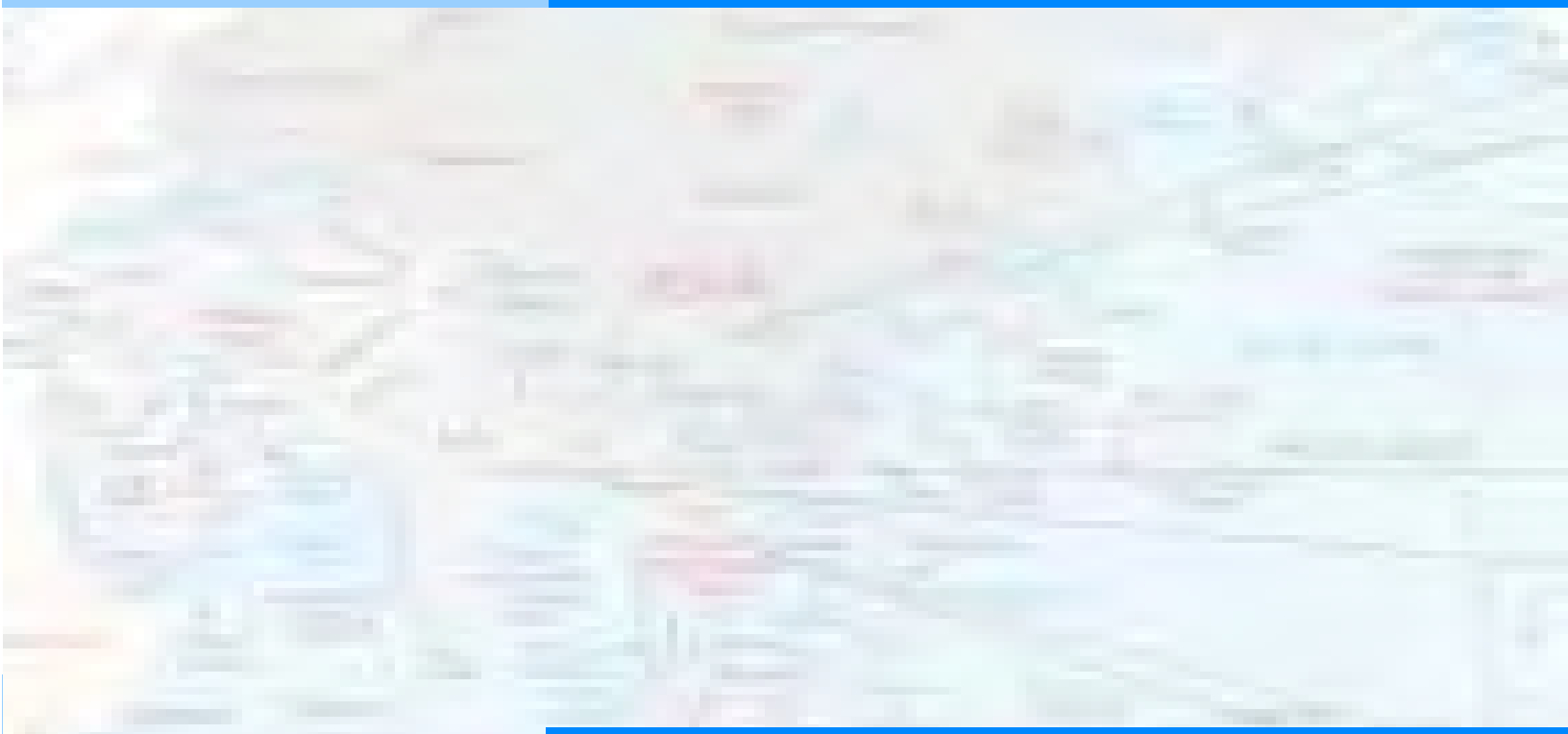

Climate Adaptation in Asia: Knowledge Gaps and Research Issues in South Asia

Full Report of the South Asia Team

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The context: Climate Change, Impacts and Adaptation Research

The South Asia region, which includes countries from Afghanistan to Bhutan is characterized by poverty, conflicts and extreme, often erratic climatic variability. While floods, droughts and high intensity storms are typically understood as *normal* features of life, the degree to which people have adapted to variable climate varies across the region. The extent of adaptation is in part due to the diversity of governance systems, the different degrees of development, urbanization and social stratification which, in turn, determine access to adaptive mechanisms (technology, knowledge, and resources) on the one hand, and on the other, are changes in the hydrological systems which are at the core of livelihood strategies for millions of poor and vulnerable people of South Asia. Overlying this physical, agro-ecological, social and institutional diversity are the high human security risks and conflicts across this region that poses a particular challenge in identifying key strategic entry points for research and capacity building on adaptation to climate change impacts.

According to the recent IPCC summary report "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 average sea level" (IPCC, 2007: 5). The report goes on to suggest that, there is a "*very high confidence*" that the globally averaged net effect of human activities since 1750 has been one of warming" (p. 5). The impact at local level are clear. For example, the number of warm nights has increased in northern India and mean temperature throughout India has increased by about 0.22ºC per decade since 1970 (Kothawale and Kumar, 2005). The increase in heat inducing fluxes will change wind patterns, sea surface temperatures and as a consequence alter the monsoon. Increases in the frequency and intensity of rainfall events will exacerbate flooding, while hotter temperatures will contribute to drought and increased energy and groundwater usage. These impacts have already been observed throughout South Asia.

Climate change will cause long term impact on the Himalayan glaciers that sustain the base flows of many of the rivers of the Ganga Basin. According to IPCC (2007) glacial melt in the Himalayan region is increasing and will continue to increase in all global warming scenarios. With the reduction and possible disappearance of the glaciers, the regional hydrological system will be altered with consequences for millions living in the basin. The coastal and deltaic areas are vulnerable to changes in the mean sea level. Significant portions of the Indian coastline that are located slightly above sea level (Janakarajan 2007) are battered by 12m high storm surges. A mean sea level rise of 0.5m (IPCC, 2007 projections) or higher (if the rate of Greenland ice sheet melt continues to accelerate, (Sheppard *et al.* 2007) within the next century will inundate significant portions of India's coastline. The higher water levels imply increases in storm surges and their impacts. In addition, sea level rise poses risk to mangroves, coral reefs and breeding grounds of fish. The prognosis

for deltaic regions of Bangladesh and the Indus River in Pakistan are similar. Yet it must be recognized that a large part of the explanation of the severity and range of impacts for South Asia will never be completely quantifiable.

Ongoing research suggests that the impacts will be varied in the Indus system and Pakistan. Studies suggest that temperature increase in both summer and winter will be higher in Northern Pakistan than in the South. It is suggested that temperature increase in North and South will be higher in the winter than in the summer. The changes will increase variability of monsoon adding to severe water-stressed conditions in arid and semi-arid region of the country. The other impacts will be more rapid recession of glaciers of Hindu Kush Himalaya which is likely to lead to reduction in capacity of natural snow storage. The impacts in South Asia are summarized as follows

TABLE 1: **Summary of Hydro-meteorological Climate Change Impact in South Asia**

	Country			
Parameter	**India**	**Nepal**	**Pakistan**	**Bangladesh**
Temperature	India is warming at the rate of 0.48 °C over the last 100 years. Since 1993, there has not been a single year when annual mean temperature was less than the normal. Projections show a temperature rise of 2.5°C to 4.9°C over the end of the 21st century.	Average temperature in Nepal increasing at the rate of 0.06 °C per year. The temperature in the Himalayas, however, is increasing at a faster rate.	A 3 to 5°C overall increase in temperature over the next century. Temperature increases in both summer and winter are higher in Northern Pakistan than in Southern Pakistan. Whereas temperature increase in Nothern and Southern Pakistan are higher in winter than summer.	Geographically part of the larger South Asian land mass the projection of warming rate for Bangladesh would similar to that of India.
Precipitation	Over all, the hydrological cycle is predicted to be more intense, with higher annual average rainfall as well increased drought. Summer monsoon rainfall over: a. Western Ganga Plain (GP): increasing trend (170 mm/100 yrs) from 1900. It is predicted that the rainy days will decrease. b. Central GP it shows decreasing trend (5 mm/100 yrs). c. Eastern GP: decreasing trend (50 mm/100 yrs) during 1900-84 and increasing trend (480 mm/100 yrs) during 1984-99	Increased variability in both monsoon and winter rainfall patterns. Daily rainfall will become more erratic and intense. The eastern mid-hills will show a general increase in rainfall. Where as in the western mid-hills a general decrease is projected. The central Tarai will see a marked increase in the rainfall with prediction of around 10 to 20 percent.	Increased variability of monsoon. The southern regions of the country are likely to get increased rainfall (up to 20 percent) where as the northern regions will experience decreased rainfall (5%)	The hydrological cycle will be more erratic with uneven, intense rainfall. It is likely that rainfall will be deficit and contribute to increased instances of drought.

	Models show a maximum expected increase in precipitation over central India (10 to 30percent) ,,	The rainfall pattern in the mid mountains will depend upon the micro-climate and is difficult to be generalized.		
River flow	Flows likely to be extremely high during the summer monsoon periods in the Ganga Basin. Snow melt water provides more than 85 percent of the winter flows in the Ganga. The present contribution is projected to reduce to about 30% over the next 50 years.	Analysis of mean monthly river discharge show global warming would melt snow cover on the mountain tops earlier, thus shifting the peak discharge month from August to July changing the regional hydrology of the Ganga and its major tributaries. These changes are likely to impact on glacial lakes and their breach with major local impacts. Faster melting of glaciers could lead to increased flooding as well as more pronounced variations in water availability throughout the year.	Glaciers contribute more than 60 percent of the Upper Indus Basin's flow. Studies indicate conflicting findings regarding the impact of global climate change on glaciers in Pakistan. Upper Indus Basin will see a 15 percent reduction in annual flow and a considerable change in intra-annual flow will be observed.	The impact of changing river flows is likely to be significant as more than 90 percent of flow originates outside the country' territory. The result is frequent floods and low flow condition which is likely to adversely impact the saline and fresh water balance along the coast. Cyclone and storms are likely to become more intense.

Source: Compiled from various sources.
ttp://www.defra.gov.uk/environment/climatechange/internat/devcountry/pdf/india-climate-5-water.pdf
Kumar and Parikh (2001a and 2001b)
Mall et al. (2006)

Approach and Methodology

This report presents South Asia-wide review of climate change adaptation research, intended to identify present knowledge, gaps on adaptation and application including the practice of research. Unlike the case of China, which is one nation, South Asia involves seven nations: Nepal, India, Bangladesh, Bhutan, Pakistan, Afghanistan and the island nations of Sri Lanka and Maldives. These island states are not part of the study though we organized one consultative meeting in Sri Lanka which was backed by a field visit. The political and administrative boundaries add a layer of complexity on the geographical and linguistic diversity, political structure and governance mechanisms, stage of economic development, socio-cultural context and research capabilities. These issues inherently have implications on the question of adaptation to impacts of global climate change.

This scoping study makes a distinction between planned and autonomous adaptation strategies including ways in which social and physical infrastructure enable adaptation (Synthesis Report). This chosen framework has helped to identify gaps and research issues in the course of the study. This report explores how groups in the vulnerable areas of the region are likely to experience stresses from impacts of climate change. Two issues emerge as crucial here. The first is the Himalayan Gap in IPCC AR4 2007. The second, which is related with the first, is the uncertainties associated with actual regional and local scale impacts of global climate change. This later limitation means that it will be difficult to attribute impacts to climate change per se, which in turn will make identifying adaptive responses difficult. This will be more so as the impact of climate change will intersect with existing poverty and vulnerabilities of people living in vulnerable places.

This analysis is based on information from the literature, interviews with key informants, and regional consultations involving local and national experts (researchers, civil society institutions, donors and local government officials). These discussions provided the team with information about existing and planned adaptation research in South Asia as well as climate change impacts, particularly on vulnerable people in vulnerable places. Informal 1-1 discussions were also held with experts attending the COP meeting in Bali in December 2007. The following consultative meetings were held.

TABLE 2: **Consultation meetings in South Asia**

Location	Date	Host Organization	No. of Participants
Dhaka	January 4-5, 2008	1-1 interview	15
Kathmandu	January 28, 2008	ISET Nepal and ICIMOD	33
New Delhi	February 12-14, 2008	1-1 interview	5
Colombo	January 25, 2008	Practical Action	35
Kathmandu	April 22, 23, 2008	ISET Nepal and ICIMOD	42
Islamabad	April 3, 2008	IUCN and Lead Pakistan	42

Voices from Consultations

The consultative meetings provided opportunities for regional and national professionals to present their own research and experience as well as to share perspectives on adaptation. Climate change has been recognized as a concern and efforts are being taken to reduce the vulnerability of people and the threat to national development. The views expressed in the meetings and consultations are summarized in the following section.

SCIENCE OF CLIMATE CHANGE

Global Climate Science

The science of global climate change is fairly robust in its ability to predict changes in temperature regimes. However, while it is well established that an increase in the concentration of greenhouse gases will increase average global temperature it is difficult to pinpoint, what the corresponding micro-level changes will be. In particular, the impacts climate change will have on physical and biophysical systems are not so evident. Nor are the socio-political impacts, which are likely to be pervasive. As a result of such uncertainty both adaptive policy making and implementing it is a major challenge.

Though our understanding of the impacts of climate change has improved, it is yet difficult to identify the specific impacts with any precision. Ordinary folks, particularly farmers appreciate that the inter-annual variability of precipitation has an enormous impact on their livelihoods, but their understanding the particular causes and effects of climate change is limited. Farmers and coastal fishermen, for example recognize that their environment is changing but cannot identify exactly how.

One of the major difficulties lies in assessing the impacts of climate change at the regional scale. Existing Global Circulation Models (GCMs) do not capture regional scale changes; regional-scale models at a resolution of 30 km x 30 km must be created. While not considered a priority in the past, times have changed. Some modelling centres like those in Italy and Iran already run climate models suitable for South Asia. One such model predicted the path and incidence of recent cyclones but similar models need to be developed specifically for the Himalayan region too. Regional climate analysis by agencies such as ICIMOD in Kathmandu aims to put climate science into the regional context.

The lack of resources for downscaling of GCMs is a key constraint and, more particularly, for setting up a laboratory to run regional climate model. Such a laboratory would help analyse local-level variations and contribute to the science of climate change. It would need to consider the financial resources for operation including a sustained supply of electricity (one cycle would last 90 days). Twinned with district-based maps, model outputs can be used to devise decision support systems and to build local capacity.

Climate change impacts

Climate change may have the following impacts:

1) Untimely rainfall: Unseasonal heavy rainfall in February damages *rabi* crops. It also has an adverse effect on urban drainage systems
2) Short-term heavy rainfall: Rates like 350 mm in six hours and 10 mm an hour cause drainage problems and urban flooding, whether in Dhaka or elsewhere, like in Bombay (July 2005), Patna, and towns in the Nepal Tarai. Though such changes may not be scientifically documented, it is clear to scientists and farmers alike that climate is becoming more erratic.
3) Flash floods: Flash floods occurring in mid-April before the onset of the monsoons are common in upland areas of Nepal and India. In Nepal, flash floods are caused when landslides block a river and are later breached, thus damaging crops. The changed hydrological sub-processes could also lead to greater washing of nutrient from highland to lowlands
4) Increasing magnitude and frequency of flooding in main rivers.
5) More frequent droughts: it is possible that even during the monsoons rainfall is deficient affecting water storage at the community level for drinking and irrigation.
6) Irregular hydrological processes: there is sometimes too much water and sometimes too little.
7) Greater storm surges and more powerful cyclones are increasing. The increase energy of storms is worrisome.
8) Coral bleaching, as a result of global warming, could affect tourism in countries like Sri Lanka, and lead to loss of annual income.
9) Sea-level rises and increasing salinity: Predicted sea level rise will damage coastal wetlands, brackish water marshes, mangroves swamps and freshwater marshes that merge in to estuarine system.
10) Rising in temperature: higher temperature will affect production and impact food security.
11) Health: Malaria, dengue and diarrhea are on the rise, though the latter is also correlated with behaviour (not washing hands).
12) Biodiversity: Areas rich in biodiversity from the Himalaya to the lower Ganga plains are at risk from climate change and its associated problems

Climate change has resulted in serious impacts in South Asia especially on the sectors such as agriculture and water and on those dependent on them for sustenance. The exact impact, however, needs to be disaggregated across different variables and assessed continuously. Analysis of cyclones offers an entry point for such an enquiry: because they damaged the livelihood base the affected population ends up as refugees in urban slums.

We need to build our capacity to assess the impacts of climate change on societies and economics and to consider the relevance of various decision-making regimes if we are to make policies more efficacious.

Information, Gaps and Uncertainty

***Information*:** Scientific information, database management and dissemination are essential to plan adaptation measures. Only if we have good quality data available to predict any climate-related disaster, whether a tsunami or a severe flood can we be better prepared to formulate and implement adaptation policies. Better ways to support on-ground initiatives and also strengthen early warning systems are needed.

While good quality data and a high-level confidence in its accuracy generate robust predictions, their lack may result in the adoption of policies which do more harm than good. Information is normally collected and mapped at the national or regional level, but local information and variances need to be factored in order to make micro-level predictions. The procedure to collect data at the local level should be simple, easy and dependable.

There are various means of disseminating information such as newspapers, visual and electronic media: telephone, internet, mobile phones etc. Among them, radio is one of the most popular ways of disseminating climate related information. The flow of information through it should be accurate and timely. At present, communication of early warning and meteorological messages from high-land to low-land (For example Nepal Tarai to Eastern Uttar Pradesh is difficult. We need to develop site specific and better technological information systems to enable adaptation. It is within this context that we need to conceive of regional cooperative mechanisms for sharing of data.

Communication systems can become important gateways which can be conceived in terms of Amartya Sen's conception of entitlements. These are specific underlying systems that allow people to choose strategies. Access to cell phones, for example could facilitate adaptation. There need to be targeted entry points where systems do make a difference. Within the system we need to take advantage of local knowledge and establish communication between the scientific and local communities. Equally important are the linkages between formal and informal information systems so that the data is transferred into information and then to knowledge.

***Gaps*:** To address data gaps we need an iterative process, the homogenization of the available data and preparation of data inventory. Data availability will never be perfect in part because no rainfall network will ever cover all areas, but more can and must be done.

The number of stations for monitoring the rise in sea-level is inadequate. There aren't enough stations to monitor sea-water level or the concentration of salt water either. Such stations are necessary to assess how changes in deep sea water level correspond with changes in sea level along the coast. Because of the influence of the continental shelf the changes are not identical. Data on salinity is crucial to determine the impacts on agriculture and other livelihoods.

Our understanding of the dynamics of natural science is limited. Though geomorphology is changing due to changes in regional hydrological and sediment flows, we know little about the implications of such changes for the lives and livelihoods of people living in the South Asian region.

Changes in hydrological sub-processes wrought by climate change will affect sediment processes within the hydrological cycle too, but current analyses of the sediment dynamics peculiar to coastal regions are based on the notion that the hydrological cycle is fixed. We need a more scientific approach if we are to grasp the potential changes in geomorphology and land subsidence caused by climate change.

The idea that Bangladesh will be submerged by the sea due to a climate change-induced sea-level rise needs to be revisited. Decades-old embankments in coastal Bangladesh do withstand high tides though they cannot actually prevent storm surges. However, those

embankments which were built many decades ago and have grown weak due to poor maintenance need to be strengthened so they can withstand more frequent and higher tides.

With the advantage of hindsight it can be argued that the emphasis on sea-level rise was strategic: it was able to draw the attention of scientific and development communities to the threat Bangladesh faces due to climate change. The way forward is to begin to fill gaps in our knowledge of scientific processes and to make tangible adaptive strategies. To progress, requires tinkering with institutional landscapes so that they incorporate incentives to foster adaptive strategies.

Uncertainty: The fact the various global circulation models (GCMs) yield contradictory results, creates problems at the operational level, particularly while engaging the policy-makers. In mountain environments, the problem is exacerbated because models do not account for effects caused by changes in elevations. Such uncertainty makes it difficult to attribute changes to climate dynamics and is not conducive to policy-making.

VULNERABILITY

How does one distinguish between vulnerability caused by climate change or other factors? Climate proofing of development efforts have been taken into consideration. Micro-level "vulnerability atlases' developed for each area will be a useful tool if the political ramifications (i.e. access) can be appropriately dealt with. Composite indices covering all of South Asia are also necessary. The physical and biological extent of vulnerability is given below:

Physical

In the meetings, participants raised many issues about the nature of impacts on the different regions of South Asia. The discussions focused on definitions such as hotspots, areas of interest and themes of interests. The following emerged broadly.

Hotspots: are defined as locations that are *particularly* vulnerable to climate change and have large vulnerable populations. The Indo-Ganga plain and Deltaic areas do feature prominently as hotspots as they have large numbers of poor and vulnerable people as well as severe climate risks.

Areas of interest: are defined as locations that are not hotspots, but where climate impacts may have major implications for vulnerable populations; however, there are no easily identifiable or clear criteria (e.g. declining rainfall) required to qualify as a hotspot.

Themes (or dynamics) of interest: are conceptually grounded and not geographically based. Processes/themes/dynamics, such as migration or tipping points that could either mitigate or enhance impacts of climate change on vulnerable populations but that are poorly understood. These are strategic entry points, often themes that cut across different regions, where research could contribute to or catalyse change.

In the discussions participants expressed views about the challenges of the EGB as follows

TABLE 3: **Characterisation of climate-vulnerability issues in the Eastern Ganga Basin**

Lower Basin	Mid-hills	Higher regions
Flooding & shifting of river channels	Landslide in upper slopes and *bishyari*	Snowmelt/glacial sets of impacts (GLOF)
Changes in rainfall pattern	Siltation process	Permafrost melting
Effect of upper and middle hills	Dry areas in the corn growing south slopes	Changes in transhumance systems
Engineering structures exacerbating impacts due to episodic events	Absence of irrigation in middle hills	Change of precipitation patterns, implications for buildings and other infrastructure
knowledge system of underlying design factors not appropriate under CC, lack of data	From middle hills and upwards have a clear warming trend – direct temperature impact, particularly on agriculture,	Irrigation system in higher areas (snow-fed) being affected – major impacts on farmers – migration, tourism, shifting the nature of agriculture emerging as a major response
Economics and politics of investment in resilient structures	Explosion of road networks and possible slope destabilization	Linkage with hydropower – lower snow/glacial flows, possibly more peaked storm flows, possibly higher sediment flows.
Irrigation scarcity, depletion of water level, lower runoff. People face major water scarcity problems for irrigation	Social exclusion factors as elsewhere	Water storage issues (major dam issues with large scale sedimentation)
Information and data availability (river gauging and hydrometeorology) both establishment and maintenance plus use of data – data collection driven by hydropower and irrigation, need for automated data	Absence of good downscaling of CC impacts aside from temperature. Winter precipitation decline, summer increase possible outcome.	Out-migration
Neglect of non-perennial rivers	Declining spring-water sources – possibly related to rainfall patterns (but lack of any data to substantiate)	
Changes in temperature, cropping patterns, alien species – high impact on biodiversity, health, agricultural impacts	Overall region has problems for attribution	
Changes in land use system urbanization, implications for basin structure, poor lands being cultivated	Major linkage with hydropower – water availability and increase in sediment load	
Effect in conjunction with mining of stream beds		

Houses on embankments

Box 1: **From Riches to Rags in Eastern Uttar Pradesh**

Manoharchak, a small village of 104 households, is situated on the banks of Rohini River, 40 kilometers North of Gorakhpur. Agriculture, the main source of income for the residents, gets seriously affected by flooding caused by the 35-year-old Rohini River embankment outside the village. Although the embankment does check regular floods, it has affected agricultural *Kharif* season due to water logging. Most farmers own less than one acre of land and the village lacks basic water supply, sanitation and health services. Out-migration is rampant.

On the night of July 31, 50 meters long breach in the Rohini embankment next to the village allowed Rohini floods to enter and inundate villages. A number of link bunds and roads linked to the Rohini embankment also breached following the main breach. More than 30 km was inundated. More than 1000 acres of cropped land was wiped and around 500 acres of land was affected by sand deposition (the depth of sand deposition varies from 5 feet at the mouth of the breach to around 1- 2 feet at the margins.

Manoharchak was devastated as forty people lost lives. So was Dev Narayan. Farmer Dev Narayan began using of "Narendra Dev, 97" a variety of paddy that matures early and suitable for water logged areas. Almost eighty percent of the farmers use "Narendra Dev, 97". Laments Dev Narayan, *"My fifteen bigha of paddy fields had reached a stage of bearing harvest. We had expected a bumper harvest. This breach and consequential deposition of sand has shattered my dreams. How will I and my family survive?"*

Until 2004, Dev Narayan was a middle class farmer who owned twenty *bigha* of land (shared among his 5 brothers). The 2004 floods in Rohini had damaged about five *bigha* of this asset. In the remaining portion, five *bigha* of paddy is covered by three of sand. Water gushing out of the embankment washed away one of his daughters.

Participants expressed views that the climatic characteristics and demographic distribution within will be helpful while planning for the following:

- weather indexing
- early warning system
- alternative livelihoods and
- to develop methodologies for assessing vulnerability.

Social

Most *dalits* and displaced poor people settle on marginal lands on the Indo-Ganga plains that are highly vulnerable to climate changes. These places usually have water and food scarcity and very little scope for local livelihood diversification. Majority of these people live on less than one dollar per day. The coastal population is vulnerable to the threats posed to their livelihoods because the sea is growing rougher. Similarly, the mid and higher regions are prone to floods, GLOF, *bishyari* and landslide. In the coastal areas, when warning is issued for a storm, people need to come back from fishing earlier and their investments go to waste. Other problems are that coastal fishermen have no alternative sources of livelihood and the growing population density puts pressure on the limited resources. In other places, floods, landslides and droughts cause loss of property and assets. These cause the poor to fall into debt and ultimately they are forced to migrate which can be both seasonal and permanent. In many areas, due to climate-induced disaster, landlords have become beggars. When male members seasonally migrate to other places, household responsibilities will fall on the women who stay behind. They will have to take care of the household as well as work in their fields. As a result, due to the increase work burden, there are other impacts, such as on children's education, health, leisure time, etc.

Providing a supply of drinking water to communities marooned by floods is a major challenge facing South Asia. Climate change puts an additional stress on existing hazards and makes prevention, which has not been a focus, still more difficult. In most regions of South Asia gender is a cross-cutting issue underlying vulnerability.

VECTORS AND DISEASES

Other major issues related with climate change are the spread of diseases and increase in the number of vectors. Climate change as one of the drivers of change is influencing human health and their well-being. Water-borne diseases are rampant and results in annual losses of millions of dollars. In the last few years changes in disease patterns have also been observed. Once eradicated diseases like malaria have now become widespread. Mosquitoes have also been seen in higher altitudes where they remained virtually absent earlier.

BIODIVERSITY

Climate change also impacts ecology and thereby the dependent livelihoods. This potential impact intersects with the present challenges of inequitable sharing of benefits and access to it among groups, within groups and between upstream-downstream users. With the changing climate already the tree lines are shifting up. There are possibilities of changes in distribution of plant species too. Rangelands and biodiversity are shifting beyond their normal range. Species loss is already occurring. High altitude wetlands, which play an important role in regional hydrological systems have also dried or are on the way to becoming dry.

FOOD SYSTEMS

Food systems are other vulnerable sectors. Broadly speaking production, access to food supply and nutrition will all be affected. In Bangladesh, apart from rice, corn is also cultivated as feed for poultry and livestock. This shift in patterns hurts the poor and the marginalized most because they do not generally consume the poultry (which is consumed predominantly by more well-off populations in urban areas), but suffer from rising food prices. Similarly, in other countries like Nepal and India, paddy, corn and other crops are highly affected by climate change.

Box 2: **Impact of Climate Change on food Production**

"While India is a high-growth economy, the benefits have been unequally shared and there is a large human development backlog. Around 28 percent of the population, some 320 million people live below the poverty line, with three-quarters of the poor in rural areas. Unemployment among rural labourers, one of the poorest groups, is increasing, and almost half of rural children are underweight for their age. Superimposing incremental climate change risks on this large human development deficit would compromise the ambition of 'inclusive growth' set out in India's Eleventh Five–Year Plan. Projections for other countries in South Asia are no more encouraging.

Country	Impacts
India	For 2.5°C, yield loss for rice & wheat between 32 and 40%.
	And for 4.9 °C yield losses between 41 and 52%
Nepal	Majority of the households do not produce sufficient food. They migrate in search of livelihood. Climate change will bring significant effect on production. So SO far, the deficit has been met by food purchased. Climatic change may disrupt the distribution too.
Pakistan	Agricultural yield losses of 6–9 percent for wheat with a 1°C increase in temperature.[1]
Bangladesh	A 4°C temperature increase could reduce rice production by 30 percent and wheat production by 50 percent.[2]

[1] HDR 2007-07, p. 94.
[2] HDR 2007-07, p. 94.

Farmers are adopting indigenous varieties of paddy that are resistant to flood, drought and salinity. Over the past 35 years in coastal Sri Lanka for example (Hambantota district) increasing soil degradation due to soil pollution, water logging, over use of fertilizers and pesticides and salinity have forced farmers to abandon their fields. Some have now diversified their income or others have migrated to the labour or construction sector.

LINKS AMONG CLIMATE HAZARDS, DISASTER RISK REDUCTION AND DEVELOPMENT

The impacts of climate change are discernible in water and hydrological sub-processes such as floods and droughts. Adaptation should be linked to initiatives in disaster risk reduction and management. While there is an emerging discourse arguing that disaster mitigation is long term, the national and local governments still pursue relief as a chosen strategy. Though important from a humanitarian perspective, relief is also not accessible to those serious affected and remains as a fire-fighting measure.

Integrating responses to climate change impacts within the operation of government and non-government organizations is a challenge as few have included climate change issues

within their scope of operation. Since climate-related impacts are uncertain, local institutions feel they are beyond their capacity to handle responses and have not accorded much attention to them. Often warnings about storms are issued but either the system fails or the warning goes unheeded. In both cases, those on the coast are hit hard. Fishermen at sea return to find their homes and other assets destroyed and their source of livelihood undermined. Investments in developing multifunctional warning systems could benefit the vulnerable. In this connection we need to look at insurance and loan mechanisms to alleviate climate change impacts.

Bureaucracy and institutional filters

We need to recognize the structural limitations of the political systems and the bureaucracy. The existing state architecture lacks the capacity to address the challenges posed by climate change impacts. Because coordination among government agencies is poor and each agency has inbuilt filters designed to keep it in its comfort zone, the ability to adjust rules, regulations and policies necessary for addressing climate change impacts is lacking. How bureaucratic limitations can be overcome in the process of change is a key question but without an answer. Donors are also constrained in their ability to introduce change. Organized to work with government agencies, they become in the government morass and can offer few options.

Unlike the central bureaucracy and donors, the parliament, *upzillas* and the union *parishads* could play a crucial role. Such regional and local-levels state institutions do not however have power, resources or decision-making authority to implement adaptive measures. Politicians, including parliamentarians and other policy-makers could be allies to promote systemic adaptations if they are engaged.

Role of stakeholders

Discussions identified actors that range from farmers, banking institutions, the business sector, the Rural Employment Guarantee Programme (such as NREGP in India); research institutions; the Planning Commission; local level governments; local level political leaders; civil society bodies; NGOs; universities and regional networks and the electronic and print media.

Governments

Central: Because coordination among government agencies is poor, government formulated policies are rarely implemented effectively. Inter-ministerial politicizing is pervasive and scope of operations quite narrow. In any case, climate change is not an immediate priority for decision-makers who are grappling with many other more pressing issues. Most see climate change as a future problem and many lack a basic understanding of the related issues. In the past, external support provided through bilateral aid, research and NGOs has helped the government play a role in global negotiations. The Climate Cell Centre in Bangladesh is one example of an institution established with such support. The Environmental Ministry of Nepal also has sought support.

The difference between the Finance Ministries' immediate budget priorities and long-term resources needed for climate adaptation needs to be addressed. Officials argue that

budgetary allocations for climate change needs to be increased but Finance Ministries' have not been included in the process of change. Since funding is crucial we need to introduce creative ways of engaging the Finance Ministries.

Climate policy needs to be mainstreamed into regular developmental and governmental activities. In particular, the Planning Commission must create institutional incentive mechanisms. Unfortunately, this is easier said than done and: while only a sustained effort can institutionalize new pathways, official seek to meet tangible and pragmatic short-term goals. Uncertainty about the impacts of climate change remains. In addition, the government should play a major role in facilitating the process, but has limited capacities. The gap between, what needs to be done and what, at present, can be done is at the local level. Finally, before new ways of working better can even be internalized, innovation must be tested and their outcomes assessed. Only their will adaptation to climate change is institutionalized.

Local: Local government can play an important role in implementing programmes concerning adaptation to climate change, but in all South Asian countries the devolution of decision-making authority is the subject of political contestation. Besides, while devolution is necessary, it is also possible that local institutions will be captured by the local elite and that a disjunction between the state and the society will be developed. What kinds of governance mechanism would create a balance of power is a question that is very pertinent for climate change adaptation, particularly because it is the poor who are most vulnerable.

District-level governments must be involved in the adaptation process and need support of capacity building packages. We need to build capacity of local governments to:

- Use existing knowledge both from both natural and social sciences
- Engage with stakeholders
- Integrate climate change into the functioning of local governments and implement programmes

Private Sector

The private sector can assume a greater role in dealing with climate change by promoting renewable energy such as solar and wind. The private sector is also involved in the agriculture sector, (selling of seeds, trading in grains and other activities). It has too little incentive to invest in adaptive processes except perhaps those in agriculture. Both the opportunities and the limitations of the carbon market need to be examined.

The role of the private sector needs to be viewed in the context of general investment in of smaller economies. The fact that foreign direct investment is on the wane, but imports are increasing has an important bearing on livelihood diversification as a strategy for adaptation. In particular, since imports are cheaper than the products of local industries, the bottom 40 per cent of the population have few options for climate change related threat to their livelihoods of diversification. The impacts of climate change further debilitate an already precarious situation.

Participants in the consultations recognized that private sector's major strength is providing innovative solutions. The countries of South Asia have varied capacity to take advantage from carbon market. Developing of carbon neutral energy platforms was recognized as a key to enable adaptation.

Civil society voices

As climate change grows more serious we need to look critically at the role of civil society. Their voices should find salience in public dialogues and they should avoid their proclivity for insular and self-serving behaviour.

Overall the discussions emphasized that we need to organize ourselves to catalyse adaptive strategies. To that end we need process and procedures to put ideas into practice.

Governmental Commitment

Both political will and efficient state machinery are important if work in a particular state is to be substantive. For the modelling and interpretation of data, an expert committee headed by the principle scientific advisor to the Prime Minister has to be formed in all the countries of South Asia.

The new Agricultural Policy of India currently being prepared will include issues related to climate change and adaptation. The government has agreed in principle to pilot projects on adaptation and is seeking inputs for the national document. Identifying linkages between the government and other sectors and ministries will be a key aspect of the document.

Most of the South Asian countries do not yet have a climate change policy but for negotiations and international discussions, they seek cabinet approval. It is necessary to conduct pilot projects on adaptation to generate learning which can assist in future planning. Extending the jurisdiction of the ministries that are involved in environmental management to take on climate change needs to be undertaken.

Policy and research links

Developing local-level leadership is important if micro-level realities are to be captured and considered during policy-making. At present, there is disconnect between policy-makers and local-level realities. The science and research community, in collaboration with policy-makers, needs to take stock of existing capacities and resources. India has a high scientific capability to accommodate new paradigms as climate change makes the future more uncertain. The country needs to utilize its large number of universities to generate new knowledge and strengthen their capacities to do so.

It is also important to understand where the gaps are and where the demand for research is coming from. There is also a need to listen to a range of stakeholders including policy makers to see how they perceive the problem. Research on climate change adaptation needs a mental shift and it is important to create a space for this shift. Climate change adaptation is not only about the environment but also about economics, trade etc. There is a need for incentives to bring in strong players across the board. There is also a need for strong organizations/institutions that are well managed, with good infrastructure, good science etc. One of the key ideas from the Resilience Alliance is to look at adaptation as an experiment and to adopt an approach of curiosity and the willingness to question assumptions. There is thus a need for a paradigm shift and to build funding mechanisms and management institutions.

We need to reflect why development efforts have failed to address poverty related issues in the past. Unless this is understood, any efforts towards climate proofing will not succeed. There also needs to be further discussion about whether adaptation needs to be nested in the larger development dialogue. For this, there should be a major shift in the way

development is conceptualized and we should not put all our eggs in the 'science basket'. How research shapes up will be critical. The overarching issue for food production for example, will be that of water. If there are funds to allocate to research in these areas then a good entry point would be through understanding rainfall patterns. However, one has to explore how research can change actions on ground. It should be made explicit on how research can support processes of autonomous adaptation. Research needs to look across the entire continuum of adaptation. The demand side of research like who wants the research services, where and how is adaptation becoming part of poverty reduction strategies are important, so is the political context of adaptation which needs to be explored. The overall challenge is going to be knowledge dissemination and how it is going to be used. The main obstacle is the lack of regional information and the main challenge is the need to translate complete scientific findings into easily understandable take home messages.

At the governmental level, a whole set of micro-level processes are taking places that are linked with the preparation of NAPAs. Some governments (e.g. Sri Lanka) have issued a notification that all abandoned paddy fields should be planted with traditional/indigenous varieties with organic fertilizers and through integrated pest management systems. As a result of this initiative, efforts are under way to establish agro-ecotourism sites in some districts (e.g. Hambantota) to showcase these traditional rice varieties.

We need to:

a) Clarify where adaptation is genuinely needed and make a distinction between adaptation and development.
b) Decide how to inform farmers and local people and discuss how they could get what they need to know, perhaps though the market.
c) Integrate climate change adaptation measures into other sectors and make it part of development action.
d) Develop a method to calculate the costs of adjustment to climate variability.

Dialogue, networking and advocacy

To make advocacy more effective, it is essential to build networks and use knowledge better. The media has frequently spurned discussions on various issues of climate change. We need new tools which can boast communication and advocacy and promote coordination among NGOs and civil society groups.

Better information management is essential. Climate change issues began gaining currency in 1992 after the UNFCC and the IPCC began publishing assessment reports. In response, groups in developing countries began looking at the impact of climate change on agriculture and water resources. While such reports have generated a wealth of information, the challenge now is to convert this information into knowledge that can be used on the ground to improve adaptive strategies.

To sensitize local population to the variety of issues related to climate change impacts and to communicate them with different audiences we need to develop creative strategies and target-oriented approaches. Broadcasting climate change issues in the mother tongues of those who are most vulnerable could be a first step. A second initiative would involve encouraging young people to enter in the public discourse by reinvigorating the education system. A third need is for climate change database, which among other things, can help build the capacity to create climate change models. The challenge is to link knowledge with policy formation and that policy need to be translated into with action.

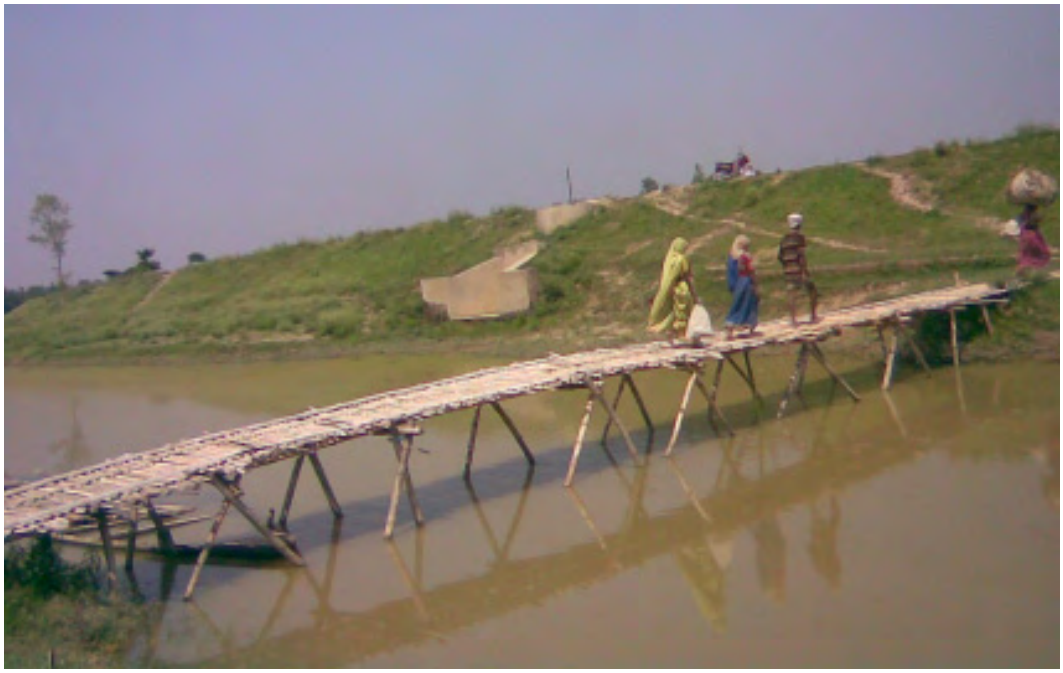
Education and societal capacity

It is necessary to educate people about and provide training on climate impacts and adaptation issues. Plans need to be formulated to initiate short-term courses. Outside experts can serve as resource persons. The capacity of the government to coordinate and integrate climate change issues into development activities must be built. The challenge is to catalyse social learning to bring on board scientists to communicate with social scientists within a framework that recognizes the key role education plays in adaptation processes.

Too few young professionals are entering the climate change debate. Part of the problem is that general society and the education system both focus on the commercial sector. Not only do education institutions not currently include climate as part of their curricula, but doing so would require an interdisciplinary approach incorporating both natural and social sciences. Investing in an education system that recognizes the threats posed by climate change is important if we are no ensure that a new generation of informed professionals join the government, private and development sectors.

Adaptation Process

Adaptation is a multifaceted process defined as the ability to shift strategies. Adaptation occurs at the individual and community level but the larger national framework can support adaptation. People should be able to choose from a range of options. South Asia must strive to implement climate resilient development by safeguarding or retrofitting past investments, as appropriate. The approach should be holistic, address all sectors, and adopt an incremental approach. Adaptation may be conceived to be the outcome of interaction among government agencies, supporting or enabling infrastructure and communities or individuals. Again most of the participants in the consultation felt that clear differentiation between coping and autonomous adaptation will be necessary.



Temporary bridge in Nepal Tarai

People traditionally cope with stresses, including those due to climate change, by adopting one of two strategies: storing assets on roofs in flooded areas, change cropping pattern or migrate. Adaptation in contrast, is as a strategy between these two responses that enables one to tackle newly emerging problems and progressively do better. Community based adaptation activities are being undertaken but we need to better understand how they can be scaled up and what their limitations are. We also need to increase our understanding of the options for adaptation and to target them at those most likely to be affected by climate change, which are often the socially, economically and politically vulnerable.

The process needs to capitalize on the intrinsic strengths of a society. We need to better understand internal dynamics that help identify societal resilience. Adaptation should strengthen and build on that resilience. Adapting to climate change will take a long-time, not less of than five years. Developed nations need to show their commitment to finance adaptation. The funds currently allocated for adaptation will not suffice. Financial and legal reforms as part of adaptation strategies are also crucial.

The need to synergize between all water conservation strategies and look at a water budget for this region is crucial. Also a word of caution against the government promoted tubewells since groundwater is declining and is going to be crucial for this region. The need to rejuvenate traditional water harvesting systems was emphasized. We need to come up with a package of options because adaptation is about making gradual adjustments in sources of livelihood whenever necessary. Awareness and education; research and studies; promotion of clean energy and policies are key strategies that enable adaptation to climate change impacts.

Mitigation

We need to pursue a low carbon-emission path including focus on enhancing economic efficiency. Technological innovation can increase efficiency. The issue of using forests as sources for carbon sequestration and the limitation of community forest movements to take advantage of carbon financing was recognized. We need to view mitigation as a continuum of adaptation and development.

Piloting

We need to pilot tools and strategies which will build local capacities. Support from bilateral or multilateral donors can provide resources and fill in the gaps in existing government programmes. Climate cells need to be developed at the district level, which is the most appropriate scale at which packages of options for adaptation should be adopted. We also need to improve upon existing methods of adjustment.

Flexibility of institutions

At its most fundamental level, adaptation is about developing the capacity to switch strategies when faced with constraints. Humans do strategize and take strategic decisions when faced with stresses such as illness, a challenge to family welfare or threats to children's education. What strategies are chosen depends on access to a variety of support systems, including knowledge, technology and finances as well as social relationships.

This understanding of adaptation is helpful in devising adaptive measures. Decision-makers must be knowledgeable about emerging constraints and about what strategies work. The fact is that not only the climate but also the social context is changing rapidly. This brings to the fore several questions: Who should make the decision, who should sit at the table

and who should define the agenda? What type of information should be collected and who should have access to it? How should risk be distributed? Who should benefit and who should not? What incentives do individuals and groups have to act and how do those shape their perception of – and responses to – emerging constraints?

In a context characterized by uncertainty, conventional practices offer little insight into what needs to be done. It is impossible to design tools that will address all climate change-related problems once and for all because changing conditions will periodically render earlier proposals out-of-date or irrelevant. We need to develop processes, frameworks and capacities which will generate the new knowledge needed to identify solutions as contexts change and new constraints arise. To adapt to an ever-changing future will require innovative adjustments and a critical mass of thinkers. We need to invest in people and build their capacities to adjust.

Global and Local Linkages

Global politics impacts climate change. Decisions made by the international community such as the Bali Road Map (2007), have implications for the mitigation of and adaptation to climate change in poor countries. How the officials, civil society and market actors of such countries should engage at the global level is an important question. The practice pursued thus far is to prepare policy briefs, but we must ask ourselves if this practice should continue to be pursued, and how effective other initiatives have been in order to devise new strategies. One suggestion is that policy briefs also contain verifiable, measurable and monitored indicators.

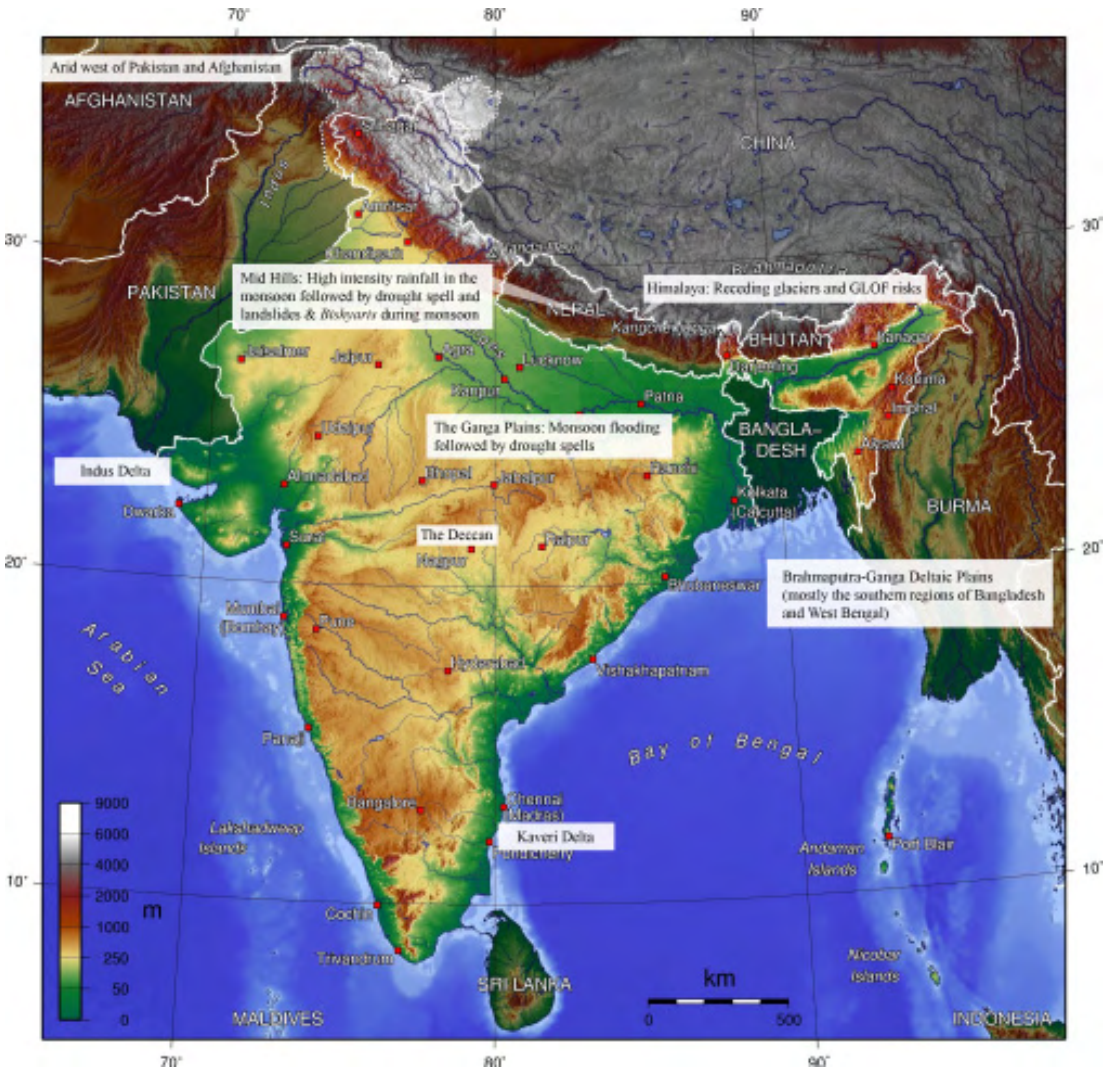
The presentation of global scientific findings causes confusion at the local level because conveying the meanings of jargon in readily graspable terms is difficulty. We need to demystify the science of climate change so that impacts are seen as they truly are day-to-day problems with concrete solutions – and not as esoteric problems with abstract solutions. The challenge is to devise ways to convey concepts effectively and to tap into the wealth of knowledge contained in reports, documents and gray literature which provide anecdotal evidence of climate change adaptation. Through reflective analysis such tales must be converted into knowledge that can be applied.

The UNFCC needs to address and enhance the space for voices from the South, but this will only be possible by making long-term investments in capacity building. Professionals from developing countries need to participate in global processes in local organizations. Regional and local networks need to be established and sustained. Since the Bali COP meeting there has been a qualitative change in our notion of adaptation but we need to pay attention to mitigation too. Regional expertise is not well represented in the IPCC process. As a result many of the lessons it draws are very abstract and do not sufficiently address actual problems.

Our Approach and Analysis

Based on the discussion in the meetings, 1-1 interviews, small group discussions, a review of secondary literature and ISET's extensive experience in South Asia, we have focused on the following areas of vulnerability:

i. The Impoverished Arc of the Eastern Ganga Basin (EGB) – A hotspot
1. The Middle Hills of the Himalaya
2. High Himalayan Region
ii. Densely Populated Major River Deltas – A hotspot
iii. Semi-Arid Southwest Asia: water scarcity, drought and conflict
iv. The Deccan Plateau



The EGB straddling Eastern India, Nepal and Bangladesh is an area of high vulnerability to climate change impacts. The areas of vulnerability are High Himalaya and Middle hills. The next areas of vulnerability considered are the deltaic and coastal regions. The semi-arid/arid Southwest Asia stretching from the southwestern provinces of Afghanistan and Pakistan to parts of the western states of Rajasthan and Gujarat in India are the other area of vulnerability. The fifth area of vulnerability is South Asia's Deccan Plateau.

The discussions on the EGB, Middle Hills and High Hills draws on the regional consultation held in Kathmandu in January 28, 2008 and on 1-1 discussions (in Bangladesh and India) with government and civil society actors as well as ISET's ongoing research on the costs and benefits of disaster risk reduction strategies in Eastern Uttar Pradesh, Bihar and the Nepal Tarai through other DFID-IDRC funded projects.

In addition, ISET participated in a regional consultation meeting in Sri Lanka, co-organized by Practical Action (January 2008) and a field-visit to a coastal salinity area of vulnerability (Hambantota) where farmers are experimenting with traditional paddy varieties. Given that coastal issue in India and the impacts of increasing salinity on potable water and agriculture, particularly in the aftermath of the Asian Tsunami (2004), as well as the vulnerability of fishing communities and the marine environment (eco-tourism and eco-services), we have also taken this as an area of interest. However, while sea level rise, as a result of global warming and thermal expansion, has been predicted to have a considerable impact on coastal populations, livelihoods and infrastructure, particularly in dense urbanized pockets, it is difficult to attribute the impact of coastal salinity on climate variability because the linkages between rise in deep sea level and coastal levels are not scientifically well established. The discussions on semi arid regions are drawn from secondary literature and consultations in April in Islamabad in partnership with IUCN and LEAD-Pakistan. A representative from Afghanistan Research and Evaluation Unit (AREU) also participated in the meeting. Before we go into the discussion on our areas of high vulnerability (and hotspots), the next section outlines a small caveat on the dimensions of social vulnerability in South Asia.

4.1 Vulnerability, Poverty and Social Exclusion

In South Asia vulnerability to climate variability should be seen within the context of the opportunities and risks posed by conflicts and globalization on the one hand, and on the other, its intersection with other dimensions of social exclusion including, gender, caste, ethnicity and faith (religion). Some of the key issues that are common to the three vulnerable areas are as follows:

- **Poverty** remains as a core dimension of vulnerability. Poverty encompasses not just lack of income, but "the deprivation of basic capabilities" including the lack of ability to access resources such as health care, education or political representation. Although poverty greatly contributes to vulnerability, not all vulnerable people are poor. For example, during the Gujarat drought of 2002, middle-income farmers who depended on high intensity agriculture were some of those who were most heavily affected as their ability to invest in irrigation – dig deeper wells – declined, and unlike small and marginal farmers they were less likely to migrate. Indeed, reliance on one stream of income or lack of livelihood diversity can make people more vulnerable to climate related shocks (Moench and Dixit, 2004).

- **Gender:** It is socially constructed roles, rights and responsibilities between women/men defines differential access to and/control over resources and opportunities, thereby influencing differential vulnerability (Ahmad and Mustafa, 2007) to climatic hazards. In most of South Asia, poor women, children (particularly girls) and the elderly carry disproportionate "vulnerability bundles" which places them in the highest risk category, even *amongst* marginalized communities and the poor. Women generally have less access to or ownership over productive resources such as land, water, labour and credit; less access to opportunities to build their skills and capacities through education; and less access to participate in decision-making and governance at different institutional levels.

  Although there is a thrust towards creating legal and political spaces for women (and marginalized communities) to participate in decentralized institutions, both around local governance (village councils) and community led natural resources management (e.g. Water User Associations), socio-cultural barriers to women's effective participation (decision-making, articulation of voice) are strongly embedded in patriarchal systems. Separate spaces for women, e.g. Self Help Groups around access to savings and micro-credit are important beginnings, but they tend to exclude the poorest and are often differentiated along caste or faith ascriptions. More significant, is the need to understand the informal institutional practices, spaces and social networks through which women negotiate change.

- **Caste:** Social hierarchies, inherited and occupational, determine who has access to 'common' resources such as water or where people live in village communities in much of rural EGB (e.g. *dalits* or scheduled castes tend to have their habitation in low lying flood prone areas) and their entitlements, educational and livelihood opportunities. Lower caste women face the triple burden of poverty, caste and gender – they often have to walk further to collect water and fodder as they are denied access to the village well, particularly during dry seasons – and often face sexual harassment at the hands of upper caste men. *Dalit* and tribal social movements have played an important role in negotiating basic human and livelihood rights, while state policies on reservation (quotas in institutions of learning and jobs) are increasingly being contested.

- **Faith:** The discussions on vulnerability to climate variability in South Asia should also be located within the framework of sustainable livelihoods and the meaning of sustainability loses in a social context fraught with conflict, fear and violence. From the heart-wrenching partition of the sub-continent, to the numerous communal riots and ethnic strife that this region is subject to, we feel that strategies to build resilience, particularly around collectives and community spaces, need to address some of the core questions around identity, albeit sensitively and within a culturally embedded development paradigm.

In addition, while religions vary in their theological or spiritual interpretation of stewardship, they share a common commitment to the core principles of cross-generational justice and concern for the vulnerable. At a time when the world focuses too often on religious difference as a source of conflict, climate change offers opportunities for moral reflection, inter-faith dialogue and action (Human Development Report 2007-08, p. 61)

4.2 Areas of High Vulnerability: Hotspots

4.2.1 The Impoverished Arc of Eastern Ganga Basin (EGB)- A Hot Spot

The Eastern Ganga Basin (EGB) is home to three countries Nepal, India and Bangladesh. In India the Ganga basin is straddled by Uttarakhand, Uttar Pradesh, Bihar, Jharkhand and West Bengal. The region is one of the most politically and ecologically diverse in the world (Table 3). It is also one of the most poor. Indicators of basic economic development and access to key services lag far behind those in other regions as we mentioned above (Table 4).

In addition to high levels of poverty, the region is likely to be stressed by a complex range of impacts as climate change proceeds. The EGB has complex climate dynamics ranging from glacial processes to flash floods, inundation and increasingly, drought (due to delayed or deficient monsoon rains). Declining snow cover and glacial retreat, potential increases in overall precipitation, higher variability and potentially more intense extreme rainfall events, rises in sea level, changes in temperature, etc., in combination, will reshape hydrologic and ecosystem dynamics in the basin in ways that substantially increase the vulnerability of populations residing there. This will compound the already high levels of exposure to floods, extreme storms, cyclones, drought, landslides and other natural hazards across virtually all parts of the basin. Despite decades of investment in flood control embankments, irrigation and other measures to mitigate the impact of extreme climatic events, the frequency and intensity of such events is widely recognized as a major factor contributing to endemic poverty in the region. In the EGB floods, droughts and storms are recurrent and exacerbate scarcity of potable water, food insecurity, loss of livelihood, increasing mortality and morbidity and outbreak of diseases, invasive species and loss of ecosystem and bio-diversity. The impacts have incurred changes in the water resources, coastal resources, agriculture, health, livelihoods food security and habitat. Impacts are particularly high on poor rural populations that depend primarily on poorly diversified agricultural systems for their livelihoods. The limitations inherent in depending on climate vulnerable livelihoods, particularly agriculture, intertwine with prevailing social and economic conditions of exclusion and gender differentials to push large sections of the population further into marginalization, endemic poverty and debt traps.

Overall, given its *geographical*, *economic* and *social* conditions, the EGB is a hotspot of concern in relation to both poverty and the impacts of climate change. Among the poorest and the weakest group of South Asian community, the people living here are also among the most vulnerable to the impacts of climate change. Even without climate change the challenges of bridging the development deficit are daunting. Climate change is likely to compound these challenges further.

The impacts of climate change on poverty in the EGB will not be limited to the region alone but threaten development, undermine poverty alleviation efforts and lower human security across South Asia. In the absence of opportunities for local livelihood diversification, those unable to cope with loss of livelihood migrate to cities. The result is rapid growth of shanty settlements in vulnerable sections of urban centres and metropolitan areas where the migrants live in even more vulnerable conditions. The rate of expansion of the settlements outpaces the facilities and infrastructure to support and sustain the population there.

Critical issues facing the development of effective strategies for responding to climate change in the EGB relate to both the direct challenges associated with a more dynamic hydrological system and economic diversification beyond agricultural livelihoods for particularly vulnerable populations.

TABLE 4 | **Matrix of Broad Geographical, Political and Hydro-ecological Characteristics of the EGB.**

Geographical Region	Country	Political/Administrative Unit	Hydro-ecology
Western Plain	India	Punjab and Haryana	Less rainfall, deeper groundwater, lower sediment load in rivers
		Himanchal Pradesh	
		Delhi	
		Rajasthan	Dry
Central Plain	India	Uttar Pradesh	Medium rainfall
Eastern Plain	Nepal	Bihar	High Rainfall with punctuated intense rainfall, high groundwater table, high sediment load
	Bangladesh		
Northern Mountains	India	Uttarakhand	Lower rainfall
	Nepal		Diverse rainfall
	China		Rain shadow
	Bangladesh		
Southern Region	India	Jharkhand	Low rainfall
Coastal Region	India	West Bengal	High rainfall
	Bangladesh		

TABLE 4 | **Basic Development Indicators**

Country	State	Population Million	Population (%) without access to			
			Latrines	Electricity for lighting	Banking Services	Improved drinking water
India*	Punjab	26.6	43.2	8.1	51.5	2.4
	Himanchal	6.55	66.6	5.2	40.5	11.4
	Delhi	17.1	22	7.1	49	2.8
	Rajasthan	64.6	71	45.3	71.1	31.7
	Uttar Pradesh	190.9	68.6	68.1	55.9	12.2
	Bihar	93.8	80.8	89.7	78.7	13.4
	Jharkhand	30.01	80.3	75.7	69.9	57.3
	Uttarakhand	9.5	54.8	39.7	40.2	13.3
	West Bengal	87.9	56.3	62.5	63.2	11.5
Nepal		25	60	60	40	18
Bangladesh**		41	85.74	68.8	75	3.3

* *Based on Census of India 2001* ***Population in India's Ganga Basin 440 million*

Where the hydrologic dynamics are concerned, conventional engineering designs may face major limitations in the context of increased variability, high sediment loads and the unpredictability of flow and other event probabilities. Strategies that mitigate floods and droughts by enhancing drainage and storage within natural components of the system, particularly wetlands, groundwater and forest systems, may prove more resilient and represent a strategic point of entry for research. Such approaches could also support the expansion of fisheries, aquaculture and the production of diverse ecosystems services that are of particular importance to the rural poor. They could also help to mitigate the

impacts of climate change on water quality by providing a degree of natural capacity to filter water as pollutant loads increase. At present, communities respond to floods and droughts through the development of protective measures such as raising villages, moving to elevated lands that become points of refuge during floods and using higher plinths that make houses remain above flood waters or developing secure water sources to mitigate droughts. Approaches that build off these practices represent a strategic point of entry for adaptation research.

Where diversification and social flexibility are concerned, prior research in the EGB indicates that some section of the local populations to adapt to floods and droughts through migration, economic diversification and the development of communication and remittance systems that support early warning and recovery. As a result, understanding the underlying enabling systems on which non-agricultural livelihoods (and for that matter, agricultural intensification) and other sources of social flexibility depend represents potentially strategic point of entry for supporting both autonomous adaptation to climate change and poverty alleviation. Economic diversification depends heavily on the availability of energy, transportation, communication and financial systems. It also depends on institutional and knowledge systems (such as access to global languages) that enable or serve as gateways to economic diversification and wider livelihood opportunities. As a result, in the EGB research on such systems could represent a critical point of entry for enabling autonomous adaptation while addressing poverty. Tangible courses of action could emerge from such research related to the development and design of institutions and infrastructure.

4.2.2 The Middle Hills of the Himalaya

This is an area where climatic impacts are poorly understood but could be major and that contains substantial agricultural populations whose livelihoods are vulnerable to climate change. The region contains many micro climates, ecological niches, population, low production and migration. Climate change induced impacts would largely be reflected in temperature changes. In fact analysis shows that temperature in the higher elevation show increasing trends with emergence of pests, diseases like citrus bug and fungal where as they did not exist in the past. New invasive species of grass have appeared. It is early to speculate but it is clear that occurrence of these diseases is due to the changing temperature and humidity regime. The impacts threaten the economic base of those who relied on agriculture and horticulture as sources of livelihood.

Another change is that people are gradually shifting from farm-based livelihoods to other types of livelihood because farming has ceased to become beneficial and climate change impacts have imposed uncertainties. The combined changes are that livestock is kept to earn cash income than to produce manure as it was in the traditional farming system. In addition traditional practices of nutrient recycling have been replaced by the application of chemical fertilizers, whose supply is dependent on a volatile market. We need to understand the implications of such changes on agriculture policies. Changes in the rainfall patterns of the monsoon have affected local farming practices. In addition changes are seen in ecological properties and vegetation types of the mid hills and valleys. The present knowledge system is unable to explain or find solution to these explain the extent of these changes. We need to expand our capacity to understand the sensitivity of the hills and valleys to such changes.

In addition to the Himalayan rivers, EGB's many rivers also originate in the mid hills and the Chure range. They are supplemented by rainfall and spring low and these also bring

high flood in the monsoon directly interfering lives of the millions living in the Northern part of the Ganga Basin.

4.2.3 High Himalayan Regions

The high Himalaya receives precipitation in the form of snow. Water is retained in the high slopes in natural reservoirs and sustains the base flow of the rivers that originate in the region. Although populations in these regions are small and scattered, snow and ice melt provide a critical source of base flow for the regional rivers. South Asia's major rivers that originate in the Himalaya are the Indus and its tributaries, the Yamuna and the Ganga. The tributaries of the Ganga that originate in the Central Himalaya range of India and Nepal are the Mahakali, the Karnali, the Gandaki and the Kosi. These four rivers accounts for 75 per cent of the flow of the Ganga at Farakka (Pun, 2004) The contribution by these rivers in December is about 41 per cent which increases to 122 per cent in June. This regional hydrological system sustains the lives of the millions who live in the basin. Climate change will alter this dynamics and will have major implications for vulnerable populations at a regional level. In South Asia not all rivers originate in the Himalaya and are snow fed as mentioned in the above section.

4.2.4 Densely Populated Major River Deltas – A hotspot

The major river deltas in South Asia including the Ganga, Brahmaputra, Indus, Krishna, Cauvery, and Mahanadi deltas are hotspots where the impacts of climate change on vulnerable populations are likely to be particularly intense for a combination of biophysical and social reasons. In addition to deltaic region, coasts also remain vulnerable to sea level rise (SLR). These include the coast of Bangladesh, India, Pakistan and Sri Lanka.

In its Fourth Assessment Report, IPCC has projected sea level rise (SLR) in a range of 18-59 cm during this century from temperature rises of 1.8-4.0 degree Celsius (IPCC 2007). For Asia, IPCC has projected sea level rise of at least 40 cm by 2100 which will cause an additional 80 million coastal residents to be flooded.[2] The majority of those flooded will be in South Asia, particularly in Bangladesh and India. SLR will affect coastal areas in several ways including the inundation and depletion of wetlands and lowlands, coastal erosion, increased coastal storm flooding and salinization. Impacts will vary by location, depending on coastal morphology, the extent of human modification and vulnerability of already marginalized and poor communities living in these areas with limited institutional capacity to support adaptation.

According to a recent report from Greenpeace (2008) on climate migrants, the three South Asian countries sharing a coastline, namely Bangladesh, Pakistan and India, are home to nearly 130 million people living in area of about 160,000 sq km known as the Low Elevation Coastal Zone (LECZ) which is within 10 metres above average sea level. Populations most at risk in this zone include those living in densely populated urban centres such as Mumbai, Kolkata and Chennai in India, Karachi in Pakistan and rural populations in low-lying deltaic basins such as the Ganges-Brahmaputra in Bangladesh or the Cauvery Delta in Tamil Nadu as table 5 indicates.

[2] SLR as projected by the IPCC is largely attributed to an increase in greenhouse emissions and thermal expansion of oceans. IPCC figures do not take into account changes in ice flow due to the melting of glaciers and ice-sheets because of the uncertainty associated with the timing and impact of ice-melt. According to other scientists, IPCC projections are under-estimates if 'business as usual' conditions continue (Greenpeace 2008).

TABLE 5: **Summary of Low Elevation Coastal Zone (LECZ) Statistics for three countries in South Asia**

	Area of LECZ Sq km	Population in LECZ	Urban population in LECZ	Percentage of urban population in LECZ in cities exceeding 5 million
Bangladesh	54,461	65,524,048	15,428,668	33%
India	81,805	63,188,208	31,515,286	58%
Pakistan	22,197	4,157,045	2,227,118	92%

Source: Greenpeace (2008)

Deltaic areas are characterized by:

High levels of physical exposure to extreme storms, flooding from upstream sources and inundation as sea level rises: Deltaic areas have large areas near sea level where river channels meander and large areas are subject to frequent inundation both from upstream sources and the ocean. As a result, they are particularly vulnerable to the impacts of sea level rise, cyclones and flooding.

Sensitive Ecosystems: Deltaic wetland and estuarine ecosystems often have high levels of biodiversity where productivity and ecosystem function depend on a delicate balance between saline, brackish and fresh water sources. Climate change has a high potential to disrupt such systems. Inundation of low-lying lands with saline water during extreme events can, for example, damage the productivity of rice-growing agricultural regions for decades.

Large and vulnerable populations in both rural and urban areas: Deltaic regions in South Asia tend, for a variety of reasons, to be among the most densely settled locations in the world. They are among the most intensively cropped areas. Rural populations residing in delta areas are generally poor, often lack access to basic facilities such as communications systems and storm shelters, and are engaged in climate sensitive livelihoods such as agriculture and fishing. Deltaic regions also contain large urban centres, such as Dhaka, Calcutta and Karachi (See Box 2 on Indus Degradation). Poor and low income populations in these centres often settle in low-lying areas that are particularly vulnerable to flooding and storm surges.

Human induced exposure to hazards/maladapted landuses: In urban settlements, initially low-lying areas have often subsided further (often below sea level) due to a combination of groundwater extraction from aquifers beneath the city, reductions in sediment deposition associated with flood control structures, upstream impoundment and soil oxidation as wetlands dry out. As a result, when flood and storm defences built along the cities are breached, the impact of flooding is much more severe. Similar impacts occur in rural area where the flood drainage is often blocked by lineaments such as embankments, roads, railways including growth of housing colonies and urban expanse as low land and wetlands are encroached upon. In deltaic areas due to the low gradient such structures also constrain drainage and exacerbate flooding.

The Indus delta is such a region where these different factors intersect. Home to one of the world's oldest civilizations, the Indus is the longest river (3,180 km) and the third largest, in terms of annual flow, in the Indian subcontinent. Originating in the Tibetan plateau, in

the Himalayan glaciers near Lake Mansarovar, the river runs a course through Ladakh (J&K) and across the border through the provinces of Punjab and Sindh in Pakistan till it merges into the Arabian Sea near the port city of Karachi. The river's estimated annual flow stands at around 207 cubic km and its total drainage area exceeds 1,165,000 square km. While the Indus is the main source of water for agriculture, industrialization and domestic use in Pakistan, over the years the river's flow has been declining substantially, partly as a result of excessive groundwater withdrawal and partly due to changing rainfall patterns.

According to Wescoat (2007) water supply in the lower Indus basin is falling behind agricultural and urban demand, particularly in Karachi where population growth exceeds the physical and institutional capacity of the public water system. Karachi, which depends on the Indus for 93 per cent of its water supply, is facing an increasing unmet demand for domestic water as a result of population growth and unplanned urbanization (unconnected squatter settlements), as well as tremendous inefficiencies of costs, operations and management in the current institutional structures with leakages accounting for 30-35 per cent of water loss (Ali 2006). Current water demand in Karachi is 650 million gallons per day while supply is only 550 MGD. According to the Pakistan Water Sector Strategy, demand is expected to increase to 1007-1351 MGD by 2010 (Ali 2006).

Conflict between the provinces on the sharing of Indus basin water obstructs cooperation on lower basin water issues. Of the 140 million acre feet (MAF) of water annually available in Pakistan in a normal year, some 40 MAF reach the Indus delta.[3] The delta used to be a vast network of creeks surrounded by rich silt that yielded abundant rice crops for exports, but with little precipitation in the upper reaches, the mixed economy of agriculture, livestock, fisheries and sea trade has changed substantially. Mangrove swamps – once covering more than 850,000 acres and providing an important ecosystem for fish spawning and prawn cultivation has now shrunk

Box 3: **Environmental Degradation in the Indus Delta**

The Indus Delta covers an area of 600,000 hectares stretching for about 200 km south of Karachi beyond the Indo-Pakistan border in the Rann of Kutch. The Delta comprises a network of creek systems and is densely covered with mangrove forests. It has immense ecological significance for sustaining the productivity of coastal and near-shore fisheries, wildlife habitat as well as the provision of other benefits such as protection from storm surges. There are about thirty settlements in the area with a population of about 150,000.

Fishing is the most important economic activity in the Indus estuarine system. It is estimated that about 5000 boats operate from the various coastal villages. The Indus estuarine area used to be well known for its shell fish, pearl oysters, window pane oysters and shrimp. The creek system serves as nursery grounds for a number of commercial species of fish and shrimp, and can be said to support the entire marine fisheries of the Sindh Coast. During the last three decades however, the Indus deltaic areas have been facing an increasing magnitude of environmental problems caused by the rapid industrialization and urbanization along the Sindh Coast, and further exacerbated by the impacts of climate change.

Karachi, with a population of about 13 million is the largest port and the industrial and commercial hub of Pakistan. It contains about 6000 small and large industrial units, which are a major source of marine pollution. Over 262 MGD (million gallons per day) of untreated domestic and industrial waste is generated and is discharged through different pathways into the coastal environment. The main impacts of pollution along the coast are habitat loss, eutrophication, smothering of inter-tidal marine fauna and flora and bioaccumulation of toxic substance. All these effects are leading to the eventual loss of marine resources in the near-shore environment of Karachi. Major development activities in the coastal belt, in the absence of appropriate environmental safeguards have resulted in the loss of mangrove forests and of the fisheries dependent upon them. Hence the natural protection provided by the mangroves as barriers against storm surges has been compromised. The recent past has witnessed an increasing frequency and intensity of storm events that may be attributed the changing climatic conditions, and the brunt of these disasters has been borne by the highly vulnerable coastal communities.

Furthermore, Karachi that generates over sixty percent of the country's revenue and is the most densely populated urban center is also at risk not only from storm events but also from future sea level rise. Huge investments have been made in the city's infrastructure and mega development projects aspiring to compete with the Dubai coastal development model, are being implemented on its shores. Although sea level rise along the Karachi coast has not been significant till now, projections classify Karachi as being vulnerable to flooding due to sea level rise. Unfortunately this factor is not being considered in current land use planning, nor is any disaster preparedness and management plan in the making.

[2] The large-scale harnessing of the Indus waters began as early as 1890, when the Punjab irrigation system was built and used the four major eastern tributaries of the river for perennial irrigation, increasing the ingress of salt water and reducing the flow to the delta

Box 4: **Cauvery Delta: vulnerable spot to climate change in South India**

The river Cauvery is one of the most important rivers in India. This is an inter-state river which runs to a total distance of 802 KM passing through Kerala, Karnataka and Tamil Nadu States and the Union territory of Pondicherry. Total drainage area of the basin is 81,155 sq km. The basin is spread over four coastal districts (Thanjavur, Nagappattinam, Tiruvarur, Cuddalore, Pudukkottai) and eight inland districts (Tiruchi, Salem, Karur, Ariyalur, Perambalur, Namakkal, Erode, Tiruppur). Besides, coastal districts of Karaikkal and Pondicherry also fall under this basin. The chain of rivers and canal net work are unique in this basin which also provides excellent drainage facility. While 80% of the area is under paddy 20% of the command area is under other crops such as banana, sugarcane, coconut, vegetables etc.

This basin receives rainfall from both south-west (June-September) and north-east (October-December) monsoons in the ratio of 3:7. Total annual average rainfall in the basin varies from 1000 to 1400 mm. Invariably, the north-east monsoon brings heavy to very heavy rainfall through cyclonic storms, which is often devastating. In the monsoon months, the entire delta would be flooded with water. In the summer months, when the river water is stopped, the seawater floods in the delta region through the canals and rivers which join the sea.

As a matter of fact, the Cauvery delta is the most affected basin in South India. The Cauvery delta's 1,800 year-old irrigation system is a complex network of rivers, canals and drainage systems with thousands of miles of canals and channels. Nagappattinam district, which almost entirely lies within the delta, is a narrow stretch of land 165 km long and 15-20 km wide. This district has two major disadvantages: a) most of the district falls within the low elevation coastal zone, and b) 56% of the land also lies below sea-level. A further 18% of the district which is just at sea-level is water-logged and marshy. Already the Cauvery delta, on the whole, suffers from saltwater intrusion up to five kilometres inland, as well as severe drainage problems. Due to its flat terrain, the region is prone to flooding from drainage canals and seawater, in particular during the October to December monsoon months when most of the monsoon rain falls within a few days, often combined with cyclones and high wind storms.

This is also a district where 90% of the population consists of small and marginal farmers with a very high concentration of landless agricultural labourers. A series of shared learning dialogues (SLD) that have been conducted in the basin at various levels and with various groups by the present author (during the year 2007). SLDs clearly suggest that economic loss already incurred in the coastal districts of the basin is quite high due to salinisation of land and groundwater and the consequent crop loss and agricultural employment. Furthermore, the coastal region of Tamil Nadu is very densely populated (528 people/km^2, almost double the state average of 372 people/km^2), which only suggests that seawater rise may result in a good number displaced from their original habitats losing their land and livelihoods. The rapid industrialization along the coastal region, and in particular in the cities of Chennai and Cuddalore, has further aggravated the situation and made coastal cities and towns more vulnerable to the impacts of climate change. Many chemical, textile, oil refinery, thermal power and fertilizer industries are established along coastal zones for easy disposal of effluents into the sea.

Cuddalore and Nagappattinam districts are already vulnerable to multiple factors such as seawater flooding, lack of drainage, land and groundwater salinization, and industrial wastes, in addition to the low-lying elevation of the land. 56% of area in the Nagappattinam district (the most vulnerable of all coastal /delta districts) is flood prone, 18% water logging and marshy land, 3% saline and 7% coastal land. Since most part of this district lies below sea level, the degree of vulnerability is quite likely to go up due to impact of climate change Climate change coupled with existing anthropogenic factors will aggravate this already vulnerable situation. There are a good number of backwater rivers in this basin, particularly in Cuddalore and Nagappattinam districts through which seawater flooding takes during dry months, increasingly so in the last two decades due upstream irrigation development on a massive scale. Long-term, non-land based adaptive strategies are needed for the region, more comprehensive than the simple engineering solutions currently planned for the delta. The predicted impacts of climate change such as sea-level rise, and increasing intensity and frequency of cyclones and storms are likely to severely impact this already vulnerable region. All coping measures undertaken to date have been ad hoc and structural with largely no effect. Non-land based, long-term disaster preparedness and risk reduction strategies and early warning systems have not been part of any policy planning framework so far.

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to less than 500,000 acres (Eckholm 2003) and important fish and shellfish industries are ecologically stressed by the upstream impounding of fresh water and sediment (Omar 2007).

Some of the most affected communities are the fisher-folk who live in small towns and villages such as Keti Bundar about 80 miles south of Karachi. Once a bustling port, people there are now poor, malnourished, and usually barefooted. "We can't wear shoes because sea water is all around and they become ruined," said Beer Jat, a 70 years old fisherman (cited in Global Policy Forum 2003). They have been forced to move time and again in search of fresh water and are poised to migrate again because the once productive 600,000-hectare delta cannot provide them with a living. Cattle are now being replaced by camels and the once rich Indus delta is now slowly dying because there is no fresh water flowing

into it. Deep sea trawlers have also contributed to the rapid depletion of marine resources affecting the livelihoods of poor fishing communities. (See Box 3)

Perennial drought often intersects with heavy rainfall and sudden flash floods which in the absence of early warning systems impacts the safety and security of riverine communities in the low-lying areas of the deltaic region.

4.2.5 Semi-Arid Southwest Asia: water scarcity, drought and conflict

The semi-arid region of Southwest Asia, which includes Afghanistan, Pakistan (Sindh and Baluchistan provinces) and parts of the western Indian states of Rajasthan and Gujarat, faces severe water scarcity and recurring drought with impacts on agriculture, livestock, energy, livelihoods and the environment on the one hand, and on the other it is a region characterized by intense social conflicts, with global implications. The latest drought in South Asia (2000–2003) affected more than 100 million people, with severe impacts felt in Gujarat and Rajasthan States in western India, in Pakistan's Sind[h] and Baluchistan provinces, as well as in parts of Iran and Afghanistan (Thenkabail, 2004). The drought impact intersected with 'chronic conflict' (particularly in Afghanistan, Pakistan) and limited opportunities for livelihood diversification or building resilience as 'surplus reserves' can be looted by local militia. Much rural development in Afghanistan is still led by the controversial Provincial Reconstruction Teams, while foreign aid continues to pour in, largely in the name of 'humanitarian assistance' and the 'war on terror'. Although poppy cultivation has been banned, and prolonged drought is ending in many areas, some 2 million refugees have begun to return, and the pressure on national and donor development agencies to address questions of food security and access to shelter, healthcare, water, education, and income opportunities are considerable.

This area of vulnerability also has low human development indicators including, high infant and maternal mortality rates, low adult literacy rates and limited access to potable water and improved sanitation, particularly in rural areas. In addition, gender disparities are high with women's access to and control over resources and their participation in the public domain (decision-making) constrained by poverty, ongoing conflicts and the socio-cultural practice of *purdah* that limited mobility.

Livelihoods in this region depend on a combination of agriculture, non-farm activities (e.g. weaving carpets), livestock and animal husbandry (fisheries in coastal parts of Sindh and Baluchistan) and migration, both to urban areas (Kabul, Herat, Karachi) and across national borders (Iran). Although canal-irrigated crop production has played a dominant role in the agricultural economy of southwest Pakistan, the poor (small and marginal farmers), like in Afghanistan depend on rain-fed agriculture drawing water from covered springs (*karezes*), shallow wells or localized runoff. Better-off farmers have access to tube wells, but with each dry spell, resources to dig wells deeper are diminishing (Bhattarcharyya *et al*. 2004). Traditional systems of collecting snow (*cha*) in underground storage tanks which used to provide water for families as well as for sale during the summer, are not as actively used or promoted in Afghanistan while village level institutions like *shuras* (village councils), water *waqils* (water judges) and *mirabs* (water distributors) are not meeting the expectations of farmers to manage scarce water resources efficiently and equitably. Nor do they provide space for the negotiation of water rights or the participation of women and other marginalized groups (pastoralists).

While knowledge on adaptation in the region is limited, there is rich and insightful documentation, particularly from Afghanistan (AREU) on people's coping strategies, built

around social networks embedded in culture and faith. For example, access to informal credit, mostly for consumption purposes is seen as an 'entitlement', and most households in Afghanistan are engaged in both giving and receiving credit. This ranges from small loans at flexible interest rates to the giving of survival alms to the most poor and vulnerable (e.g. physically challenged). Although such informal systems are increasingly under stress, the introduction of a more formal micro-credit system, as part of the state's approach to livelihood and economic growth is viewed with scepticism by many (Klijn and Pain 2007). Experience from India and Bangladesh also suggests that unless access to micro-credit, which is typically mobilized through (women's) self-help groups (SHGs) is facilitated by pro-poor, inclusive and gender-sensitive organizations, the poorest are unlikely to benefit, their debt burdens can increase (through multiple loans, limited opportunities to manage risk and invest in productive activities, and inability to repay if money is spent on alcohol or for consumption only) pushing them further into a downward spiral of impoverishment.

Livestock are critical to the rural economy of this region – during periods of drought and scarcity they are invaluable assets for sale or exchange, but increasing pressure on rangelands (pasture), cropping systems (fodder) and water resources, in the absence of institutional arrangements, is making it difficult for livestock owners to manage their stock. Ethnic conflicts in Baluchistan and the Afghan war have made many transhumance routes dangerous (landmines) while, unlike India, there are few examples of symbiotic relationships between farmers and pastoral nomads (access to fallow fields for livestock during the winter months in return for manure).

4.2.6 The Deccan Plateau

Physical Context: Rainfall Variability: The Deccan Plateau also known as the Peninsular Plateau lies south of the Indo-Ganga plain. It is located between three mountain ranges – the Western Ghats, the Eastern Ghats and the Satpura and Vindhya ranges in the north and has an elevation ranging from 100 metres in the north to 1000 metres in the south.

The climate of the region varies from sub-tropical in the extreme north to tropical in most of the region with distinct wet and dry seasons. The monsoon season runs from about June to October. March to June can be very dry and hot with temperatures exceeding 40°C regularly. Although the region is home to some of India's major river systems, including the Godavari, Krishna and Cauvery, these depend on the rains, and tend to dry up in the summer months leading to inter and intra-state conflict over water.

Despite predictions that India is likely to receive more rain in the coming years (Defra, 2005), these are still predictive and states such as Andhra Pradesh have typically been receiving less than the national average: "Though the average rainfall over the last 100 years appears to be stable or increasing, rainfall in the crucial month of July has been declining," (Hill 2002 cited in Reddy *et al*. 2004: 54). Erratic rainfall and highly variable distribution add to the uncertainty of a region where agriculture is largely rain fed.

Shifting Agriculture: Agriculture in the Deccan Plateau, as in 60 per cent of India, is rain-fed, but has been typically overlooked by government policies that have focused on Green Revolution led irrigated agriculture with its high chemical inputs and heavy mechanization. Since the advent of structural reforms in India, there has been a considerable shift towards cash crops like the controversial BT cotton (India is the 3rd largest grower of BT cotton in the world) and other food crops (groundnut) for export or agro-processing. Consequently, there has been a drop in the production of traditional food grains (millet, sorghum, barley) which have been

the mainstay of local diets and cultural systems. Without access to water harvesting and irrigation systems or alternative drought resistant crops or social safety nets such as crop insurance, small and marginal farmers have suffered the increasing vagaries of climate and neo-liberal economic policies (TERI 2003). Not surprisingly, there have been a spate of farmer suicides in this region, particularly in Andhra Pradesh, as a result of growing debt burdens and many farmers, including large farmers have been forced to migrate.

In addition, monolithic institutions such as ICRISAT which have traditionally been doing research on improved rain-fed crop varieties are not only moving towards GM crops and biotechnology, but have done little to involve farmers in in-situ agro-conservation, despite some early initiatives on participatory seed/ crop pesticide trials with women farmers. Currently ICRISAT is working with ILRI (the International Livestock Research Institute) and local farmers to assess the importance of crop residues for livestock (crop-fodder management) and higher yields of better quality groundnut have been inter-cropped with sorghum (see: www.ilri.org/research).

Diminishing Biodiversity: The Deccan Plateau is the largest eco-region in India and is rich in biodiversity. It contains about 20 per cent of the country's natural habitat of dry deciduous forests, with a significant proportion of teak trees. However, population pressure and growing dependence of tribal and pastoral communities on declining forest resources has led to an increase in cases of human-wildlife conflicts (Reddy *et al*. n.d.). Although there are several successful examples of government and NGO led community (Joint Forest Management) and agro-forestry initiatives, policy, institutional and capacity gaps in managing and conserving biodiversity while providing employment opportunities for local communities remain.

The Deccan Development Society (DDS), has been working with more than 5,000 small and marginal farmers, primarily women, in drought prone districts of Andhra Pradesh to enhance their food and livelihood security through a range of interventions including, natural resources management and the setting up of community grain and seed banks (see: www.ddsindia.com). Today the organization is experimenting with community radio and video, empowering poor women to share their experiences and learning with others, both in the region and beyond, breaking social boundaries around mobility and access to technology as well as providing a communication platform for strengthening climate and disaster resilience.

Watershed Development: Poverty Alleviation in Drought prone Areas: Over the past 25 years, the Indian government has spent several millions on watershed development and management programmes, particularly in drought-prone regions, to address poverty alleviation, livelihood

Box 5: **Putting people at the centre of climate resilient development**

"Putting people at the centre of development – women and men, with and without land – helped APRLP to focus on different ways that land and non-land-based livelihoods might be supported for everyone living and working in an area, not just those who owned the land. This had implications for the way watershed funds were used in APRLP. Instead of large sums of money going to structures like concrete dams and machine built drainage ditches, the focus turned to low-cost structures placed through consultation with land-users as well as engineers and community leaders. Money was reserved for productivity enhancement in agriculture and livestock, which provided viable livelihood options for many small and marginal farmers as well as capacity building in a range of skills. So, while the watershed programme maintained a focus on land-based activities, and the concern for water and land management, it broadened its remit to look at all land in a watershed, not just so-called 'productive land' and also embraced the need to look at livelihood options beyond the land, in enterprise development, for example.

The formation of village organisations (VOs), made up of smaller self-help groups of women in villages, who took over the management of the watershed programme from watershed committees/ watershed associations which had often been dominated by land-owning men, was a bold move. Women do a considerable amount of work on the land, yet until five or six years ago, they were rarely involved in the watershed programme which was seen as a men's programme supported by technical staff from government who were usually men too. That has changed. Even under the Hariyali Guidelines which were put in place in 2003 by GoI, where the *Panchayati Raj* system has been given a central role in watershed development, the VOs are now seen as a sub-group of the Gram Sabha and play a key management role."

Source: Seeley, J. (2007) *Lessons learnt from the Andhra Pradesh Rural Livelihoods Project, 1999-2007*, pp.12-13.

security and natural resource sustainability. Watershed development essentially involves in-situ moisture conservation through land, soil and water management measures that in the long run increase agricultural productivity, recharge groundwater and provide employment opportunities. Although the benefits tend to accrue to (male) landed farmers, many NGOs have tried to involve rural women and the landless as well as address domestic water priorities.

The DFID funded Andhra Pradesh Rural Livelihoods Project (APRLP) which ran from 1999 to 2007 focused on pro-poor watershed development as an approach towards developing sustainable rural livelihoods in five drought prone districts of the state. One of the key lessons of this project was its focus on people, and not resources, as in the typical approach to most watershed programmes in the country. Beginning with people and their livelihoods necessitates looking at risk – whether climate or political instability – and seeing how that is likely to shape outcomes (See box)

In sum, this area has a large poor agricultural population that will be heavily affected by climate change *if* variability and drought increase. As with the arid zone regions, the primary uncertainty here is the degree to which climate change *per se* is likely to compound existing patterns of vulnerability.

4.3 Cross cutting research issues

The extent of research on climate change impact in South Asia varies according to the countries. Climate change research is vast and complex, and cannot be carried only by a single country or institute, rather there have to be numerous organizations working specifically on different aspects of climate change phenomena including the adaptation measures that needs to be undertaken in the face of changing climate patterns together at policy, intermediary and policy level. While decades ago developed countries established research institutes to study climate change, possible impacts and measures to ameliorate the impacts a very few countries in South Asia can speak of solid research foundation. Even in countries such as India and Pakistan the climate research base is mostly on modelling and physics. In smaller countries like Nepal, Sri Lanka and Bangladesh such capacities are more limited.

Both rural and urban populations of South Asia have lived with droughts, floods and extreme storms. Recent studies and literature express consensus that the region faces climate change and within countries would experience varied impacts. These studies show that there is high uncertainty as to how the global scenarios will translate to local levels. Past research has focused on the impact climate change will have on monsoon, hydrological systems and agriculture. Overall it is likely that the present water regime will be more erratic whose impacts will impinge on the agriculture water system resulting in drought and floods. For these reasons, from the perspective of vulnerability and adaptation challenges, the regions identified in the report are of concern.

The research capacity in South Asia also varies. As elsewhere, research attention is targeted to assessing the *effects* of climate change and these are based on global model studies. The data system that forms the basis of robust climate research remains weak. This latter factor is an important issue for future research effort, particularly because for informed decision-making needs to be based on well grounded data management and that they need to be user-friendly. Recent studies also suggest climate change impacts will impinge on ecosystems and biodiversity, and that when they are intertwined with the on going change

processes due to globalization, penetration of communication systems and so on the challenges is going to be daunting to adapt to climate change impacts. Yet adaptation to climate change research is a new concept in the region where basic challenges of development remains high.

Three major issues to consider are reductionist research, crossing and assimilating the natural and social science divisions, and outreach. In all countries, governments have invested in research on agriculture, new seed varieties, technologies and support services. However there is limited understanding on ongoing change processes such as male migration which has led to the 'feminization of agriculture', as incentives have changed in response to prices changes due to trade, increasing resource scarcity and domination of markets. In all of South Asia, there is evident disjunction between research and decision-making processes. This will be a major lacuna to be overcome because adaptation to impacts of climate change and mitigation needs to heed to behaviour at the level of households, community and local governments. There have been very limited attempts at interdisciplinary research that bridges social and natural sciences. And lastly, research efforts do not take cognisance of the fact that different groups use the research outputs differently.

To help us select the research theme we have endeavoured to develop a set of criteria to help bridge the gap in climate impact adaptation in South Asia. To do so we have used information solicited during consultative meetings, 1-1 interviews, literature review within the conceptual framework that study has used. These themes correspond to issues identified as "gaps" in knowledge and our own analysis.

1. Impacts on poor, vulnerable and socially excluded:
2. Area of interest of high climate impact:
3. Research themes not covered by existing programmes:
4. Autonomous and planned adaptations
5. Systemic Issues that enable adaptation

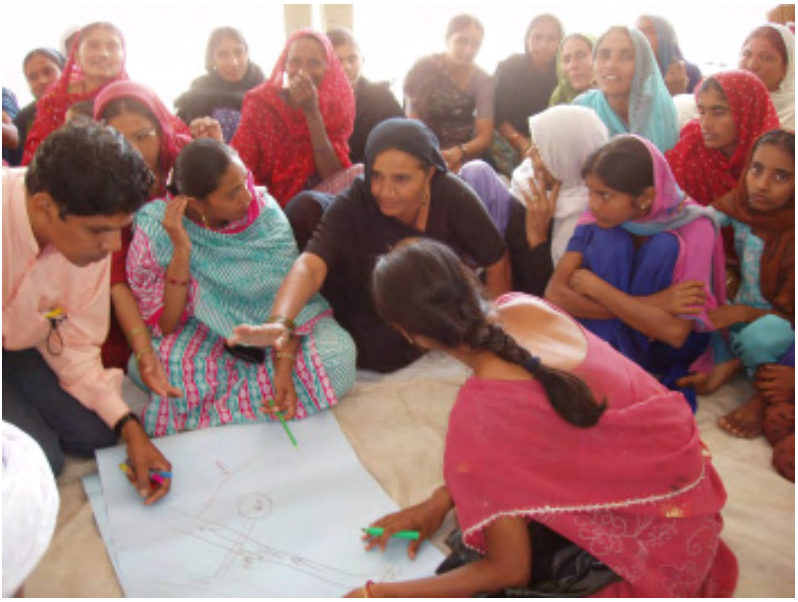
Box 6: **Embankments in North Bihar, India**

Embankment has been a preferred choice to provide protection from flooding in North Bihar. In Bihar about 3,500 kilometers of embankments are expected to protect settlements and agricultural lands from flooding. In reality this is not the case. Embankments produce both gainers and losers.

For household living close to an embankment provides immediate protection from rising flood waters. It also serve as a road and helps in mobility. In stretches of embankments families have settled. Embankments are site of refuge during flood.

Embankments provide a false sense of security from flooding. They constrain drainage and cause waterloging which damages productive land. The silt that a river brings is deposited between the levees causing the bed to rise in comparison to adjoining lands. They prevent the nutritious silt from getting deposited to the agriculture land. The quality of repair and maintenance of the embankment is poor which makes them highly vulnerable to breach during a high flood. The other unintended consequence of embankment building is encroachment of private land and displacement of farmers who have not been compensated.

Based on our consultations and interactions in South Asia, a number of cross-cutting issues were identified as important entry points for research, practice and capacity building in the region. These included: water management, especially the management of groundwater aquifers as buffers, the implications of glacial melt on regional hydrology, the impact of Glacial Lakes Outburst Floods (GLOF) in Himalayan region and management within 'open' basins. The last issue begs some more explanation since the precise scientific basis (flow, flood stage, sediment load etc.) will be unachievable goal under a dynamic hydrological cycle we need design method to suit an uncertain water regime. A open basin that allows river flow and flood to adapt to the flood plains is a concept better suited. The other issues are understanding the impact of climate variability on health, particularly the spread of infectious and waterborne diseases (typhoid, hepatitis), vector (malaria, Japanese Encephalitis etc.) plus the "incubation" of new diseases (bird flu, chikungunya). In addition, the impacts of climate risks on migration, the growth of small peri-urban



Village women in planning exercise

towns and unplanned urbanization need to be better understood as the divide between the urban and the rural is getting blurred. Effective governance in terms of access to the systems that enable adaptation, including participation in decision-making at different levels, was also pointed out to be critical to adaptation.

Currently, most adaptation in South Asia is occurring through autonomous processes at the individual, household or community level. These processes are largely undocumented and often occur below the radar screen of government actors. Direct projects designed to promote adaptation (such as watershed management and drought proofing) focus primarily on community based strategies and have been heavily promoted by governments across the region, often with some support from NGOs and/or local government (e.g. *panchayats* in India). They have provided useful insights about *in-situ* adaptation, but limitations of the community based methods have not found salience as ongoing processes of transformative changes (globalization, communication, increasing participation in labour market and remittance flows, feminization of agriculture in many regions and so on) have altered the nature of geographically defined and geographically dependent communities. Accompanying this is the decline of community based resource management institutions: people, activities and products are increasingly mobile and horizontal networks of support are giving way to more vertical linkages, based on relationships of power and patronage. At the same time, the growth of formal and informal, market-based institutions for delivering water, energy, fuel and fodder are emerging, but they lack the organizational mechanisms or commitment to engage in questions of equity and governance.

South Asia has a long tradition of participatory, action-research on the one hand, and on the other, scientific and technical capacity for research on climate impacts, cost benefit analysis of disaster risk reduction and adaptation interventions and alternatives, whether it be energy, biotechnology or communication systems. However, there is little cross-fertilization or shared learning between micro-analysis (typically case studies) and macro public policy processes, between 'professionals' (academics, scientists) or among disciplines (engineering, social scientists, and ecologists) and communities of practice. In a social context fraught with conflicts at different scales, the democratization of knowledge is as important as the democratization of decision-making.

In the following sections we present the research themes identified from our consultations, review and analysis. Each thematic issue is followed by a few key questions that provide strategic points of entry for research in the region.

4.3.1 Research to better understand water allocation, management and governance in conditions of relative scarcity and abundance

At the heart of the discussion on livelihoods, vulnerability and adaptation to climate variability in both the hotspots in South Asia is the question of water – too little, too much or of poor quality. While there is much to learn from the revival of traditional community water management systems in Rajasthan and Gujarat or forest management in Nepal, the social and

political context of Afghanistan and Pakistan require a re-building of collectives as much as a re-building of safe and secure public spaces. Locating community water management institutions within a larger, more nuanced framework of peace-building is as important as it is to frame questions of water rights, access and accountability. Adaptation strategies that do not address questions of risk, fear and conflict will not be sustainable – and water, symbolically intrinsic to all faiths – has the potential to be a mediator in this process. We need research on

- Water management strategies that are resilient and able to flexibly respond to or moderate large fluctuations in water availability/flows represents a critical point of entry for both flood and drought affected areas.
- Production systems, such as inland and deltaic fisheries and aquaculture that could accompany such strategies also represent a strategic point of entry with particular relevance for the livelihoods of poor populations in rural and peri-urban areas.
- Water resilient crop varieties, intercropping, time and space management of crops, demand responsive water management (drip irrigation, volumetric metering) is also important but is already a major focus of investment by governments and possibly also agribusiness.

4.3.2 Research on social and institutional mechanisms that support migrants

Migration, particularly of young, able-bodied men, has been an important part of livelihood diversification strategies in South Asia and has ranged in scale from rural to small towns, provincial centres and big cities or across national boundaries. However, there are local differences – for example, the war in Afghanistan has led to huge internal displacement and Pakistan has hosted more than 2 million refugees. Nepal's decade long insurgency caused large number of internally displaced population. Gender differences in migration are also significant – while women in parts of rural Rajasthan, Gujarat and hills of Nepal manage land in the absence of their men, particularly during periods of water scarcity, they little access to resources as these are linked to land tenure. In Nepal and Bangladesh, poverty has compelled households to 'push' women and young girls into exploitative trafficking systems that take them to cities as far afield as Calcutta, Delhi and Bombay. Similar examples can be found in the tribal belt of western and central India – where years of drought throughout the 1980s and 90s forced young, *adivasi* women into the sex trade.

It is clear that climate-induced migration is going to increase (Greenpeace 2008) putting pressure on already strained and resource-poor local municipalities, peri-urban centres and crowded metropolitan cities to manage basic services (water, sanitation, solid waste management etc..) and provide shelter, leave aside disaster resilient shelter that can withstand flash floods, etc. In addition, livelihood and social security for migrants is precarious since they lack land tenure, have irregular sources of income and cannot easily avail of bank accounts or financial services. Thus, they are dependent on conventional sources of remitting money (e.g. through the post-office or middlemen) or simply carry it home themselves, putting them at the mercy of border security agencies.

- There is a need to understand how climate variability has affected migration patterns, both in water scarce and water rich areas, and the extent to which remittances are used for productive investments either in climate-proofing infrastructure (hand pumps, tube wells or flat roofs and raised, *pucca* homes in flood prone areas) or to set up new small businesses.
- Although there are examples of emerging initiatives to support migrant labour which address the communication, insurance and social security needs of migrants (e.g. the migration facilitation centre which evolved from DFID's Western India Rain-fed Project and provides migrants with ID cards and information on employment opportunities), there has been little documentation on the learning from such initiatives or their potential for up-scaling or replication.

4.3.3 Research on the role of financial mechanisms in spreading risks

Given the increasing pressure on traditional risk sharing strategies (borrowing from family, friends, social networks) and the exploitative nature of moneylenders, particularly during disasters when the poor are even more vulnerable, access to financial institutions for micro-credit, insurance and financial services has been promoted, particularly in India and Bangladesh through a variety of institutional mechanisms. These range from women's Self Help Groups and their federations for group savings and micro-credit to banks for the poor (Grameen, SEWA) to rural/urban cooperative banks and non-banking financial institutions (Basix, Friends of Women World Banking, India) as well as emerging risk transfer or micro-insurance schemes, both public and private sector, which are often linked to social incentives (e.g. free education for poor girls). However, the effectiveness of many of these interventions as poverty alleviation and livelihood security strategies has been questioned and there is a need to more systematically explore links between micro-finance (credit, insurance and financial services) and climate adaptation.

In the predominantly Islamic context of Pakistan and Afghanistan, and even within similar communities in other countries on the other hand, socially and culturally embedded informal practices of giving, particularly to the poor and vulnerable (alms giving), contrast with recent attempts to promote interest-based lending through formal institutional structures (Klijn and Pain 2007). The IFAD-funded Dir Area Support Project in the North-West Province of Pakistan promoted small micro-enterprise, including technical and managerial skills, along with credit to rural women in a predominantly conservative social context where women's mobility is restricted and where interest-based lending is not socially acceptable. The project made the lender an active risk-sharing partner in enterprises developed by women. (see: www.ruralpovertyportal.org/english/regions/asia/pak/voices/microcredit.htm).

- Given that most micro-credit or insurance schemes rarely reach the 'poorest of the poor' (or the chronic) poor, there is a need to better understand how micro-finance can be linked to larger social support systems that strengthen livelihood/disaster risk resilience rather than increase the risk/debt burden for the poor.
- Equally, there is a need to look at the efficacy of financial incentives that facilitate risk sharing/transfer such as, low-cost premiums and flexible repayment rates.

4.3.4 Research on managing rangelands and enhancing livestock productivity

Given the inherent dependence on livestock assets in the drought prone region of Southwest Asia and the declining availability and quality of pastures, there is a need to re-think how community based management of common pool resources may work in a context where social relations between sedentary populations (farmers) and pastoral groups are exacerbated by conflict. While there is much to learn from community watershed programmes in Rajasthan and Gujarat, resource allocations for technical solutions to soil and water conservation have not been matched by adequate attention to the property regimes that govern access to water and land. There is also a limited understanding of how and to what extent soil-water depletion affects pastures in the hills. This relationship is important because if water conservation plays any significant role in biomass production, it is the ground grass that would be benefited. But water conservation for this purpose has never been part of livestock development. However, potential for cross-cultural learning exists in the recent attempts to extend market access for dairy products to livestock owners in the semi-arid region of Kutch in northern Gujarat through small joint ventures between the National Dairy Development Board and women's federations promoted by NGOs like the Kutch Mahila Vikas Sangathan (KMVS). In this region devastated by the 2001

earthquake, milk was always a means of exchange, but with access to cooling units, transport systems and veterinary services women are now able to earn important supplementary income to support their families.

- The interface between cropping [cereal production] and fodder needs to be analysed to maximize returns for marginal and poor farmers.
- The reciprocal sharing arrangement between local farmers and pastoralists is under stress and its implication for adaptive strategies in the arid and drought prone regions need better understanding.
- The focus on chemical fertilizers has lessened use of livestock for manure with implications on nutrient cycle. As climate change impact is likely to stress agriculture system, the livestock interface will be further affected. We need better handling of this interface as in the hills the emerging tendency is to keep buffalo for cash income and not for nutrients.
- Milk production can be a source of income for the 'poorest of the poor' in the hills. This option is however limited due to poor access to market. There is a need to better understand how market access to poor farmers can be improved to strengthen livelihood/risk resilience.
- In hills, animal feed is imported from other areas. If milk is promoted in poor areas we need to explore the interface between animal feed (maize and rice husks), local fodder production, and market (both feed import and milk export).
- Carrying capacity of the hills for goats and small animals which can/should be a part of livestock productivity for poverty reduction.

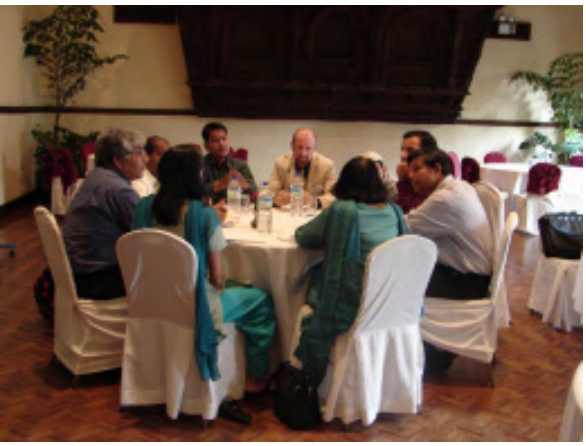
4.3.5 Research on the role of "gateway" infrastructure and knowledge systems in enabling autonomous adaptation and the links between the energy requirements of such systems and carbon mitigation.

Most avenues for economic diversification, whether within agriculture or beyond agriculture and into non-farm systems, require substantial energy inputs. This is also true for the transportation and communication systems that enable flexible access to labour and product markets, early warning and so on. As a result, there are direct linkages between the development of adaptive capacity and mitigation of greenhouse gas emissions. Access to secure (although not necessarily large) energy sources appears, among other factors of production, to be a key enabling input for climate adaptation. This is also true for other gateway knowledge and institutional/physical infrastructure systems, particularly those enabling mobility and communications. Such systems are critical factors supporting the development of social networks and the creation of jobs, goods, information, services, remittances and people in and out of areas vulnerable to climate stress.

- We need to understand how access to such systems and the dynamics they create within regional systems enables alleviate relative poverty and resilience of vulnerable populations, particularly women, the poor and socially marginalized groups.
- We also need to Research on such systems is a strategic point of entry from a variety of perspectives.

4.4 Actors and Partners

Research leadership in South Asia varies tremendously given the diverse nature of states and state formation, the presence of market institutions as well as state-civil society relations. While all countries in the region are parties to the UNFCCC and in the past decade, countries such as India are seen as major leaders in negotiations on the Kyoto Protocol and in adopting CDM and other emission control/mitigation measures. India and


Consultative meeting in Kathmandu

Pakistan have brought out their First National Communication on Climate Change, while Bangladesh has developed its NAPA. India is working on its 2nd NCC and plans to announce its framework on adaptation and the proposed adaptation fund in the summer of 2008. Disaster risk management policies, programmes and institutional mechanisms from national to district and community level are in place in most countries, though their capacity to respond is highly skewed and the links between DRR, vulnerability, adaptation and climate variability still need to be spelled out. In Afghanistan and Pakistan given their political contexts and the underlying conflict, research and practice on climate adaptation is largely driven by the state and a range of donor agencies as well as a few, well-funded, autonomous research institutes. In India, Bangladesh, Nepal and Sri Lanka there are many successful examples of community based natural resource management (forest) and development programmes (drinking water supply, irrigation, community electricity and micro hydro etc..) which though not designed as climate adaptation measures per se show the scale and potential of adaptive mechanisms in drought, flood prone, coastal and mountain or upland areas.

4.5 Capacity Building Needs

The 1992 UNCED conference's Agenda 21 (Chapter 37) conceived capacity building as, "a country's human, scientific, technological, organizational, institutional and resource capabilities. The goal of capacity building is to enhance the ability to evaluate and address the crucial questions related to policy choices and modes of implementation among development options, based on an understanding of environment potentials and limits and of needs perceived by the people of the country concerned". Capacity building is a long-term and continuing process, in which ministries, local authorities, non-governmental organizations and water user groups, professional associations, academics and others participate. Adaptation research in South Asia needs focus on capacity building because

- The scale of climate change induced impact is enormous, but appreciation of the problem is low.
- The link between research needs and supply is weak.
- Limited funding is allocated for research.
- Catalyzing change need continuous support.
- Educational and capacity building institutions are fragmented and interaction among them is inadequate.
- Curriculum is conventional and teaching materials insufficient.
- The education system is inertial to accommodate emerging constraints due to climate change impacts.

The needs for capacity building are however dynamic and changing. There are no ready solutions, and any research programme must suit the local situation and organizations. Local government, communities and NGOs are the main clients for capacity building, but central government and the private sector also need support to respond to the constraints that climate change is likely to bring about. Community groups and local government actors need to improve their capacity to plan, organize and respond to the emerging challenges in their locality. Local government play an increasingly important role in enabling both planned and autonomous adaptation at local levels.

Conclusion

In South Asia the processes of globalization and increasing mobility are creating unprecedented inter-linkages among livelihoods, economic, social, environmental and communication systems. These processes are fuelled by ongoing economic and social systems dependent on use of fossil-fuel. Our analysis has explored fault lines within these linkages and implications for livelihoods and poverty alleviation as climate change impacts invokes attentions for developing adaptive capacities. South Asians, however, do not depend on services from local environment to meet their basic fuel, fodder, water and other livelihood needs. In fact, in many places these services are imported representing a virtual flow of such services from producing regions to consumers. The ability to access services depends on purchasing power—an outcome of livelihood diversification and intensification within mixed-economy basket. The ongoing environmental degradation, however, threatens both the capacity of provisioning of the basic services and the traditional livelihoods base.

The change processes including climate change also represent challenge to conventional knowledge system that would enable responses to emerging constraints. Conventional approach and tools and methods it generates cannot respond as change processes make the basis on which they are generated irrelevant. We need innovative approaches that iterate among knowledge generation, hypothesizing, implementing and reflecting for redefinition and generate new knowledge.

It is worth reiterating that research needs to be interactive across disciplines. Reductionist research on climate, hydrology, ecology and agriculture needs to be pursued to support maintenance of services such as food and drinking water. Such research must be linked with other forms of research on social and economic systems if the new knowledge generated is to translate into procedures and instruments for enabling adaptive strategies. At the same time, policy must be informed of varied disciplinary concerns. Disconnected research on individual themes has little chance of contributing to action on the ground or the formulation of effective policies.

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ANNEX I:

AGENCIES AND ACTORS

INDIA
TERI
UNDP
ActionAid India
IIM Ahmedabad
WWF India
Winrock International India
MoEF
NIDM
MSSRF
The Climate Group
Khemka Foundation
CSE
GTZ
SDC
IDRC
IARI
Royal Norwegian Embassy
World Bank
DFID
Institute of Global Warming and Ecological Studies (IGWES

NEPAL
Winrock International (Nepal)
Ministry of Environment, Science and Technology
Department of Hydrology and Meteorology (DHM)
Biogas Support Programme (BSP)
Trust for nature conservation (NCST)
World Wild Life Fund (WWF)
Nepal Water Conservation Foundation (NWCF)
Institute of Social and Environmental ISET-N
Action aid Nepal
International Centre for Mountain Development
World Conservation Union Nepal
Clean Energy Nepal
Practical Action Nepal
LI-BIRD
Climate Change Network-Nepal
Climate Change NGO Group
Climate Change Task Force
Task Group on Disaster Management

PAKISTAN
Clean Development Mechanism Cell (CDM)
World Food Programme
Global Change Impact Studies Centre GCISC
Ministry of Environment
Rural Development Policy Institute
World Bank
LEAD Pakistan
Water Resources Research Insttitute (NARC)
Care International
Pak-EPA
WWF
DFID
National Disaster Management Authority
Focus Humanitarian Assistance
PC
IRSA
Concern Worldwide
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GTZ
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