of some Himalayan glaciers

Glacier	**Period**	**Retreat of Snout (metre)**	**Average retreat of Glacier (metre/yr)**
Triloknath Glacier (Himachal Pradesh)	1969-1995	400	15.4
Pindari Glacier (Uttar Pradesh)	1845-1966	2,840	135.2
Milam Glacier (Uttar Pradesh)	1909-1984	990	13.2
Ponting Glacier (Uttar Pradesh)	1906-1957	262	5.1
Chota Shigri Glacier (Himachal Pradesh)	1986-1995	60	6.7
Bara Shigri Glacier (Himachal Pradesh)	1977-1995	650	36.1
Gangotri Glacier (Uttar Pradesh)	1977-1990	364	28
Zemu Glacier (Sikkim)	1977-1984	194	27.7

Due to sea level rise and intrusion of saline water, coastal fresh and ground water sources would likely to be polluted. Salinity has become a problem over a large part of coastal area of Bangladesh due mainly to reduced surface water flow in the coastal rivers. The reduction is caused by upstream withdrawal of the Ganges water at Farakka and at 29 other points in India and Nepal (Mirza, 2004). A 45-cm sea level rise could inundate could inundate 11% of Bangladesh (IPCC, 2001). Possibility of coastal inundation with one-meter sea level rise for India is 0.4% of the geographical area. For Pakistan a 20-cm sea level rise could inundate 0.2% area of the country. Entire Maldives could go under water with one-meter sea level rise, posing risks to water, human settlements, etc.

In Pakistan and western-India, future risk to ground water would come from increased water demand for irrigation and other purposes from warmer temperature, unsustainable uses of this resource, and reduced recharge in drought years.

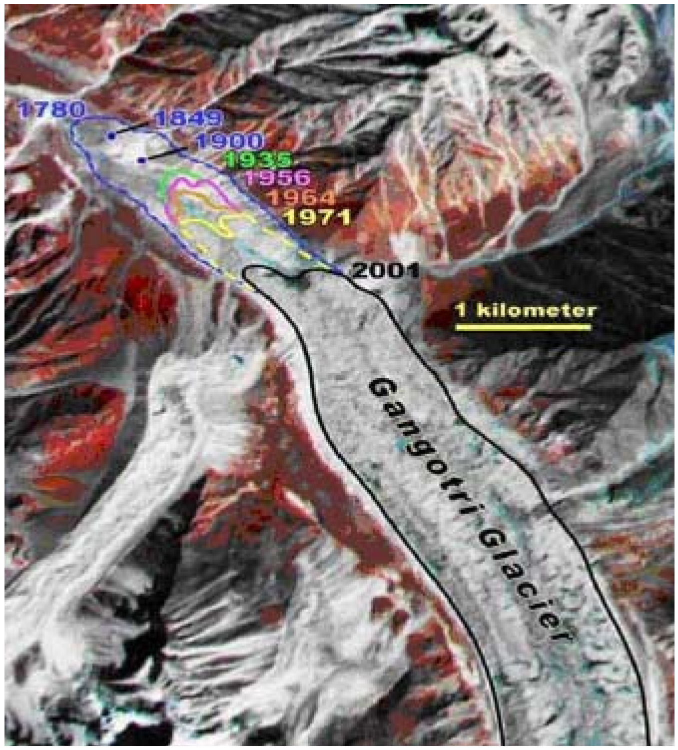

Figure 2. Composite satellite image showing how the Gangotri Glacier terminus has retracted since 1780 (Photo: courtesy of NASA EROS Data Center).

- *The relationship between global mean temperature increase and the distribution of water resources impacts and vulnerability:* Depending on climate and hydrological dynamics and geographical, population and ecosystem distribution, regional difference in impacts and vulnerability may be conspicuous. At present, the great pressure on water resources is from rising human populations, particularly growing concentrations in urban areas. **Figure 1.3** shows the impact of expected population growth on water uses by 2025, based on the UN mid-range population projection and the current rate of water use (UNEP and Earthscan, 2000). Possible increases in water requirement due to increased agricultural production to meet the growing needs of the burgeoning population and rapid economic growth to tackle widespread poverty would likely substantially increase the total water requirements. The recently released IPCC report (IPCC, 2007b) concluded that freshwater availability in Central, South, East and Southeast Asia particularly in large river basins is projected to decrease due to climate change which, along with population growth and increasing demand arising from higher standards of living, could adversely affect more than a billion people by the middle of this century.

- *The relationship between global mean temperature increase and the probability of extreme weather events*: As mean climate changes, so too will the probability of extreme weather events such as days with high or very low temperatures, extreme floods, droughts, tropical cyclones, and storms in South Asia will change. However, changes in the distribution of temperature and precipitation could make extremes much worse. IPCC (2007a) projected how in future extreme weather events would likely to occur (**Table 3**). Most of the climate models are in agreement about substantial changes in precipitation in the monsoon region

(Table 1). Therefore, it is very likely that flooding events will increase in the monsoon regions especially in the mega-delta areas of Ganges-Brahmaputra and Meghna (IPCC, 2007b). Mirza (2003) concluded that a 2^{o}C rise in global mean temperature could increase mean flooded area in Bangladesh by 25%. Due to increases in magnitudes of peak discharges of major rivers in Bangladesh, recurrence interval of extreme floods will also change. For example, magnitude of a current 20-year flood (5% probability of occurrence)

Table 3. Recent trends, assessment of human influence on the trend, and projections for extreme weather events for which there is an observed late 20th century trend.

Phenomenon and direction of trend	**Likelihood that trend occurred in late 20th century (typically post 1960)**	**Likelihood of a human contribution to observed trend**	**Likelihood of future trends based on projections for 21st century using SRES scenarios**
Warmer and fewer cold days and nights over most land areas	*Very likely*	*Likely*	*Virtually certain*
Warmer and more frequent hot days and nights over most land areas	*Very likely*	*Likely (nights)*	*Virtually certain*
Warm spells / heat waves. Frequency increases over most land areas	*Likely*	*More likely than not*	*Very likely*
Heavy precipitation events. Frequency (or proportion of total rainfall from heavy falls) increases over most areas	*Likely*	*More likely than not*	*Very likely*
Area affected by droughts increases	*Likely* in many regions since 1970s	*More likely than not*	*Likely*
Intense tropical cyclone activity increases	*Likely* in some regions since 1970	*More likely than not*	*Likely*
Increased incidence of extreme high sea level (excludes tsunamis)	*Likely*	*More likely than not*	*Likely*

Source: IPCC, 2007a.

Mirza (2003) analyzed probability of occurrence of a current 20-year flood of the Ganges, Brahmaputra and Meghna rivers in future in the context of 2^{o}C, 4^{o}C and 6^{o}C global mean temperature change (**Table 4**). The results show that floods with a magnitude of current 20-years would occur more frequently in future.

Table 4. Changes in the probability of exceedence of a current 20-year flood for the Ganges, Brahmaputra and Meghna rivers under the climate change scenarios

GCM	ΔT (^{o}C)	Ganges		Brahmaputra		Meghna	
		T	p	T	p	T	p
CSIRO9	2	9.2	0.11	19.9	0.050	11.86	0.08
	4	4.5	0.22	19.94	0.050	7.16	0.14
	6	<2.33	>0.42	19.97	0.050	4.41	0.23
HadCM2	2	28.2	0.035	9.8	0.10	6.82	0.15
	4	41.2	0.024	5.5	0.18	3.15	0.31
	6	61.8	0.016	3.4	0.29	1.85	0.53
GFDL	2	13.1	0.08	15.05	0.07	5.56	0.18

	4	8.7	0.11	11.41	0.09	<2.33	>0.42
	6	5.8	0.17	8.69	0.12	<2.33	>0.42
LLNL	2	19.0	0.052	18.80	0.053	8.25	0.12
	4	18.1	0.055	17.83	0.056	3.63	0.28
	6	17.3	0.057	16.87	0.059	<2.33	>0.42

Source: Mirza, 2003.

2.0 ADAPTATION AND COPING MECHANISMS: A SYNTHESIS OF THE APN PROJECT[3]

The Asia-Pacific Network for Global Change Research (APN), Japan funded a research project entitled *"Water Resources in South Asia: An Assessment of Climate Change-Associated Vulnerabilities and Coping Mechanisms"*[4] from 2002-2005. Under this project, a number of case studies on vulnerabilities and coping mechanisms associated with extreme water hazards and were conducted in the selected hydrological units (SHUs) in Bangladesh, India, Nepal and Pakistan (**Figure 3**). These SHUs are the 'hotspots' because they are frequently battered by extreme water hazards and put people and the economy at risks. The hydrological units selected for the flood survey were the Mahanadi basin in India, the Bramhaputra basin (locally known as Jamuna) in Bangladesh and Bagmati basin in Nepal. The drought surveys were conducted in the Sabarmati basin in India and the Sutlej and the Indus basins in Pakistan. In each of these SHUs smaller vulnerable sectors/hotspots were identified so as to focus on the most heavily populated, disaster- prone agrarian zones in these basins.

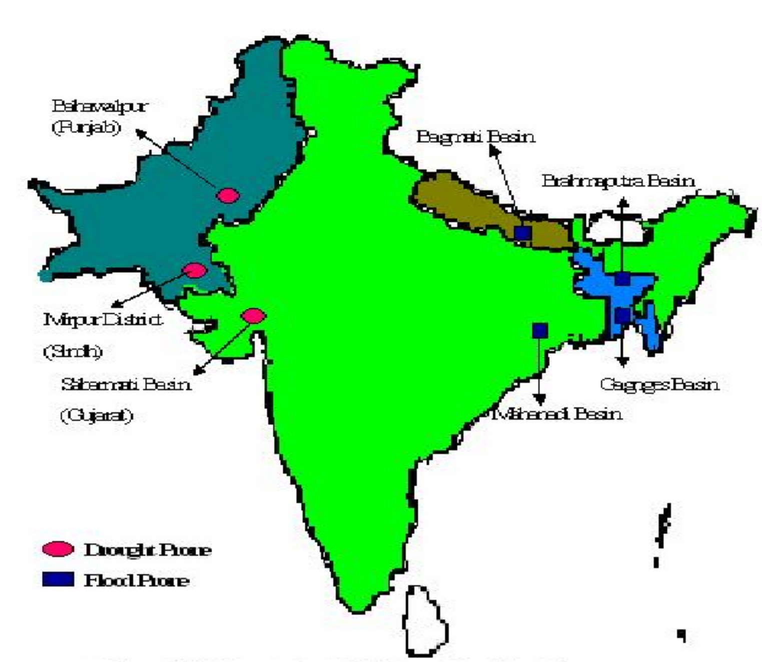

Figure 3. Selected Hydrological Units (SHUs) of South Asia where the field surveys were conducted.

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[3] This Section has been summarized from Muhammed (2004).

[4] The Project was funded by the Asia Pacific Network (APN), Fred J. Hansen Institute for World Peace (HIWP), San Diego State University, and the START Secretariat, Washington, DC. Four countries- Bangladesh, India, Nepal and Pakistan participated in this study. The author acted as the Advisor to this project.

Bangladesh

The questionnaire survey was conducted in about 300 households in Islampur Upazilla in the Brahmaputra River basin. An absolute majority, about 96 per cent of the respondents, reported that floods used to occur every year. The general awareness of the respondents regarding causes of floods was found to be high. About 85% of them reported that rise in water levels in rivers was the major cause, while the others identified the following few causes lead to occurrence of floods: (a) excessive rainfall in the upstream areas, (b) breach of embankment, and (c) reduction in drainage capacity and flow.

From the field survey results, flood coping was found to be a common practice in the SHU. About 63% of the respondents (n = 296) reported that they used to consider various flood response options in anticipation of an imminent flood. About half (48.3%) of the respondents adopted short-term measures while only 20% of them considered medium-term measures to cope with the hazard. Only 13.3% of the respondents reported that they used to adopt long-term measures in anticipation of flood. Of those respondents, who considered short-term measures (n = 145), 60.7% of those relocated themselves to safer places or shelters. Raising platforms within the household (13.8%) and use of stilts (15.2%) were the other two important short-term flood coping options. The most preferred medium-term option was to store food grains in safer places (71.7%), while keeping some money to meet the additional expenses following a flood (21.7%) were the second major medium-term flood preparedness options. Only a handful of households did consider longer-term flood response measures (n = 40). Raising plinth above floods level and build dwellings on stilts were the most preferred longer-term options for the respondents.

Flood warnings (i.e., with increased lead time to react & prepare early) well in advance and their dissemination in culturally sensitive terminologies/units and language could significantly facilitate local level coping. People opined that issuance of warning could be greatly facilitated by utilizing electronic media, since they had access to radio and to some extent, television. Respondents opined that early warnings would have allowed them to take precautionary measures in each vulnerable household, to safeguard assets and investments on perishable items. It came out from the survey that people were not well aware of the flood warning issued by the Flood Forecasting and Warning Centre (FFWC), located in Capital Dhaka despite its relentless efforts to improve upon current forms of forecasting and warning. It also indicates that a wide communication gap persists between the FFWC and the grassroots vulnerable population. In absence of flood warning from formal institutions, people used to seek advice from elderly people. In order to consider any preparatory coping measure, people used to apply ancestral knowledge.

The respondents who reported that collection of potable water during a high flood was a moderate to highly difficult task; they were requested to recommend solutions to the problem. Only 70% of the respondents (n = 103) could recommend solutions. To majority of the respondents (70%), raising base of the tube wells above flood level was the most preferred option, while 23.3% of the respondents opted for increasing length of the pipe (i.e., tube) of the well. ***Figure 4*** provides relative weight of various solutions recommended by the respondents with regard to availability of potable water during floods.

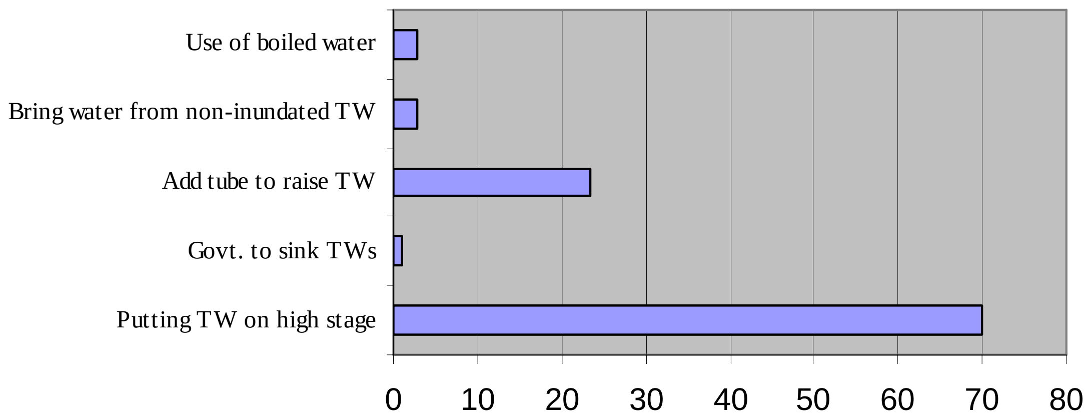

Figure 4. Recommendation to solve drinking water problem during floods.

India

For the flood survey, three villages in the Nayagarh district of Orissa in the Mahanadi delta were selected as the hotspot. The local population has devised certain practices to cope with the impacts of flood. Loss of livelihood forces extensive borrowings. The loans are often taken from the informal sector comprising of friends, relatives and local moneylenders. The households also have to resort to dissaving and sale of assets to meet their economic needs. The regular incidence of flood has also prompted many households to preserve dry food and grains to cope with the flood impact. Some households even hold contingency fund to cope with the eventuality of a flood. In order to reduce agricultural output loss the farmers usually cultivate *Champeswar* – a local variety of paddy. The crop is tolerant to water stagnation and can sustain almost seven days submergence. In this case only 50% of the crop is generally damaged. If however, the water stands for more than ten days, the entire crop is lost. The seeds are generally available from Government depots or have been individually stored using traditional means of storage.

Table 5. Strategies usually adopted to cope with flood hazards

Strategy	Number of reporting households	% of reporting households
Short-term measures		
Store dry food and medicines	14	31.82
Work in other villages	8	18.18
Crop insurance	8	18.18
Migration	1	2.27
Protect livestock	8	18.18
Pray	5	11.36
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Total	**44**	**100.00**
Long-term measures		
Build flood resistant houses	13	30.23
Build floodwalls around houses	2	4.65
Keep contingency funds	24	55.81

Buy polythene ------- **Total**	4 ---- **43**	9.30 -------- **100.00**

Source: Muhammed, 2004.

Nepal

In response to flooding hazards and disasters, various coping mechanism are adopted by the affected families, community, and government and non government relief agencies and organizations. Evacuation of lives, livestock and whatever possible essential housed properties from the flood affected sites, seeking temporary shelter, cloths and loan, seeds, building materials from the relatives, friends, villagers government and the relief agencies are the common conventional methods of coping actions as emergency measures by an individual household. From the PRA survey, adaptation measures pertaining to rescue and relief, livelihood, repair, reconstruction, and mitigation have been identified. These measures are inadequate to redeem the victim from disaster. In addition people also adopt some preparedness measures for coping the uncertainties of flood which are:

- Construction of wooden benches above the expected flood level for rescue and evacuation;
- Protection and storage of food, clothe and medicine, plastic sheets etc;
- Plantation of flood tolerant paddy, sugarcane or banana in the flood prone area;
- Storage of some extra amount of paddy seed for re-plantation;
- Temporary shifting of vulnerable members like pregnant women, children, old, sick and disable persons to safer places belonging to them or relatives or friends.

These all activities are mainly done by individual households with some assistance from relatives and friends. There is also a people to people communication of warning of the upcoming flood based on the information related to rainfall intensity and water level of the Bagmati River in Kathmandu, weather forecast, and cloud condition in the upper catchments of the river.

According to household survey estimates during flood times a family needs an average of NRs 5,676 (approximately US$ 85) a minimum amount to sustain his family. Out of this about 45% is meant for food and shelter, 18% for cloths, 25% of medicines, rest for other purposes which include utilities, transport, etc. It is also estimated that an average household spends about NRs. 16,832 (approximately 253 US$) on relief, recovery, reconstruction and rehabilitation during high flood events. About 48% households have spent more than NRs 10,000 (approximately 150 US$) for response and recovery activities in the last flood event. The main sources of spending are previous saving, loans, extra wage labor, mortgaging land, and selling property (land, livestock and Jewelry). In addition, dismantling house structure (9%), and migration to other areas (8%) are other means of adjustment. It was perceived that the price of the basic staple foods rose by 28% in average with standard deviation of 12%. This indicates that flood inflicts severe economic stress upon the people living in flood prone area. The condition of indebtness, dissaving and losing land and livestock, the main livelihood assets brought about by such unsustainable coping measures worsens the livelihood of the people and forces them to live under vicious circle of poverty.

Pakistan

The major coping mechanism to drought hazard is to sell the livestock followed by the sale of belongings. It becomes rather clear that the farmer's bank is livestock. It's his blood line and serves as his insurance. In terms of dire need this is the asset sacrificed to ensure economic survival. Reinvestment in better times is also centered on livestock. In terms of long-term measures no significant response was stated, perhaps peoples are so wretched with the vagaries of weather in form of drought that they have yet to learn what outside frontier functions exists to address this problem.

Key findings from respondent survey in Bahawalpur:

• The main reason for drought is stated to be low rainfall. Only 10% of the farmer showed any willingness to sell water during period of drought. This result clearly suggests the high value of water in general and particularly during periods of droughts. For the remainder the values are rather outrageous as water is survival and values attached to it are astronomical.

• Respondents said that provision of subsidized loans and encouragement of local industries would go a long way to motivate farmers to adopt modern irrigation system like trickle system.

• Majority of the farmers stated that they experienced crop damage during a normal drought. In the drought that occurred in 2002 they experienced damage. The main damage was to the cotton and sugarcane crops. The most frequently used variety for wheat is *Inquilab* which also seems to be dominant in the Punjab. Several varieties of cotton are in the system with different degrees of sensitivity to drought.

• The most demanding measure from government is provision of canal water. While 16% state that loans should be provided this aspect is rather well placed in ADBP providing loans. Recently other commercial banks have also granted loaning at rather subsidized rates.

• Farmers do not take any significant precautions to preserve seed. It seemed that they do not apply any seed treatment. Farmers responded that the a fair rate to ensure their crop over five years period was any where between 100% or almost 20% per annum. Farmers in the sample are unaware of the modern techniques of crop husbandry to cater to the problems of brackish water.

• Majority state that there should be a shift in favor of drought and salt resistant crops.

• Almost all the farmers stated that they experienced other damages to their livestock especially to cattle, poultry and grazing grounds. Farmers generally reduce the impact of drought on the farm by shifting livestock to other areas and by reducing the number of livestock maintained on the farm. Regarding the migratory aspect of livestock it is rather unique to the Bahawalpur area as was observed extensively during the survey where people were seen maintaining two types of household to meet conditions of severe water shortage.

• The main coping strategy adopted during the 2002 drought focused on sale of livestock and sale of belongings. Farmers also make changes in the feeding pattern. They mix what ever green fodder is available with straw, bran and other concentrates.

• Significant investment occurred in farm water management. However, 86% farmers do not buy the effectiveness of on-farm water user associations so much promoted by various International

Development Organizations. The effectiveness of local rural development projects seems to carry the same fate.

3.0 ENHANCING ADAPTIVE CAPACITY THROUGH GOVERNANCE

Losses from extreme weather events are on the rise globally as well as in South Asia. There is no discernible evidence that extreme weather events are increasing. Mirza (2001) analyzed high impact flooding events for the Ganges, Brahmaputra and Meghna rivers in South Asia and found increasing trends for some rivers but they also remained unchanged in other cases (**Table 6**). However, in addition to extreme weather events, there are other reasons for increasing damages which include increased development, expansion of human settlements in vulnerable places, virtually no change in design criteria of infrastructures, etc. The implications of these practices are widening adaptation deficit[5]. However, the deficit can be reduced through effective governance. There are many ways the governance can be introduced and/or enhanced which include climate focus development, mainstreaming climate change into development and institutional reforms, etc.

Table 6. Results of the statistical tests applied to the peak discharge data of the Ganges, Brahmaputra and Meghna rivers and the flooded areas in India and Bangladesh

Peak discharge/Flooded Areas	Station/Basin	Statistical Tests: Cumulative U Deviation	Worsley Likelihood Ratio	Kruskal-Wallis	Mann-Whitney
a. Peak discharge	Hardwar	Change (-)	Change (-)	Change (-)	Change (-)
The Ganges	Farakka	No Change	No Change	Change (+)	No Change
	Hardinge Bridge	Change (+)	Change (+)	Change (+)	No Change
The Kosi	Barahkshetra	No change	No change	No change	No change
	Pandu	Change (-)	Change (-)	Change (-)	Change (-)
The Bhahmaputra	Bahadurabad	No change	No change	No change	No change
The Surma-Meghna	Kanairghat	Change (+)	Change (+)	Change (+)	Change (+)
The Meghna	Bhairab Bazar	No change	No change	No change	No change
b. Flooded area	The Ganges	Change (+)	No change	Change (+)	Change (+)
India	The Brahmaputra	No Change	No Change	No Change	No Change
	The Meghna	No Change	Change (+)	No Change	No Change
Bangladesh	-	Change (-)	No change	No change	Change (-)

Note: The shaded rows denote locations within the border of Bangladesh.

3.1 Climate Focus Development

Infrastructure projects are mostly susceptible to extreme events especially flooding and cyclonic storms and surges. Although precise information on infrastructural loss due to these events is not available, in Bangladesh 40% of the flood losses is incurred by the infrastructure sector. Some climate considerations are taken into account in many routine development practices. For example, weather hazards (flood height, wind speed, etc.) are taken into consideration for roads

[5] The adaptation deficit is characterized by insufficient knowledge and timely action to offset the growth in vulnerability and damage potential that results from the growth of population, the increase of material wealth or the persistence of poverty and the expansion of human settlement in high hazard zones. Increases in the adaptation deficit can be directly related to climate change and are resulting in high levels of both insured and economic loses (Burton, 2004).

and highways and new urban development projects. However, economic consideration appears to be an obstacle in such situation. Consideration of extreme weather events often makes a project costly and such projects are not usually competitive for external funding. It is often said that The Asian Development Bank (ADB) recently conducted a study in the Pacific Island Nations.

There are several entry points to promote climate focus development in water sector. They are: Poverty Reduction Strategy Paper (PRSP); National Water Plan (NWP); National Water Policy; Five-Year Plan Document (FYPD); National Communications; National Adaptation Plan of Action (NAPA); Millennium Development Goal Plans (MDGs) and Environmental Impact Assessment (EIA). The Bangladesh PRSP did mention the link between natural hazards and poverty. "…There exists a direct link between natural disasters and the situation of poverty in the country. Hazards like floods, cyclones and droughts are noted for aggravating poverty in two ways: through destruction of food stocks and meager assets of the poorer households; and, through making employment opportunities scarce.

The Bangladesh PRSP further states…Poverty often leads to vulnerability to disasters, particularly to floods, riverbank erosion, coastal cyclones and tidal surge. The poorer households usually settle on less desirable high-risk peripheral land; and are unable to afford disaster proof housing. Consequently they are compelled to evacuate in case of a disaster, and have lower access to social and economic support needed for recovery." Although, the PRSP outlined in its objective to construct infrastructure projects in the climatologically high risk areas but it acknowledges that "…In general, the approach of risk reduction and pre-disaster mitigation have largely been peripheral and would have a long way to go before they become 'mainstreamed' in development projects and activities of not only the government, but also of the NGOs, and the corporate sector. Disaster mitigation activities remain ad hoc for the most part; not yet incorporated into regular project planning guidelines and operational procedures; and the long term impact assessment, monitoring and evaluation have remained inadequate." (GOB, 2004). However, the strategies to take into account climate change into projects/programs targeted at poverty alleviation are missing in the PRSP of Bangladesh. The Pakistan PRSP document several times mentioned 'drought' and its implications on poverty. It discusses water related infrastructure development and rehabilitation but does not mention how climate change would be taken into account. PRSP document of Nepal did not mention 'flood', 'landslides' and 'drought' at all.

3.2 Mainstreaming of climate change into development planning

Mainstreaming climate change into development planning can foster water governance as it will take into account future vulnerability, risk and adaptation. In the context of climate change, the term mainstreaming has been used to refer to integration of current and future climate change vulnerabilities or adaptation into government policy and implementation levels (Agrawala, 2005; Srinivasan, 2007). Srinivasan (2007) listed several benefits of mainstreaming: to ensure that current projects are no longer at risk from climate change or no longer contribute to the vulnerability of its recipients; to ensure that future projects are consciously aimed at reducing vulnerability by incorporating priorities that are critical to successful adaptation, such as ensuring water rights to social groups are exposed to water stress during droughts; to use resources efficiently and effectively; to avoid mal-adaptations; and to ensure consistency between the needs of poverty eradication and adaptation.

Several actions promote adaptation include integration of climate information into environmental data sets, vulnerability or hazard assessments, broad development strategies, macro policies, sector policies, institutional or organizational structures, or in development project design and implementation (Burton and van Aalst, 1999; Huq *et al.*, 2003). With the implementation of mainstreaming initiatives, it is argued that adaptation to climate change will become part of or will be consistent with other well established development programs, particularly sustainable development planning (Adger *et al*., 2007).

Srinivasan (2007) proposed three distinct approaches for mainstreaming climate change in water sector. They are: (1) ***Top-down*** (e.g. expanded irrigation systems) vs. ***bottom-up*** (e.g., community based water harvesting or allocation systems); ***Policy level*** (e.g., integrated water management policies accounting for climate change impacts) vs. ***operational level*** (e.g., location and design of drainage structures, dams/reservoirs & hydropower facilities); and ***Traditional*** (e.g., Water managers would construct a drainage system in area projected to experience more intense rainfall with pipes with larger-diameter by replacing the old-ones) vs. ***modern*** (e.g., a mainstreamed adaptation strategy in water sector that includes measures which address the underlying factors of vulnerability to climate change, particularly at local levels).

Mainstreaming initiatives can occur at four levels – international, regional, national and local or community. At the international level, mainstreaming of climate change can occur at the policy formulation, project approval and country level implementation of projects are being funded by the international organizations. Most of the water sector infrastructure projects are funded by the international and bilateral funding agencies. Mirza (2003) analyzed present state of integration of climate change into development funding policies of international funding agencies and found very slowly progressing processes. Various multi-lateral and bi-lateral development agencies, such as the Asian Development Bank are attempting to integrate climate change adaptation into their grant and loan activities (often known as climate-proofing) (Perez and Yohe, 2005; ADB, 2005). Other aid agencies have sought to screen out those loans and grants which are mal-adaptations and create new vulnerabilities, to ascertain the extent to which existing development projects already consider climate risks or address vulnerability to climate variability and change, and to identify opportunities for incorporating climate change explicitly into future projects. Klein *et al*. (2005) have examined the activities of several major development agencies over the past five years and found that while most agencies already consider climate change as a real but uncertain threat to future development, they have not explicitly examined how their activities affect vulnerability to climate change. Klein *et al.* (2005) develop a portfolio-screening tool to assess systematically the relevance of climate change to their ongoing and planned development projects.

Agrawala and van Aalst (2005) identified following five major constraints to mainstreaming: (1) Relevance of climate information for development-related decisions; (2) Uncertainty of climate information; (3) Compartmentalization with governments; (4) Segmentation and other barriers within development-cooperation agencies; and (5) Trade-offs between climate and development objectives. The Adaptation Policy Framework (APF) (Lim *et al*., 2005) developed to support national planning for adaptation by UNDP provides guidance on how these obstacles and barriers to mainstreaming can be overcome. Mirza and Burton (2005) found that the application of APF was feasible when they applied it for urban flooding and droughts in Bangladesh and India, respectively. However, they concluded that the APF application could encounter problems like micro-level socio-economic information and identification of gaps in the stakeholders' participation in the projects planning, design, implementation and monitoring. At present, the literature on adaptation as part of sustainable development policy within government portrays mainstreaming as a potential opportunity for good practice to build resilience and reduce vulnerability. But these opportunities are dependent on effective, equitable and legitimate actions to overcome barriers and limits to adaptation that have been identified in this literature (Agrawala and van Aalst, 2005; Lim *et al*., 2005; ADB, 2005).

3.3 Institutional and Policy Reforms

Major institutional concerns related to mainstreaming of climate change in South Asia are (Srinivasan, 2007): (1) ***Inefficient regulatory frameworks for water management***; In all South Asian nations, water related legal provisions are dispersed across various irrigation, water supply and sewerage, groundwater and environmental acts. There is no exclusive water laws; no explicit legal framework on water extraction rights or water trading. All South Asian nations have very ineffective water pricing and collection policies (Srinivasan, 2007); (2) ***Functional responsibilities are widely spread over***; A number of institutions are responsible to run water sector activities. In most of the cases, the functional responsibilities are un-coordinated or poorly coordinated. In India, Ministry of Water Resources, Central Water Commission, Central Ground Water Board; ICAR and Planning Commission look after water sector activities. In Bangladesh, eight organizations are responsible for development and services of water sector. In both India and Bangladesh, Ministry of Environment and Forest does not have any explicit role for water sector except for water quality monitoring and EIA approval; (3) ***National Water Policy***; India is the pioneering nation in South Asia to adopt first National Water Policy in 1987. It was revised in 2002. This document contains many references to water use efficiency and integrated watershed development but no reference to climate change and adaptation. Bangladesh adopted its first National Water Policy in 1999 with broader objectives of ensuring fulfilling national goals of economic development, poverty alleviation, food security, public health and safety, a decent standard of living for the people and protection of the natural environment. However, there is no specific reference to climate change and sea level rise. Pakistan's draft National Water Policy mentions about climate change in two occasions. It underscores the need of assessment and monitoring of impacts of climate change on water resources development and factoring them into future water development strategies. The policy document also emphasizes on taking into account climate change induced increasing prevalence of droughts while developing a drought management plan. Nepal does not have a National Water Policy Document. ***Five-year Plan***; India's 10th Five-Year Plan (2002-2007) does not have any explicit reference to climate change but mandates decentralization of water supply, water audits, efficient water use, integrated flood management, etc. Bangladesh's Fifth Five Year Plan (1997-2002) does not explicitly address climate change and adaptation.

3.4 Regional Cooperation

Bangladesh, Bhutan, India and Pakistan share large river basins –Ganges, Brahmaputra, Meghna and Indus. Water related disputes erupted after division of British India into two independent states-India and Pakistan in 1947. These two nations entered into a permanent treaty on the waters of the Indus River in 1960. Bangladesh and India are yet to resolve water sharing problem of their common rivers except for the Ganges waters on which both countries signed a 30-year Treaty in 1996. The problem is more institutional than engineering. India and Bangladesh constituted the Indo-Bangladesh Joint Rivers Commission (JRC) in 1972 to foster cooperation in water resources development. Mirza (2006) listed a number of weaknesses of the JRC which include: administered by engineers, lack of executive power, and transparency, etc. India and Nepal have a history of water cooperation for more than six decades. However, no institution similar to the JRC was created to develop water resources of the common rivers as well as to foster cooperation. India and Bhutan have also cooperative framework on water but does not have any formal institutional shape. India and Pakistan have the Permanent Indus Water Commission created under the Indus Water Treaty. As climate change is emerging as a threat to water resources of many common rivers South Asia, transformation of existing institutions and new institutional setups are required to tackle climate change related challenges.

4.0 CONCLUDING REMARKS

Climate change together with other socio-stresses (e.g., population growth, urban expansion, economic growth, globalization, etc.) will have substantial impact on water resources in terms of scarcity (drought) and abundance (flooding). This region has been historically vulnerable to climatic extremes and the vulnerability will highly likely to increase in future due to climate change. Coping capacity of most of the population is limited due to low per capita income, lack of access to social capital and administrative and political dis-connected functionalities. Vulnerability of population from extreme hydro-meteorological hazards can be reduced through adaptive governance which includes climate focused development, mainstreaming adaptation in development planning, institutional and political reforms and international cooperation.

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